Green Infrastructure Planning in Germany and China

A comparative approach to green space policy and planning structure

Tinghao Hu[1], Jiang Chang[2], Ralf-Uwe Syrbe[3]

1. School of Mechanics and Civil Engineering | China University of Mining and Technology Xuzhou
2. Institute of Architecture and Urban Planning |China University of Mining and Technology Xuzhou
3. Leibniz Institute of Ecological Urban and Regional Development Dresden

DOI 10.7480/rius.6.96

Abstract

Green Infrastructure (GI) provides an important life-support system for regions and cities. Inspired by, supported by or copied from nature, GI is intended to deal with issues that traditional grey infrastructure can hardly accomplish. Initiated by the European Union's (EU) Biodiversity Strategy, Germany was an early adopter and thus a role model for the GI approach. In particular, a systematic GI planning system composed of formal and informal planning instruments has been established and implemented from the national to the local level. In comparison, China has not yet officially issued guidance or laws for GI planning. Instead, GI implementations are mainly concentrated at the urban and local scale in the form of green municipal engineering. Scrutinizing the spatial planning system in China, however, we can identify a top-down "5+1" model as a GI planning framework. This includes five types of statutory and non-statutory planning together with the garden city movement. Germany may benefit from China's diversified and inclusive GI development model and its efforts to promote regional transformation and enhance citizens' sense of pride in their city. On the other hand, China can learn from Germany's integrated GI planning system and top-level design. Due to the cross-cutting nature of the issues involved, China's national spatial planning system must be reformed in order to improve GI planning in the country.

The aim of this paper is to compare GI planning in Germany and China, two countries at different developmental stages and with contrasting social and governmental systems. In so doing, we hope to build a "bridge" for the exchange of experiences.

KEYWORDS

green infrastructure, green space, planning system, Sino-German

1. Introduction

Green infrastructure (GI) is considered to be an important life-support system, vital to improving the urban ecology and maintaining sustainable development (Rouse & Bunsterossa 2013). As a contemporary planning tool, GI focuses on examining the status quo and overall benefits of natural and semi-natural elements in cities and regions at multiple scales (Mell 2013; Hersperger et al. 2020). It is inspired by, supported by or copied from nature to deal with sustainable development issues in human settlements. Since the 21st century, the GI approach and ecosystem services have been seen as an important means of improving human well-being.

Germany attaches great importance to preserving the natural environment and biodiversity in the process of city and regional development. Guided by Nature-based Solutions (NbS), the country was an early adopter and thus a role model for the GI approach. In particular, a systematic GI planning system composed of formal and informal planning instruments has been established and implemented from the national to the local level. In contrast, GI is a relatively new concept in China, which has not introduced any guidance or laws for GI planning at the national level. Nevertheless, the national government has recently promoted what it calls "Ecological Civilization", accompanied by the implementation of large numbers of GI projects. Chinese policymakers now comprehend the advantages of the GI approach compared with traditional gray infrastructure in the urban context, especially in improving urban resilience, mitigating natural disasters and controlling urban growth (Byrne 2015; Wang & Banzhaf 2018). In 2018, the State Council of China promulgated an institutional reform plan and decided to establish the Ministry of Land and Natural Resources. This will be followed by a reform of the country's spatial planning system. Various spatial planning functions previously scattered over multiple departments will all be gathered in the newly formed Natural Resources Department. Especially with regard to GI issues, Germany's mature green space planning system can provide a valuable reference to China in this process, particularly in how to deal with different planning levels and planning implementations at diverse scales. Due to its rapid transformation, China has necessarily encountered many new problems while trying to ensure sustainable development. Meanwhile the country's fast and diversified inclusive renovation and development model provides opportunities for experimentation, thereby deepening existing theories, which may also be applied to the German context.

Since the original development of the GI concept, scholars and practitioners around the world have produced a wide range of policies, principles and forms of implementation (Mell 2013; Wright 2011). There is an ongoing discussion on how to establish best practices and planning implementations to share the values of GI. If we focus our evaluative lens on comparisons of

national and sub-national practice, we see a huge disparity in approach, application and structural/institutional support. From another point of view, we can see as well how localized interpretations are made by this common conceptual framework and how implementations are integrated into the existing planning framework. (Mell et al. 2017). To this end, in the current paper we intend to compare GI planning systems and their implementations in Germany and China, two countries at different developmental stages and with contrasting social and governmental systems. In so doing, we aim to build a bridge for experiential exchange between policymakers, practitioners and academics in order to determine whether transferable knowledge can be identified, recognized and translated between Germany and China.

Our analysis involves the following four tasks:
-To combine and summarize the background and research content of the GI concept;
-To analyze the development process and GI planning framework in China and Germany;
-To compare the GI approaches in policy settings, spatial planning framework, at different scales and
-To pinpoint methods and strategies for mutual benefits and innovations in GI planning and implementations.

The article is divided into five sections. This introduction is followed by Section 2, which considers the research paradigm of GI. In Sections 3 and 4, we discuss in detail the development process and spatial framework of GI in both countries. In Section 5, the GI planning approaches in Germany and China are compared and evaluated in order to reveal the potential for mutual benefits. In the final section, we derive some conclusions from our findings, which can be helpful to both countries.

2. Research paradigm of Green Infrastructure

2.1 Overview of the concept

GI is an important life-support system that can greatly improve urban ecology and help to ensure sustainable development (Ahern 2000; Weber 2000). In the late 1990s, GI was explicitly introduced in the United States. For example, Charles Little's book *The Greenway in the United States*, defines GI as "the expansion of the greenway system" and "a new infrastructure category" (Little 1990). Since then, GI has quickly become popular in the landscape planning community. Yet it is not really a new concept; its roots lie in efforts in the 20th century and even earlier by Western nations to provide leisure space for urban residents as well as to maintain public health (Benedict & McMahon 2006). Typical examples are, from the 19th centu-

ry, Olmsted's "Emerald Necklace" project in the United States (Olmsted Necklace) as well as Ebenezer Howard's idyllic urban theory (Canzonieri et al. 2007). Subsequently, the green belt concept (Mell 2009), greenway planning (Fábos & Ryan 2004) as well as garden city movements have laid the foundation for the formation of this concept.

Considering the range of international research and the varying definitions of GI, it is difficult to give GI a "global" interpretation. Previous studies have mostly focused on an evaluation of localization within national scales. The findings of these investigations are highly diverse, reflecting the specific research objectives, methods and contents (Benedict & McMahon 2006; Lennon 2015). We can summarize the different research perspectives as follows: Landscape architects and planners strive to realize landscape functions through nature-based design and configuration (Sandström & Carlsson 2008; Walz & Syrbe 2013); conservationists emphasize the GI functions of biodiversity and habitat protection (Syrbe et al. 2013); urban planners are more concerned with the comprehensive benefits that GI can provide for cities (Lafortezza et al. 2013; Madureira & Andresen 2014); architects and municipal engineers stress the role of GI in greening buildings and regulating storm water (Lehmann 2014; Nickel et al. 2014); finally, geographers and ecologists focus on the ecosystem services and human well-being that GI provides (Tzoulas et al. 2007; Meerow & Newell 2017). Although academics from different countries and disciplines argue about the meaning of GI, "ecological networks", "connectivity" and "multifunctionality" are often cited as common features of GI, regardless of the precise definition (Rouse & Bunsterossa 2013; Canzonieri et al. 2007; Lennon 2015; Peter 2018). Recently, with increasing cross-disciplinary cooperation, the vanguard of GI research is focused on the following seven aspects: The ecosystem services of GI (Liquete et al. 2015; Maes et al. 2015), GI and climate-change response (Matthews et al. 2015), GI and flood regulation (Ahiablame et al. 2012; Lafortezza et al. 2013), GI and the improvement of air quality (Ng et al. 2011), GI and Low Impact Development (LID) (Yu et al. 2008; Dhakal et al. 2017), GI and human well-being (Tzoulas et al. 2007; Liu et al. 2014; Nickel et al. 2014), GI and civil participation (Lovell & Taylor 2013; Byrne et al. 2015) and GI construction methods (Lennon 2015; Chang et al. 2018).

2.2 Structure, functions and scales of Green Infrastructure

Spatially speaking, GI tends to consist of core areas, corridors and stepping stones (Weber et al. 2006; Hansen & Pauleit 2014) *(see Figure 1)*. Table 1 gives an overview of the GI paradigm, drawn from a literature review. The main characteristics are:

-Regarding constituent elements, GI includes vegetation and water bodies in both natural and semi-natural settings;

-Regarding scale, GI ranges from country, to region, to city, and site scale;

-Regarding its interdependency, GI appears as multi-functional, multi-scale and connective;

-Regarding research goals, the main purpose of GI planning is to optimize the supply of ecosystem services, to realize human well-being, to conserve biodiversity and to foster green urban (municipal) infrastructure development.

"Nature-based Solutions (NbS)" is the essence of GI methodology. These emphasize the inspiration and support that can be obtained from nature as well as the use or imitation of natural processes to address various social challenges while ensuring economic, social and environmental benefits (European Commission 2015).

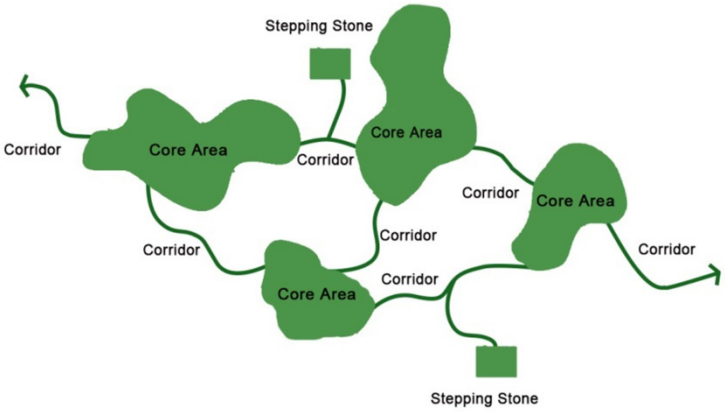

Figure 1. Structure and components of green infrastructure. © Draft Thinghao Hu

Topics	Foci	Representatives	Planning objectives	Scales
Human well-being	National life-support system	Benedict & McMahon (2002); Canzonieri et al. (2007)	Realizing environmental, social and economic sustainability	From national to local scale
	Ecological network; Connectivity; Multifunctionality; Landscape function	Sandström & Carlsson (2008); Madureira et al. (2014)	Improving ecosystem services; Controlling urban sprawl; Land protection; Environmental protection; Smart growth	Natural and semi-natural areas of regions and cities
	Storm water management; Urban heat island control; Natural disaster control	Matthews et al. (2015)	Improving urban resilience and residents' quality of life	Urban scale
	GI and ecosystem services	Tzoulas et al. (2007); Maes et al. (2015)	Providing a variety of environmental, social and economic values and services	Regional and urban scale
	Synergy and trade-offs of GI functions	Lovell & Taylor (2013); Hasse et al. (2014)	Maximizing the benefits of ecosystem services; Sustainable development	Natural or semi-natural areas
	Planning and implementations of GI	Meerow & Newell (2017)	GI planning approaches	From national to local scale
Nature and Biodiversity Conservation	Strategic network; Biodiversity conservation	Syrbe et al. (2013); Liquete et al. (2015)	Enhancing ecosystem services; Maintaining biodiversity	Natural and semi-natural areas, ranging from national to regional, urban and local scale
	Habitat conservation; Regulating and supporting services	Weber et al. (2006); Walz & Syrbe (2013)	Preserving biodiversity	Natural and semi-natural areas of cities
	Ecological restoration and protection	Chang et al. (2018);	Sustainable land use; Ecological protection	From national to local scale
Green municipal engineering	Urban rainwater management; Permeable pavement design	Nickel (2014); Ahiablame et al. (2012)	Greening of municipal infrastructure	Urban scale
	Vertical greening and green roof	Lehmann (2014)	Green buildings; Energy-saving and environmentally-friendly design	Urban and local scale
	Low impact development; Sponge city development	Yu et al. (2008); Dhakal & Chevalier (2017)	Design for resilience; Sustainable landscape planning	Urban and local scale

Notes: The table is drawn from a review of the papers listed under "Representatives". Those sources can be found in the list of references.

Table 1: The GI paradigm.

3. Green Infrastructure planning system in Germany

3.1 Development process

In Germany, systematic GI strategies were established with the aim of preserving biodiversity and ecosystem services (European Commission 2013). These were triggered by a series of EU initiatives (i.e. Natura 2000, EU Biodiversity to 2020, etc.) intended to constrain the deterioration of habitats and the loss of biodiversity. As a key member of the EU, Germany implemented a GI development process largely in line with EU policies. In this process, Germany is continuing to deepen its understanding and response to GI, realizing that the multi-scale, multifunctional, inclusive and connective nature of GI can effectively prevent the loss of biodiversity and strengthen the supply of ecosystem services (Lafortezza et al. 2015).

Germany is a federal republic with a decentralized legislative system and 16 highly autonomous states (Länder). At the federal scale, GI planning is generally limited to overall guidance, providing basic planning for state, regional, and local development. In 2006, Germany passed a federal reform bill that revised and clarified the jurisdiction of the federal and state governments. In particular, more legislative and policy-making authority for environmental and ecological protection was transferred to the federal government such as waste disposal, the protection of air quality and water conservation. The federal government and the states implemented an "information sharing - synergy - trade-off - compensation" approach to dealing with ecological and environmental issues, aiming to minimize the likelihood of conflicting policies between the federal government and states in the areas of nature, biodiversity, marine environment and landscape protection. This also laid the policy foundation for Germany to issue GI policies and guidance documents at the federal level. In the same year, ministers from the 16 autonomous states jointly issued their "Concepts and Strategies for Spatial Development in Germany" at a ministerial conference. This policy paper emphasized the sustainable development of large-scale green spaces at the federal scale, and is seen as the official inception of GI planning in Germany (Mell et al. 2017). Since then, the country has launched a series of GI planning initiatives, policies and strategies, which continue to deepen and improve the understanding and application of GI (see Table 2 for details).

3.2 Spatial framework of Green Infrastructure planning in Germany

As already pointed out, GI is not a particularly new concept. In Germany, research has been conducted since the 1960s on urban ecology and the creation of high-quality human settlements (Blume & Sukopp 1976). Along with a deeper understanding of the relationship between human and nature, the concept of GI has been expanded to include biodiversity conservation and ecosystem services in the context of sustainable development, so it became more

interdisciplinary. Similarly, the spatial planning of GI in Germany constitutes a fully integrated system rather than merely a series of vertical or horizontal plans. Running from the national to local level, a spatial framework has been established by a series of spatial planning instruments, which are based on comprehensive plans and sectoral plans, guided by strategies/policies, and mostly implemented by informal plans (see Figure 2).

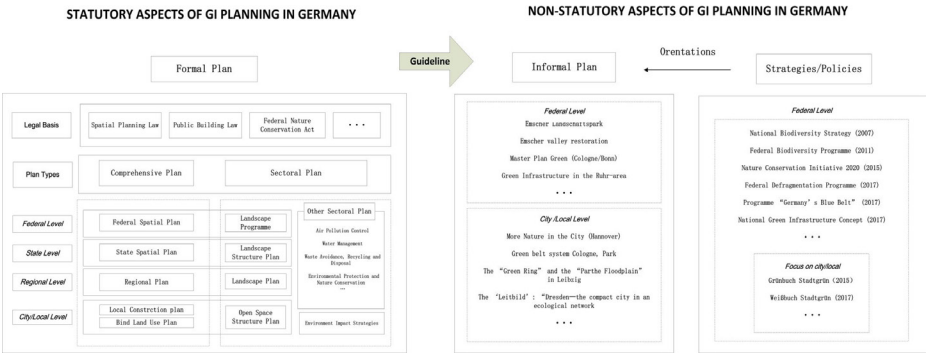

Figure 2. GI spatial planning system in Germany. © Draft Thinghao Hu

Regarding planning legislation, instruments for GI planning include comprehensive planning, landscape planning within sectoral planning, environmental impact assessments as well as other sectoral planning that more or less affects the design and implementation of GI planning (i.e. air pollution control, water management, environmental protection and nature conservation, etc.). Of these regulatory instruments, landscape planning occupies an extremely important position. The German Federal Natural Protection Act of 1976 clearly specifies the responsibility and role of landscape planning as a planning tool in protecting and maintaining landscapes and their development. Landscape planning encompasses almost all the spatial aspects of ecological protection in Germany, including collecting, assessing and summarizing diverse data about the environment and landscape. In contrast to other forms of sectoral planning, landscape planning enjoys regulatory power due to the principle of environmental priority. Therefore, comprehensive plans, land use plans and other sectoral plans must take the requirements of landscape planning into consideration (Heiland 2010).

It should be noted that in Germany, landscape planning only takes account of nature and biodiversity protection if landscape functions need to be assessed for projects or activities whose impact will conflict with the goals of nature protection (Albert et al. 2012). In contrast, GI planning specifically focuses on human well-being, using anthropocentric approaches to address

ecosystem services. It can be said that the success of today's GI planning in Germany largely depends on the close intertwining of the GI concept and the country's system of landscape planning. Specifically, the GI concept reflects the traditions and expanded scope of the German landscape planning system. Regarding scale, this system covers four levels: landscape policy planning, regional landscape planning, landscape planning and green space structure planning. These correspond with the four GI scales: the federal, regional, urban and local scale. Functionally, the "multifunctionality" emphasized by GI not only encompasses natural environmental protection and governance in the traditional sense, but also ecosystem services such as climate regulation, natural disaster prevention, control of the urban heat island effect, and the establishment of recreational space. The GI concept updates our understanding of the relationship between human and nature while providing new meaning to green space planning.

In addition to the statutory perspective of planning instruments, a large number of GI issues are resolved at different scales by means of informal instruments. At the federal level, GI plans and strategies mostly take the form of overall approaches, guidelines and standard principles aimed at realizing sustainable development, planning GI elements and networks, protecting biodiversity and promoting the quality of life. For instance, the "National Biodiversity Strategy" (BMUB 2007) implemented the EU Biodiversity Conservation Strategy at the federal level by means of habitat restoration, peatland ecological remediation and ecological compensation. Moreover, the "Federal Defragmentation Programme" provides a federal-scale GI network based on the national road network (BfN 2012) while the "Nature Conservation Initiative 2020" proposed an additional 40 strategies to improve the status of biodiversity and human well-being. This initiative also promoted the idea of using urban GI to build a renewable energy base. In 2017, the Federal Agency for Nature Conservation (BfN) issued the "Federal Green Infrastructure Concept", a policy paper which clearly defines GI as "a sustainable tool that aims to achieve natural protection and promote ecosystem services" (BfN 2017). Alongside the implementation of the EU's requirements for GI development, we can pinpoint additional GI elements at the federal level (i.e. core patches, corridors and biological diversity hotspots) as well as further planning goals and requirements for different types of protection. This is the first time that Germany has clearly proposed the GI planning paradigm at the federal level.

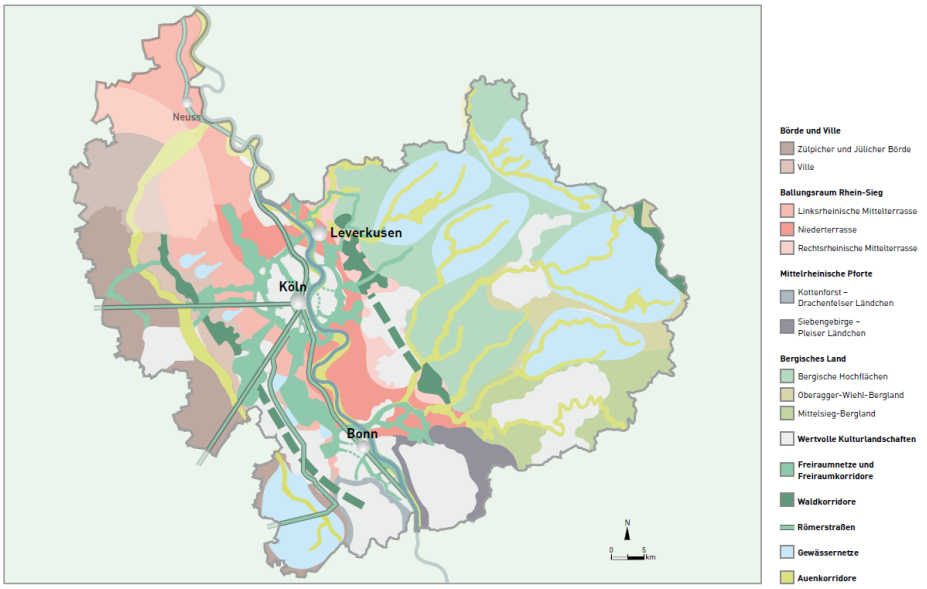

Figure 3. Spatial structure of "Master Plan Green (Cologne/Bonn)"
Source: https://www.region-koeln-bonn.de/de/themen/natur-und-landschaft/masterplan-gruen/index.html

At the regional level, one of the most dominant trends in spatial and sectoral planning in Germany in recent years has been the increasing popularity of informal approaches such as strategic masterplans, which are now widely used as a complement to formalized planning frameworks (Allin 2011; Blotevogel et al. 2014). Primarily, this seems to reflect a lack of flexibility and responsiveness on the part of formal planning structures, especially when reacting to short-term changes and issues. For example, the metropolitan region of Cologne/Bonn has drafted and implemented an informal "Master Plan Green (Cologne/Bonn)" aimed at sensitizing municipalities to regional-scale GI development (Reimer 2013) (see Figure 3). This plan takes full account of the new background and demands of regional planning in terms of energy transformation, climate change, transportation and sustainable infrastructure design. The plan places Cologne and Bonn at the core, with the Rhine as the main axis. It reshapes the urban landscape by integrating blue-green infrastructure in the planning area using natural-based solutions. This project integrates the following eight factors: nature and landscape maintenance, residential development, energy/climate control, structural policy and economic adjustment, regional development, inter-regional cooperation, tourism & leisure, and culture. It provides a good example of regional and departmental cooperation towards sustainable development.

At the urban and local levels, the policy paper Green Book: Green in the City – A Livable Future" issued by BMUB and BMEL in 2015 defined the urban green space, outlining its functions and providing examples of best practices (BMUB 2015). The conclusion is that successful GI planning requires the multidimensional functions of urban greening combined with the approach of strategic networks. In 2018 came the supplementary policy paper "White Book: Green in the City – A Livable Future". This went even further by proposing 10 specific recommendations for GI implementation at urban scales.

Green Infrastructure policies and plans	Year	Scale	Department	Key contents
Concepts and Strategies for Spatial Development in Germany	2006	Federal	Federal Ministry of Transport and Digital Infrastructure (BMVI)	Sustainable development of green spaces at the federal scale
National Biodiversity Strategy	2007	Federal, state	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)	Implementing the EU Biodiversity Conservation Strategy at the federal level through habitat restoration, peatland ecological remediation, and ecological compensation
Federal Biodiversity Programme	2011	Federal, state, urban	Federal Agency for Nature Conservation (BfN)	A number of strategies have been proposed to improve the federal ecosystem and create more urban green spaces
Federal Defragmentation Programme	2012	Federal	Federal Agency for Nature Conservation (BfN)	A federal-scale GI network based on the federal highway network was proposed
Nature Conservation Initiative 2020	2015	Federal, regional, urban	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)	40 strategies have been proposed to improve the status of biodiversity; the idea of using urban GI to build a renewable energy base
Green Book: Green in the City – A Livable Future	2015	Urban, community	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB); Federal Ministry of Food and Agriculture (BMEL)	Multifunctionality, current challenges, and urban GI development strategies were discussed
Federal Green Infrastructure Concept	2017	Federal, state, urban	Federal Agency for Nature Conservation (BfN)	The basic paradigm of German GI planning and development was determined
White Book: Green in the City – A Livable Future	2018	Urban, community	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)	10 specific strategic approaches to promote urban GI development were proposed

Table 2: German policies and plans on Green Infrastructure at the federal level

4. Green Infrastructure planning system in China

4.1 Development process

Influenced by international trends and practices in ecology, Chinese scholars began exploring the issue of urban green space in the 1990s following the Opening of China. Scientists investigated ecological spatial organization methods and ecological planning practices in the urban context. On the one hand, the main content of urban ecological planning theory and practice in this period was the design of a planning system for urban green space. This marked the beginning of an orderly and standardized development of China's green space. Nevertheless, the implementation of green space planning was mainly focused on urban areas, emphasizing the importance of greenery in "core areas" and of "key points". On the other hand, China's large-scale "eco-city construction" began in this period. At the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil, in 1992, China made a commitment to formulate its own "National Agenda 21" (A White Paper on Population, Environment and Development in the 21st Century) to reflect the aims of the UN's Agenda 21. This was an overall strategy, plan and a series of measures to ensure the country's sustainable development. At the city and local level, a significant component of the Agenda was the construction of various "Eco-cities" such as "The National Environmental Protection Exemplary City", "The National Health City", "The National Garden City" and, more recently, "The Low-carbon City" and "The Sponge City".

In China, the approach of creating ecological networks can be traced back to the notion of "ecological infrastructure", first proposed by Kongjian Yu. Similar to the concept of GI, this highlights the key function of safeguarding landscapes as well as sustaining ecosystem services for human well-being (Yu et al. 2001). Since 2009, the GI concept has become popular among Chinese academics, frequently appearing in scholarly literature. As a tool or framework to protect natural resources and guide the sustainable development of urban space, it is seen as an important instrument to protect natural resources and guide sustainable urban development (Li 2009).

Since GI is a relatively new concept in China, most discussions are between academics. While the government has not yet issued any GI guidance policy at the national level, a series of recently promulgated eco-environmental guidelines reflects the need for GI functions as well as concern about ecosystem services and biodiversity conservation. In 2012, for instance, "ecological civilization" was written into the Constitution at the 18th National Congress of the Communist Party of China and became one of the important elements in the 13th Plan for National Economy and Social Development (2016-2020) (short: the Five-Year Plan). In addition, China's 13th Five-Year Plan of National Ecological Protection (2016-2020) noted that the protection

of urban biodiversity and the restoration of urban green space are key complementary factors to expand ecological services. Guided by the Five-Year Plan, China has issued a series of "environmental protection and ecological control programmes". This category of plans further extends and refines the relevant provisions of green space development and environmental protection. Table 3 lists some programmes that take an active part in GI promotion and development.

Plans and Programmes	Department	Planning period	Requirements for GI Development
Plan for Promoting Ecological Civilization Construction	State Forestry Administration	2013-2020	Proposes specific requirements for urban forestry construction action and rural development.
National Main Function Zones Planning	Central People's Government	Issued in 2010, to be realized in 2020	National territory is identified as optimization development areas, key development areas, limited development areas, and prohibited development areas.
National Ecological Protection and Construction Planning	National Development and Reform Commission, and 12 other departments	2013-2020	Proposes five specific measures to improve urban ecology, including: urban green system planning, urban circulating forest and country park construction, urban heat island control, urban water quality management, urban vertical greening and low elevation greenbelt construction.
National Forestation Programme	State Forestry Administration	2011-2020	Puts forward requirements and measures on urban and rural afforestation, green channel and green network construction, restoration of post-mining areas.
Ecological Function Area Planning	Ministry of Environmental Protection; Chinese Academy of Sciences	From 2015	According to the nature background and ecosystem services, ecological function areas at national scale can be categorized into three major classes (ecological regulation, products provision, and human security); there are 242 such areas in China.

Table 3: China's plans and programmes to promote GI development at national level
Source: Grunewald, K., Hu, T., Kümper-Schlake, L., Wei, H., & Xu, Q. (2018). Towards 'Green Cities'—Fields of Action and Recommendations. In: Grunewald K, Li J, Xie G, Kümper-Schlake L. Eds. 2017. Towards green cities: Urban biodiversity and ecosystem services in China and Germany. Springer International Publishing (Cities and nature) pp. 175-197.

It can be said that the guiding ideology of "ecological civilization" is currently the catalyst promoting the formation of China's GI plans and thinking. Here there are three aspects to be mentioned: First, this ideology contributes to setting up a new type of urban ecological plan, even though this is not yet secured in law. Second, "ecological civilization" is closely connected to ecological security and urban security planning (such as flood control planning, watershed planning), thereby expanding the vision of urban ecological plan-

ning. And third, it fosters an increased awareness of ecological processes. The notion of "ecological civilization", along with its various sub-types (such as water ecological civilization), is included in the scope of urban ecological planning, thereby binding ecological civilization and grey infrastructure planning more closely together. In this way, China has started to think about solving municipal issues by means of nature-based solutions.

Figure 4. Yanweizhou Park during the monsoon and dry season
Source: Top picture from: Yu, K. (2017). Resilient Landscape-Yanweizhou Park, Jinhua. Urban Environment Design. 2017(03), pp. 327-329. Bottom picture from: Yu, K., Yu, H., Song, Y., & Zhou, S. (2015). Landscape of Resilience on the Design of Yanweizhou Park in Jinhua City. Architectural Journal. 2015(04), pp. 68-70.

Today, China's construction of sponge cities shows just how GI planning can be implemented by applying the idea of "ecological civilization". A typical example of this is Yanweizhou Park in Jinhua (see Figure 4). Jinhua City is located in the subtropical region of eastern China. During the wet summer monsoon season, the city is often affected by flooding. In order to protect a prominent sandbar from being inundated, the local water conservancy department built two flood control embankments, which however disrupted the local people's access to the waterbody and so harmed their appreciation of water environment. Influenced by the "sponge city" concept, the local government began to revise their ideas, aiming to establish a hydro-elastic landscape adapted to regular flooding which could maintain local people's links to nature while protecting the only floodplain habitat in the city centre (Yu 2015). With these goals in mind, Yanweizhou Park was established to transform the flood-risk area into a place of harmonious coexistence by means of sustainable landscape design. Local vegetation and a stepped bridge system adapted to seasonal flooding are the basic components of the park. A cascading hydrodynamic riverbank was constructed to collect and purify rainwater as well as to protect the ecological landscape alongside the river. In addition, the park has a full-area hydroelastic design with 100% infiltration coverage, including large-scale gravel pavement for pedestrians, ecological parking lots and permeable concrete roads (Yu et al. 2017).

4.2 Spatial framework of Green Infrastructure planning in China

GI is not identified as a priority policy in China's National Planning Policy Framework. Instead, a series of spatial planning approaches addresses various issues of sustainable development. After scrutinizing the spatial planning system, we can summarize the GI planning framework as a top-down "5+1" model. This encompasses five types of statutory plans: *National Economic and Social Development Plan, National Level Ecological Environment and Control Plan, Land-Use Plan, Urban Master Plan and Urban Green Space System Plan,* as well as *Non-statutory Plan* and *Garden City Movement* (Figure 5). The Plan for *National Economic and Social Development*, also called the "Five-Year Plan", is the overarching plan specifying the various stages of national economic and social development. In terms of GI development, this basically acts as the steering wheel, setting aggregate indicators for the country as a whole. The national Environmental Protection and Ecological Control Programme is a generic term for a series of plans that play an active role in GI construction and maintenance. Certain contents and regulations in related plans explicitly specify goals and tasks at regional, provincial and urban scale. The Land-Use Plan is one of the strictest forms of land management. It can pertain to the national, provincial, urban, and county level. It directly determines the scale, function and structure of green space in urban areas. An Urban Master Plan compre-

hensively regulates the economic and social development of urban sites, in particular the land use, spatial layout and urban management. Based on the Land-Use Index determined by the Land-Use Plan, an Urban Master Plan will further determine the layout and form of green space in urban areas. The Urban Green System Plan is a special form of the Urban Master Plan. Based on the urban characteristics, the development goal and land use layout determined by the Urban Master Plan, it formulates indicators for the development of urban green space and specifies types of landscape and green system at different scales. At the urban scale, local governments are establishing R&D institutions, universities or colleges to compile non-statutory plans that are closely related to the development and protection of GI, such as *Key Ecological Function Areas Plan, Biodiversity Conservation Plan, Wind Corridor Plan*, etc. In addition, a series of urban gardening movements have rapidly arisen in China such as the National Garden City, the National Forest City and National Ecological Garden City. These have played a positive role in improving the ecosystem services of GI in the city.

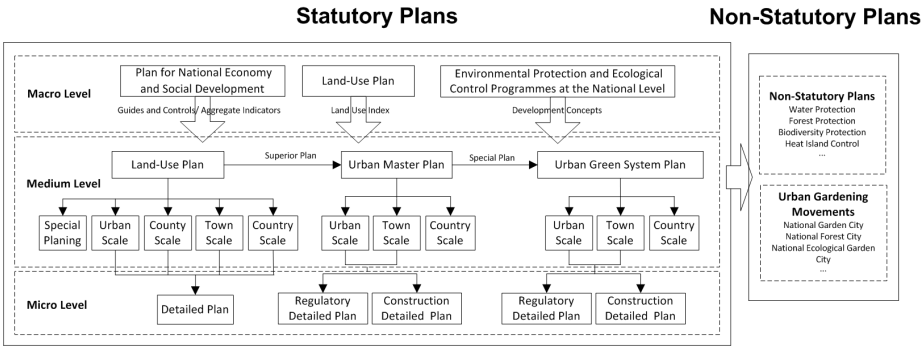

Figure 5. GI spatial planning system in China. © Draft Thinghao Hu

Among those planning approaches, there are currently three kinds of statutory plans for administrative management in China, which are the responsibility of different departments. These three plans are the Land-Use Plan under the supervision of the land and resources management department, the Urban Master Plan under the supervision of the planning and construction management department, and the Environmental Protection & Control Plan under the supervision of the environmental protection department. However, these three kinds of plans lack overall coherence in terms of planning objectives and contents, and to some extent there are functional overlaps, conflicts and contradictions. Meanwhile, their respective developmental levels and focus are different when dealing with the same issues.

The housing & construction department and land resources department aim to secure their areas of responsibility by strengthening urban and rural planning and land use planning. At the same time, the environmental protection department has introduced new types of spatial planning such as ecological environment planning and so-called ecological "red lines". Objects are misaligned and are treated at different depths by the various plans. In order to make up for their own insufficiencies, each plan is constantly improving its respective planning system. The plans overlap in large areas, and there is a lack of integration and a certain degree of fragmentation between the various plans. Alongside the continuous expansion of various departmental plans, all departments are competing for the control of spatial planning management. This is driven by competition for power between various departments during the period of social transformation and transformed governance. The belief that "development is good sense" (发展就是硬道理) has made China choose a growth-oriented policy system from top to bottom. It's highly entrepreneurial government is characterized by utilitarian and short-term growth goals, making the competition in spatial planning increasingly fierce.

5. Comparison of planning approaches to green infrastructure in Germany and China

5.1 Policy settings

GI policy settings in China and Germany are entirely different. In Germany, there is a strong policy of guiding, coordinating and allocating GI resources rather than offering specific planning contents. In China, however, GI guidance policy or strategies are still lacking due to the relative newness of the GI concept. However, considering the ecological and environmental protection policies promulgated by the country in the past five years, we can see a greater emphasis on ecosystem services and biodiversity. In the latest Five-Year Plan, "ecological civilization" is the key strategy for the current stage of development. Its essence is to maintain the balance of natural ecology and achieve harmony between nature and human activities.

Unlike Germany, China's GI-related policies and strategies lack statutory force. Instead of specific indicators and requirements, imprecise and vague expressions are employed such as "vigorously develop", "deeply implement" or "constantly improving". Those "ambiguous" planning guidance frequently resulted in mass deviations in planning goals or requirements when GI projects were implemented from central to local levels. Instead, planning should explicitly mention the specific goals, functional department, implementation process and index parameters rather than leaving these to the imagination of local authorities. In Germany, the federal government made clear and detailed clauses regarding the definition of GI, various categories of GI elements, as well as control and management regulations in its "Federal Green Infrastructure Concept (2017)". China needs to adopt this kind of upper-level

guidance. Regardless of the different political systems, China requires a specific top-down design of GI to ensure the quality and quantity of GI projects and to reduce "vanity projects" as well as unnecessary waste in GI project construction.

5.2 Spatial planning framework

From the horizontal perspective, Germany's GI spatial planning system is supported by a solid body of law and a series of spatial planning instruments. These provide specific instruments and methods for the protection, development and construction of GI at different levels and scales. The GI spatial planning system greatly benefits from the reciprocal feedback mechanism (*Gegenstromprinzip*). The final GI implementation is actually a state of equilibrium achieved through the interaction of upper-level planning and lower-level planning. In this way we see that GI planning is not a unidirectional top-down flow.

In China, the GI planning system is embedded within a strictly vertical, top-down planning framework. However, as mentioned above, there are numerous problems in the horizontal relationship between different plans, leading to a non-unified, incoherent pattern of GI development. While there are a considerable number of seemingly well-implemented GI flagship projects (largely due to generous funding), these projects, when compared to equivalent German GI projects, show an overly fast construction schedule, excessive budgets, and fierce competition in the bidding process. However, due to the systematic problems mentioned, most GI practices implemented at urban and local scales merely reflect quantity and indicator requirements for spatial layout rather than aspects of required functions and quality. For instance, in the context of constructing sponge cities, some wetland projects pay too much attention to the role of municipal functions while neglecting civil participation and human well-being. In some cities, the construction of a "flagship project" comes at the cost of reduced ecological resources in nearby rural areas.

5.3 Planning scales

GI projects have been implemented in Germany at multiple scales. Since ecosystem services extend beyond administrative boundaries, GI functions should not be limited to administrative borders. Compared with Germany, planning implementations in China are mostly concentrated at the urban and local scale using green municipal engineering methods, as can be seen in China's sponge cities. Due to the country's vast territory, diverse terrain and different climate regions, there are only a few cases of planning beyond urban scale. As a result, it is hard to form a continuous ecological network at the national scale. *"Ecological Function Area Planning"* is China's current

attempt at this. According to the classification of ecosystem services, national ecological function areas can be categorized into three major classes (ecological regulation, products provision, and human security), leading to the identification of a total of 242 areas in China. However, departing from the connectivity and network emphasized by GI, these areas are isolated from each other and are defined only in terms of individual functions. Compared with GI planning at the national scale, regional planning cooperation and cooperation between cities is easier to realize due to the same type of natural environmental conditions they possess as well as the similar economic and policy conditions. Therefore, cooperation between cities and regions needs to be further strengthened in China.

5.4 Planning design and civil participation

The systematization and implementation of GI planning requires the extensive participation and cooperation of multi-stakeholders. In Germany, local governments, academics, non-governmental organizations as well as the public are closely involved in the negotiation process to resolve planning issues, status problems and determine planning visions for future development. Yet it cannot be denied that such decision-making mechanisms also make spatial planning activities compete with a strong system of sectoral policies, leading to poor efficiency and flexibility in GI planning process (Lennon 2015).

In China, the government acts as the principal actor specifying the planning and design requirements for GI development. Under this system, the government first sets up a project and declares the design requirements. This is followed by the participation of contractors, R&D institutions, universities or colleges in a binding procedure to compete for the planning and design tasks. When the design phase is complete, the planning scheme is reviewed by the planning regulation commission and then presented to the public for feedback before final implementation. Using this method of implementation, GI projects can be completed within two to three years. However, the "public participation" phase of Chinese planning process can actually be understood as a "planning results demonstration". The role of multi-stakeholders participation is highly restricted in both the goal-setting and final decision stages. Normally, the decision-making stage of the plan is merely the result of negotiation between the government and GI planners.

6. Discussion and conclusion: Towards mutually-beneficial green infrastructure planning

It has proved difficult to establish a transferable rationale for GI not only due to the different national conditions of Germany and China but also the dynamism of planning discussions and relative novelty of GI praxis. Against this background, the basic aim of this study is to take account of the current state of affairs and find the best pathway to sustainable development in the two countries by means of the GI approach, as well as to identify potential strategies to achieve those goals. For this reason, the discussion offers the opportunity to broaden both Germany's and China's developmental vision as well as to introduce some fresh thinking to GI planning.

Based on this comparative study, Germany can benefit from China's experiences as follows:

Firstly, Germany can consider the usage of GI to promote China's development and the revival of regional industry. Currently, German planners are facing the challenge of shrinkage processes in the form of structural crises, outmigration and general demographic decline due to low birth rates. Thanks to the rapid development and large investment in "ecological civilization" construction in China, the country boasts a number of projects in the field of renewable energy based on the GI approach such as wind power plants, biomass and photovoltaics established in old industrial heartlands. For example, coalmining is a sector currently affected by both shifting energy structures as well as resource exhaustion. Shenjiazhuang coal mine- a local coalmining enterprise in Ci County, China, has pursued an industrial transformation model called "Photovoltaic +". The result has been to establish a multi-industry cluster of photovoltaics plus agriculture as the basic industry, accompanied by the development of ecotourism and the processing of agricultural products. The "Photovoltaic +" project has not only increased the number of available jobs, thereby attracting young people to the local region, but has also boosted regional development. This case of regional recovery through the transformation of traditional industries into green industries could serve as a model for Germany. In the future, both countries can exchange their respective experiences by organizing symposiums and field visits, etc. Germany can also offer its advanced technologies to aid China's green industry, thereby ensuring a win-win situation.

Secondly, China's fast, diversified and inclusive development model provides a great experimental field to explore and advance existing theories in Germany. This is a process which demands the participation of German enterprises, landscape planners and architects. For example, in 2008 the government of Xuzhou cooperated with its counterpart in North Rhine-Westphalia in the project "Implementation of ecological restoration of coalmining subsidence areas in north Xuzhou". After 10 years of joint efforts, Xuzhou won the "Habitat Scroll of Honour Award" in 2018 for its achievements in restor-

ing areas suffering from subsidence as well as in the treatment of solid waste from coalmining. With its current vigorous promotion of "ecological civilization" and sustainable development, China is highly receptive to ideas and solutions that could be provided by additional external actors in the concerned areas. Therefore, German enterprises, landscape planners and architects could participate in the project bidding process and bring their experience of GI planning and design to bear in China.

Thirdly, the Chinese government has gathered successful and remarkable experience in fostering citizens' awareness of and participation in "ecological construction". A series of urban gardening movements has arisen with great rapidity such as the National Garden City, the National Forest City and the National Ecological Garden City. The respective ministry establishes guidelines with specific indicators for such "urban gardening movements" and provide subsidies and supporting policies if cities meet the specified standards. Later, the ministries evaluate the experiences of selected cities and extend the most successful examples to the national scale. Urban gardening movements not only help to protect and develop urban green space and the natural environment, but also promote an understanding and pride of local people in their urban setting as well as boosting a sense of responsibility and environmental awareness (see Figure 6). There is no doubt that Germany's strict protection of the natural environment can be considered a role model for many countries around the world. Drawing on the Chinese experience, city and local governments in Germany can organize activities that make use of the natural environment such as marathons, rowing competitions and triathlons in order to reduce any residual disconnection between humans and nature, thereby improving the pride and happiness of urban residents.

Figure 6. Civic participation in national forest city construction movement in Xuzhou, China
Source: Photo provided by Xuzhou Forestry and Garden Bureau.

Fourthly, it is essential to regard urban GI as a way of promoting cultural services for the elderly. Urban parks and green space have a special appeal for elderly Chinese living in the city. For many older citizens, the biggest challenge of aging is not physical decline but rather psychological changes and a lack of purpose after retirement (Hu et al 2016). In China, urban parks have become important leisure and recreational sites for older people, who engage in sports as well as other activities, or simply meet up for a chat. Urban parks also provide the ideal platform for the realization of active aging. In Germany, local authorities and communities can use green space and even allotment gardens to organize activities as well as promote communication between elderly citizens (see Figure 7).

Figure 7. Parks are ideal places for elderly Chinese to exercise and take part in social activities.

There is no doubt that China can learn and benefit from Germany, which acts as a role model in GI planning and implementation. Although many GI projects have been speedily and efficiently implemented in China, it can be questioned whether these projects will really achieve the sustainable development goals of the country's cities. In addition, cross-sectoral issues often arise when different statutory plans propose conflicting standards regarding the same issue at identical planning levels. In view of these problems, the following four specific points should be learned from Germany. *Firstly,* quantity and quality should be accorded equal importance when GI projects are being

planned and implemented. *Secondly,* it is vital to regard GI as a long-term goal. This will avoid any rush to achieve some instant benefit and thus neglect long-term interests. *Thirdly,* planning scales need to be expanded from local and urban scale to regional level. *Fourthly,* multi-stakeholder cooperation and civil participation should be further enhanced in the planning process.

In view of these suggestions, it seems unlikely that progress will be made without changing the existing spatial planning system in China. In March 2018, the country's State Council issued an institutional reform scheme which foresaw the establishment of the Ministry of Land and Natural Resources to supervise the implementation of a new territorial and spatial planning system. This provides an unprecedented opportunity for GI planning and implementation in China over the next years. The national spatial planning system will be integrated, thereby solving the problem of overlapping spatial planning by exercising control over the use of all land matters. Although the implementation rules for the new territorial and spatial planning system have yet to be issued, "multi-planning integration" and "ecological priority" have been determined as basic principles. This revision of the national spatial planning system is undoubtedly a direct response to criticism of the current chaotic situation of multi-regulations. No doubt this will prove to be a tortuous process in which problems cannot be predicted beforehand, but must be identified and solved step by step. Clearly, Germany's system of spatial planning is a result of its history, culture, ideology and social developmental stage, and cannot be completely copied by China. However, a balanced and comprehensive legal system, horizontal and longitudinal hierarchical coordination mechanisms, as well as spatial planning and departmental resource integration can be regarded as essential components of China's reform and reconstruction of spatial planning.

It is hoped that this study provides a straightforward entry point for readers to understand the GI concept and planning approach in Germany and China. As a policy and planning framework bringing comprehensive benefits, Germany has gathered extensive experience in the GI approach. China, where GI is a relatively new concept, thus has a great opportunity to learn from Germany. Although the two countries are quite different in a number of respects, we believe that this comparative study will broaden the ideas and perspectives for stakeholders to better solve current issues or problems that may be encountered in the future. Furthermore, we strongly recommend that the two countries focus on common challenges in future research, discussing ways of solving these through closer cooperation.

ACKNOWLEDGEMENTS

This work was supported by National Natural Science Foundation of China (NSFC). We would like to thank the NSFC for funding the project "Research on Space–Time Evolution Laws And Optimization Model of Green Infrastructure in Coal Resource Based Cities" (No. 41671524); Research on the Potential, Mechanism and Planning Response of Brownfields Greening from the Perspective of "Urban Double-Repair" (No. 51808543). We would also like to thank the other members who have supported this publication with comments and ideas.

REFERENCES

Ahiablame, L. M., Engel, B. A., & Chaubey, I. (2012). Effectiveness of low impact development practices: Literature review and suggestions for future research. *Water, Air, & Soil Pollution 223*(7), 4253-4273.

Albert, C., von Haaren, C., & Galler, C. (2012). Ecosystem services – Old wine in new bottles or an incentive for German landscape planning? *Naturschutz und Landschaftsplanung 44*(5), 142–148.

Allin, S. (2011). A new understanding of formal land use plans in Germany. *International Journal of Sustainable Society 3*(4), 385–396.

Benedict, M. A., & McMahon, E. T. (2002). Green Infrastructure: Smart Conservation for the 21st Century. *Renewable Resources Journal 20*(3), 12-17.

Benedict, M. A., & McMahon, E. T. (2012). *Green infrastructure: Linking landscapes and communities.* Island press.

Blotevogel, H. H., Danielzyk, R., & Münter, A. (2014). Spatial planning in Germany. Institutional inertia and new challenges. In M. Reimer, P. Getimis, & H. H. Blotevogel, *Spatial planning systems and practices in Europe. A comparative perspective on continuity and change* (pp. 83–108). Routledge.

Blume, H.-P., & Sukopp, H. (1976). Ökologische Bedeutung anthropogener Bodenveränderungen.*Schr.-R. f Vegetationskunde 10*, 75–89.

Bundeministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit. (2015). *Grün in der Stadt für eine lebenswerte Zukunft*. BMUB.

Byrne, J. A., Lo, A. Y., Jianjun, Y. (2015). Residents' understanding of the role of green infrastructure for climate change adaptation in Hangzhou, China. *Landscape and Urban Planning 138*, 132-143.

Canzonieri, C. (2007). ME Benedict and ET McMahon. *Green Infrastructure: Linking Landscapes and Communities 22*(5), 797-798.

Chang, J., Hu, T., Liu, X., & Ren, X. (2018). Construction of green infrastructure in coal-resource based city: A case study in Xuzhou urban area. *International Journal of Coal Science & Technology 5*(1), 92-104.

Dhakal, K. P., & Chevalier, L. R. (2017). Managing urban stormwater for urban sustainability: Barriers and policy solutions for green infrastructure application. *Journal of environmental management 203*, 171-181.

European Commission. (2008, December). *Natura 2000 - Protecting Europe's biodiversity*. European Commission.

European Commission. (2011, March). *EU biodiversity strategy to 2020*. European Commission.

European Commission. (2013, November). *Building a green infrastructure for Europe.* European Commission.

European Commission (2015). *Towards an EU Research and Innovation policy agenda for nature-based solutions & re-naturing cities. Final report of the Horizon 2020 expert group on 'nature-based solutions and re-naturing cities'*. European Commission.

Fábos, J. G., & Ryan, R. L. (2004). International greenway planning: An introduction. *Landscape and urban planning 2*(68), 143-146.

Federal Agency for Nature Conservation. (2017, March). *Federal Green Infrastructure Concept.* Federal Agency for Nature Conservation, Bonn.

Grunewald, K., Hu, T., Kümper-Schlake, L., Wei, H., & Xu, Q. (2018). Towards 'Green Cities'—Fields of action and recommendations. In K. Grunewald, J. Li, G. Xie, & L. Kümper-Schlake (Eds.), *Towards green cities: Urban biodiversity and ecosystem services in China and Germany* (pp. 175-197). Springer International Publishing (Cities and nature).

Haase, D., Larondelle, N., Andersson, E., Artmann, M., Borgström, S., Breuste, J., Gomez-Baggethun, E., Gren, Å., Hamstead, Z., Hansen, R., Kabisch, N., Kremer, P., Langemeyer, J., Rall, E. L., McPhearson, T., Pauleit, S., Qureshi, S., Schwarz, N., Voigt, A., Wurster, D., & Elmqvist, T. (2014). A quantitative review of urban ecosystem service assessments: Concepts, models, and interpretation. *Ambio 43* (4), 413-433.

Hansen, R., & Pauleit, S. (2014). From multifunctionality to multiple ecosystem services? A conceptual framework for multifunctionality in green infrastructure planning for urban areas. *Ambio 43*(4), 516-529.

Hersperger, A.-M., Bürgi, M., Wende, W., Bacău, S., & Grădinaru, S. (2020). Does landscape play a role in strategic spatial planning of European urban regions? *Landscape and Urban Planning, 194*(2020), 103702.doi: https://doi.org/10.1016/j.landurbplan.2019.103702

Hu, T., Shen, S., & Chang, J. (2016). The construction practice and its enlightenment of age-friendly cities abroad— A case study on New York City in the United States and London in Canada. *Urban Planning International 31*(4), 127-130.

Jia, X. F., & Dai, F. (2015). Review of progress in research on green infrastructure in China. *Landscape Architecture 8*, 118-124.

Lafortezza, R., Davies, C., Sanesi, G., & Konijnendijk, C. C. (2013). Green infrastructure as a tool to support spatial planning in European urban regions. *iForest-Biogeosciences and Forestry 6*(3), 102.

Lehmann, S. (2014). Low carbon districts: Mitigating the urban heat island with green roof infrastructure. *City, Culture and Society 5*(1), 1-8.

Lennon, M. (2015). Green infrastructure and planning policy: A critical assessment. *Local Environment 20*(8), 957-980.

Li, K. (2009). Green infrastructure: Concept, theory and practice. *Chinese Landscape Architecture 25*(10), 88-90.

Liquete, C., Kleeschulte, S., Dige, G., Maes, J., Grizzetti, B., Olah, B., & Zulian, G. (2015). Mapping green infrastructure based on ecosystem services and ecological networks: A Pan-European case study. *Environmental Science & Policy 54*, 268-280.

Little, C. E. (1995). *Greenways for America.* JHU Press.

Liu, W., Holst, J., & Yu, Z. (2014). Thresholds of landscape change: A new tool to manage green infrastructure and social–economic development. *Landscape ecology 29*(4), 729-743.

Lovell, S. T., & Taylor, J. R. (2013). Supplying urban ecosystem services through multifunctional green infrastructure in the United States. *Landscape ecology 28*(8), 1447-1463.

Madureira, H., & Andresen, T. (2014). Planning for multifunctional urban green infrastructures: Promises and challenges. *Urban Design International 19*(1), 38-49.

Maes, J., Barbosa, A., Baranzelli, C., Zulian, G., Silva, F. B., Vandecasteele, I., ... Jacobs-Crisioni, C. (2015). More green infrastructure is required to maintain ecosystem services under current trends in land-use change in Europe. *Landscape ecology 30*(3), 517-534.

Matthews, T., Lo, A. Y., & Byrne, J. A. (2015). Reconceptualizing green infrastructure for climate change adaptation: Barriers to adoption and drivers for uptake by spatial planners. *Landscape and Urban Planning 138*, 155-163.

Meerow, S., & Newell, J. P. (2017). Spatial planning for multifunctional green infrastructure: Growing resilience in Detroit. *Landscape and Urban Planning 159*, 62-75.

Mell, I., Allin, S., Reimer, M., & Wilker, J. (2017). Strategic green infrastructure planning in Germany and the UK: A transnational evaluation of the evolution of urban greening policy and practice. *International Planning Studies 22*(4), 333-349.

Mell, I. C. (2009). Can green infrastructure promote urban sustainability? *Proceedings of the Institution of Civil Engineers-Engineering Sustainability 162* (1), 23-34.

Mell, I. C. (2013). Can you tell a green field from a cold steel rail? Examining the "green" of Green Infrastructure development. *Local Environment 18*(2), 152-166.

Ng, E., Yuan, C., Chen, L., Ren, C., & Fung, J. C. (2011). Improving the wind environment in high-density cities by understanding urban morphology and surface roughness: A study in Hong Kong. *Landscape and Urban planning 101*(1), 59-74.

Nickel, D., Schoenfelder, W., Medearis, D., Dolowitz, D. P., Keeley, M., & Shuster, W. (2014). German experience in managing stormwater with green infrastructure. *Journal of environmental planning and management 57*(3), 403-423.

Pauleit, S., Liu, L., Ahern, J., & Kazmierczak, A. (2011). Multifunctional green infrastructure planning to promote ecological services in the city. In J. Niemelä (Ed.), *Urban ecology. Patterns, processes, and applications* (pp. 272-285). Oxford University Press.

Rouse, D. C., & Bunsterossa, I. F. (2013). Green infrastructure: A landscape approach. *Apa Planning Advisory Service Reports 571,* 1-164.

Sandström, A., & Carlsson, L. (2008). The performance of policy networks: The relation between network structure and network performance. *Policy Studies Journal 36*(4), 497-524.

Syrbe, R. U., Michel, E., & Walz, U. (2013). Structural indicators for the assessment of biodiversity and their connection to the richness of avifauna. *Ecological indicators 31*, 89-98.

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemela, J., & James, P. (2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. *Landscape and urban planning 81*(3), 167-178.

Walz, U., & Syrbe, R. U. (2013). Linking landscape structure and biodiversity. *Ecological indicators 31*(8), 1-5.

Wang, J., & Banzhaf, E. (2018). Towards a better understanding of Green Infrastructure: A critical review. *Ecological indicators 85*, 758-772.

Weber, T., Sloan, A., & Wolf, J. (2006). Maryland's Green Infrastructure Assessment: Development of a comprehensive approach to land conservation. *Landscape and urban planning 77*(1-2), 94-110.

Wirth, P., Jiang, C., Syrbe, R. U., Wende, W., & Hu, T. (2018). Green infrastructure: A planning concept for the urban transformation of former coal-mining cities. *International Journal of Coal Science & Technology 5*(1), 1-14.

Yu, K. (2017). Resilient Landscape-Yanweizhou Park, Jinhua. *Urban Environment Design 03*, 327-329.

Yu, K., Lei, Z., & Dihua, L. (2008). Living with water: Flood adaptive landscapes in the Yellow River Basin of China. *Journal of Landscape Architecture 3*(2), 6-17.

Yu, K., Li, D., & Chao, L. (2001). Ten landscape strategies to build ecological infrastructure. *[Chinese] Planners 17* (6), 9-13.

Yu, K., Yu, H., Song, Y., & Zhou, S. (2015). Landscape of resilience on the design of Yanweizhou Park in Jinhua City. *Architectural Journal 2015* (04), 68-70.