Integrating the Value of

Biodiversity and Ecosystem Services

into Urban Policy in China and Germany

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Integrating the Value of
Biodiversity and Ecosystem Services
into Urban Policy in China and Germany (2nd edition)

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Preface

Cities represent a socio-ecological system in which the highest density of human population coincides with a mosaic of various types of habitats and niches, ranging from natural remnants, semi-natural, emulated natural, to entirely human-created habitats. Interactions between social and ecological systems critically shape the liveability of cities since urban biodiversity and ecosystems provide a wide spectrum of ecosystem services (ESS) – encompassing but not limited to air and water purification, climate regulation, recreational benefits, mental and physical health improvement – thereby enhance human well-being and the resilience and sustainability of urban areas. However, the ongoing trend of urbanisation including outward expansion and inward (re-) densification, which can be widely observed in both China, a representative transitional economy, and Germany, an industrialised economy, has resulted in serious loss and fragmentation of ecological habitats and niches in urbanising areas. In response to the constant sealing of soil associated with urbanisation and densification in Germany, the German Government has set up an aim to limit soil sealing arising from development projects to less than 30 hectare per day by 2030. However, over the past decade, the intensity of sealing has decreased slightly, and in 2018, it still lies around 56 hectare per day. In the transitional China, the share of urban population is expected to reach 80% (~1.1 billion people) by 2050 (United Nations 2019) which unavoidably leads to drastic land use changes in and around urban areas. Since the provision of ESS in cities d epends on functioning ecosystems, a further loss of urban biodiversity as a consequence of ongoing urbanisation potentially influences the resilient and robust supply of ESS, and subsequently the liveability of cities. One important aspect for the protection and restoration of biodiversity is to understand the economic consequences of a potential loss of urban biodiversity and ESS as well as potential gains when increasing quantity and quality of urban biodiversity and ESS.

In order to raise awareness of the loss of biodiversity and ESS in urban areas and to highlight their benefits for the resilience of cities and human well-being, the German Federal Agency for Nature Conservation (BfN) commissioned a research project entitled “Towards Green Cities: The Values of Urban Biodiversity and Ecosystem Services in China and Germany”. It aims to bridge the linkage between economic consequences, degradation and loss of biodiversity, and ESS supply so as to identify strategies for the consideration of urban biodiversity and the enhancement of ESS in urban planning and development.With this, the BfN supports the Sino-German Urbanisation Partnership initiated by Premier Li Keqiang and Chancellor Angela Merkel in 2013 and adopted by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), and the Chinese Ministry of Housing and Urban-Rural Development (MoHURD) in 2015.

The present study **“Integrating the Value of Biodiversity and Ecosystem Services into Urban Policy in China and Germany”** incorporates knowledge and experiences on the economic value of biodiversity and ESS in urban China and Germany and targets decision makers and practitioners in urban planning and policy regime. Building upon a series of international workshops held in China and Germany during 2015 and 2016, where various case studies in China and Germany were shared, compared, and discussed, this study identifies targets and opportunities for integrating the value of biodiversity and ESS into urban policy in China and Germany. It therefore shows how synergies can be created between biodiversity conservation and the provision of ESS in cities where concentrations of people, land competition, and demand for diverse ESS are highest. Additionally, measures and actions are recommended to limit the loss of biodiversity and secure the supply of ESS in urban areas (for additional context and complementary reading please see Grunewald et al. 2018.).

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This publication **Integrating the Value of Biodiversity and Ecosystem Services into Urban Policy in China and Germany** builds upon a series of international workshops held in Berlin (Germany), Chengdu (China), and Nanjing (China) in 2015 and 2016, involving participants from academic and policy making spheres.

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Core Messages

(i) IMPACTS OF URBANISATION ON BIODIVERSITY AND ESS IN CHINA AND GERMANY

Cities offer a mosaic of natural and transformed habitats which harbour a wide range of diverse ecological niches ranging from natural remnants to novel urban ecosystems. Recent studies show that major cities in China and Germany host a large quantity and diversity of flora and fauna including threatened and protected species. In the past decades both **China and Germany have experienced rapid urbanisation processes**, induced by rural-urban migration flows, re-densification, and population growth in urban areas. China's statistics indicate that its urbanisation level increased unprecedentedly from 19.4% in 1980 to 60.6% in 2019. In Germany, the urbanisation level only slightly increased in the same period from 72.8% to 77.4%. Nevertheless, today both countries are facing similarly an **increase of soil sealing, a degradation and fragmentation of habitats and significant loss of biodiversity and ESS in urban areas**. Germany targets a 30 hectare per day threshold for soil sealing by 2030. However, while the soil sealing rate has been reduced from around 69 hectare per day in 2014 to 56 hectare per day in 2018 (Federal Statistical Office 2020), no evidence shows this target can be expectedly hit. Both countries are parties to the Convention on Biological Diversity (CBD) and have developed their National Biodiversity Strategies and Action Plans to address the loss of biodiversity and ESS and to take the multiple benefits of diverse urban nature into account.

(ii) ECONOMIC VALUATION OF BIODIVERSITY AND ESS IN URBAN AREAS – CASE STUDIES FROM CHINA AND GERMANY

Case studies highlighting the economic value of urban biodiversity and ESS in China and Germany show that **urban green spaces could enhance climate regulation and mitigation, air pollutant removal, rainwater runoff reduction, residential well-being and life satisfaction, and recreational benefits**. Moreover, these studies demonstrate that the **benefits of additional green space would at least outweigh the construction and maintenance costs of green space**. However, urban governments, especially those under severe fiscal and revenue constraints, have strong motivation to subject urban green spaces to the dictate of incessant capital accumulation (via real estate development and commodification of urban land). Sufficient provision of green space represents a key aspect of good living conditions as well as healthy and resilient urban ecosystems. However, **green spaces are still not sufficiently provided in many Chinese and German cities**. Furthermore, **environmental inequalities** exist due to the **uneven distribution of green space within urban areas in China and Germany.**

(iii) OPPORTUNITIES FOR INTEGRATING THE VALUE OF BIODIVERSITY AND ESS INTO URBAN POLICY IN CHINA AND GERMANY

Integrating the value of biodiversity and ESS in urban areas requires (i) **to recognise the benefits and economic value of biodiversity and ESS** in the context of sustainable development strategies in China and Germany, (ii) **setting targets for an ecosystem-friendly urban policy and planning**, and (iii) **implementing policies and instruments** to achieve these targets. Tangible measures for ecosystem-friendly urban policy and planning in China and Germany should incorporate (i) **conservation and protection** of existing urban green space (establishing a "no net loss principle" for urban green spaces) and (ii) **provision of new urban green spaces** in order to ensure (iii) **sufficient and equal access to green space** ($10m^2$ per capita and access to green space within 300m around the household). Moreover, the integration of biodiversity and ESS into urban development policies requires the **establishment of adequate indicators** and the integration of ESS in municipal and national reporting and accounting systems.

Impacts of urbanisation on biodiversity and ESS in China and Germany

Urban green spaces, biodiversity and ESS

Urban green spaces, ranging from remnants of pristine natural to urban-industrial landscapes (Kowarik 2011; Lo and Jim 2012; Lachowycz and Jones 2013), provide an essential structural and functional contribution to cities. A rich diversity of habitats harboured within urban green spaces helps to conserve the biodiversity in the urban context (see Box 1). The state of urban habitats and its biological diversity is determined by urban design, planning, and management, which are, in turn, influenced by the economic, social and cultural values and dynamics of the human population (Müller and Werner 2010). Urban green spaces provide multiple benefits for urban dwellers such as opportunities to enjoy physical activity and recreation, share social contact and promote mental and physical health (ten Brink et al. 2016; WHO 2016).

On city level, varied urban habitats harbour a substantial amount of endemic, rare and endangered species and thus can play a significant role in biodiversity conservation (Sukopp and Wittig 1993; Müller and Werner 2010; Kowarik 2011). For example, the city of Berlin (Germany) hosts a total number of over 9,000 species including 2,179 vascular plants, 350 birds, and 59 mammals (Kühn et al. 2004). In China the city of Beijing hosts an extensive vascular plant diversity of 2,276 species, including 207 species of conservation concern such as endemic, threatened and protected species (Wang et al. 2015). There is a reduction in species richness from the urban fringe to the centre, with the species richness peaking at the urban fringe (Müller and Werner 2010). For example, in Central European cities, the number of vascular plant species decreases from more than 400 species per km^2 at the urban fringe to less than 50 species per km^2 in the city centre (Godefroid 2001).

Box 1: Definition of Urban Biodiversity

"Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (CDB 1992: 3)."

"Urban biodiversity is the variety and richness of living organisms (including genetic variation) and habitat diversity found in and on the edge of human settlements. This biodiversity ranges from the rural fringe to the urban core. At the landscape and habitat level it includes: remnants of natural landscapes (e.g. leftovers of primeval forests), traditional agricultural landscapes (e.g. meadows, areas of arable land) and Urban–industrial landscapes (e.g. city centres, residential areas, industrial parks, railway areas, formal parks and gardens, brownfields) (CBD 2012: 8)."

In connection to diverse urban nature, a wide range of ESS can be provided, which contribute particularly to human well-being by reducing environmental pressures e.g. air purification, climate change mitigation and adaptation (Baró et al. 2014; Burkart et al. 2016), and providing recreational, aesthetic and health benefits (Tameko et al. 2011; Shanahan et al. 2015) (see Box 2).

Box 2: Definition of Ecosystem Services (ESS) (MEA 2005)

Ecosystem services are benefits that humans obtain from ecosystem functions or as direct and indirect contributions of ecosystems to human well-being. ESS can be classified into four categories as follows.

Provisioning Services: These services include the provision of material goods such as food, raw material, water, genetic resources etc. and biomass-based inputs.

Regulating Services: Ecosystems contribute to climate, waste and disease regulation and represent important buffer zones protecting against flood events and soil erosion.

Cultural Services: Biodiversity and ecosystems have recreational values, are part of the cultural heritage and identity, have spiritual and historical values and play an important role for science and education.

Supporting Services and Habitats: Urban areas can offer various habitats for many species of flora and fauna and help to maintain the genetic diversity.

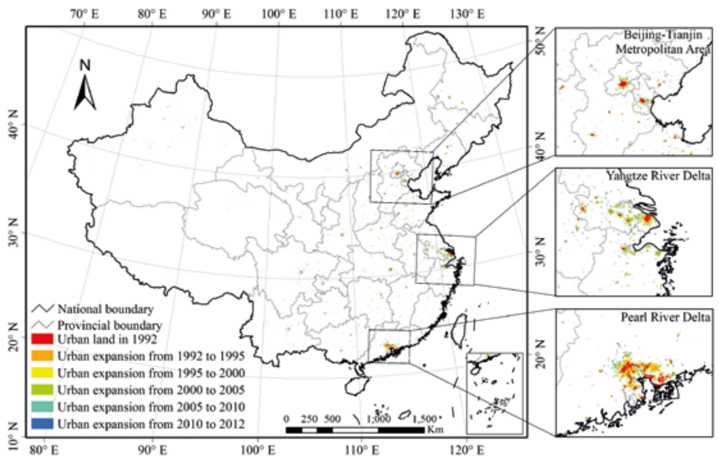
Urbanisation as a crucial driving force for the loss of biodiversity and ESS

Worldwide one of the most detrimental consequences of urbanisation is the fast pace at which biodiversity is being lost (Elmqvist et al. 2013, 2016). An important facet of this biodiversity loss is the corresponding loss of ESS (Bartkowski 2017), especially in cities where concentrations of people and demand for diverse ESS are the highest. As a consequence, the impact of urbanisation on the loss of biodiversity and ESS has gained increasing attention in China and Germany and beyond.

In China, an unprecedented high rate of urbanisation has been observed since 1978 when economic reform began (see Figure 1). In 1980, the urban population in China accounted for 19.4% of the total population, which increased to 60.6% in 2019 (National Bureau of Statistics of China 2020; Yang 2013) and is expected to reach 80% by 2050 (United Nations 2019). The drastic urbanisation is mainly attributed to internal migration flows from rural to urban areas and development of non-built-up areas (Lu et al. 2007, Chen et al. 2013). As the most populous nation, the process of urbanisation in China is unique in terms of size and potential impacts (Zhang and Song 2003; Wang et al. 2012).

Most of the environmental and landscape impacts of urbanisation are associated with the loss of urban green spaces and urban biodiversity (Kong and Nakagoshi 2006; Zhou and Wang 2011).

Figure 1. The dynamics of urban expansion in China from 1992 to 2012 (Adopted from He et al. 2014)



One example for the loss of urban green space due to ongoing urbanisation is the city of Kunming (Yunnan province, Southwest China), where the build-up area has expanded from 16% of the whole city area in 1992 to 43% in 2009 (Zhou and Wang 2011). During this process, large areas of urban green spaces have been turned into impervious surface, as indicated by the decreasing of the percentage of grass, agricultural, and forest lands. The continuous expansion of built-up land has significantly transformed urban green space patterns and distributions. The increased dominance of build-up land eventually simplified Kunming's green space pattern. Such a landscape simplification might deprive the habitats for creatures, disrupt the structure of habitats and ecological processes, and reduce biological diversity (Zhao et al. 2006; Kim and Pauleit 2007; Zhao et al. 2010). Similar trends have been found in the city of Beijing (Wang et al. 2007; Su et al. 2011), Shanghai (Zhao et al. 2006; Li et al. 2013), Jinan (Kong and Nakagoshi 2006), and Shandong Peninsular (Wang et al. 2014).

Germany can be characterised as a country with a long tradition of urbanisation and a large share of urban population of 70% since the 1960s. Although less intensive in comparison with China's urban expansion, many German cities face an ongoing trend towards re-densification associated with the redevelopment of inner-city brown land into residential areas (Kabisch et al. 2010). Recent immigration together with other driving forces, such as rising demand for housing, are leading to an increase in the population density of many German cities. This redevelopment and densification process is inevitably connected with soil sealing in the city centre and, as a consequence, with a loss of urban green spaces and biodiversity. In response to the constant sealing of soil, the German Government has set the target to limit soil sealing in Germany to 30 hectare per day by 2030 (Haase and Nuissl 2007). However, the intensity of sealing only slightly decreased over the last decade and still lies around 56 hectare per day in 2018 which is equivalent to the size of 79 football fields (Federal Statistical Office 2020). In addition, the ongoing trend in cities towards smaller households induces an increase in space for housing which adds further pressure on urban green spaces (Keilman 2003; Haase et al. 2013).

Urban green spaces in international policies, national biodiversity strategies and action plans and related initiatives

Several international political initiatives are addressing the loss of biodiversity and its importance for human-wellbeing in urban areas. To give an example, the Sustainable Development Goals (SDG) emphasise the necessity to build more sustainable and greener cities in Goal 11 "Sustainable Cities and Communities" (UNHABITAT 2016). In one of the related targets cities are encouraged to provide universal access to safe, inclusive and accessible green and public space (SDG, Target 11.7). The New Urban Agenda, adopted in 2016 at the Habitat III conference, envisages cities "(...) to protect, conserve, restore and promote their ecosystems, water, natural habitats and biodiversity, minimize their environmental impact and change to sustainable consumption and production patterns (UN 2017: 4)." These goals and agenda are providing entry points for city administrations to further integrate the value of urban green space into a more sustainable city planning.

The 15th meeting of the Conference of the Parties (COP 15) to the Convention on Biological Diversity (CBD) is scheduled to take place in Kunming, Yunnan, China in 2021 under the overarching theme “Ecological civilization: Building a shared future for all life on earth“. At CBD COP 15, a Post-2020 Global Biodiversity Framework (Post-2020 GBF) is due to be agreed. The framework will set out an ambitious plan to implement broad-based action to bring about a transformation in society’s relationship with biodiversity and to ensure that, by 2050, the vision for biodiversity, “Living in harmony with nature”, is realised.

Subnational, regional and local governments are the key agents in implementing actions to address local biodiversity loss and to help national governments achieve the global objectives of the CBD. It is at the subnational and local levels where decisions related to nature and people are directly implemented. Their complementary and distinct role has been recognized in a number of CBD COP decisions since 2008, most notably in COP Decision X/22. In the run-up to CBD COP15 and to urge CBD parties to elevate ambition in order to halt biodiversity loss, a statement of intent, known as “The Edinburgh Declaration”, has been agreed between subnational, regional and local governments across the world, calling for greater prominence of the role that subnational governments, cities and local authorities play in implementing the Post-2020 GBF.

Both, China and Germany are Parties to the CBD and have developed their National Biodiversity Strategies and Action Plans (NBSAPs). Main purpose of the NBSAP is to guide national actions to achieve global strategic goals on the conservation and sustainable use of biodiversity. In the past years, biodiversity strategies and action plans at national levels have inspired subnational decision-makers and administrations to develop complementary plans for local and regional levels. These Local Biodiversity Strategies and Action Plans (LBSAPs) have proved to be very useful instruments that can steer successful decision-making if some criteria are met: LBSAPs shall reflect NBSAPs, but should be formulated much more practical and concise. They should be embedded in area-based planning, overall regional development strategies and ideally address other sectors’ challenges in the municipality, such as concrete climate adaptation needs and public health demands. Furthermore, the targets shall be aligned with measurable and time-specific milestones to ensure consistency with Biodiversity Strategies and Action Plans at other levels and allow for synergies and smooth coordination with other government levels.

The German National Biodiversity Strategy (NBS) formulates visions and objectives for the development and conservation of urban green spaces (under B 1.3.3 “Urban Landscapes”). The vision for the future emphasises that urban areas should provide their inhabitants with a high quality of life, areas for everyday recreation activities, and also incorporate habitats for many species of flora and fauna (BMU 2007). The main requirements include: a) to increase the greening of human habitations and accessibility until 2020, and b) to preserve the landscape functions and ESS in urban areas (see Table 1).

Table 1: Quality targets and specific objectives of German NBS in the urban context (adopted from BMUB 2007: 42-43)

	Quality targets	Specific objectives
B 1.3.3 Urban Landscapes	By the year 2020, the greening of human habitations, including the green spaces close to residential environments (such as courtyard plantings, small areas of lawn, roof and facade planting) will have been significantly increased. Publicly accessible green spaces with varying qualities and functions are available within walking distance of most homes.	Utilise the existing mechanisms of landscape planning, parkland planning and urban development in order to develop urban green spaces and interlink biotopes
		Give greater consideration to brownfield and gaps between buildings when increasing the density of or ecologically upgrading residential areas.
	Habitats for urban-typical endangered species (such as bats, chicory, wall ferns) are conserved and extended, in a way which continues to facilitate the active brownfield development of towns and communities as well as the comprehensive restoration of buildings to improve energy efficiency.	Maximise existing opportunities to improve the immediate environment of residential buildings, e.g. by means of de-sealing, courtyard and building plantings, renaturation and traffic calming.

These requirements have been updated in 2016 (NBSAP Section 7: Greening our cities). A major challenge associated with these requirements is that there is an urgent need to limit development in populated areas and restrict land consumption, yet at the same time construct more and better natural urban spaces in cities (e.g., private gardens, urban parks etc.). To meet this challenge, it is necessary for all stakeholders to adapt a more integrated approach aiming to improve the conservation of biological diversity in cities.

In 2018, based on a primary research review jointly carried out by seven federal ministries on urban green spaces, BMU published the “White Paper: Green Spaces in the City” in which targets, planning potential and concrete measures for creating high-quality green spaces in ten distinct fields of action are illustrated. The overall purpose is to integrate the creation, maintenance and preservation of urban spaces into urban development and associated planning processes so as to ultimately increase the number of green spaces in German cities. To support the implementation of the White Paper, the Masterplan Urban Nature was developed. In recent years, the German Federal Government and the federal states have also included “Green spaces in the city” into their Administrative Agreement on Urban Planning Funding, ensuring actions to increase urban green spaces are financially supported. In 2017 the financial support was further increased by adding a new urban planning funding programme “Future Urban Green Spaces” (BMU 2018).

China launched its National Action Plan for Biodiversity Conservation (NAPBC) in 1994. Since then, various programmes have been developed to integrate biodiversity into land use planning at different levels. For example, the National Outline Land Use Master Plan (2006-2020) issued by the State Council stressed the guiding principle of coordinating land use for production, livelihood and ecology conservation by giving priority to nature and ecology conservation. In 2010, National Plans of Main Functional Zones were issued. Local governments are required to control urban land use as well as identify development zones and define core areas for nature reserves, forest parks, geological parks, and natural habitats in order to conserve diverse flora and fauna.

Most recently, in a position paper for the United Nations Summit on Biodiversity "Building a Shared Future for All Life on Earth: China in Action" released jointly by the Ministry of Foreign Affairs and the Ministry of Ecology and Environment of China in 2020, the Chinese government stressed its commitment to protect biodiversity. Moreover, the concept of ecological civilization has been written into China's constitution in 2018 and embedded in the master blueprint of national development. An inter-agency government coordination mechanism has then been set up at the national level to coordinate actions in mainstreaming biodiversity. At the subnational level, 27 local governments have announced their Provincial Biodiversity Conservation Strategies and Action Plans as the means by which the national conservation concerns are translated into local actions.

Facing the threats to and pressures on natural habitats and ecosystems brought by rapid and extensive urbanisation, the implementation of China's NAPBC and other subsequent measures have contributed to the protection of biodiversity via development, construction and management of nature reserves, scenic spots and urban green areas. Main challenges related to biodiversity conservation in cities have been identified, including a) to formulate a legal system for biodiversity conservation and sustainable utilization of natural resources in urban areas, b) to effectively manage and protect ecologically vulnerable areas such as green land, rivers/lakes and natural wetlands in urban planning, and c) to improve the implementation capacity.

To meet these challenges, it is crucial a) to further integrate biodiversity considerations into national (sectoral or cross-sectoral) plans, programmes, and policies, b) to recognise the economic value of urban biodiversity and ESS, and c) to integrate scattered, sometimes inconsistent, regulations into a holistic framework.

In order to improve the integration of biodiversity and its economic value as well as to better respond to challenges brought by climate change, concepts such as Nature-based Solutions (see Box 3) have been developed in recent years and are increasingly being integrated into local strategies, policies and actions. For instance, in 2014, the Chinese government launched the "Sponge Cities" programme designed to control urban surface-water flooding by mimicking the natural hydrological cycle. Encouraging the use of 'blue' and 'green' infrastructures rather than solely relying on grey infrastructure to tackle urban water issues, the "Sponge Cities" programme represents a transformation of urban planning and management approach in Chinese cities.

Later, in 2017, the initiative "Climate Adaptation City Pilots" was developed by MoHURD with the aim to increase the capacity of cities in developing appropriate climate change adaptation strategies. In the guidelines, green technologies and ecosystem-based approaches are highlighted to reduce greenhouse gas emissions and enhance the resilience of ecosystems, thereby stabilizing the provisioning of important ESS.

In an effort to further mainstream biodiversity considerations into national policies, the report "Post-2020 Global Biodiversity Conservation" published by the China Council for International Cooperation on Environment and Development in September 2020, put forward several recommendations on ecological conservation and restoration for China to include in its 14th Five-year Plan (2021-2025). Actions that coherently address biodiversity loss as well as mitigation and adaptation to climate change were specifically highlighted (CCICED 2020).

Box 3: The concept of Nature-based Solutions (NbS)

Nature-based Solutions (NbS) as an umbrella term for ecosystem-related approaches (IUCN, 2016) are defined by the European Commission (EC, 2015) as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions." The concept of NbS is grounded in the knowledge that healthy natural and managed ecosystems produce a diverse range of services on which human wellbeing depends. Hence, working with nature rather than against it is vital to help society address challenges facing humanity. The IUCN Global Standard for NbS with its 8 criteria and 28 indicators has been developed to ensure the quality and credibility of NbS (IUCN, 2020).

The value of urban biodiversity and ESS – Case study examples from China and Germany

Urban policy and planning decisions are facing trade-offs between different land uses, e.g. new urban parks vs. residential construction and re-densification. These decisions are sometimes made to the disadvantage of urban green neglecting the multiple benefits of urban biodiversity and ESS. The economic valuation of changes in ESS provision affected by particular policies provides several opportunities: First, it assesses the overall societal benefits and costs of biodiversity and ESS, in contrast to benefits and costs that occur on the level of individual or private land users – it thus shifts the conventional business perspective (usually concerning only private benefits and costs) to a holistic economic perspective (concerning the societal benefits and costs). Second, it is possible to evaluate a bundle of ESS, extending from several ESS which can be traded in the conventional market to those intangible non-marketed ESS. And third, the economic valuation of ESS allows a comparison of these benefits with relevant costs for optimizing policy interventions. Highlighting costs and benefits related to urban green spaces, biodiversity and ESS provision can support the decision-making processes, such as urban infrastructure development and planning proposals (CBD 2012). Therefore, the valuation of urban biodiversity and ESS represents a key aspect to inform decision makers about the potential synergies and trade-offs between nature conservation and human well-being.

The valuation of ESS typically contains two major steps. The first step is to identify relevant ESS and to assess biophysical changes with regard to the boundary conditions (climate, elevation, etc.) of ecosystems which underpin ecosystem structures (e.g. species composition and diversity) and ecosystem processes (e.g. nutrient cycle and primary productivity) (Turner et al. 2000; Bateman et al. 2013). It should be emphasized that the assessment of biophysical changes aims at determining the contribution of the final ESS to the provision of goods and services (Boyd and Banzhaf 2006; Bateman et al. 2013).

Isolating the contribution of ESS represents the last part of assessing the biophysical changes. The second step is the economic valuation of ESS, based on the Total Economic Value (TEV) (see Box 4).

Box 4: Total Economic Value and Economic Valuation Methods

The Total Economic Value (TEV) comprises use and non-use values. Various economic methods are suitable to quantify these use and non-use values, which can be roughly divided into two groups: Revealed Preference Methods (RPM) and Stated Preference Methods (SPM). RPM such as the Hedonic Price Method (HPM) or the Travel Cost Method (TCM) try to infer the value of a non-market good via actual market behaviours of individuals on related markets (Alpizar et al. 2001; Alriksson and Öberg 2008). SPM such as contingent valuation method (CVM) and discrete choice experiment (DCE) use surveys to ask respondents directly about their preferences for hypothetical transformation(s) of the considered ecosystem services (Rambonilaza and Dachhary-Bernard 2007). By comparing the ESS value and costs of different alternatives, the welfare effects can be derived (welfare analysis).

Total Economic Value (TEV)			
Use Values			*Non Use Values*
Direct Values	**Indirect Values**	**Option Values**	**Existence Values**
‣ Recreation ‣ Fishery ‣ Agriculture ‣ Forestry	‣ Water Purification ‣ Carbon sequestration ‣ Coastal Protection ‣ Climate Regulation	‣ Future direct and indirect use	‣ Existence value of habitats and species (intrinsic value)
Possible economic valuation methods			
‣ Market Price ‣ Travel Cost Approach ‣ Hedonic Pricing Method ‣ Contingent Valuation ‣ Choice Modelling	‣ Production Function and Averting Behaviour Method	‣ Contingent Valuation ‣ Choice Modelling	‣ Contingent Valuation ‣ Choice Modelling

Over the last decade an increasing number of case studies from China and Germany have been published underlining the economic value of biodiversity and ESS in the context of urban development. These studies serve as a powerful tool to raise awareness of the role of biodiversity and ESS in urban areas, stimulate mutual learning and facilitate knowledge exchange between science and policy to integrate the concept of ESS into policy sectors, and underpin planning and management decisions across all levels from local to regional, to national governments. Valuable information has been generated for improving urban land use planning, developing targeted response measures, and communicating trade-offs between planning options (Albert et al. 2016). Moreover, case studies on the value of biodiversity and ESS provide helpful information to establish targets, policies and instruments to protect biodiversity, ESS and a sufficient distribution of urban green. In the following, key findings of empirical studies from China and Germany are summarised.

Climate change adaptation: Urban parks can regulate micro climate within cities via ameliorating the urban heat island effect (UHI) (Dugord et al. 2014; Zhang et al. 2014). The UHI effect is influenced by specific urban structures, land use patterns and the degree of surface sealing (Oke 1973; Weng et al. 2004). Central inner-city areas often suffer from higher surface temperatures especially in those summer days experiencing extreme heat wave episodes, which are expected to increase under climate change scenarios. These higher temperatures in urban areas would influence the mortality rate of urban dwellers. Tan et al. (2010) demonstrate that in summer the mortality rates in the city center of Shanghai is significantly higher than in suburban areas, which is attributed to heat-related mortalities in highly urbanized regions. During the heat wave in 1998, Shanghai's mortality rate in the urban districts was about 27.3 per 100,000 inhabitants, compared to only 7 per 100,000 inhabitants in the suburban districts. Providing more green spaces in the city center can reduce heat-stress and hence potentially lower heat-related mortality. The study by Tan et al. (2010) provides no economic valuation of the heat related mortality reduction by additional green space. However, it is principally possible to value mortality-risk reduction by applying approaches such as revealed and stated preference methods and the value per statistical life (VSL) (Cropper et al. 2011).

The heat amelioration benefit of urban green spaces can also be estimated by considering the cost saving effect for cooling energy needed. Leng et al. (2004) analyze the heat stress reduction potential and microclimatic regulation function of urban forests in Beijing. Based on the assumption that energy for cooling is needed for 100 days per year, they find urban green spaces to reduce cooling cost by RMB93.5 x106 (1 € = RMB 10.4 in 2004). A review of empirical studies in China suggests that the characteristics of urban green space and albedo of city surface would jointly regulate the quantity of evapotranspiration and the economic value of urban green spaces in various Chinese cities (Jim and Chen 2009a).

Moreover, some highly urbanised areas in China such as Beijing, Guangzhou and Shanghai have become increasingly prone to flooding induced by sudden heavy rainfalls in recent years. An empirical study by Zhang et al. (2015) highlight the importance of urban green spaces for the reduction of surface runoff particularly at the local level. The runoff reduction rate in Beijing continuously decreased from 23% in 2000 to 17% in 2010, mainly attributed to the changes of urban green spaces. In addition, this study finds a significant regional difference in rainwater runoff reduction that was closely related to the changes in the largest patch and aggregation of urban green spaces as observed in different regions. The annual economic benefit of rainwater runoff reduction provided by urban green spaces in Beijing is estimated at approximately 1.34 billion RMB (1 € = RMB 8.01 in 2012), which was equivalent to three-quarters of the maintenance cost of Beijing's green spaces (Zhang et al. 2012).

Climate change mitigation: Urban vegetation contributes to the balance of greenhouse gases (GHG) via carbon storage. Studies estimating the mitigation effect of urban trees in Germany are rare as the majority of studies focus on carbon stocks of national forests in non-urban areas (e.g. Dieter and Elsasser 2002, Wutzler et al. 2007, TEEB 2015). However, Aevermann and Schmude (2015) try to quantify the value of the carbon storage of an urban park in Munich. Based on this study the climate mitigation benefits of this urban park sum up to 600,000 € per year.

Several studies on the storage potential of urban forests exist in China. Liu and Li (2012) show that the urban forest in Shenyang stores 337,000 t carbon which is equivalent to RMB 92.02 million (1 € = RMB 8.01 in 2012). Another national study estimates the total amount of carbon stored by the vegetation of the urban green infrastructure of 35 major Chinese cities. By the end of 2010, the total carbon stored by green space in these cities is estimated to be 18.7 million tons, with an average carbon density of 21.34 t/ha (Chen 2015).

Generally, cost-based approaches have been used to quantify the ability for carbon sequestration, i.e. damage and mitigation costs or tax per carbon emission unit (see TEEB 2015 for an overview on methods). As these numbers are missing for the Chinese context, studies usually utilise benchmarks from other sources, such as carbon tax suggested by the Swedish government (Jim and Chen 2009a).

Urban residents' well-being and life satisfaction: Studies have shown that urban green spaces have a positive influence on urban residents' well-being and life satisfaction. Smyth et al. (2008) investigate the relationship between environmental factors such as atmospheric pollution, traffic congestion and access to parkland and residents' well-being in 30 Chinese cities. They found that those urban residents who had greater access to urban parks reports higher levels of well-being. Similarly, a study of Bertram and Rehdanz (2015) investigates the impact of urban green space on residents' well-being in the city of Berlin (Germany) and finds that residents living closer to green space state significantly higher well-being levels. According to this study, the amount of green space within a 1 km buffer that leads to the largest positive effect on life satisfaction is 35 hectares, yet 75% of the respondents have less green space available within this zone. This study also identifies a monthly Willingness to Pay (WTP) of 26.82 € per person for a one hectare increase of green spaces in 1 km radius around the place of residence.

A national study by Krekel et al. (2016) investigates the impact of urban land use on residential well-being in 32 German major cities with more than 100,000 inhabitants. This study demonstrates the relevance of urban green space for residential well-being and finds that residents who live closer to urban green spaces or are surrounded by more green spaces show higher level of life satisfaction. The study also revealed that residents who live closer to green spaces suffer significantly less often from some diseases such as diabetes, sleep disorder, and joint diseases. The aggregated benefits in association with residents' well-being of a new park in a German major city would sum up to 934,000 € per year.

Against the backdrop of the global COVID-19 pandemic, studies carried out recently witnessed an increased desire for, or use of, urban green spaces during the pandemic, underscoring the vital health and well-being benefits nature provides in an urban context.

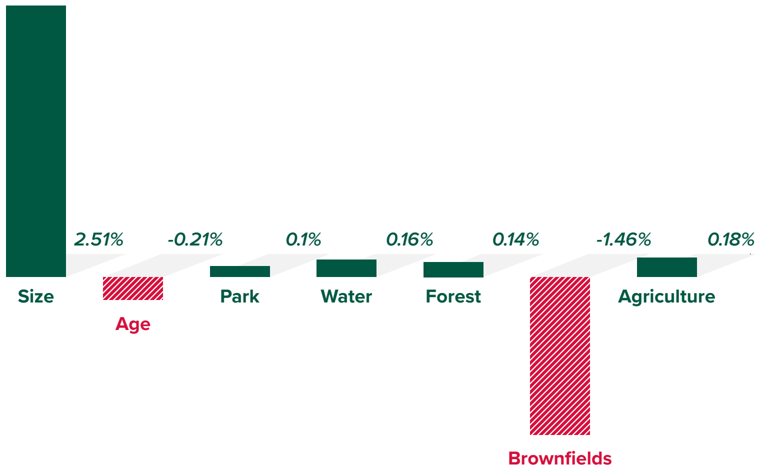
A research conducted by Kleinschroth and Kowarik (2020) shows that in comparison to other popular outdoor urban activities, search requests for "go for a walk" or the equivalent German terms "spazieren gehen" increased sharply in mid-March of 2020, a time when lockdown measures were widely adopted in many countries. Similarly, Derks et al. (2020) found a strong association between an unprecedented surge of visits to Kottenforst, a large peri-urban forest around the German city of Bonn, and the COVID-19 lockdown situation.

Additionally, the result of a study conducted in China by Xie et al. (2020) examining the health status of Chengdu residents through an online survey during the COVID-19 crisis, shows that residents' visits to urban parks during the pandemic can be beneficial in improving overall health and meeting social interaction needs even when the frequency was reduced to once a week. These studies demonstrate the critical importance of urban nature as an essential resilience infrastructure during times of crisis.

Urban green spaces and real estate prices: Studies investigating the capitalisation of urban green space in real estate prices by applying the Hedonic Pricing Method (HPM) value a bundle of ESS connected with urban biodiversity rather than a single ESS. An extensive body of literature exists worldwide, whereas a rather limited number of studies exist in China (e.g. Jim and Chen 2009b, 2010) and in Germany (e.g. Kolbe and Wüstemann 2015). Nevertheless, studies in China and Germany provide an interesting ground for the analysis of social preferences for urban biodiversity and ESS as well as associated economic values. A study from China by Jim and Chen (2006a) explores the impacts of key environmental elements on residential housing value by investigating 652 dwelling units in Guangzhou (south China), including window orientation, green-space view, and proximity to wooded areas and water bodies, and exposure to traffic noise (Jim and Chen 2006a). The study finds that the view of green space and proximity to water bodies contribute to an increase of house prices by 7.1% and 13.2%, respectively. The study demonstrates that the HPM could be applied in the Chinese context with an increasingly expanding and commercialised residential property market. The findings of such HPM-studies provide helpful information for urban policy and planning focusing on urban nature conservation, and design of green-space networks.

Several HPM-studies can be found in Germany (e.g. Kolbe and Wüstemann 2015; Wüstemann and Kolbe 2017a). A study by Kolbe and Wüstemann (2015) shows, that in Berlin, a 1% increase of the amount of green spaces in a 500-meter buffer around the real estate would lead to an average increase of 1,428 € (0.46%) in house prices. Although this amount is rather significant, the impact of most structural variables is higher (see Figure 2). Another study by Wüstemann and Kolbe (2017b) finds, that in Cologne the establishment of a new 3.14-hectare park would lead to a price increase of about 1.25 million € in surrounding real estate (Wüstemann and Kolbe 2017b).

Figure 2: Impact of structural and land use variables on housing prices* in the city of Berlin (Kolbe and Wüstemann 2015)



* Relates to a 1% increase of land use in a 1km buffer around the real estate

Resident's perception and attitudes towards green space: Several studies in China and Germany try to investigate social preferences for urban green space (Jim and Chen 2006b; Chen and Jim 2010, 2011; Jim and Shan 2013; Bertram et al. 2017). An on-site survey of resident's perception of and attitudes towards urban green space in Guangzhou finds that stress reduction, health enhancement, children development, and social interaction (to a lesser degree) are the main benefits of urban green spaces (Jim and Shan 2013). Moreover, the findings show that the socioeconomic background, including gender, age, marital status, education, occupation, and residence area, significantly influence the perceptions of attitudes towards green space. The study findings provide substantial support for the conservation of urban green space in China. Another study by Chen and Jim (2010) analyses Guangzhou residents' motivations and WTP for an urban biodiversity conservation program in the National Baiyun Mountain Scenic Area (BMSA). This peri-urban natural site offers important habitats to several endemic species and is under increasing development pressures from recreational and residential use.

The study identifies five motivational factors including environmental benefit, ecological diversity, nature-culture interaction, landscape recreation function, and intergenerational sustainability. The study finds a median WTP of 149 RMB per household (about US$19.5) per year and an aggregate of 291 million RMB (approximately US$38.2 million) annually to support the biodiversity conservation project.

In Germany a study by Bertram et al. (2017) examines recreational values of urban parks in Germany and identifies residents' social preferences and WTP for urban park attributes. This study finds that on weekdays, respondents prefer urban parks with sport facilities in closer proximity to their homes while the size of the parks is not important. On weekend days, larger parks with picnic facilities are preferred while distance becomes less important. In addition, cleanliness and maintenance are two important attributes for respondents, regardless of whether a park is visited on weekdays or weekends. These findings underline the importance of the temporal context and the variety-seeking behaviours when residents' preferences for outdoor recreation are considered.

Costs and benefits of urban green space: The economic valuation of ESS provided by additional urban green spaces can assist cost-benefit analysis to justify more resources for the provision of urban green spaces (Chen and Jim 2008). Costs for additional green spaces mainly arise from construction and maintenance of green spaces and also from opportunity costs associated with the loss of profits mostly from real estate development. Construction and maintenance costs of green space can vary significantly between cities and urban districts according to their facilities, usage intensity (number of visitors), administration, and transaction costs. Krekel et al. (2015) estimates construction costs of an additional hectare of urban green in the city of Berlin ranging from 3,333 € to 134,000 € per year, the average maintenance costs of playgrounds and smaller sports facilities located within urban parks ranging from 20,000 €/m^2 to 67,000 €/m^2 per year. Opportunity costs would arise mainly for not using the land for real estate, which depend on land values that can vary strongly between cities and locations.

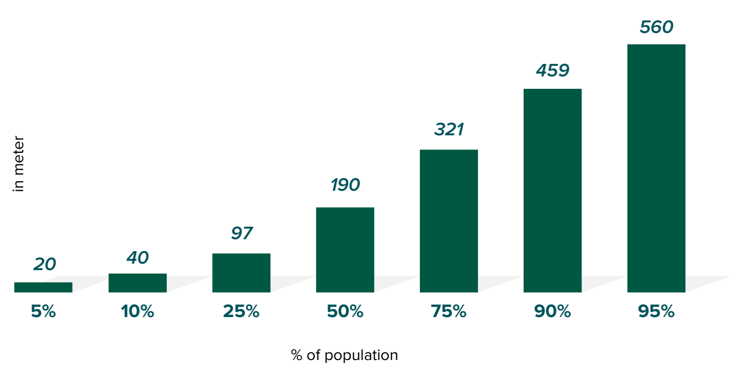
Nevertheless, studies comparing costs and benefits found that the benefits for additional urban green space would at least exceed the costs for construction and maintenance of this additional park (Wüstemann and Kolbe 2017b, Krekel et al. 2016). A study on urban green space provision in Zhuhai (Guangdong province, south China) shows that the construction cost for intensively used green space sum up to RMB10/ m^2 and for extensively used green space to 150 RMB/m^2, respectively. Using a contingent valuation survey, the economic benefit associated with leisure opportunities is estimated at 12.3 million RMB per year. The discounted benefit-cost ratio (at 4% discount rate over a 40-year period) was 0.88 (Chen and Jim 2008). The authors emphasize that this figure not necessarily means that the construction of new urban parks is not worthwhile, as the leisure value presents only a small fraction of the total economic value of urban green spaces. When the value of all other ESS (such as air quality improvement, energy savings, water purifying, etc.) were included, the benefit would exceed the cost by a large margin as indicated by the analysis of urban trees in Chicago (United States) (McPherson 1994). The Climate Technology Needs Assessment of the Chinese Urban Sector shows that managing urban water resources through Nature-based Solutions, comparing to adopting conventional infrastructures, can reduce up to 15% of construction cost and save around 5% of the total investment (TNA 2015).

Accessibility and environmental justice: As urban green spaces provide a high variety of ESS, the provision of a sufficient amount of urban green spaces represents a key aspect of healthy living conditions in urban areas. In Germany, the National Strategy on Biological Diversity (BMU 2007) sets a target that every household in Germany should have access to urban green spaces within a "walking distance". Targets on municipality level in Germany include the City of Berlin which targets a minimum amount of green space provision of 6 m² per capita and the City of Leipzig defining a minimum amount of green space per capita of 10 m² (Kabisch and Haase 2014). In China, the national target gradually evolved from 3.5 m² per capita in 1986 to 6.5 m² in 2000 and 13.08 m² in 2014 (Wang 2009, MOHURD 2016).

Despite increased public urban green space per capita in Shanghai from 0.7 m² in 1990 to 7.3 m² in 2014 (Shanghai Bureau of Statistics, 2015) and improved green accessibility index from 2000 to 2010 (Fan et al., 2017), social groups of different status and household composition in Shanghai do not equally enjoy the access to public green space (Shen et al., 2017). In the city of Hangzhou, 92% of the urban population have access to urban green spaces within 10 minutes (Sang et al. 2013). Environmental inequalities associated with green space provision becomes an emergent problem in many parts of China. Poor housing areas (usually equipped with inadequate green spaces) and pollution impacts are disproportionately concentrated amongst low-income households (Wolch et al. 2014). Moreover, a negative relationship has been found between China's land-based urbanisation and the provision of public green spaces (Chen and Hu 2015). It indicates that while new homeowners inside gated residential compounds can enjoy adequate accessibility to green spaces, in contrast, those lower-income earners - who cannot afford new commercial housing - would be facing a deprivation of public green spaces.

In major German cities, it was found that 26% of urban households have no green space within a 300 m buffer around their homes (Figure 3) (Wüstemann et al. 2016, 2017).

Figure 3: Maximum distance (m) of population (%) to the nearest green site in German major cities (Wüstemann et al. 2017)



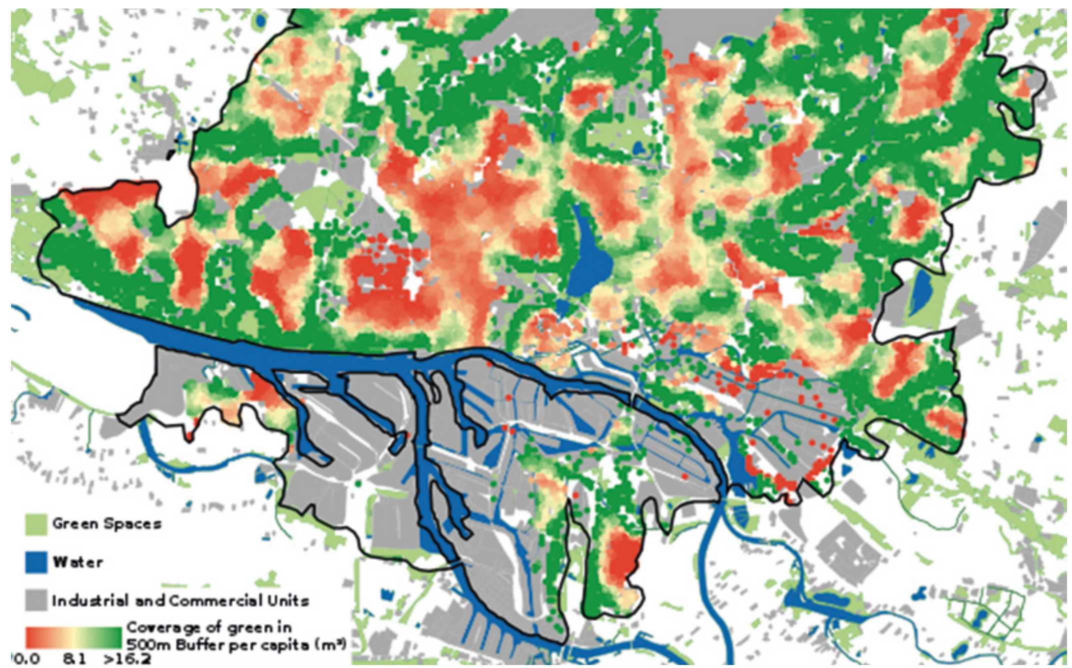
On average, a German household has access to 4.4 hectare green space within a 500m buffer around residence location, and the average green space provision within this zone amounts to 8.1 m² per capita (see Table 2).

Table 2: Urban green space provision in 53 German major cities (Wüstemann et al. 2017)

	Median
Distance to green (meter)	183
Amount of green spaces in 500m-buffer around the place of residence (hectare)	4,4
Amount of green spaces per capita in 500m-buffer around the place of residence (m²)	8.11

Compared with other European countries, the green space provision per capita in German major cities is comparatively low (Fuller and Gaston 2009). Furthermore, studies investigating green space provision in German major cities prove an unequal distribution of green space across and within cities. (Kabisch and Haase 2014; Wüstemann et al. 2016, 2017). Figure 4 shows the unequal distribution of urban green space in the city of Hamburg, Germany demonstrating that particular areas (red colour) are undersupplied with green space.

Figure 4: Unequal distribution of urban green spaces in the city of Hamburg (Wüstemann et al. 2016)



Summary of case study findings

Assessing the economic value of biodiversity and ESS in urban areas provides information about the outcome of different planning scenarios and supports the optimization of various alternatives in relation to the provision and management of urban green spaces. In addition, economic valuation can provide helpful information regarding potential synergies and trade-offs between different planning options. Climate change adaptation and mitigation, health, social cohesion, and economic development are challenges which can benefit from considering the value of biodiversity and ESS in urban areas. These challenges are addressed by a growing body of literature on the valuation of biodiversity and ESS in China and Germany.

The case studies presented here underline the economic value of biodiversity and ESS in urban areas. A major finding is that the benefits of additional green spaces in urban areas would exceed the construction and maintenance costs, even though the type and magnitude of ESS provision depends on the structure and location of green spaces. The case study findings offer suitable approaches and methods to assess the multiple benefits of urban green spaces which could be used to support the process of defining opportunities to protect biodiversity. The case studies show that in many cases urban green is unevenly distributed within and across cities. Moreover, environmental inequalities in green space distribution in relation to the socioeconomic background of households often exist.

Opportunities for integrating the value of biodiversity and ESS into urban policy in China and Germany

The conservation of biodiversity and the adequate provision of ESS represent key aspects for the sustainable development of urban areas in China and Germany. The consideration and successful integration of biodiversity and its economic value into sustainable urban development strategies requires (i) binding targets for ecosystem-friendly urban policies, and (ii) the implementation of urban policies in order to secure the achievement of these targets.

a) Consolidating knowledge base

Extensive academic efforts should be made to eliminate the wide disparities across the case studies and consolidate the knowledge base by establishing (i) accepted methods and instruments for the assessment and valuation of biodiversity and ESS, (ii) standardisation of data collection and analysis methods, and (iii) implementation of benefit transfer (Jim and Chen 2009a; Kroll et al. 2012). The research findings generated by empirical case studies can be shared and form a knowledge base for integrating urban biodiversity and ESS into national accounting and reporting systems, and thus inform decision-making processes in order to maximise natural capital (WWF 2014), although this is still one of the major challenges for science and research (De Groot et al. 2010; Ahern et al. 2014).

b) Protecting existing green spaces

To secure adequate and sustainable provision of ESS in expanding and densifying cities and to enhance urban residents' well-being and urban ecosystem adaptability to climate change (Green et al. 2016), all existing green spaces and associated diverse flora and fauna should be strictly protected in China and Germany (following a "no net loss principle") by legal frameworks. Especially in many Chinese cities, the "no net loss principle" should serve as a principal objective to be strictly enforced, so that the current trend of transforming green spaces into commercial and residential structures (Zhao et al. 2013; O'Connor and Liu 2014; Chen and Hu 2015) could be halted.

c) Providing additional green spaces

The provision of additional green spaces should be emphasised in urban policies and planning, via natural restoration and low impact development. Besides urban parks and residential gardens, roadside greenery, vertical green, roof greening and greening of courtyards offer high potentials to increase the abundance of green space in urban areas (Jim 2004, 2013). Biodiversity can be enhanced and reintroduced into cities by urban agriculture and community gardens, meadows and urban forests. Abandoned brownfields should - wherever possible – be transformed into urban green spaces. Ecological principles should be advocated to connect green patches (as stepping stones) via greening main roads and riverine spaces (as corridors) into comprehensive ecological networks, so as to provide habitats and conduits for biodiversity (Alvey 2006; Ignatieva et al. 2011).

d) Limiting urban sprawl and soil sealing

Limiting urban sprawl and soil sealing can assist the protection of green spaces and the conservation of biodiversity in urban centres and fringe areas (Kong and Nakagoshi 2006; Zhou and Wang 2011). In Germany, the concept of an integrated urban development "Doppelte Innenentwicklung" has been proposed to further enhance green spaces in residential areas while avoiding urban sprawls through a structural development of neighbourhoods in city centres. Furthermore, the German government set up a target at 30 ha per day soil sealing to control further land sealing. The integrated urban development as an interface between urban development, spatial planning and nature conservation offers a tool for the achievement of this goal (Kong et al. 2010; Jim 2013). Other local development strategies and targets can also be tailored based on local socioeconomic characteristics, in which raising the awareness of urban green spaces' ESS amongst local stakeholders, urban planners and decision-makers is essential (Kabisch 2015).

e) Sufficient access to green space

All households should have sufficient access to urban green space – a key aspect of human well-being and healthy society within cities. In Europe, 300 m has been proposed as a qualitative boundary to determine accessibility for people to exploit green spaces for recreational purposes (Sturm and Cohen 2014). In addition, all urban areas in China and Germany should provide an amount of $10m^2$ green space per capita.

Environmental inequalities related to urban green space should be fully eliminated. In addition to "conventional indicators" such as green ratio and green space per capita, other criteria such as equal accessibility and connectivity could serve as a comprehensive approach to integrate the pattern and distribution of urban green spaces into urban planning and pertinent policies (Wang 2009). This is especially important because the current economic and social situation in China and Germany, including the increase of housing prices, the densification of the urban population and the rise of income inequalities, might lead to further social segregation and environmental injustice in the future. Quantitative targets such as green space coverage and per capita green space ignore quality aspects of green space including biodiversity, green space connection, park facilities, ecological service function and habitat fragmentation. The neglect of urban green quality by policy and planning often leads to higher maintenance cost with less ESS benefits.

Therefore, a comprehensive set of indicators that includes both quantity and quality of green space should be developed in order to safeguard residents' access to green space and the elimination of environmental inequalities in both China and Germany.

f) Financing urban green spaces

Financing the construction and maintenance of urban green space represents a major challenge for many cities in China and Germany. One promising approach could be the establishment of a fund for financing the construction and maintenance of green space in urban areas. Since many municipalities face financial constraints in China and Germany, sources like emission trading mechanisms and national funding schemes might be a source for financing urban green space. Moreover, institutions such as health insurances and municipal waterworks which benefit from the various ESS of urban green spaces (e.g. health effects, water purification) also represent potential contributors for the fund. Furthermore, funding models such as Payments for Ecosystem Services (PES), Biodiversity Offsets, Carbon Finance and Tradable Planning Permits as well as Civic Participations and Public Private Partnerships represent innovative ways to finance the provision of urban green spaces (Merk et al. 2012).

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