ECOSYSTEM SERVICES IN THE CITY

PROTECTING HEALTH AND ENHANCING QUALITY OF LIFE

Summary for decision-makers

NATURKAPITAL
DEUTSCHLAND – TEEB DE

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Ingo Kowarik, Robert Bartz, Miriam Brenck, Bernd Hansjürgens

NATURKAPITAL
DEUTSCHLAND – TEEB DE

IMPRINT

Recommended citation
Natural Capital Germany – TEEB DE, 2017. Ecosystem services in the city – Protecting health and enhancing quality of life. Summary for decision-makers. Technical University of Berlin, Helmholtz Centre for Environmental Research – UFZ. Berlin, Leipzig.

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This summary for decision-makers is based on the comprehensive academic report: »Naturkapital Deutschland – TEEB DE: Ökosystemleistungen in der Stadt – Gesundheit schützen und Lebensqualität erhöhen«. All authors and reviewers of the academic report are listed on page 75 of this summary report.

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Acknowledgements
The authors and the »Natural Capital Germany – TEEB DE« coordination group would like to thank everyone who actively contributed to this »Summary for decision-makers«, particularly the many authors of the full-length version on which this summary is based.

Funding and expert support
As a research and development project within the departmental research plan, »Natural Capital Germany – TEEB DE« is supported by the Federal Agency for Nature Conservation (BfN) with funds from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). Advisers: BfN, Section I 2.1 Legal Affairs, Economics and Environmentally Friendly Regional Development.

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Graphical concept | Layout
Metronom | Agentur für Kommunikation und Design GmbH, Leipzig

Title image
Tree at the former airport, Tempelhofer Feld, Berlin (photograph: Christo Libuda, www.lichtschwaermer.de)

Overall production
Druckerei Mahnert GmbH, Aschersleben

This report is printed on Magno Satin (FSC-certified paper).

Published in 2017
Print run 1,000 copies
ISBN: 978-3-944280-31-8

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NATURAL CAPITAL GERMANY – TEEB DE: OVERALL PROJECT AND POSITIONING OF THIS REPORT

»Natural Capital Germany – TEEB DE« is Germany's follow-up study to the international TEEB study (The Economics of Ecosystems and Biodiversity), which examines the relations between nature's services, economic value, and human well-being. By adopting an economic perspective, »Natural Capital Germany – TEEB DE« aims to make nature's potential and services more visible and measurable. Putting an economic value on natural capital should help to incorporate nature's services more effectively into private and public decision-making processes, leading to multiple positive impacts on various social objectives. Preserving and promoting natural resources, biodiversity and associated services offers huge benefits for society, and encourages socially, economically and ecologically sustainable development. Finally, the project supports the fulfilment of environmental, sustainability, and nature conservation objectives and strategies, particularly the German National Strategy on Biological Diversity.

The project is funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMU) and the Federal Agency for Nature Conservation (BfN), and led by Prof. Dr. Bernd Hansjürgens of the Helmholtz Centre for Environmental Research (UFZ). This project would not have been possible without the voluntary work of numerous contributing authors.

»Natural Capital Germany – TEEB DE« centres around four thematic reports written by teams of experts from the academic world and from the field. These four main reports draw on the available studies, concepts and case studies of the services provided for humans by Germany's ecosystems, focusing on:

1) Natural Capital and Climate Policy – Synergies and Conflicts (2014)

2) Ecosystem Services in Rural Areas – Basis of Human Wellbeing and Sustainable Economic Development (2016)

3) Ecosystem Services in the City – Protecting Health and Enhancing Quality of Life (2016)

4) Natural Capital Germany – A Synthesis (2017)

»Summaries for decision-makers« have already been published on the first two reports, together with an introductory brochure and a brochure for companies.

- The Value of Nature for Economy and Society – An Introduction (2012)

- The Business Perspective – Being Prepared for New Challenges (2013)

»Natural Capital Germany – TEEB DE« is supported by a project advisory board, with high-level members from academia, business, and the media. An associated stakeholder committee has also been tasked with informing, interlinking and involving social interest groups in this project, including representatives from environmental and trade associations, government departments, German Federal States and public stakeholders.

This summary report outlines the key findings form the third »TEEB DE« report on »Ecosystem Services in the City«, and illustrates selected results for decision-makers in politics, administration and society. The report was prepared under the leadership of Prof. Dr. Ingo Kowarik, Technical University of Berlin, Department of Ecology, Chair of Ecosystem Science / Plant Ecology.

Both the comprehensive academic report and this summary for decision-makers hope to raise awareness of the correlations between nature's multiple services and human health and well-being in attractive towns and conurbations, make nature's services and values in urban spaces more visible, and share ideas for giving greater consideration to ecosystem services in private and public decision-making processes.

FOREWORD AND ACKNOWLEDGEMENTS

Worldwide the majority of people – more than 50 percent – live and work in an urban environment; in Germany this is true for more than three-quarters of the population. The need for healthy living conditions and to feel at home in an urban living, working and leisure environment is a growing priority. At the same time, there are escalating challenges associated with the dynamic transformation of our cities, not least as a result of climate change. There also is a growing realisation that we humans are increasingly reliant on urban nature. Children are spending less and less time in the open countryside. Their main experience of nature tends to be urban nature. As a result, urban green spaces are now more important than ever, because they shape our living conditions and thus ourselves. Urban nature is also gaining importance as location factor for employees and business decisions.

In stark contrast to this, many decisions regarding land use in towns are made to the detriment of urban green spaces. Roads, buildings and technical infrastructure facilities are eating up more and more land. Often, urban nature is seen more as a cost contributor than a service provider. In consequence, all too often, alternative appropriation of funding is considered more pressing than maintaining or even increasing public spending on urban green spaces.

This is where the »Natural Capital Germany – TEEB DE« report comes in: It aims to demonstrate that it is worthwhile preserving urban nature on both public and private land, with its many different near-natural and cultural elements – because urban nature benefits health and fosters social cohesion. For children and adolescents it often is the only possibility to experience nature, and it makes cities and locations more attractive. Therefore, investing in the natural capital of cities is economically advantageous. We have to raise awareness for the numerous benefits of urban nature among decision-makers, as well as across business and society as a whole. »Making the invisible visible« is our motto. Our mission is to identify the multiple services provided by nature, capture their value and importance, and anchor this in private and public decisions relating to land use.

We hope that our report will help to achieve this.

This summary for decision-makers, »Ecosystem Services in the City – Protecting Health and Enhancing Quality of Life« draws on selected findings from the comprehensive academic report, which explains the underlying scientific foundations in detail.

More than 130 individuals from academia, politics, administration and society contributed to the academic report, both as authors and as reviewers, and we would like to take this opportunity to thank them. We would particularly like to thank the coordinating authors of each chapter. All authors and reviewers of the academic report are listed at the end of this summary report.

We would also like to express our sincere thanks to the following groups and individuals:

- The project advisory committee on »Natural Capital Germany – TEEB DE«: Stefanie Engel (University of Osnabrück), Uta Eser (Büro für Umweltethik), Karin Holm-Müller (University of Bonn, Member of the German Advisory Council on the Environment – SRU), Beate Jessel (President of the Federal Agency for Nature Conservation), Marion Potschin (Nottingham University), Christian Schwägerl (scientific, political and environmental journalist), Karsten Schwanke (meteorologist and television presenter), Antje von Dewitz (CEO of VAUDE), and Angelika Zahrnt (Honorary Chair of Friends of the Earth Germany – BUND).

- The working group that accompanied the »Natural Capital Germany – TEEB DE« project: Hans-Ulrich Bangert (Working Group on Nature Conservation, Landscape Management and Recreation – LANA, Saxony State Ministry for the Environment and Agriculture), Rüdiger Becker (association »Kommunen für biologische Vielfalt e. V.«, City of Heidelberg, Office of Environmental Protection, Trade Supervision and Energy), Axel Benemann (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety – BMUB), Carolin Boßmeyer (»Biodiversity in Good Company« Initiative e. V.), Ann Kathrin Buchs (Joint Water Commission of the German Federal States – LAWA, Lower Saxony Ministry for the Environment, Energy and Climate Protection), Deliana Bungard (German Association of Towns and Municipalities), Andreas Burger (Federal Environment Agency – UBA), Wiltrud Fischer (project leader at the Federal Ministry of Education, Science, Research and Technology – BMBF at the German Aerospace Centre), Claudia Gilles (Deutscher Tourismusverband e. V.), Alois Heißenhuber (Scientific Advisory Board of the Federal Ministry of Food and Agriculture – BMEL »Biodiversity and Genetic Resources«, Technical University of Munich – TUM), Udo Hemmerling (German Farmers' Association), Till Hopf (Nature and Biodiversity Conservation Union – NABU), Barbara Kosak (BMEL), Jörg Mayer-Ries (BMUB), Günter Mitlacher (World Wide Fund for Nature – WWF Germany), Michaela Pritzer (Federal Ministry of Transport and Digital Infrastructure – BMVI), Catrin Schiffer (Federation of German Industries – BDI), Reinhard Schmidt-Moser (LANA, Ministry of Energy, Agriculture, the Environment and Rural

Areas of Schleswig-Holstein), Annette Schmidt-Räntsch (BMUB), Ulrich Stöcker (Environmental Action Germany – DUH), Magnus Wessel (Friends of the Earth Germany – BUND), Markus Ziegeler (German Forestry Council – DFWR), Jochen Zimmermann (Federal Ministry for Economic Affairs and Energy – BMWi).

- The participating scientists at the Federal Government's departmental research institutions, including the »Ecosystem Services / Natural Capital« (KNK) Centre of Excellence at the Federal Agency for Nature Conservation, which contributed with critical feedback and extensive information.

The views expressed in this brochure reflect the opinions of its authors only, and should in no way be interpreted as the official stance of the organisations involved.

Berlin and Leipzig, September 2016

Ingo Kowarik, Robert Bartz, Miriam Brenck and Bernd Hansjürgens

INTRODUCTION TO THE SHORT REPORT FOR DECISION-MAKERS

This summary for decision-makers outlines the key findings of the »TEEB DE« report »Ecosystem Services in the City – Protecting Health and Enhancing Quality of Life« (Natural Capital Germany – TEEB DE, 2016) which is based on a comprehensive scientific analysis of the ecosystem services provided by urban nature.

The report summarises the current status of knowledge about urban ecosystem services, and illustrates their importance for society as a whole. It also identifies starting points for incorporating the value of urban ecosystem services more extensively into public decision-making.

This summary is primarily aimed at public decision-makers who influence and control the development of our towns and cities, as well as urban planners and politicians with urban development links. It is also dedicated to interested members of the general public and anyone wishing to actively contribute to sustainable urban development.

Chapter 1 provides an introduction to the challenges of urban development and the concept and valuation of ecosystem services as used in this report.

Chapter 2 provides examples of urban ecosystem services and their economic significance.

Chapter 3 highlights the synergies between different ecosystem services as well as between biodiversity and ecosystem services, and illustrates a multifunctional approach to identifying conflicting land use interests.

Chapter 4 offers a number of starting points and tools to highlight the social importance of urban ecosystem services and ensure their wider integration into public decision-making.

Chapter 5 contains a brief conclusion.

KEY MESSAGES

Urban nature and ecosystem services

- Urban nature delivers numerous ecosystem services, and helps to **protect the health of urban residents and enhance their quality of life**. Urban ecosystems provide regulating (e.g. temperature regulation), cultural (e.g. recreation) and provisioning services (e.g. food).

- The economic approach to urban nature centres around the benefits of nature to humans. **It helps identifying the beneficiaries of nature and its services, highlights the societal significance of ecosystem services, and shows paths how to incorporate these services into private and public decision making.** The economic approach thus contributes to the mainstreaming of nature and ecosystem services into other sectors beyond nature conservation and related policies.

- In practice, the multiple ecosystem services delivered by nature in cities are often overlooked, and disregarded in decisions on land use and architectural design. The TEEB approach on capturing the value of ecosystem services and biodiversity is a tool for **selectively incorporating information about the value of nature into planning and decision-making processes**. It may complement existing nature conservation and sustainable urban development tools.

Social importance of urban ecosystem services

- City residents are often more exposed to **excess temperatures, fine dust (particulate matter) and noise** than rural inhabitants. These environmental pressures can impair human health and cause elevated sickness and mortality rates. They limit quality of life and incur major costs to society, especially for healthcare. Urban nature, and particularly its regulating ecosystem services, can help to minimise these environmental pressures.

- **During summer heat waves** there is a **significant increase in sickness and mortality rates**. For example, around 4 to 5 % of mortalities in Berlin are linked to heat. **Urban vegetation can significantly reduce peak summer temperatures**. Records show that a green space measuring 50 to 100 metres wide is between 3 and 4 °C cooler on hot, windstill days than the surrounding built-up area.

- In Germany, each year, particulate matter pollution causes around 47,000 deaths and countless incidences of respiratory and cardiovascular disease requiring treatment. Urban green plays a major role in air pollution control. **Trees filter dust, and are capable of reducing particulate matter pollution by between 5 and 10 %**, rising to a maximum of 15 % with multiple rows of dense vegetation.

- In a residential environment, nature is especially beneficial to human health. Green spaces invite us to get active, play sports, and spend time outdoors. **Contact with nature reduces stress** – a key factor in the most common illnesses in Germany, responsible for billions of Euros in healthcare costs (cardio-vascular diseases, musculoskeletal disorders and mental health issues). **Contact with nature also helps to reduce aggression and anxiety, and raises concentration and performance levels**.

- Environmental pressures are particularly high in socially disadvantaged areas, which tend to be undersupplied with green spaces. **In this way, urban nature becomes a matter of social justice**. Promoting urban ecosystem services in areas with the greatest needs is an important starting point for more environmental justice in our cities.

- Urban nature helps to **strengthen social cohesion**. Parks, rivers and lakes are freely accessible and may be used by anyone, regardless of their social status or cultural background. Community gardens invite encounters, joint activities and intercultural exchange. Experiencing urban nature helps residents to identify with their neighbourhood and city. It is important to consider the needs of different user groups when designing open spaces.

- Experiencing and interacting with nature through play is pivotal to the **healthy development of children and adolescents**. It encourages autonomy, creativity, risk competency and social skills, as well as linguistic and motor skills. For this, they need freely accessible green spaces in the immediate vicinity of their home, such as gardens, wasteland and nature discovery spaces. Green classrooms such as forest schools and school gardens provide space for environmental education and experiencing nature.

- **Growing food in the city – in gardens, on balconies and in public spaces** – not only helps people to become partially self-sufficient, but also promotes an **awareness of regional products and a healthy diet**. This has economic relevance, because obesity and related diseases incur major costs, both to the healthcare system and to industry, for example due to illness-related absenteeism. Although self-sufficiency usually is not the top priority, it can play an important role for individual households. A study of allotments in North Rhine-Westphalia estimates the level of self-sufficiency among gardeners at around 48 % for vegetables and 54 % for fruit (excluding tropical fruits).

- **Urban nature is a location factor**. A green city is an attractive location for companies and a popular place to live. Environmental quality, leisure value and an attractive living and working environment are significant »soft factors« in location decisions. For companies, it is worthwhile preserving and encouraging urban nature, for example by designing near-natural grounds. Extensively designed green spaces also save maintenance costs and benefit employees' health, motivation and performance, as well as the company's image. Recent studies verify that real estate values rise significantly with an attractive green environment.

- Having green spaces close to your home can positively influence **satisfaction with life**. For example, in a city neighbourhood with an average supply of green spaces, **one hectare of additional green space** statistically equates to **an improvement in life satisfaction equivalent to an additional annual income of 276 Euro**.

Sustainable urban development: Interlinking city and nature more closely

- **Making ecosystem services more visible**. Urban nature provides a range of ecosystem services that benefit different sectors of society. Considering the benefits and values of these ecosystem services is an important step in achieving sustainable urban development. In specific decision-making situations, highlighting the values of ecosystem services can help to identify and use the multiple benefits of open spaces and small-scale green structures.

- **Promoting biological diversity**. Biological diversity provides the basis for a broad spectrum of urban ecosystem services. Preserving and promoting biodiversity in urban habitats not only contributes to nature conservation (e.g. the German National Strategy on Biological Diversity), but also enhances quality of life and the city's attractiveness.

- **Broadening city planning tools to include information on ecosystem services**. Alongside landscape planning and open space planning, city planning plays a key role in urban development. The values of urban ecosystem services should be more widely incorporated into this process. When drafting land use plans and deciding on land design, the services of nature are all too often neglected as »purely environmental issues« and their value to the city's social and economic development remains unrecognised. The guiding principle of qualitative inner development in cities (German: »doppelte Innenentwicklung«) which combines structural development with the creation of urban green spaces, provides an important strategic framework for preserving and developing open spaces, and hence for strengthening ecosystem services and biodiversity.

- **Strengthening intra- and inter-community cooperation**. Within cities and communities, those segments which benefit from green infrastructures, such as health, education, youth and family, social affairs, climate protection and adaptation, and nature conservation, must be interlinked more closely. Highlighting and debating the importance of urban nature for society creates the opportunity to identify synergies between different objectives and develop joint solutions. One key area for cooperation between local authorities is e.g. a coordinated land use policy.

- **Offering targeted economic incentives**. Offering financial incentives in addition to the existing mechanisms should encourage the supply of nature's services and minimise environmentally harmful behaviour. Several options are available: they range from price-based instruments (such as wastewater charges or charges related to sealing) and quantity-based solutions (such as tradable planning permits) to the consideration of the financial requirements for the provision of ecosystem services in the context of fiscal equalisation schemes between municipalities.

1 THE »GOOD LIFE« IN CITIES: A KEY TASK FOR SOCIETY

1.1 CURRENT CHALLENGES FOR CITIES: HEALTH, QUALITY OF LIFE, SOCIAL ISSUES

In Germany, just over three-quarters of the population live in a densely or intermediately populated area; in 2012 the figure was 77 % (StBA, 2014). This includes both cities and urbanised environments, i. e. locations where two cities, or a city and its surrounding communities, have coalesced. Therefore, it is a key task for society, to ensure favourable living conditions in our cities, by assuring health and a good quality of life, a minimal environmental footprint, a wealth of nature, and social cohesion. There are some major challenges to overcome if we want to ensure the sustainable, socially, environmentally and economically compatible development of urban regions.

Health risks from environmental pressures

Health is vital to a »good life«. However, various environmental factors pose a threat to human health, especially in conurbations. In particular, motorised individual traffic creates pollutant emissions and noise pollution in towns and cities, intensive industrial production is often (still) a source of emissions, and remoteness from green spaces and nature impairs well-being. The effects of these factors are often exacerbated by the individual behaviour of city dwellers (such as lack of exercise, and an unhealthy diet).

Persistently high levels of »land loss«

In Germany, -> HUMAN SETTLEMENTS AND TRANSPORT INFRASTRUCTURE are still being built on new land, at a rate of almost 70 ha per day (sliding four-yearly average for the years 2011–2014; StBA, 2016). While this may represent an improvement in living conditions for individuals, continuing urban sprawl often causes environmental damage to the surrounding area, and may also adversely impact the cities themselves (for example, increased traffic volumes, social segregation, cost of maintaining the infrastructure).

For many years, city planners have tried to stem the urban sprawl with the »inner development over external development« model, but with limited success, since the current control mechanisms do not offer adequate incentives. Councils are still competing with one another for jobs and tax revenues, leading to the ongoing zoning and development of surrounding land (see BfN, 2008; Schröter-Schlaack, 2013; Deutsche Bundesregierung, 2016). What is more, inner development fails to give adequate consideration to ecosystem services. Usually, a project's economic benefits (such as creating value in the real estate sector) are appraised without consideration of economic costs associated with a loss of urban nature (for example, adverse impacts on health, impaired quality of life, loss of compensating effects of green spaces) (see Box 1 for a definition of urban nature). The guiding principle of a -> QUALITATIVE INNER DEVELOPMENT, dedicated to selectively promoting green infrastructure in cities, can help to limit the adverse consequences of densification.

Violation of environmental justice

As structural density rises, so too does the risk of environmental pressures such as air pollution and urban heat islands, which may pose a significant threat to the quality of life in the city. These pressures may cause city dwellers to migrate to the suburbs, weakening city centres, possibly contributing to social segregation, and exacerbating urban sprawl. Disadvantaged sections of the population often tend to live in more polluted areas of the city with fewer open spaces, and often with a poor design quality (Hornberg et al., 2011; Hornberg and Pauli, 2012). One of the major challenges for urban development is to control the distribution of urban nature in a way that gives more people access to green spaces with the associated benefits for health and quality of life (Bunge et al., 2011).

Incidentally, improving neighbourhoods with parks and green spaces near homes can cause displacement effects. The neighbourhood becomes more attractive, which in turn leads to a stronger demand for housing, and prices rise. It is an urgent challenge for sustainable urban development to find ways of dealing with these effects and creating and maintaining attractive, green living environments for low-income households.

BOX 1

What is urban nature?

For the purposes of this report, urban nature refers to the totality of natural elements occurring on public and private land in the city. Based on the concept of the »four natures« (Kowarik, 1992), urban nature includes the remnants of pristine ecosystems and rural cultural landscapes, as well as landscaped elements in parks and gardens, together with novel types of »wild« nature, e.g. on urban-industrial wasteland. Despite their many differences, all components of urban nature are capable of delivering ecosystem services to the urban population, and improving the living conditions in cities. We have therefore opted for a comprehensive definition of urban nature including its many different types (cf. Figure 1). Urban nature is often referred to as urban green space.

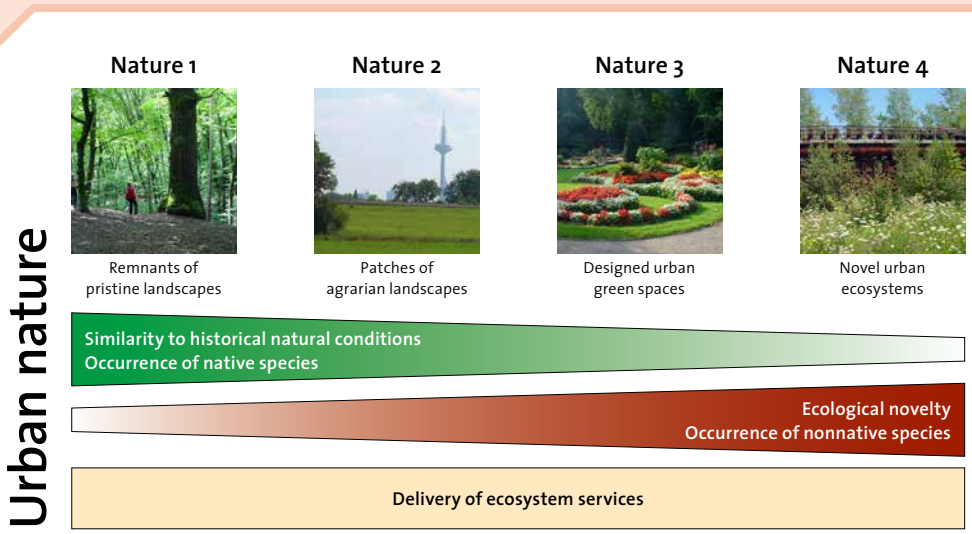


FIGURE 1 ▸ Urban nature as generic term for different types of nature that can be found in urban areas and vary significantly regarding their land-use legacies, ecological characteristics and cultural imprints. (Source: own illustration / Ingo Kowarik)

Climate change as a threat

Climate change exacerbates existing environmental problems. Higher temperatures are a growing threat to health, particularly in cities (Harlan and Ruddell, 2011). Extreme events such as heatwaves and storms are becoming more frequent and putting pressure on cities. Ecologically active open spaces can at least partially buffer these types of pressures. Valorising urban open spaces as a »green infrastructure« (EU, 2013) demands a fresh conceptual approach (BMUB, 2015a; Heiland et al., 2012), as well as financial input from local authorities.

Loss of social cohesion

The urban population is becoming more heterogeneous in terms of its origins, cultural backgrounds and social milieus (EU, 2011). Demographic change, new lifestyles, more individualised behaviour and recent immigration are placing new demands on urban nature in its role as a social space. These developments are linked to social conflicts, further exacerbated by difficult working and living conditions. The growing challenge here is to strengthen cohesion in an increasingly heterogeneous, evolving community. The integration of migrants and the inclusion of those with chronic illnesses and disabilities are key tasks in this regard. Public spaces must accommodate a wide range of different user interests.

Growing disconnection from nature

Urban nature has important social functions whose importance escalates as access to private open spaces by social groups diminishes. Children and adolescents are spending less and less time in and with nature, partly due to an inadequate supply of urban nature in their own environment, but also as a result of changing lifestyles (-> INDOOR CHILDHOOD; Zinnecker, 2001). Such disconnection from nature may impair young people's development and skills, and reduce their sense of responsibility towards nature (Miller, 2005). It is therefore important to give all city dwellers access to nature in their neighbourhoods, and to strengthen environmental education and awareness, so as to promote experience of nature and environmental justice.

Loss of biological diversity

The number of species in Germany continues to decline, and -> URBANISATION is on the rise. The extent to which cities can help to preserve biodiversity is therefore an increasingly important issue. Although urban areas may be very species-rich (Kühn et al., 2004), many species are confined to small populations, and their survival hangs in the balance; rare and endangered species tend to be confined to special habitats (Wittig, 2002). The densification of urban areas could therefore significantly impair their function for -> BIOLOGICAL DIVERSITY. One key challenge is to promote biological diversity in the scope of integrated concepts – such as green infrastructure – wherever possible and to involve other stakeholders from urban society on the process alongside the public sector.

1.2 THE TEEB APPROACH – WHY AN ECONOMIC PERSPECTIVE ON URBAN NATURE CAN HELP

TEEB means »The Economics of Ecosystems and Biodiversity«. The international study of the same name (TEEB, 2010) highlighted the importance of nature and the services it provides for society as a whole. »Natural Capital Germany – TEEB DE«, with which this report is aligned, was Germany's follow-up project to the international TEEB study.

So what is it all about? If we build on our **-> OPEN SPACES**, these spaces are no longer available for other purposes. When we seal urban land, we stop being able to utilise its many and varied ecosystem services such as filtering and water protection services. The **-> ECONOMIC PERSPECTIVE** on urban nature enables a more comprehensive understanding of the consequences of changing urban land use and the implications for society.

The **-> TEEB APPROACH** aims to help city decision-makers to embrace this information and give it due consideration in their work and decisions affecting the use of urban nature, both directly and indirectly. An economic perspective can also raise awareness of urban nature issues; it can show society what it means to lose or conserve urban nature; it may inspire a more systematic assessment of all the pros and cons of a decision; and it can offer more scope for participation in decision-making processes (Lienhoop and Hansjürgens, 2010).

We have deliberately opted for a broader interpretation of the economic – in contrast to a business – perspective. The emphasis is on the interests of all people in urban areas, rather than individual or business interests. Where this report contains references to the economic value of urban nature, it is essentially referring to this macro-societal interpretation: We consider nature's values that can be monetarised, i. e. expressed in monetary units, as well as those values which cannot be monetarised and which may be difficult to quantify.

The TEEB approach comprises the following stages: (1) Identifying and recognising, (2) assessing and demonstrating value and (3) **-> CAPTURING THE VALUE** of nature. Recognising value is shaped by the socialisation and cultural characteristics of a society. Demonstrating value is a conscious process that uses suitable approaches and methods (including economic valuation methods, see Naturkapital Deutschland – TEEB DE, 2016, chapter 2) to elucidate value. Capturing value means considering urban nature in private and public decisions.

FIGURE 2 ▸ Green facade with insulating effect, Department MA 48 in Vienna. (Photograph: Nicole Pfoser, 2012)

FIGURE 3 ▸ Vertical facade greening as external solar protection, Institute of Physics, Humboldt-Universität, Berlin-Adlershof. (Photograph: Nicole Pfoser, 2009)

1.3 ON THE CONCEPT OF ECOSYSTEM SERVICES

The importance of urban nature for city dwellers has long been known, and already is basically taken into account in urban development. The ecosystem services approach, which has become internationally established with the United Nations Millennium Ecosystem Assessment (MA, 2005) and the follow-up TEEB studies, takes this one step further: It offers a conceptual framework for systematically assessing ecosystem services and identifying their social value. This approach can therefore contribute to the objective of sustainable urban development (Elmqvist et al., 2013; McPhearson et al., 2015).

In this report, ecosystem services are defined as »direct and indirect contributions of ecosystems to **-> HUMAN WELL-BEING**«, i. e. services which provide »a direct or indirect economic, material, health or psychological benefit« (Natural Capital Germany – TEEB DE, 2012). Figure 4 illustrates the fundamental importance of ecosystem services for human well-being.

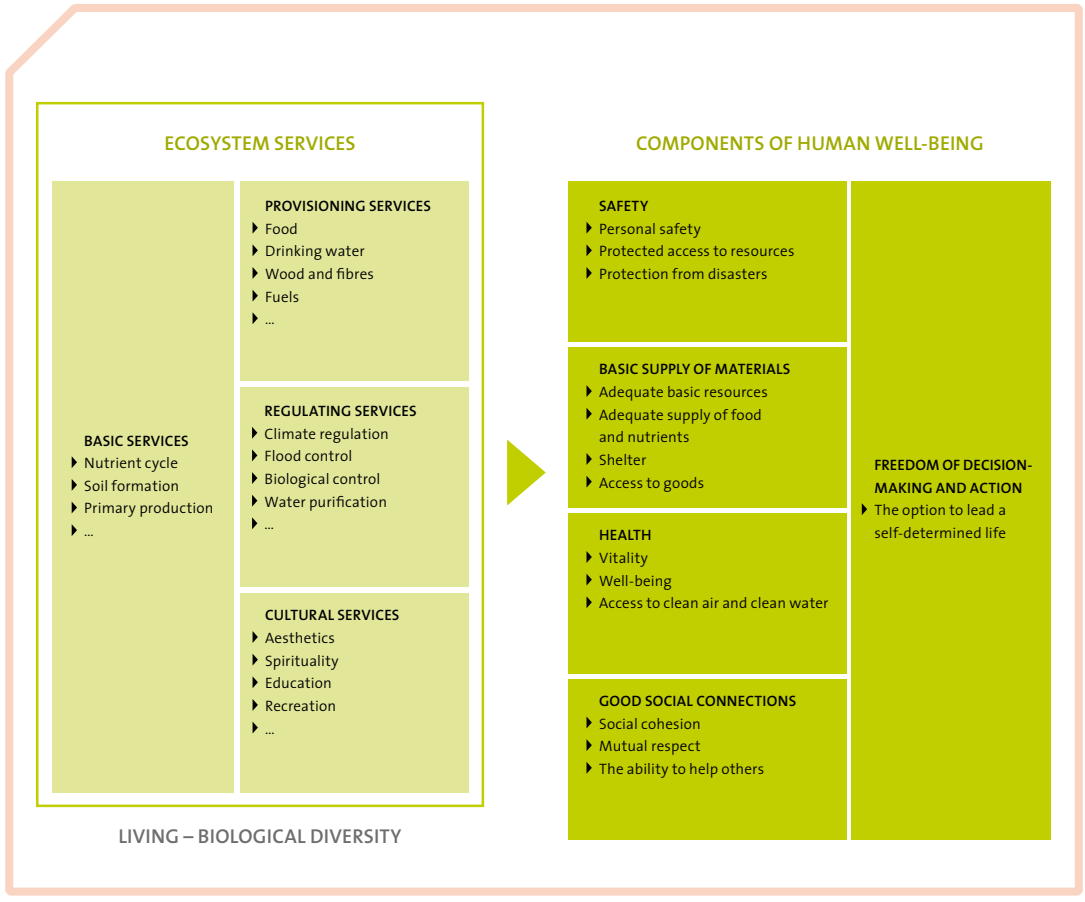
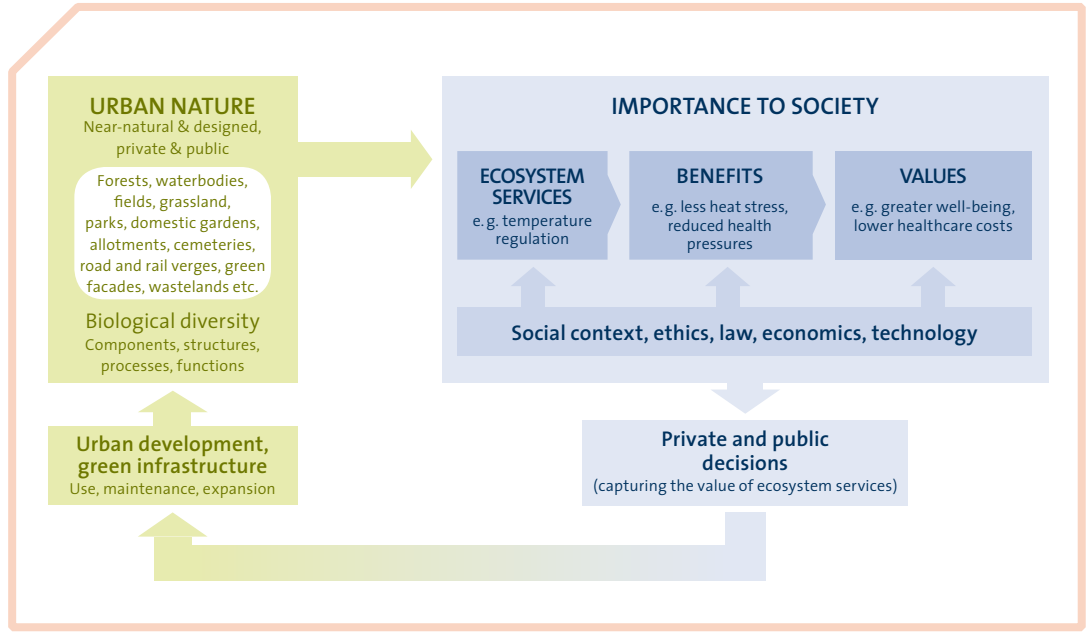


FIGURE 4 ▸ »Millennium Ecosystem Assessment« approach to ecosystem services and their importance for human well-being. (Source: Natural Capital Germany – TEEB DE, 2012; translated and amended based on MA, 2005; BfN, 2012)



We distinguish between three categories that directly benefit humans: **-> PROVISIONING SERVICES**, **-> REGULATING SERVICES** and **-> CULTURAL SERVICES**. Another category are **-> BASIC SERVICES** (also known as »supporting services«) which are closely related to ecosystem functions (processes such as soil formation, nutrient cycles and photosynthesis). Like biological diversity, these basic services are indispensable foundations of the provisioning, regulating and cultural services.

In an urban context, ecosystem services are found at the interface between urban nature and society (see Figure 5). However, the ecological functions of urban nature only become ecosystem services by virtue of their benefits for society and their utilisation. The importance of these benefits may vary significantly between individuals, different social groups, and society as a whole.

FIGURE 5 ▸ Importance of urban nature to society, illustrated by the concept of ecosystem services: The complex interactions between urban nature and ecosystem services are influenced by social conditions as well as by urban development decisions. (Source: own illustration according to de Groot et al., 2010; Potschin and Haines-Young, 2011; Ring et al., 2014)

2 URBAN ECOSYSTEM SERVICES: VITAL FOR QUALITY OF LIFE AND A CITY'S ATTRACTIVENESS

The »TEEB DE« urban report includes numerous examples of how -> URBAN NATURE, in its diverse manifestations, considerably enhances a city's attractiveness as a place to work, live and do business. Urban nature is therefore vitally important to society. It contributes to health, social cohesion, the development of children and adolescents, the supply of food, and as a location factor. Although studies quantifying the macro-economic importance of urban nature are not available in all these areas, it is nevertheless clear that urban nature offers huge economic benefits.

2.1 URBAN NATURE PROMOTES HEALTH AND QUALITY OF LIFE

Compared to the surrounding countryside, cities tend to be more affected by overheating, high concentrations of particulate matter and other air pollutants, and noise. Such pressure factors, both individually and especially in combination with one another, can significantly impair health and lead to elevated rates of illness and mortality. In Berlin, for example, 4 to 5 % of all deaths are linked to heat stress (Scherer et al., 2013). Climate change will exacerbate this pressure. More frequent, more intensive and longer-lasting heatwaves (IPCC, 2013) and the continuing expansion of -> URBAN HEAT ISLANDS pose a growing health threat, especially for older people and those with cardiovascular and respiratory diseases.

Health pressures not only impact individual quality of life; they also incur substantial costs to the healthcare system. EU-wide, the costs to the economy of air pollution alone are estimated at between 330 and 940 billion Euro / year, corresponding to between 3 and 9 % of the EU's gross domestic product (EEA, 2010, 2013).

The regulating ecosystem services provided by urban nature help to minimise these pressures. For example, trees and other elements of vegetation sequester particulate matter and other air pollutants (see also Box 2) and minimise heat stress by creating shade and evaporation cooling. For example, roadside vegetation which allows adequate airflow can reduce particulate matter concentrations by up to 15 % (Kuypers et al., 2007).

Plants act as a barrier to the spread of transport-related air pollutants (Säumel et al., 2012; von Hoffen and Säumel, 2014). This barrier effect can also be used selectively to shield residential buildings, for example, from sources of dust. Admittedly, dense tree plantings can also cause pollutants to accumulate in narrow streets. A structurally and species-rich herbaceous vegetation in streets and on buildings therefore effectively complements the filter function of trees. Here -> BIOLOGICAL DIVERSITY is important, because different types of leaves bind different particle types (Weber et al., 2014).

BOX 2

Air purification service of urban nature

The air purification service performed by urban vegetation has been established in a number of study regions. In Chicago, for example, the benefits of urban vegetation filtering carbon oxides (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3) and particulate matter (PM10) have been monetarised at around US $ 6.4 million per annum (Nowak et al., 2010). In Barcelona, urban nature binds 166 tonnes of particulate matter (PM10) per annum, accounting for 22 % of the dust emissions incurred within the city, with an annual monetary benefit of 1.1 million USD (Baró et al., 2014).

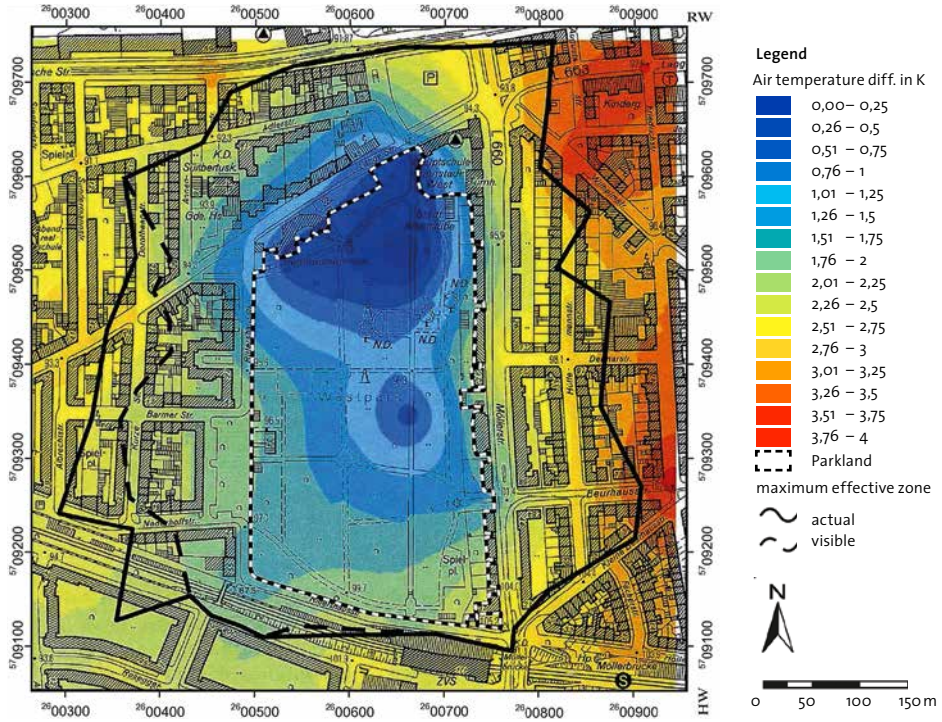
FIGURE 6 ▸ High emission levels on a heavily frequented inner-city road. (Photograph: Lauranne Pille)

Waterbodies, forests and parks provide so-called cool islands which significantly reduce temperatures in the surrounding areas overnight (see Figure 7). Even small green spaces can reduce the temperature by 3 to 4 degrees compared with the built-up surrounding area (Bruse, 2003). Urban nature can also contribute significantly to noise reduction; firstly, with the direct noise-minimising effects of absorption, reflection, scattering and shielding by vegetation; and secondly, indirectly, by creating a natural positive sound corridor and audio-visual shielding which makes the noise more palatable (such as birdsong). In particular, this helps to reduce stress, which is a common problem with potentially far-reaching health consequences.

Urban nature not only minimises environmental pressures, but also directly encourages the physical and mental health of human beings. Here are a few examples:

- Just being able to see nature already has positive effects. For example, patients in hospital wards recover more quickly if they are able to look out on a green environment (Ulrich, 1984): The time spent in hospital by patients with a tree view was almost a whole day shorter than the time spent by patients in rooms with a view of a brown brick wall (7.96 days instead of 8.70 days, ibid.).

FIGURE 7 ▸ Lower night air temperatures in a Dortmund park and their effects on the environment. The differences refer to the coldest point on the north edge of the park.
(Source: Bongardt, 2006; cf. also Naturkapital Deutschland – TEEB DE, 2016, chapter 3.1)



- Near-natural and landscaped open spaces encourage physical activity with various health-promoting effects, such as strengthening the cardio-vascular system and the immune system (Bowler et al., 2010; de Vries et al., 2013).

- Contact with nature helps to reduce stress, aggression and anxiety, and promotes concentration and vitality. According to one US study, fewer social conflicts occurred in housing estates where the apartments faced a green environment (Kuo and Sullivan, 2001).

- Children with ADHD (attention deficit hyperactivity disorder) are able to concentrate significantly better after a twenty-minute walk in the park than after walking for the same amount of time in a residential or city-centre area (Faber Taylor and Kuo, 2009). The study found that contact with nature helped to balance out the children's lack of concentration, and was roughly as effective as taking medication.

- Visiting -> **OPEN SPACES** near one's home or place of work promotes health in general, as well as the fostering of social relationships (Maas et al., 2009), and may help to balance out inequalities in the health of different social groups (Gilbert, 2016).

- A recent study of 32 German cities confirms a clear correlation between people's individual satisfaction with life and the accessibility of green spaces, as well as the proportion of green spaces in cities (Krekel et al., 2016). Research on a case study in Cologne, Germany, shows that in a neighbourhood with an average proportion of green spaces, one hectare of additional green space equates statistically to an additional income of 276 Euro / year / inhabitant in terms of life satisfaction (ibid.). A comparative calculation (see Box 3) illustrates that the value of one hectare of green space for individual life satisfaction can be almost twice as high as the land's commercial value as building plot.

BOX 3

The value of a park
(Comparative calculation: Burkhard Schweppe-Kraft, based on Krekel et al., 2016)

The study by Krekel et al. (2016) shows that the more access they have to green spaces, the greater nearby residents' satisfaction with life. In statistical terms, the life satisfaction gained from one hectare of additional green space equates to an additional income of 276 Euro / year. If we apply this approach to a green space in Berlin-Wilmersdorf, the following picture emerges (see Figure 8): With the local population density, the total value of one hectare of green space for all inhabitants within a 1 km radius is approximately 1,049,000 Euro / year. Using average standard land values, an area of this size would have a commercial value of approximately 15,000,000 Euro if sold as real estate. With a standard calculatory interest rate of 3 %, a one-off payment of 15,000,000 Euro is equivalent to an annual payment of 450,000 Euro. In other words, the real estate value of the land is less than half of its value as public green space.

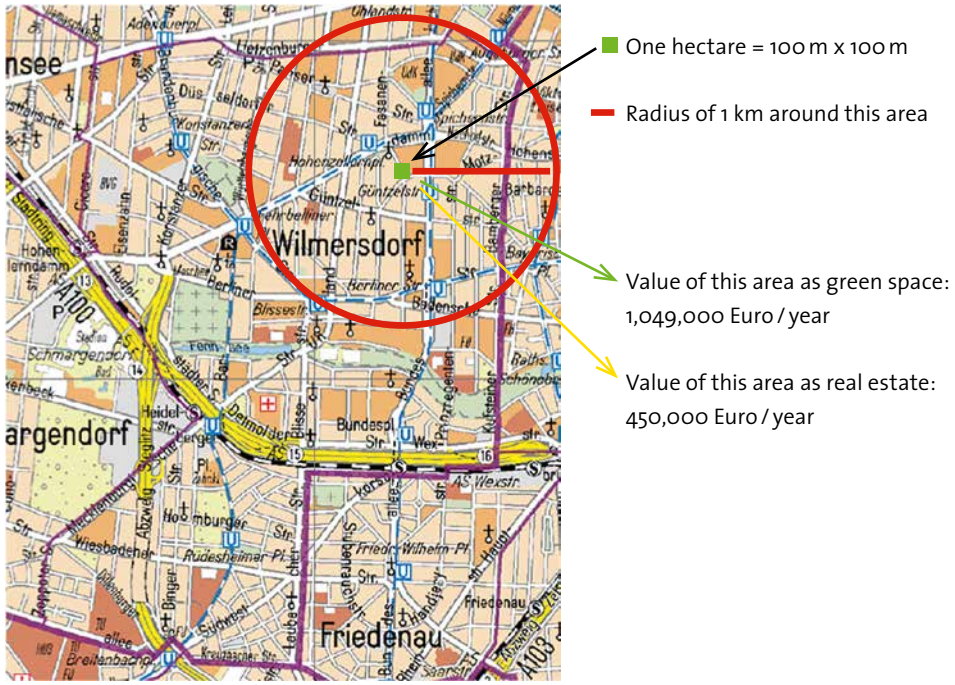


FIGURE 8 ▸ Valuation of public green spaces using the life satisfaction method, as illustrated by the example of Berlin-Wilmersdorf.
(Source: own illustration / Burkhard Schweppe-Kraft; map: Geoportal Berlin, 2016)

Overall, the benefits of urban nature on health have huge economic significance, because of the healthcare savings they facilitate. The three most expensive diseases for the healthcare system alone – cardio-vascular disease, musculoskeletal disease and mental health disorders – generate sickness costs of more than 100 billion Euro / year in Germany (StBA, 2014). Stress is known to be one of the causes of these diseases. The services of urban nature in reducing stress therefore also have major economic relevance.

The example of the UK's »Centre for Sustainable Health Care« shows that several healthcare stakeholders are now investing in the conservation and promotion of urban nature, in recognition of its obvious health-promoting effects. For example, around 40,000 trees have been planted by more than 180 project partners (Centre for Sustainable Health Care, 2016). Optimising the urban infrastructure with regard to its health-promoting qualities, and thereby forging new alliances between urban development and the healthcare sector, is essential for sustainable urban development.

2.2 URBAN NATURE RELIEVES PRESSURE ON CITY INFRASTRUCTURE AND REDUCES COSTS

Unsealed soils contribute significantly to the retention of contaminants and the infiltration of rainwater. This reduces the cost of technical water processing, relieves pressure on the sewer system, and lowers the risk of damage due to flooding.

Precipitation water seeps into the soil, evaporates, or runs off on the surface. More water runoff translates into higher costs for building and maintaining the necessary sewer system. Additionally, land owners must pay stormwater charges for sealed land. Table 1 shows the general percentage of water volume runoff depending on the type of land sealing or vegetation. It is clear that green spaces and green roofs effectively reduce water runoff, helping to reduce both the costs of building and maintaining a -> GREY INFRASTRUCTURE and stormwater charges. As well as reducing the risk of flooding, unsealed land and green roofs also create value with additional ecosystem services.

Surface type	Type of stabilisation	Average runoff (% of precipitation)
Sloping roof	Metal, glass, slate, fibre cement Brick, roofing felt	90–100 80–100
Flat roof (tilt up to 3° or approx. 5 %)	Metal, glass, fibre cement Roofing felt Gravel	90–100 90 70
Green roof (tilt up to 15° or approx. 25 %)	Covered with humus < 10 cm height Covered with humus > 10 cm height	50 30
Roads, paths and courtyards (flat)	Asphalt, seamless concrete Plaster with sealed joints Solid gravel covering Plaster with open joints Loose gravel covering, turf pavers Composite stones with joints, water-permeable stones Grass pavers	90 75 60 50 30 25 15
Gardens, meadows and cultivated land	Flat land Sloping land	0–10 10–30

TABLE 1 ▸ Average runoff on different types of surfaces. (Source: according to DWA, 2007)

The Aachen example in Box 4 illustrates the potential cost savings by keeping unsealed land open and integrating green roofs into residential areas. It is clear that opting not to seal courtyards and gardens and providing comprehensive roof greening also pays off financially. As heavy rainfall is likely to become more frequent in the course of climate change, the percolation services of soil in populated areas will become even more important.

BOX 4

Cost savings from urban nature in residential areas

For a residential development in Aachen, a study explored the costs and benefits associated with roof greening and minimal sealing of courtyard and garden areas as climate adaptation measures (BMVBS, 2013). For one 6.7 ha section of the project, the study devised three scenarios with different levels of greening and sealing (see Table 2). The assumed costs comprise the additional costs in relation to the basic scenario (investments plus essential re-investments and maintenance costs over a period of 50 years). Scenarios 2 and 3 lead to considerable savings compared with the basic scenario. Lower costs are incurred for the necessary infiltration infrastructure (smaller retention basins thanks to localised infiltration), lower stormwater charges, and lower energy costs. Within the context of a -> MULTI-CRITERIA ANALYSIS (MCA), alongside the monetary costs and benefits, other benefit aspects were also taken into account: micro-climatic effects, added aesthetic value, and positive effects on -> BIODIVERSITY and fire protection. All assessment criteria were weighted by a number of different stakeholders. Analysis reveals that scenarios 2 and 3, with a higher proportion of roof greening and reduced sealing of the courtyards and gardens, are worthwhile, having weighed up the costs and benefits. Incorporating other positive effects (e. g. additional benefits such as microclimatic effects, fire protection) reinforce this result. Scenario 3 with 70 % roof greening and no sealing of the internal courtyards and gardens is the most rewarding alternative.

	Cost difference from basic scenario (Euro) (50 years, discount rate 3 %)	Difference in benefits from basic scenario (Euro) (50 years, discount rate 3 %)
Scenario 1 (basic scenario) 0 % roof greening, 25 % internal courtyard sealing, 50 % garden sealing	–	–
Scenario 2 30 % roof greening, 0 % internal courtyard sealing, 50 % garden sealing	55,100 – 142,500	238,000
Scenario 3 70 % roof greening, 0 % internal courtyard sealing, 0 % garden sealing	128,500 – 330,200	597,000

TABLE 2 ▸ Investing in green roofs and green courtyards pays off. Three greening scenarios for a residential development in Aachen were assessed with a cost / benefit and multi-criteria analysis with PRIMATE (for methodological information see BMVBS, 2013, page 62 ff.). Analysis shows that for 10,000 individual MCA, scenario 3 is the best in approximately 9,200 cases, making it the most suitable alternative with 92 % probability. (Source: own illustration / Miriam Brenck, Oliver Gebhardt)

FIGURE 9 ▸ Rooftop photovoltaic installation with green roof, Münchner Technologiezentrum. The output of crystalline photovoltaic modules can be boosted by around 4 % if combined with extensive green roofs. (Photograph: ZinCo GmbH, 2011)

Green roofs can also boost the effectiveness of photovoltaic installations, strengthening the economic arguments for integrating them into urban environments (see Figure 9). Green facades also bring positive economic effects: their thermal insulating properties help to save heating costs in winter and air-conditioning costs in summer, and increase well-being during hot spells.

2.3 URBAN NATURE STRENGTHENS SOCIAL COHESION

Particularly in growing cities and disadvantaged neighbourhoods, urban open spaces are increasingly vital for individual leisure time and encouraging encounters, exchange, integration and positive identification with the neighbourhood.

Public open spaces like parks, watersides, community gardens and nature discovery spaces are freely accessible for people to spend their leisure time, either individually or together with others. Traditional allotments, used by around five million people in Germany, also play an important social role and aid integration (BDG, 2006; Dietrich, 2014).

Community gardens such as neighbourhood or intercultural gardens, often created as residents' initiatives, frequently are experimentation spaces for new forms of city living which combine social and environmental objectives. They are inclusive places that provide space for creativity as well as cultural and political exchange. Garden projects can strengthen a sense of community and help residents to identify with their neighbourhood or city. The »International District Garden« in Hanover (Figure 10) and the »Princess Gardens« in Berlin (see Box 5), which has gained widespread recognition for its role in social urban development, are only two of many successful examples. Admittedly, combining the many needs of different user groups can prove difficult, and social conflicts may still be played out in public spaces. Offering different types of open spaces and focusing on a versatile design can help to minimise such conflicts.

FIGURE 10 ▸ International District Garden Hanover: A space for exchange and creativity. (Photograph: Cornelia Surhan)

BOX 5

Appreciating new forms of urban gardening on inner-city wasteland

Since 2009, a 6,000 m² disused plot in a central location in Berlin-Kreuzberg has taken on a new lease of life, with new forms of urban gardening combined with a social and environmental mission. The »Princess Gardens« (see Figure 11) soon became well-known outside of Berlin and indeed internationally. When the land was threatened with sale by the City of Berlin in 2012, its founders launched the campaign »Let it grow!«. Within a short time, they had collected more than 30,000 signatures to preserve the gardens. The Berlin Senate and House of Representatives recognised the importance of the garden, and agreed that the land should be returned to the district to decide for itself on how it would be used. Development of the land was rejected initially. Negotiations are currently underway about its continuing use as a garden (Clausen, 2015). This could serve as a model example of how its cultural ecosystem services, i.e. the social functions of the project and its positive external effects for the district and the city, are estimated as more valuable to the society than its real estate value, currently estimated at 4.5 million Euro.

FIGURE 11 ▸ A litter-strewn wasteland at Moritzplatz in Berlin-Kreuzberg (left) was transformed into the »Princess Gardens« (right). (Photographs: Marco Clausen)

2.4 NATURE EXPERIENCES FOR CHILDREN AND ADOLESCENTS

Children, adolescents and adults feel a growing disconnection from nature (Soga and Gaston, 2016). For the younger generation in particular, this can impair healthy physical and mental development. Childhood research is already finding signs of motor, cognitive and social skill deficits (Gebhard, 2009; Kahn and Kellert, 2002). This may be linked to individual restrictions and future illness, which in turn incurs costs to the healthcare system. Children thrive on the ability to move freely and play in a near-natural environment, where they can experience elements of nature such as water, soil, plants and animals. Autonomy, creativity, risk competence and social skills, as well as linguistic, motor and scientific abilities, are all strengthened by playing freely in nature.

Green learning spaces offer a broad spectrum of approaches for contributing to the experience of nature and environmental education, thereby encouraging young people's development. These include

- School gardens, forest schools and other forest experience projects,
- Projects with a gardening or agricultural reference (see Box 6),
- Urban wilderness spaces which often develop on -> WASTELAND and may be integrated into networks of open spaces (such as former industrial sites in the Ruhr district).

Nature discovery spaces are a special category provided for in the Federal Nature Conservation Act. They aim to help young people to experience nature in areas which are particularly lacking in opportunities for contact with nature. Successful examples such as »The Paradise« in Oppenheim and nature discovery spaces in Baden-Württemberg show that it is possible to find solutions for concerns such as liability and supervision, and allow children to use these spaces with enthusiasm (see Figure 12).

FIGURE 12 ▸ Nature discovery space »Am Bächle« in Vaihingen on the River Enz. Children experience soil, water, plants and animals with all their senses. (Photograph: Bettina Marx)

2.5 PROVISIONING SERVICES OF URBAN NATURE

FIGURE 13 ▸ »Edible city« Andernach: Picking is allowed! (Photograph: Municipality of Andernach)

Urban expansion and structural densification often occur at the expense of agricultural and horticultural land. This land's contribution to sustainable health promotion is often underestimated. Food cultivation in the vicinity of people's homes gives them a direct experience of food production, raises awareness of regional products and encourages a healthy diet. The latter is highly relevant from an economic viewpoint, since obesity and the resultant follow-on diseases are a major financial pressure on society. A lack of knowledge about where our food comes from, and escalating consumption of high-calorie, low-nutrient, industrially manufactured meals are contributing to obesity in children, adolescents and adults (Lobstein et al., 2015). In Germany, for example, some 8.7 billion Euro were spent on the treatment of obesity and associated illnesses in 2008, plus a further 8.1 billion Euro in indirect costs, primarily as a result of illness-related work absences (Lehnert et al., 2015).

The vegetable-growing educational project »GemüseAckerdemie« collaborates with schools to selectively encourage a knowledge of nature, food and health among children and adolescents (Box 6).

Agriculture in the proximity of cities profits from the growing awareness for regional food: Farm shops and regional marketing of high-quality products are on the increase. For some households, being self-sufficient for some of their food is also financially important. A number of successful operating models have been established, for example whereby farmers lease parcels of land and sow vegetable seeds for subsequent self-harvesting. Allotments in the Rhine / Ruhr region achieve an estimated self-sufficiency with fruit and vegetables (excluding exotic fruits) of around 50 % (LUA NRW, 2001). Added to this is the pleasure in gardening and working in nature.

The »Essbare Stadt« (Edible City) Andernach has adopted new approaches for integrating food production into urban landscapes (see Figure 13). A city initiative to grow fruit and vegetables on public green spaces has sparked a broader trend. This example shows how positive social effects can also be achieved by involving the general public in the cultivation and harvesting of food on public open spaces. For example, it has created a new role for the long-term unemployed, which benefits them and the community. Also, residents identify more readily with their city.

BOX 6

The »GemüseAckerdemie« (Vegetable Academy) promotes knowledge and awareness of dietary habits among school pupils

Only a minority of children and young people know where their food really comes from. Fewer still have grown their own vegetables. The consequences are a diminishing appreciation of food and an unhealthy diet. Among other things, this is reflected in the fact that more than 30 % of food in Germany is thrown away, and diabetes and obesity are continuously rising (Ackerdemia e. V., 2014). Against this background, in 2013 the charitable organisation Ackerdemia e. V. created the educational programme »VegetableAcademy« to raise awareness and appreciation of healthy food and its production, particularly among children and young people. The academy offers its program to schools. Together with groups of children various types of vegetable are grown, harvested and prepared. Schools in Brandenburg, Berlin (see Figure 14), Lower Saxony and North Rhine-Westphalia are currently working with the initiative, and individual schemes are emerging. Initial monitoring results illustrate a huge potential for sustainable behavioural changes and raised awareness. Within just a year of the pilot phase, many children are already »eating more healthily, taking more exercise, developing intergenerational social skills, acquiring more confidence, and have developed a measurable awareness of agriculture and food« (Ackerdemia e. V., 2014, p. 1).

FIGURE 14 ▸ The school garden at Nürtingen primary school. (Photos: Ackerdemia e. V.)

2.6 URBAN NATURE AS A LOCATION FACTOR

Municipalities compete with one another for tax revenues, businesses, jobs, tourists, residents and a reputation as an attractive place to live. When deciding where to locate, »soft« factors are important to both companies and individuals alike (Grabow et al., 1995). Alongside general attractiveness, this also includes a city's environmental quality, leisure value, and appealing as place to live and work, aspects which are becoming ever more important, particularly for attracting highly qualified workers.

Promoting urban nature offers an ideal opportunity for municipalities to make themselves more attractive to companies, potential residents and tourists. Urban nature can significantly promote a town's positive image. This is achieved, for example, by staging competitions, such as the »national capital of -> BIODIVERSITY« and national and regional garden shows. Green spaces, which in cash-strapped periods are often mainly viewed as an expense, may contribute significantly to a city's positive external image. This is true of both historical facilities like the Potsdam Palace Gardens, and new projects such as the Duisburg-Nord landscape park, the former airport Tempelhofer Feld in Berlin or the River Isar in Munich's city centre following its -> RENATURATION, all of which are magnets for visitors.

The environmental rehabilitation of the River Emscher and its facilities in the Ruhr district proves that investing substantially in the -> REVITALISATION of a river system, including the construction of new purification plants (approx. 4.5 billion Euro), can significantly benefit the regional economy. Over the period 1991 to 2020, the scheme is expected to produce some 11.9 billion Euro in production effects and around 109,790 man years of employment, together with increased tax revenues (approx. 1.1 billion Euro) and increased social insurance contributions (approx. 580 million Euro) (Barabas et al., 2013).

It also pays for companies to promote urban nature, for example, by designing near-natural grounds (see Figure 15). In Switzerland the foundation »Stiftung Natur & Wirtschaft« (www.naturundwirtschaft.ch) has presented awards to 386 institutions for their naturalistic landscaping (as at 2015). The German foundation Bodenseestiftung (www.bodensee-stiftung.org) operates a similar award scheme. The main advantages of naturalistic landscaping include:

- Reduced maintenance costs: The cost of creating and maintaining a low-fertility meadow over ten years are approximately 1.68 Euro per square metre, per annum, significantly less than a conventional lawn (approx. 3.34 Euro, Land Oberösterreich, 2006). Additionally, stormwater charges can be avoided by converting sealed land into green soakaways.

- Potential benefits for the health, motivation and performance capability of employees: In the past, these types of benefits have usually been associated with parks. However, a more recent study showed that looking out onto a green roof rather than a grey roof aids concentration, too (Lee et al., 2015), suggesting positive effects for employees who look out onto green spaces.

- A positive external image for companies through engagement for biological diversity and the creation of an attractive »green« address (Müller et al., 2015).

A greener living environment also affects real estate prices. In Cologne, reducing the distance of an apartment to the closest park by 100 m increases the average real estate price by almost 600 Euro (total real estate price: approx. 156,000 Euro). As such, the value-enhancing effect of proximity to a city park is minimal compared with structural factors such as the size and age of the property (Kolbe and Wüstemann, 2014), but given the large number of real estate sales within the city, the value increase associated with proximity to urban nature can nevertheless generate significant additional revenues for the local authority from property transfer taxes.

FIGURE 15 ▸ Naturalistic corporate landscaping: Credit Suisse in Zürich (Uetlihof) with green facades, flower meadows and near-natural recreation areas, 2004. (Photographs: Ingo Kowarik)

3 THE WHOLE IS MORE THAN THE SUM OF ITS PARTS: FOCUS ON ECOSYSTEM SERVICE BUNDLES

3.1 ECOSYSTEM SERVICE BUNDLES

In specific planning situations, the emphasis is often on individual -> ECOSYSTEM SERVICES. For example, within the context of climate change adaptation, selective use of the soil's infiltration capacity is made to minimise flooding after heavy rainfall. This monofunctional perspective helps to develop solutions to specific challenges, and to identify a service's beneficiaries. For example, the Copenhagen city council decided to invest in boosting the rainwater retention function of open spaces, a natural solution which is also cheaper than investing in technical flood prevention solutions (Grönmeier et al., 2013).

However, the same components of -> URBAN NATURE tend to be part of a full range of ecosystem services (»ecosystem service bundles«) which can benefit various segments of society. They can also cause adverse impacts – for example, heavy use of one ecosystem service may weaken another. As different groups in urban society have different and often irreconcilable interests, conflicts can arise in the use of urban nature (for example, between park users seeking peace and quiet and those who want to party). Additionally, upgrading the value of a residential environment by making it greener can cause rent hikes and displacement effects (»green gentrification«; Gould and Lewis, 2012; see section 2.3).

A consideration of ecosystem service bundles allows us to identify mutually beneficial effects (-> SYNERGIES) as well as conflicts between beneficial and detrimental effects (-> TRADE-OFFS). Recognising the multifunctionality of ecosystem services is therefore a key step towards a socially, ecologically and economically sustainable urban development. In this regard, we must consider the relevant spectrum of ecosystem services (»supply side«) as well as the range of existing social needs (»demand side«). Figure 16 illustrates this connection by the example of city trees: The revealing of the supply and the demand side helps us to visualise their high economic importance and take it into account in the financing of tree-planting. This would represent significant progress, since until now, concerns over follow-on costs (e. g. tree pruning & maintenance) have hampered roadside tree plantings. To recognise and demonstrate the different ecosystem services and their synergies regarding ecological, social and economic objectives and capture these into decision-making, we should make use of multi-criteria approaches – as well as encourage inter-departmental collaboration (see chapter 4).

FIGURE 16 ▸ Mono- and multi-functional approach to urban ecosystem services using the example of city trees. The mono-functional approach assesses the benefits and value of individual ecosystem services to certain sectors of society (see references in individual lines), while the multi-functional approach additionally considers synergies between different ecosystem services and trade-offs between positive and negative effects (disservices; references between or within columns). The examples given are not intended to be exhaustive. (Source: own illustration / Ingo Kowarik)

Multi-functional approach

+ Ecosystem service / – Disservice	+ Benefit / – Damage	+ Positive value / – Negative value	Affected segments of society
+ Temperatures are reduced by shading and evaporation	+ Reduced heat stress for humans	+ Enhanced quality of life, fewer illnesses	▸ Neighbourhood ▸ Vulnerable groups ▸ Healthcare sector
– Less air circulation with dense plantings in narrow streets	– Heat accumulation, increased concentration of pollutants	– Reduced quality of life, more illnesses	▸ Neighbourhood ▸ Vulnerable groups ▸ Healthcare sector
+ Shaping the cityscape	+ Better image	+ More attractive residential and commercial locations	▸ Neighbourhood ▸ Businessmen ▸ Land owners
+ Structuring of relaxation areas	+ Social spaces for encounters, leisure, recuperation	+ Greater well-being, social cohesion	▸ Neighbourhood ▸ Urban society
+ Retention of precipitation water	+ Reduced load of the sewer system	+ Less investment and maintenance costs	▸ Water industry
– Impairment to structures from roots	– Damage to the sewer system and to structures	– Higher maintenance costs	▸ Water industry ▸ Real estate sector

Mono-functional approach

3.2 MAKING USE OF SYNERGIES BETWEEN ECOSYSTEM SERVICES AND BIODIVERSITY

Together with countless natural processes (such as soil formation, water cycle), -> BIOLOGICAL DIVERSITY provides the basis for the broad spectrum of urban ecosystem services (see Figure 4). The »TEEB DE« urban report does not consider it as a separate ecosystem service, although it does highlight significant synergies between the two objectives of

- enhancing the quality of life and the city's attractiveness by strengthening ecosystem services, and
- preserving and promoting biological diversity in cities.

As such, the -> TEEB APPROACH additionally helps to validate pertinent conservation objectives. The urban biodiversity strategies already adopted by various city councils contain key starting points in this regard, as illustrated by the example of Berlin (SenStadtUm, 2012). Initially, one key consideration is to preserve urban networks of open spaces or, in undersupplied areas, to create new ones. These networks, which combine to create a city's -> GREEN INFRASTRUCTURE (EU, 2014), can be used to optimise ecosystem services in line with particular local requirements. There is not necessarily a correlation between ecosystem services and biodiversity or the presence of endangered species. Even vegetation comprised of just one species (such as an avenue of trees) can deliver vital ecosystem services. However, there are two key reasons for encouraging biodiversity when reinforcing urban green infrastructure:

- Biological diversity is attractive: Recent studies show that city residents often notice differences in the biodiversity of urban nature and appreciate higher levels of biodiversity (Botzat et al., 2016; BMUB and BfN, 2016). As well as rating species rich park meadows positively, they also appreciate the »wild« vegetation around the trunks of roadside trees more than the »neat and tidy« alternative (see Box 7).
- Biodiversity encourages adaptation to new environmental conditions: Species diversity, and in particular high levels of genetic diversity, may contribute significantly to climate change adaptation according to the »insurance hypothesis« (Baumgärtner, 2007). The more diversity there is, the greater the chance of an adapted species or genotype which can continue to guarantee the supply of ecosystem services under altered conditions.

Preserving and promoting biological diversity in urban open spaces as far as possible therefore contributes to sustainable urban development. Thus, it is worthwhile promoting ecosystem services and biological diversity equally within the urban green infrastructure.

BOX 7

Does biological diversity enhance people's appreciation of urban nature?

In the course of the EU project »Green Surge«, inhabitants of cities were shown pictures of typical elements of open spaces and asked to voice their appreciation of them (cf. figure 17). For each picture alternative versions, showing different degrees of biodiversity, were presented and assessed; for the street picture an additional version without any vegetation was included. For Berlin, the evaluation showed that the respondents clearly prefer park meadows with a high biodiversity, even those who suffer from hey feaver. Wasteland is mainly seen positively, while biodiversity doesn't play an important role in this case. The evaluation of the assessment of the street pictures is surprising: While the version showing a carefully tended tree pit without any vegetation clearly caused negative responses, the one showing »wild« vegetation was mainly seen positively.

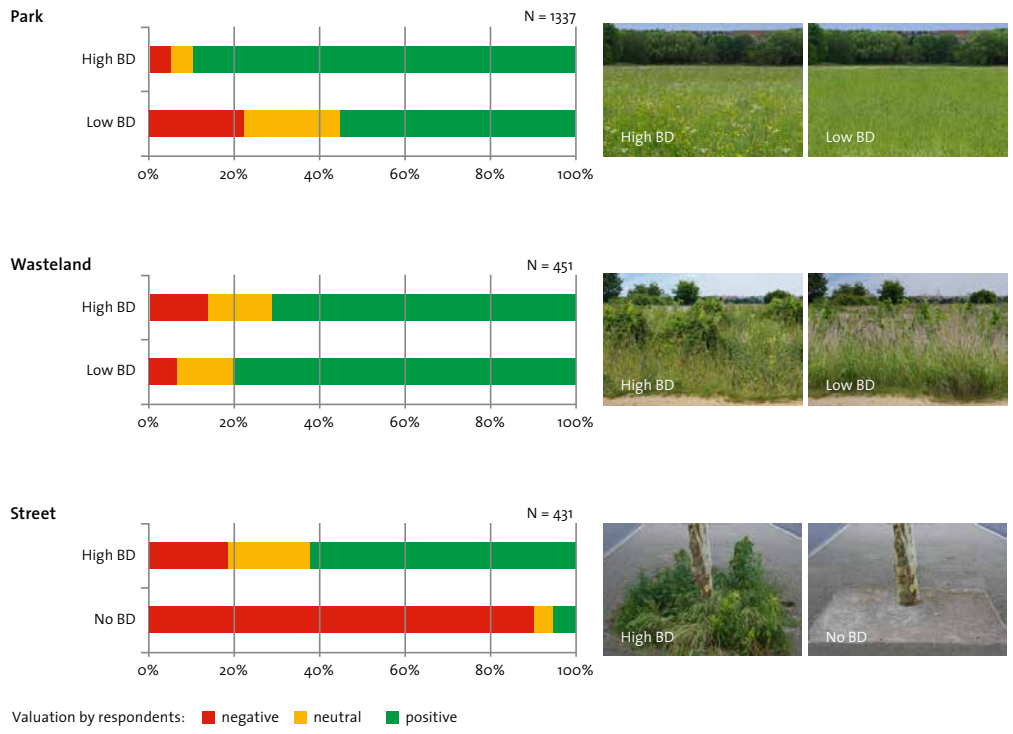


FIGURE 17 ▸ Appreciation of typical elements of open spaces in Berlin (park meadow, wasteland with wild vegetation, tree pit on a street) and its dependence on biodiversity. The diagram shows results for the assessment of pictures with high or low biodiversity and no biodiversity respectively in the case of the street scene.
(Source: own illustration / Leonie Fischer, Ingo Kowarik)

4 CONSIDERING ECOSYSTEM SERVICES IN URBAN DECISION-MAKING

-> URBAN NATURE is under increasing pressure. Many urban open spaces are being rezoned as housing and transport infrastructure, in the expectation of increased tax revenues and public funding. When deciding to build on urban open spaces, the ecosystem services of urban nature are often not recognised, or their importance to society is insufficiently acknowledged. Financially weak local authorities also face major problems in maintaining their -> GREEN INFRASTRUCTURE in the face of rising costs. Consequently, it comes as no surprise that average expenditure in this area has actually fallen in recent years (BMUB, 2015a).

The »TEEB DE« report shows that investments in urban nature are worthwhile, because they deliver numerous services for humans: for their health, infrastructure, for social cohesion, the development of children and adolescents, and as a location factor. The interactions between different ecosystems in the same place, or the »multi-functionality« of urban nature, is particularly significant.

But how can this value of ecosystem services be incorporated into decision-making processes? We have highlighted four starting points (Figure 18):

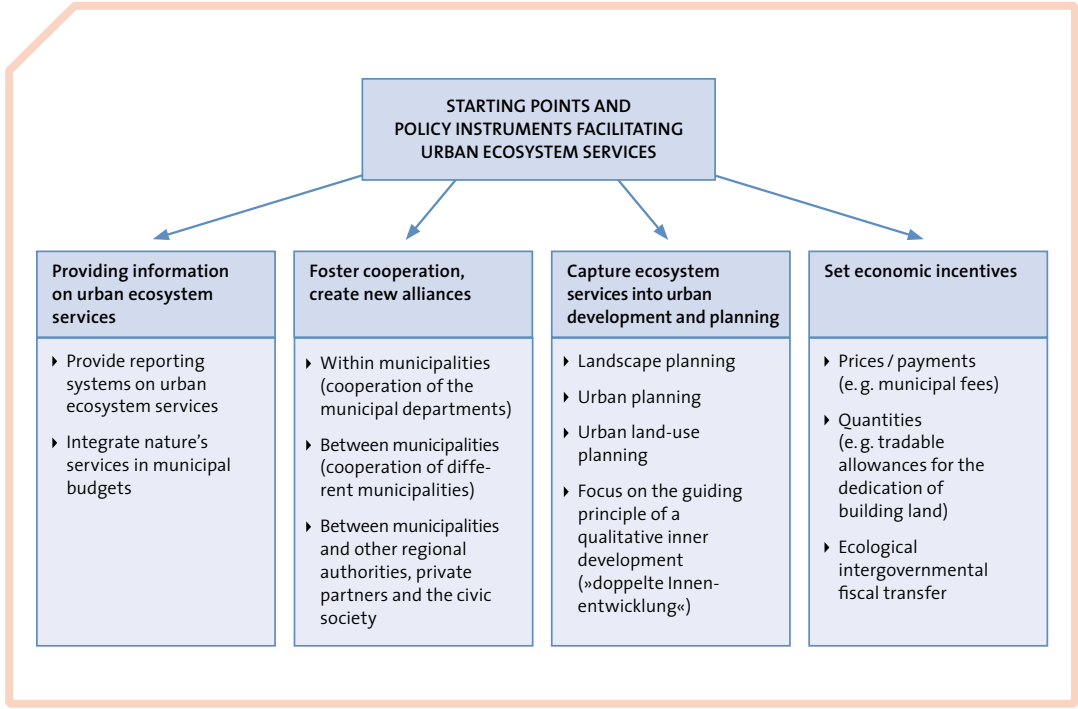


FIGURE 18 ▸ Starting points for promoting urban ecosystem services.
(Source: own illustration / Miriam Brenck, Bernd Hansjürgens)

- Comprehensive information about urban ecosystem services,
- Cooperation within a municipality and between municipalities,
- Integrative planning approaches, and
- Economic incentives.

4.1 PROVIDING INFORMATION AND INCORPORATING IT INTO DECISION-MAKING

Information about the diverse ecosystem services of urban nature as outlined in the »TEEB DE« report may provide vital support for sustainable urban development. It is essential to reflect the different ecosystem services of urban land and its benefits for a »good life« and thus the city's economic development and incorporate these values into considerations. The »TEEB DE« academic report provides a comprehensive information basis for identifying and highlighting ecosystem services and their values, with relevance both at a macro-city level and at a smaller geographical level, for example with land-use plans (see also Box 4 on design options for the land-use plan of a residential development in Aachen).

In this regard, it is important to remember that quantitative (especially monetary) assessments of ecosystem services can only ever be approximate. Qualitative assessments based on a variety of criteria as well can deliver valuable information, because some relevant ecosystem services cannot be adequately quantified (see chapter 2.2 of the long report). Additionally, every assessment depends on the local circumstances and the valuation of different user groups, which limits their transferability. For this reason, there is no such thing as a generally valid assessment of urban ecosystem services. However, the examples given in the report provide public players with key starting points for the potential to -> CAPTURE THE VALUE of ecosystem services in decision-making.

Uncovering the value of urban nature is a way of identifying the comprehensive costs and benefits of other land use alternatives, rather than focusing solely on short-term and direct benefits. This allows us to identify the potential beneficiaries and disadvantaged parties, and devise design options for land and buildings which consider the benefits to society as a whole. The aim is to encourage communication between different authorities and participating stakeholders in order to make use of -> SYNERGIES and encourage strategic collaboration.

From a societal perspective, -> NATURAL CAPITAL must become more visible in public budget decisions. One possible approach would be to replace or supplement single-entry bookkeeping, which only reports revenue and expenditure flows, with the double-entry system (Hilgers and Burth, 2011; Güse et al., 2010). The -> GREEN DOUBLE-ENTRY BOOKKEEPING system values green and open spaces as assets and includes them in the balance sheet. Depreciations associated with poorly maintained green spaces or building development, as well as investments in green infrastructure and improvements to natural capital (increase and decrease in the value of natural capital) are visible in this system. This information is especially important as decision-making basis, because local authorities are very keen to preserve their capital assets, and will therefore consider protecting natural resources (BMUB, 2015a). However, it should be remembered that government budgets can only ever reflect a small part of the true value of urban ecosystem services. The capacity of unsealed soils to retain water, cultural services such as providing space for relaxation and exercise – these and other specific services are (currently) disregarded. The true value of a local authority's natural capital is likely to be several times greater than the monetary value reported on the balance sheet.

4.2 CREATING NEW ALLIANCES AND FOSTERING COLLABORATION

A key strategic starting-point for conserving and developing urban nature and associated ecosystem services would be to encourage more widespread collaboration between all stakeholders, both the various agencies and departments within a local authority, and general cooperation between municipalities and other levels of regional and local government, as well as collaboration with private players and actors from civic society.

Within cities and municipalities, it is particularly important to link together the various agency divisions and departments that benefit from the green infrastructure. For example, this includes the sectors infrastructure, health, education, young people and family, social affairs, migration and integration, climate protection and climate adaptation, nature conservation and economic subsidies.

Collaboration to promote health

The »TEEB DE« report elucidates the fact that urban nature promotes health via various different mechanisms. Positive impacts of urban nature include effects on social cohesion and the enhancement of quality of life in urban neighbourhoods. Urban nature's contribution to the healthy development of children and adolescents is particularly important. Against this background, the competent departments within a local authority, i.e. the departments in charge of urban green, as well as those for health, young people, families and social affairs, should have a powerful shared interest in promoting urban nature and facilitating access to it for as many population groups as possible. Collaboration between public and private stakeholders can also help to preserve natural capital (see Box 8).

BOX 8

Promoting health through cooperation between public and private stakeholders

One successful example is the »Baumstarke Stadt« (city of trees) Leipzig, a tree-planting project in the city, financed from private tree sponsorship. The city council deliberately focuses on cooperation with local people and companies. Since the programme's launch in 1996, willingness to donate has increased significantly year-on-year. Each year, around one third of new tree plantings are privately funded, encouraging local people to identify with »their« urban nature (Stadt Leipzig, 2015). Similar projects have also been rolled out in other municipalities, such as Dortmund, Dresden, Hamburg and Magdeburg (Naturkapital Deutschland – TEEB DE, 2014).

Proactively promoting the health of city residents by ensuring access to the ecosystem services of urban nature for as many people as possible is also an important channel for improving **-> ENVIRONMENTAL JUSTICE** in cities. Focusing more extensively on the concept of health promotion (»salutogenesis«, Fehr, 2001) necessitates better cooperation between the environment and health sectors, and offers promising prospects for healthcare savings. For example, healthcare stakeholders in England help to fund roadside tree plantings in recognition of their importance for health (see section 2.3 above).

Although the correlations between urban nature and health as well as quality of life are basically realised, many local government decision-making processes give them inadequate consideration. All too often, individual agencies and departments within a municipality are forced to compete with one another for limited public funding, and tend to overlook potential synergies and harmonised objectives. New approaches to decision-making and coordination need to be found: In particular, we must raise the visibility of urban nature and its positive effects on meeting the objectives of different sectors, identify synergies and collaborate on the development of measures. In this regard, city planning plays an overarching role.

For example, noise reduction measures are one area where cooperation between the sectors of city planning, health, urban green spaces and nature conservation is mutually beneficial. Noise reduction plans should also be assessed for their integration of measures to promote urban nature.

The »Environment and Health Masterplan« adopted by North Rhine-Westphalia in March 2016 stresses the need for cooperation between the sectors of nature and health, formulates recommendations for improving environment-related health protection, and thus provides a key mechanism for sustainable urban development in the region (MKULNV, 2016).

Cooperation between local authorities

There are some promising approaches for cooperation between local authorities: For example, the alliance »Kommunen für biologische Vielfalt e. V.« (municipalities for biodiversity) was created in 2012 with the support of the German Federal Agency for Nature Conservation (BfN). The membership in this alliance is considered a voluntary commitment of the local authorities to engage in nature and biodiversity conservation. The network, with more than 100 members, promotes the exchange of information between local authorities, and between science and policy. It also focuses on strategic cooperation and the joint representation of interests to the Federal Government, the German Federal States and the EU. It initiates and coordinates joint projects and participation in research projects, and runs joint PR campaigns (Kommunen für biologische Vielfalt, 2016). Thus, the alliance also offers ideal conditions for raising awareness of the benefits of biodiversity and ecosystem services in public debates and decision-making processes.

Another important area where local authorities can cooperate is in business development, especially with regard to land management (UBA, 2016; see also below). Until now, councils have had to compete for businesses and employees, leading to significant volume of zoned land for commercial and industrial use. Often, however, zoned land is too large, and remains unused due to a lack of demand. As well as being detrimental to Germany's sustainability goals of reducing land use by 2020 to 30 hectares per day at the most, it stresses municipalities' budgets. Rather than generating additional revenues from property, trade and income tax, the cost of expanding and maintaining an oversized infrastructure leads to losses, not to mention the costs for society due to the lost benefits from the natural capital of these open spaces.

Closer collaboration between local authorities on business development is therefore urgently needed, with a view to a more coordinated land policy. As well as »saving« land, this could also reduce overall spending levels, without depriving individual local authorities of the benefits of commercial development.

By collaborating, regional commercial spaces could be marketed jointly, with the local authorities pooling their land. Their share of the pool would be determined by the value of the land. Commercial land could then be marketed jointly via an agency, and the trade taxes raised could be distributed according to pool shares. This would help to avoid price competition between local authorities, and ensure the more efficient use of commercial land that has already been zoned. Various commercial **-> LAND POOLS** are currently being trialled, including an alliance in the Neckar-Alb region and the »A9« alliance in Franconia.

Financing green infrastructure

Local authorities have certain mandatory tasks which have top priority in budget planning, whereas the funding of nature as a voluntary element of self-administration is at their own discretion, depending on their political priorities. It is in direct competition with other discretionary areas such as culture, sport etc. The »TEEB DE« report shows that investing in urban nature is a vital public service: Developing and maintaining a green infrastructure helps to promote health, integration and participation, as well as social cohesion and environmental justice, education, and not least, the city's suitability as a business location.

Defining the promotion of green infrastructure and ecosystem services as a mandatory task will not be easy. Raising awareness for the societal importance of urban nature should help to attract more funding, initially in the scope of the non-mandatory tasks of the municipality. Investing in green infrastructure contributes significantly to the mandatory tasks of local authorities, such as promoting health, economic development and education, and therefore does not place any »additional pressure« on the budget.

Making use of funding programmes

The report highlights funding opportunities for measures to preserve and promote nature. Table 3 contains an overview of several relevant funding programmes at EU, Federal Government and German Federal State level. The urban development funding programme »Soziale Stadt« (Social City), created in 1994, is designed particularly to foster vibrant neighbourhoods and strengthen social cohesion. Measures to stabilise and improve economically and socially deprived, structurally weak districts and neighbourhoods are financially supported. In this scope, as well funding for green neighbourhood development projects can be raised – such as the creation of community gardens, which offer numerous cultural, regulating and provisioning ecosystem services (BfN, 2015; BMUB, 2015b, 2015c).

Appropriately designed, funding programmes can promote cooperation between urban administrational sectors, and thus targeted make use of the multifunctionality of ecosystem services. This must be taken into account at every stage, from inviting bids, to advertising, through to implementation. For example, funding dedicated to a specific problem (such as climate adaptation) may include measures that add value in other areas, such as conserving biodiversity, creating cooling effects in inner cities, or providing a space for recreational use.

Programme	Donor
EU	
Natural Capital Financing Facility (NCFF)	European Investment Bank (EIB) and EU Commission (LIFE)
Joint European Support for Sustainable Investment in City Areas (JESSICA)	EIB
Interreg Europe	European Fund for Regional Development (EFRD)
URBACT programme	EFRD with national and local co-financing
Federal Government	
Federal Biological Diversity Programme	Federal Agency for Nature Conservation (BfN), Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)
Trial and development projects	BfN, BMUB
Research initiative »Zukunft Bau« (Future Building)	Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), BMUB
Urban development funding programmes	BBSR, BMUB
Funding of climate protection projects in social, cultural and public facilities under the National Climate Initiative	BMUB
German Federal States (»Länder«)	
Programmes to promote urban development at German Federal State level	Various ministries of the individual German Federal States (such as urban development funding in Baden-Württemberg provided by the Ministry of Finance and Economics in BW)
Integrated urban development (ISE) in Saxony	Development Bank of Saxony in conjunction with the EFRD
Avenues in North Rhine-Westphalia	Ministry for Climate Protection, Environment and Agriculture, Nature and Consumer Protection of North Rhine-Westphalia

TABLE 3 ▸ Examples of funding programmes for urban nature. (Source: revised according to Naturkapital Deutschland – TEEB DE, 2016, chapter 9)

4.3 INTEGRATING ECOSYSTEM SERVICES INTO URBAN DEVELOPMENT

One key message from the economic perspective of the »TEEB DE« report is that it is in society's own interest to interlink the ecosystem services of urban nature and urban development more closely. City planning, in conjunction with landscape planning and open space planning, plays a key role in this regard. The latter has an extensive range of tools and comprehensive knowledge on the development of green infrastructure, the promotion of associated ecosystem services, and hence ultimately, the preservation and qualification of urban nature with a view to social and environmental objectives.

»Ecological concerns« are social concerns

Alongside nature conservation aspects in the narrower sense of the word (such as species conservation), urban landscape planning today already assesses and illustrates the services provided by nature for humans (for example, the Berlin landscape programme includes plans for -> NATURAL BALANCE and environmental protection, as well as for recreation and the use of open spaces). Admittedly, in political and administrative decisions related statements are often viewed as »purely environmental concerns« and are therefore neglected and sidelined, whereas in fact the core of the matter is the quality of life. Hence we need a change of perspective which focuses more strongly on the services of urban nature for the quality of life in cities. The TEEB approach may help in this respect, because it uses qualitative and quantitative assessment of ecosystem services to raise awareness for the importance of urban nature to society.

The urban report combines many arguments which point in favour of strengthening urban green spaces in the planning phase, and against sidelining these with regard to other interests. Within the context of concrete planning decisions, for example, multi-criteria procedures may be used which, in addition to a monetary representation of the costs and benefits of design alternatives, also incorporate other aspects. In this way, the value of many ecosystem services can be incorporated into the deliberation processes even if it cannot be expressed numerically in terms of costs and benefits. To apply multi-criteria procedures in supporting decision-making, guidance documents may also prove helpful (such as the guidance document to support decision-making in urban climate change adaptation, BMVBS, 2013).

Qualitative inner development: Structural and ecological development

The guiding principle of a qualitative inner development (German: »doppelte Innenentwicklung«) offers key starting points for promoting ecosystem services in our cities. It aims at combining the development of open spaces and the built environment – to preserve

and improve open spaces. Unsealed land must be protected, despite structural densification, to preserve the services provided by the soil. With green roofs and facades as well as small-scale green structures, built areas have to be developed regarding a variety of ecosystem services and biological diversity (BfN, 2016). The so-called qualification of open spaces within the context of inner-city development comprises a range of different strategic approaches with powerful synergy effects:

- **Preserving and extending the network of green open spaces.** With escalating structural densification, the demand for ecosystem services is growing, particularly in neighbourhoods that are undersupplied with green spaces. Consequently, open spaces such as agricultural land, wasteland and allotments should not only be viewed as potential building land, but rather valued for their potential or existing ecosystem services within the green infrastructure. The »TEEB DE« report illustrates the fact that green open spaces are not just cost items; they are also service providers and major contributors to the attractiveness of urban locations and neighbourhoods.

- **Upgrading the network of green open spaces.** In the urban environment, open spaces are maintained by a variety of public and private bodies. The maintenance costs are a worthwhile investment in the city's natural capital, since the managed green spaces, waterbodies and roadside plantings provide valuable ecosystem services. The careful design and improvement of open spaces to accommodate the needs of different users increases the availability of the relevant ecosystem services. This necessitates cooperation between different stakeholders (see section 4.2). Because biological diversity often strengthens ecosystem services (see chapter 3), approaches for improving the green infrastructure should also include promoting biodiversity.

- **Safeguarding competency.** Many public administrations have made significant staffing cutbacks in the departments responsible for urban open spaces in recent years. Already in 2007, the German Advisory Council on the Environment warned of an overburdening of these departments (SRU, 2007). Forward-thinking investments in the future are needed to counteract this trend. Adequate staffing levels are essential if we are to bring different stakeholders together to achieve synergies in the design and development of green infrastructures in the sense of socially, economically and environmentally sustainable urban development.

- **Developing the green and -> GREY INFRASTRUCTURE together.** A technical (»grey«) infrastructure is indispensable for the provision of basic services in urban areas. The »TEEB DE« report shows that by designing green and grey infrastructure together, significant multiple benefits can be achieved. For example, »green« measures in the waterbody infrastructure can produce substantial synergies, and are often superior to »grey« approaches (Nivala et al., in print). However, the realisation of such synergies relies on better collaboration between the different players responsible for grey and green infrastructure. By promoting ecosystem services, it is possible to minimise roadside environmental pressures and reinforce social functions. Important approaches exist e. g. in »water-sensitive urban development« (Becker et al., 2015), in which nature-based solutions lead to synergies and a host of positive economic effects. These range from saved wastewater charges thanks to rainwater infiltration to major benefits for the regional economy, as illustrated by the environmental rehabilitation of the Emscher basin in the Ruhr district (Figure 19) (Bauer et al., 2015; see also Naturkapital Deutschland – TEEB DE, 2016, chapter 3.5.5).

- **Promoting ecosystem services in construction projects.** Promoting ecosystem services in public or private construction projects may cause increased investment costs, such as the additional cost of creating green roofs. The TEEB approach helps to reveal multi-functional ecosystem services, so that the positive overall effects for investors or the public sector can be ascertained (see Box 4). The ecological qualification of construction projects and existing buildings hence offers two key benefits: firstly, it reduces adverse impacts associated with densification; and secondly, it delivers positive social, economic and environmental effects.

4.4 PROVIDING TARGETED ECONOMIC INCENTIVES

Economic incentives are a key approach for strengthening urban nature and urban ecosystem services. On the one hand, such incentives should make nature usage in terms of resource consumption and damage more expensive, so as to prioritise nature-friendly land use. And on the other hand, positive incentives – such as e. g. subsidy programmes or the integration of nature conservation into fiscal transfer between municipalities – should serve as stimulator to encourage eco-friendly usage, nature conservation measures, and the more widespread delivery of ecosystem services.

At local authority level, the opportunities for economic incentives in the form of pricing tend to be very limited (Droste et al., 2017), primarily because local authorities do not usually have the (legislative) sovereignty to introduce these types of instruments (such as taxes). However, they do have discretionary scope when it comes to calculating fees and charges. Fees and charges are a type of pricing, although fee levels must be based on so-called »accountable costs« (Gawel, 2016). These costs are acquisition and maintenance costs for infrastructure, as well as certain calculatory costs applicable to investment projects, for example in water supply and wastewater disposal. There is a certain amount of scope here, because when determining identifiable costs, environmental and resource costs may also be taken into account (ibid.). This is particularly true of public charges such as wastewater and waste charges. Cemetery charges are another example of existing scopes (see Naturkapital Deutschland – TEEB DE, 2016, chapter 9.5).

FIGURE 19 ▸ Rehabilitated Emscher basin in Dortmund. (Photograph: Michael Schwarze-Rodrian)

Tradable development rights (TDR) to reduce land take

Quantity-based instruments offer another variant of economic incentives. Thereby the total volume of certain activities harmful to natural capital is limited and distributed among potential users in the form of tradable rights, so that market prices are formed according to the rules of supply and demand on the market of tradable rights. Currently, this approach is highly regarded in Germany, to implement the aim of reducing urban sprawl and the relentless growth of land developed for human settlements and transport infrastructure (Bizer et al., 2011; Köck et al., 2007; Schröter-Schlaack, 2013; UBA, 2016). Being a prominent target of the German Federal Government's sustainability strategy, this »land take« shall be reduced to not more than 30 hectares per day by the year 2030.

A system of tradable development rights (TDR) works on the principle that land can only be zoned for urban development by a municipality with the relevant permits. These permits are issued free of charge to the local authorities and could then be traded among them. Local authorities demanding additional building land could buy development rights from others municipalities who do not need them. A long-term experiment with close to 100 cities and municipalities in Germany is currently testing design options for the system and exploring potential costs and acceptance among municipal decision-makers (Melzer and Blecken, 2013; UBA, 2016).

Such an instrument is particularly relevant for cities, because it would help to reduce the development of land at the urban fringe and in rural areas while lending impetus to the (re)use of already developed areas. Selling excess planning permits would also mean that choosing not to develop land and protect open spaces would no longer be only a cost factor. The additional budget from selling permits could be used to re-develop existing built-up areas to make them more attractive to potential residents and businesses.

Ecological fiscal transfers between municipalities

Fiscal transfers take place between the German Federal States and local level and general lump-sum transfers constitute the majority of such transfers. They may be used in any way the recipient wishes, thereby acknowledging the high degree of autonomy given to the local level of government by the German Constitution. Their allocation is based on the fiscal need of a local jurisdiction in relation to its fiscal capacity (its own revenues based on local taxes).

Fiscal needs are primarily calculated according to the number of inhabitants in a municipality. Many German Federal States give special weighting to the number of residents in order to make allowance for the greater financial demands on larger cities which, for example,

provide public tasks on behalf of the surrounding area (so called spill-over effects). Examples of other -> INDICATORS for determining the financial demand include »status as a health resort« and the »number of school pupils«, or the »number of residents that receive social security benefits«. Fiscal needs associated with nature conservation or the provision of ecosystem services, however, are currently not factored into allocating fiscal transfers to municipalities in Germany.

Reform proposals that have been drawn up but not yet found their way into mainstream political debates argue that additional ecological indicators reflecting the supply of public environmental goods and services should be taken into account when calculating the fiscal needs. This would be an important step towards creating incentives for municipal decision-makers to conserve biodiversity and to promote certain ecosystem services, such as infiltration in conjunction with flood prevention.

5 CONCLUDING REMARKS: GREEN INFRASTRUCTURE IS A BASIC PUBLIC SERVICE

The arguments in this report clearly demonstrate that the quality of life in cities is highly dependent on the preservation of urban ecosystem services. -> URBAN NATURE contributes to health and well-being, it helps to reduce stress and encourages exercise; it cools our environment, reduces particulate matter in the air, and ameliorates the consequences of heavy precipitation. At the same time, urban green provides space for exchange and encounters. For many economically and socially disadvantaged citizens, it creates alternative opportunities for participating in society. Urban nature also plays a provisioning role. Its economic importance is reflected in real estate values, among other things. As the number of people living in cities continues to grow, urban nature increasingly is the primary source of access to nature, especially for children and adolescents. Whether and how people are able to experience urban nature will shape their attitude towards nature in general. Urban nature, in its multiple cultural variations, therefore constitutes a vital public service and important source of environmental education.

Protecting and expanding urban open spaces as -> GREEN INFRASTRUCTURE is a key societal task. And yet all too often, our green infrastructure is neglected in decision-making. Land use is still ongoing. We in Germany are still a long way from reaching the targets we have set ourselves; building is still given priority over preserving green spaces. In climate policy, although we talk about the need to minimise greenhouse gases, we still neglect the role of urban green spaces, urban soils and waterbodies for climate change adaptation. And we still make inadequate use of urban nature's potential to integrate refugees and population groups on the fringes of society, despite the excellent model examples available (such as intercultural gardens). Of course, conserving and promoting urban nature cannot solve all these problems at once; but it could make some significant contributions which are all too often overlooked and consequently disregarded. The total of combined effects often is the deciding factor, rather than an individual effect occurring in isolation.

Therefore it is imperative to make the invisible visible, to show starting points to help us reset our misguided economic compass, and above all, to consider our decisions in a different light. An -> ECONOMIC PERSPECTIVE, which considers the macroeconomic benefits of urban nature and its services and does not focus purely on costs while ignoring the benefits, is therefore the key in preparing for a sustainable, future-proof »good life« in the city. We are talking about the very foundations of urban life, a vital public service. A development focusing on this core concern is still in its infancy. We hope that the -> TEEB APPROACH will help to boost and accelerate this process, especially given that many urban development processes will otherwise be very difficult to reverse.

GLOSSARY

BASIC SERVICES

Basic services (also known as supporting services) are a category of -> ecosystem services. They are the pre-requisite for the supply of all other ecosystem services, and comprise processes such as photosynthesis, nutrient cycles and soil formation.

BENEFITS (OF ECOSYSTEM SERVICES)

Arise from the direct or indirect use of -> ecosystem services by humans and / or have positive significance.

BIODIVERSITY

-> Biological diversity

BIOLOGICAL DIVERSITY

The diversity of life on earth (also known as biodiversity) means the variability among living organisms and the ecological complexes of which they are part. It comprises the following levels: 1) the diversity of ecosystems or biotic communities, habitats and landscapes, 2) the diversity of species, and 3) genetic diversity within the different species.

CAPTURING VALUES

Measures designed to ensure that decisions about the nature, scope and intensity of use of natural resources make allowance for the benefits of conserving -> biodiversity and delivering a socially balanced range of ecosystem services. This includes supplying the relevant information for deliberations by public and private decision-makers, such as a (financial) assessment of alternative uses, the definition and application of management conditions, or incentive mechanisms to control the behaviour of private decision-makers.

CULTURAL SERVICES

Cultural ecosystem services are a category of -> ecosystem services of benefit and significance for recreation, aesthetics, spiritual enrichment, ethical requirements, cultural identity, a sense of place, knowledge and cognition.

DISCOUNT RATE

An interest rate used to express the present value of future benefits and costs. For private financial investments, the discount rate is based on market interest rates. Public projects often use the so-called social discount rate (SDR) to calculate the estimated value to society of future uses. Future benefits and costs are usually only discounted if society's wealth will be greater, or at least remain the same, in future.

DISSERVICE

Ecosystem functions may adversely affect the well-being of individuals, groups or society as a whole. These negative impacts are known as disservices and include damage to buildings caused by plant growth, health impairments from fauna and flora (such as allergies, transmission of diseases), or traffic dangers when trees impair visibility.

ECONOMIC PERSPECTIVE

The economic perspective considers nature and -> ecosystem services from a scarcity viewpoint. Handling scarce natural resources means considering the related costs and benefits. For the purposes of this report, the economic perspective comprises the following: 1) Being mindful of the scarcity of the diverse services nature provides for humans, and their associated individual and social value, 2) Highlighting the values of nature and ecosystem services to support decisions using various -> economic valuation techniques and 3) Investigating the framework for action by the relevant stakeholders, and tools and measures for handling -> natural capital more efficiently (-> capturing values).

ECONOMIC VALUATION

Estimating the -> value of a commodity or service in a specific context, often expressed in monetary terms. Economic valuations are based on the -> preferences of those affected (anthropocentric approach). Environmental economics has developed a range of techniques to ascertain changes in environmental quality, both directly (such as -> willingness to pay) and indirectly (for example, such as the prevention or travel costs spent). Economic valuations are often summarised into cost / benefit analyses.

ECOSYSTEM

The components of a distinct physiographic region (e. g. Lower Saxony Wadden Sea) or a specific type of physiographic region (e. g. nutrient-poor watercourses) and their interaction. The term can apply to various spatial levels (local, regional) and covers (near-)natural ecosystems (e. g. natural forest on the edge of the city), near-natural ecosystems (e. g. ancient meadows in parks) and anthropogenically shaped ecosystems (such as roads and railways).

ECOSYSTEM SERVICES

The direct and indirect contributions of -> ecosystems to -> human well-being, i. e. services and goods which directly or indirectly provide economic, material, health or psychological benefits. Distinct from the term »ecosystem function«, »ecosystem services« are an anthropocentric concept, focusing on the benefits that ecosystems provide for humans. Also known as »ecosystem goods and services«.

ENVIRONMENTAL JUSTICE

The term »environmental justice« addresses the often uneven (unfair) distribution of environmental pressures (such as noise or air pollutants) between segments of society. A lack of environmental justice can also cause health inequality. Research therefore addresses the differing distribution of environmental pressures, together with its causes, as well as the social and health implications.

FISCAL ACCOUNTING

Traditional book-keeping method used by public administrations, now being replaced by -> green double-entry bookkeeping. An accounts system that follows the budget structure records the budget estimates and any changes over the course of the budget year. Target / actual comparisons are undertaken during the course of budget monitoring, and the year-end statements are prepared. The main aim here is to calculate the surplus and shortfall.

GREEN DOUBLE-ENTRY BOOK-KEEPING

Accounting system for public budgets based around the consumption of resources which follows the commercial accounting style of double-entry bookkeeping. It facilitates the calculation of period profits from the balance sheet and profit and loss accounts. It also refers to the technical process of entering a business transaction in the account and contra-account. An ongoing process among most of the almost 13,000 regional and local authorities in Germany will reform the traditional revenue and expenditure-based fiscal budget and accounting system (-> fiscal accounting). Green double-entry bookkeeping incorporates an assessment of public green spaces into the municipality's balance sheet assets.

GREEN INFRASTRUCTURE

At EU level, defined as a strategically planned network of valuable natural and near-natural areas and other environmental elements which ensure vital -> ecosystem services and help to protect -> biodiversity. In cities, it comprises multiple types of adequate green spaces, unsealed -> open spaces and areas of water, irrespective of their use and origination or ownership situation. It significantly contributes to the quality of life and the services of general interest, and therefore is an important complement of -> grey infrastructure.

GREY INFRASTRUCTURE

Built, technical infrastructure in cities (such as roads, railways, canal systems), e. g. for provisioning and disposal, or for mobility. Generally interwoven with -> green infrastructure to a greater or lesser extent.

HUMAN SETTLEMENT & TRANSPORT INFRASTRUCTURE LAND

Land used for human settlements and the transport infrastructure comprises buildings and related -> open spaces, operating areas (excluding mines), recreational, transport and cemetery land. It cannot be equated with sealed land, because it also includes undeveloped and unsealed green and open spaces.

HUMAN WELL-BEING

This term was coined by the »Millennium Ecosystem Assessment«. It defines what constitutes »quality of life«, including basic material goods, health and physical well-being, good social relationships, security, peace of mind and spirituality, as well as freedom and choice.

INDICATOR

Measured variable. Its status or change allows conclusions to be drawn regarding the status of or changes in another variable that is impossible or too complex to measure (e. g. population changes in selected species as a measurement of changes in biodiversity in a given region).

INDOOR CHILDHOOD

Childhood researchers have observed this development primarily in cities: Children tend to spend their childhood primarily inside the home and in closed rooms.

LAND POOL

Based on § 16 of the Federal Nature Conservation Act (BNatSchG), site pools and eco-accounts refer to the stocking of land for / with compensation and substitution measures. This refers to nature conservation and landscape management measures as defined in § 15 (2) of the BNatSchG, which are carried out at no legal obligation, for which no public funding has been claimed, and for which records of the original land condition are available.

MONETISATION

Converting values (benefits, costs, willingness to pay) into monetary amounts in an attempt to gauge the extent of certain services or damages. This type of monetary -> valuation often uses a range of techniques to calculate the aggregated willingness to pay of affected individuals.

MULTI-CRITERIA ANALYSIS (MCA)

A decision-making procedure, in Germany used mainly for infrastructure projects, but increasingly in the environmental field as well. With multi-dimensional and high-complexity problems, a multi-criteria analysis (MCA) can aid systematic preparation of decision-making with a range of alternatives. These alternatives are structured, evaluated and arranged with reference to a multi-dimensional system of objectives. The MCA may be integrated into decision-making processes, used to prepare for external decision-making, or applied as a cross-target valuation method. Compare this with mono-criteria procedures such as the cost / benefit analysis, in which the pros and cons are evaluated according to a single criterion (in the case of the cost / benefit analysis, monetary units).

NATURAL BALANCE

Comprises the abiotic (soil, water, air / climate) and biotic (organisms, habitats and communities) components of nature, and the interactions between them.

NATURAL CAPITAL

An economic metaphor for the (finite) natural resources, analogous to physical capital and human capital. It refers to the valuable but limited stocks of physical and biological resources on Earth and the limited ability of ecosystems to provide goods and services. Natural capital pays »dividends« in the form of -> ecosystem services. In the long term, ecosystem services will only be able to flow if natural capital is used sustainably, i. e. if the stock is retained or at least does not drop below critical levels.

NATURE DISCOVERY AREA

Nature discovery areas are spaces dedicated to nature, largely devoid of infrastructure, which are designed to encourage children and adolescents in particular to enjoy a self-determined nature experience (§ 40 of the Federal Nature Conservation Act).

OPEN SPACE

Open spaces are undeveloped plots of land in the urban context. Here it is understood as unsealed land which, depending on its structure and natural environment, delivers -> ecosystem services in varying quantities and qualities. Open spaces help to break up and structure the built environment, and serve as fresh air corridors, gardens, parks, green spaces, playgrounds etc.

OPPORTUNITY COSTS

(also: Alternative costs). Foregone benefits of not selecting an alternative, in this case, an alternative use of land and -> ecosystems. Example: Potential income from agriculture that is foregone due to the renaturation of a floodplain.

PREFERENCE

Giving preference to an alternative, or an individual's predilection for something. A preference expresses a subjective valuation of different options considering their expected supply of needs.

PROVISIONING SERVICES

Provisioning services are a category of -> ecosystem services, referring to their contribution to the production of goods and services for humans (such as food, fresh water, firewood and building materials) that are often traded on the market.

QUALITATIVE INNER DEVELOPMENT

The concept of qualitative inner development (German: »doppelte Innenentwicklung«) was first mooted at the International Buildings Exhibition (IBA) Emscher Park (1989–1999). It focuses on the simultaneous structural and ecological development of cities with an emphasis on enhancing quality of life. Qualitative inner development aims to preserve -> open spaces, ensure adequate use of land recycling, make use of vacant lots and cautious densification, and avoid further use of new land on the city outskirts for residential, commercial and transport structures. A good quality of urban life is achieved with good architecture and buildings that are in scale with their surroundings, and which offer attractive open spaces for a variety of uses in the immediate vicinity to encourage well-being. This includes access to open spaces on foot or by bicycle, differently sized open spaces, ideally linked to one another, with a diverse and varied design, and access to the surrounding areas via these open spaces. Open spaces are designed to offer a high level of functionality to accommodate the wishes and needs of humans (recreation, health, games, sports, experiencing nature) while at the same time delivering -> ecosystem services and promoting -> biological diversity.

REGULATING SERVICES

Regulating services are a category of -> ecosystem services and refer to the functions of -> ecosystems which regulate (other) ecosystem elements and processes and (directly) benefit humans, such as the filtering effect of soil strata on groundwater quality, or a hedge's contribution to minimising soil erosion.

RENATURATION

Measures to restore anthropogenically modified habitats to a more near-natural state.

REVITALISATION

Regarding waterbodies, »revitalisation« comprises all technical, structural and administrative measures of water remediation. Unlike total -> renaturation, this primarily concerns restoring vital processes and functions (such as restoring the continuity of individual sections of waterbodies by removing transverse structures).

SYNERGY (SYNERGIES)

Interaction between mutually beneficial forces. This may produce a shared benefit for various goals, as when multiple societal objectives are attained simultaneously through balanced land use and the associated ecosystem services bundle. Synergies may also arise from promoting various -> ecosystem services, i. e. the delivery of one ecosystem service (e. g. landscape elements such as hedges providing protection against erosion) in turn encourages other ecosystem services (such as pollinating services, groundwater purification, landscape aesthetics). The opposite of a synergy is a -> trade-off, when conflicting objectives or the delivery of different ecosystem services are mutually opposed.

TEEB

The Economics of Ecosystems and Biodiversity. The international TEEB Study was initiated by Germany in 2007 during its presidency of the G8, together with the EU Commission, and carried out with the aid of numerous other institutions under the auspices of the United Nations Environment Programme (UNEP). The TEEB study aimed to assess the economic value of nature's services, determine the economic impacts of ecosystem degradation, and thereby elucidate the costs of inaction, together with the opportunities for action in order to incorporate the diverse values of nature into decision-making processes. Further information can be found on www.teebweb.org.

TEEB APPROACH

The TEEB approach to -> capture the value of -> ecosystem services comprises the following steps: (1) Recognise the value, (2) Demonstrate the value, and (3) Incorporate the -> value of ecosystem services into decision-making. Step (1) is shaped by socialisation and the cultural characteristics of a society. Step (2) is a conscious process that uses suitable approaches and methods to elucidate value. Step (3) aims to create tools and measures to ensure that aspects of urban nature and associated services are incorporated into private and public decisions, i. e. valorised.

TRADE-OFF(S)

Reciprocal relationships, e. g. relating to the supply of different -> ecosystem services, which are mutually opposed: If one improves, the other deteriorates. There are often trade-offs between the desire to maximise provisioning services (such as the production of food, wood or energy) and other ecosystem services (e. g. regulating services such as water pollution control, or cultural services, such as landscape aesthetics) or the conservation of biological diversity. Trade-offs between different target dimensions must always be re-evaluated in each specific case. The opposite of a trade-off is -> synergy, which is mutually beneficial.

URBAN HEAT ISLAND

Due to high levels of sealing and other factors, it is normally hotter in the city than in the surrounding area. This effect is known as an »urban heat island«. Over the year, the average air temperature in the city is around 2 °C higher than in surrounding areas. In individual cases, especially during summer nights, the temperature difference between the city and its environs can be as much as 10 °C.

URBAN NATURE

All natural elements occurring in urban areas, including their functional relationships (-> ecosystems). It covers remnants of original natural and cultural landscapes, as well as designed gardens and natural elements that emerge from deep site changes, such as urban-industrial -> wastelands. The collectivity of vegetation elements in an urban context is often referred to as »urban green«, whilst »urban nature« tends to be used for near-natural elements.

URBANISATION

In a general sense, this refers to the spreading of urban living, production and behaviour, often linked to the expansion of land used for -> human settlements and the transport infrastructure.

VALUATION

Procedure for determining the -> value of goods or action alternatives, derived from the purpose or occasion of the evaluation. The -> TEEB approach concerns the valuation of nature's services for humans (-> ecosystem services). Valuations are always context-dependent, and every valuation depends on complex framework conditions: ecological, social and cultural circumstances, the -> preferences of individuals, the opinions of society, wealth levels, the economic situation etc. Depending on the context and objectives, various different qualitative and quantitative techniques may be used to value ecosystem services, including valuation in monetary units (-> monetisation).

VALUE

Expresses the importance of a material or immaterial object to an individual or a community. There are several interpretations. One is to equate »value« with price (as the equivalent of a tradable object), which may be expressed in money or other currencies. »Natural Capital Germany – TEEB DE« follows an alternative interpretation of the term in its broader sense, in the meaning of the validity, importance or significance of an object, person, circumstance etc.

WASTELAND

In an urban context, a plot of land whose original use (e. g. as part of the transport infrastructure or as an industrial site) has been discontinued and abandoned, i. e. it is no longer subject to any formal use. Depending on how long the land has been left as wasteland and the extent of informal use (e. g. by walkers), wasteland may be very differently structured. Major soil changes can lead to the emergence of new ecosystem types that may be colonised by urban-typical fauna and flora species, including many non-native species, and often rare and endangered species as well.

WILLINGNESS TO PAY

Monetary amount a person is willing to pay for the supply of goods, including public goods, which are not generally traded via markets and therefore do not have a market price (e. g. action programmes to protect endangered species).

WTP ANALYSIS

A survey-based economic technique for measuring -> willingness to pay. A »contingent valuation« seeks to determine willingness to pay under certain (»contingent«) conditions. Willingness to pay can be assessed by different methods, one of which is the WTP analysis. Unlike many other economic valuation methods, it can also include the -> values of -> ecosystem services that are not reliant on use.

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NOTE ON THE COMPREHENSIVE ACADEMIC REPORT

This »Summary for decision-makers« draws on findings from the comprehensive academic report »Naturkapital Deutschland – TEEB DE: Ökosystemleistungen in der Stadt – Gesundheit schützen und Lebensqualität erhöhen« (»Natural Capital Germany – TEEB DE: Ecosystem services in the City – Protecting Health and Enhancing Quality of Life«), which was published in 2016 and to which the following authors and experts contributed:

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Chapter 2: Urban ecosystem services and their valuation
2.1 Urban ecosystem services
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2.2 Approaches to assessing and valuing urban ecosystem services
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3.1 Urban nature promotes good urban climate
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3.3 Urban nature promotes clean air
Ina Säumel (coordination); Thomas Draheim, Wilfried Endlicher, Marcel Langner
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Thomas Claßen (coordination); Michael Jäcker-Cüppers, Natalie Riedel
3.5 Urban nature ensures functioning soils and waterbodies
Stefan Norra (coordination); Miriam Brenck, Wolfgang Burghardt, Stefan Emeis, Oliver Gebhardt, Christian Heller, Christian Klingenfuß, Boris Lehmann, Diana Möller, Michael Schwarze-Rodrian, Manfred Tschöpe, Gerd Wessolek, Tobias Wirsing

Chapter 4: Urban nature promotes health
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Chapter 5: Urban nature promotes social cohesion
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Chapter 6: Experiencing nature, discovering nature and environmental education in the city
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Chapter 7: Urban nature provides
Miriam Brenck (coordination); Frank Lohrberg, Katharina Raupach, Christian Timm, Uta Berghöfer, Nicole Heinz, Knut Sturm, Lutz Wittich

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Henry Wüstemann (coordination); Jens Kolbe, Christian von Malottki, Martin Vaché
8.2 Nature and business
Frauke Fischer, Heinrich Schneider (coordination); Kerstin Fröhle, Sonja Knapp, Reto Locher, Konrad Reidl, Dieter Rink, Michael Schwarze-Rodrian

Chapter 9: Routes to implementation – Incorporating ecosystem services into city development decisions
Stefan Heiland (coordination); Miriam Brenck, Erik Gawel, Tobias Herbst, Corinna Hölzer, Irene Ring, Stefanie Rößler, Christoph Schröter-Schlaack, Martin Sondermann, Wolfgang Wende, Peter Werner

Chapter 10: Summary and recommended actions
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