Addressing climate change in cities

Policy instruments to promote urban nature-based solutions

Ecologic Institute and Sendzimir Foundation
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GREEN STAR SYSTEM

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Introduction

Intense development in many cities is placing investment pressure on undeveloped land. At the same time, cities and their citizens are facing a number of social and environmental challenges, such as air pollution, the heat island effect, water scarcity, water excess, loss of nature and lack of social cohesion. Furthermore, the populations facing these challenges often lack opportunities to express their needs or be involved in developing and implementing sustainable solutions.

The deployment of nature-based solutions (NBS) is recognized as an effective approach which protects, sustainably manages or restores nature to address many of these challenges in parallel. NBS and related concepts – e.g. green and blue infrastructure, ecosystem-based adaptation and natural water retention measures (hereafter collectively referred to as NBS) – also help to protect biodiversity, build resilience and deliver ecosystem services. While NBS are also effective individually, cities can achieve an even greater impact by adopting holistic, city-wide approaches to urban planning that functionally and physically join NBS into a coherent network. By utilising multifunctional NBS, green areas across a city can support climate change mitigation and greenhouse gas emission reductions while also producing further social, economic and environmental benefits.

Although significant potential exists, NBS remain underutilized by cities as a climate mitigation and/or adaptation solution. Barriers that have prevented wider uptake in the European context include a lack of relevant experience with and knowledge of NBS planning and implementation as well as a shortage of locally adapted policy instruments to support mainstreaming across sectoral policies.

This guidance document responds to these gaps and highlights a range of policy and supporting instruments relevant for NBS design, implementation and maintenance. Policy instruments include regulations, strategies, programmes, action plans and financial incentives. Each instrument is briefly described, including how it works and what benefits it can deliver. Case studies showcasing how different cities approach NBS and foster their integration into their policy frameworks are presented for each instrument.

Wherever possible, the case studies stem from Berlin and Leipzig, Germany to showcase the diverse set of policy instruments being used in each city to implement NBS. Berlin and Leipzig's policy landscapes are introduced below in more detail to present a snapshot of possible policy instruments to foster NBS, highlighting the importance of working in an integrated and cross-sectoral manner.

This policy document was produced as part of the project "Climate NBS Poland", supported by the European Climate Initiative of the German Ministry of Environment, to support Polish city officials in the design and implementation of such policy instruments for increased NBS implementation. This policy guide is complemented by the publication *Addressing Climate Change in Cities – Catalogue of urban nature-based solutions* (therewith referred to as *Catalogue of urban NBS*), which aims to support planners, designers and landscape architects in various sized urban areas in Europe and beyond in applying NBS instead of or alongside traditional grey infrastructure approaches (Iwaszuk et al., 2019).

Policy landscape: Berlin, Germany

The city of Berlin faces multiple challenges, including rapid population growth, congestion and pressure to densify and convert open spaces to housing and other grey infrastructure developments. Further factors such as changing weather patterns also threaten the well-being of the population and quality of environment in the city. A number of policy instruments have been developed to address these pressures, often utilising green and blue infrastructure as a tool to achieve the various sectoral goals.

The *(Integrated) Urban Development Concept Berlin 2030 – Berlin Strategy* (Chapter 1) outlines the city's development vision until 2030. The strategy aims to address current and future challenges with innovative solutions and to shape the growing city to be more sustainable, livable, socially responsible and inclusive. It sets out different areas and (cross-)sectoral issues necessary to fulfil the long-term strategic goals including areas relevant to foster NBS. Additionally, the strategy lists a number of existing strategies and ongoing programmes and initiatives that will enable its implementation.

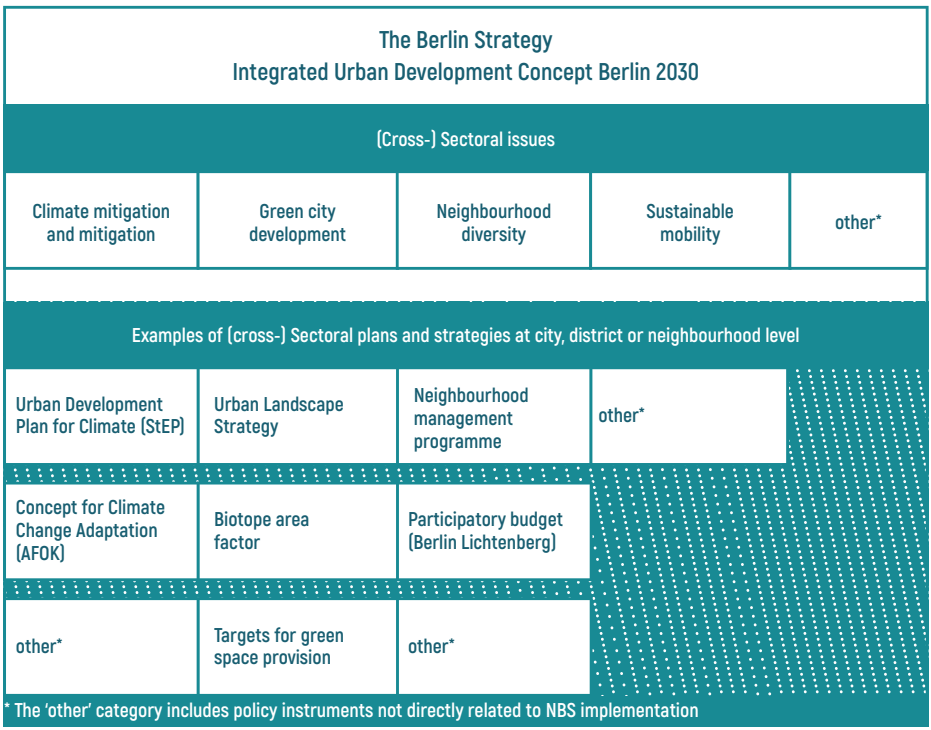
Berlin adopted a comprehensive governance approach to address climate change mitigation and adaptation, including *inter alia* a climate model as part of the Environmental Atlas (a digital map viewer to document the climate work since 1995 and inform urban planning) (Berlin, 2020a); a *Concept for Climate Change Adaptation (AFOK)* covering building and urban development, health, nature, energy etc. (AFOK, 2016); and an *Urban Development Plan for Climate* (StEP Klima, 2011) and sustainability criteria for ecological building (Berlin, 2009) to increase the standard of living of the city's population and to build a resilient infrastructure including climate mitigation and adaptation measures (Chapter 3.1).

The specific targets and objectives are determined by Berlin's energy transition law. These are legally binding as Berlin is one of Germany's 16 federal states and can therefore constitute its own laws in specific areas. This underlines the efforts to combat climate change and its impacts and stipulates

the regulatory framework for the targets set in the various strategies and concepts for urban development, climate adaptation and climate mitigation.

Another area of the *Berlin Strategy* is the development of green and blue areas, fostered through various instruments including the above-mentioned *Urban Development Plan for Climate* (StEP Klima, 2011) and the *Urban Landscape Strategy* (Chapter 2). The latter aims to support long-term sustainable urban development and improve the coverage and quality of urban green spaces. More specifically, it focuses on reaching the potential of designed green spaces, natural landscapes and spaces made and used by people for socially and environmentally conscious urban development. These targets are also supported by the *Biotope Area Factor (BAF)*, a voluntary planning instrument in Berlin (Chapter 4.1). The BAF aims to reduce environmental pollution in inner city areas and to ensure a minimum proportion of green areas in the inner city in order to provide recreational opportunities and maintain ecological functions. Moreover, Berlin set the target of providing at least 6 m^2 of green space per capita (Chapter 4.3).

The *Berlin Strategy* also focuses on reinforcing neighbourhood diversity. While city-level urban development plans shape neighbourhood development (e.g. for transport and housing), targeted programmes enabling citizens to shape their own neighborhoods can be even more effective. One example is the Berlin *neighbourhood management programme* (Chapter 4.4), which started as



an urban regeneration initiative to support disadvantaged neighbourhoods and strengthen social cohesion. Activities include small greening projects that directly engage the residents, which have had positive impacts on social conditions. The district level *participatory budget (Berlin Lichtenberg)* is another example (Chapter 5.3) of a tool which involves citizens in budgetary decisions to foster agreement in policy decisions. The urban areas that the citizens can make choices about by means of the participatory budget include public green areas and parks, roadside greenery, playgrounds and street trees.

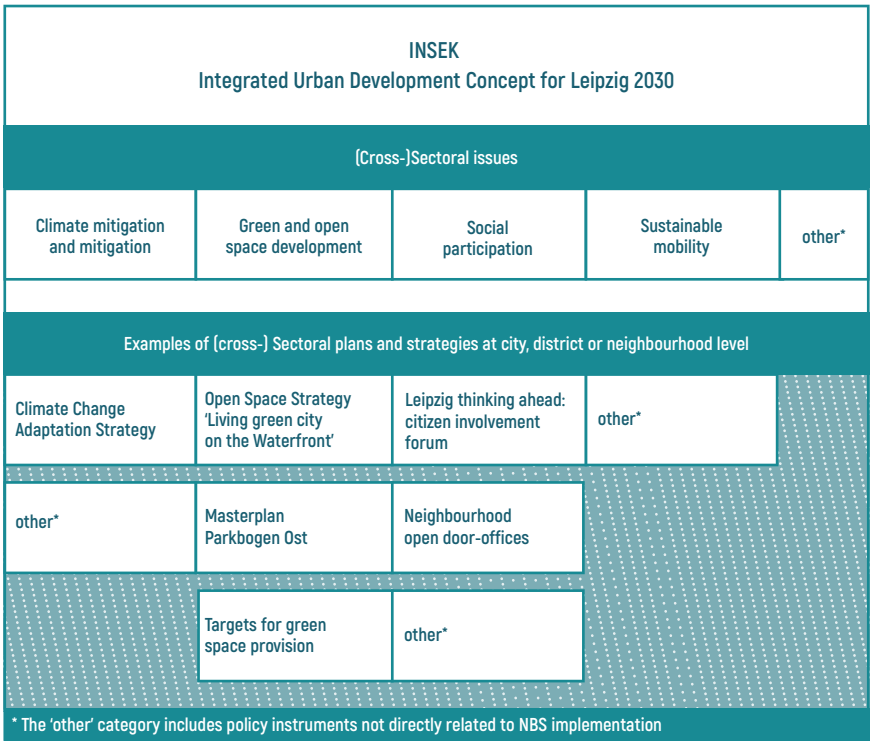
Policy landscape: Leipzig, Germany

Leipzig has undergone enormous social, economic and structural changes in the past 25 years. It has turned from a shrinking city facing a high property vacancy rate at the start of the 21st century into a rapidly growing city. A dominant ambition of the city is to achieve this growth sustainably. To this end, Leipzig developed an *Integrated Urban Development Concept for Leipzig 2030 (INSEK)*. The overall vision and goal of the INSEK is that Leipzig grows sustainably (Chapter 1). This concept builds on and integrates multiple sectoral and cross-cutting plans and strategies (e.g. open space and the environment, housing, culture, sustainable mobility, economy and work, brownfield revitalisation, healthcare).

One of the aforementioned strategies is the city's *Climate Change Adaptation Strategy* (Chapter 3.1), which aims to raise awareness about the impacts of climate change within the general public, senate administration, and private sector. The strategy outlines different fields of action, such as urban planning and buildings, mobility, green spaces and environmental protection, climate-adapted water management, health, civil protection and disaster control. The majority of these fields include NBS as measures for adapting to climate impacts, e.g. improving green spaces and increasing the number of trees to provide shade and cope with increasing temperatures.

NBS are also strongly promoted as part of green and open space development, not least to fulfill Leipzig's target of achieving at least 10 m^2 of green space per capita (Chapter 4.3). Leipzig's *Open Space Strategy* '*Living green city on the Waterfront*' (Chapter 2) recognizes the importance of diverse forms and functions of urban green spaces and water bodies and serves as a precursor to developing a *Green Leipzig 2030 Master Plan*. It highlights three thematic fields: categorising open spaces, securing access to open spaces and managing urban green and blue features.

Another example is the *Masterplan Parkbogen Ost* (Chapter 3.3), an urban regeneration strategy using NBS to revitalise Leipzig's Eastern district. In order to foster sustainable mobility and increase the district's green



connectivity to the rest of the city, a natural corridor with bicycle routes, pedestrian routes, and outdoor spaces will be created along a railway line which is no longer in use.

Leipzig also has a long history of active citizen involvement and has taken multiple measures to promote participation in policy development and implementation. Examples include the city's neighbourhood open-door offices, which serve as points of contact between residents and neighbourhood organisers (who are employed by the city). These offices provide the opportunity to collect any concerns of the citizens and present them in city-wide meetings, as well as to identify new initiatives and help develop strategic long-term neighbourhood plans.

Another initiative is "Leipzig thinking ahead", a citizen involvement forum that aims to integrate citizen ideas and priorities into government policy and agenda setting. The forum includes different formats to encourage the collaboration of citizens, stakeholders, experts, scientists and policy-makers such as events, surveys and feedback to online forums to discuss topics relevant to sustainable urban development.

1. Integrated urban development concepts

Integrated urban development approaches are an alternative to sector-oriented planning approaches. They address current and future local conditions, take into account top-down and bottom-up approaches, and deploy large participatory processes. An overarching urban development concept simultaneously tackles social, economic, cultural and spatial developments and dynamics with forward-looking planning and concepts. A unified vision of the city's future should be jointly developed by city authorities, citizens and other actors interested in shaping the city, such as entrepreneurs, cultural associations and social initiatives.

Benefits of an integrated urban development concept for NBS implementation:

- Mainstreaming multifunctional urban green areas and NBS across different sectors as key elements for sustainable urban development (e.g. climate adaptation, air quality management, biodiversity protection, housing, mobility, energy efficiency, sport, citizen involvement, education)
- Improving the livability, sustainability and attractiveness of the city as a whole, putting a strong emphasis on urban green areas and nature-based solutions
- Increasing awareness amongst different city departments about existing city goals and strategies (including those relating to NBS) and strengthening collaboration on these topics
- Advancing the involvement of citizens and other actors (e.g. civil society, business) in decision-making, planning, and implementation processes, including NBS planning
- Improving collaboration and integration between regional and urban planning objectives, helping to preserve and improve existing green areas and NBS
- Increasing the efficiency of budget spending on NBS by identifying synergies and addressing multiple objectives in parallel, and by combining public and private funding
- Establishing a framework and basis to cope with medium and long-term challenges via interdepartmental planning processes

In developing such an integrated concept, it is crucial to involve a wide range of governmental and non-governmental actors and adopt an inter-departmental approach. Such plans showcase potential benefits of integrated approach as well as synergy effects. At the same time, they require frameworks for monitoring and reviewing strategies' target achievements and implementation status. This allows the concepts to be adjusted and adapted for future challenges and developments. Two examples of such integrated concepts are outlined below.

Case Study 1.1.
Leipzig's Integrated Urban Development Concept to 2030

Motivation and objectives

Leipzig has undergone enormous social, economic and structural changes in the past 25 years. It has turned from a shrinking city facing high property vacancy rate in the early 2000s into a rapidly growing city which is determined to make this growth sustainable. *The Integrated Urban Development Concept for Leipzig 2030 (INSEK)* defines a multidisciplinary *Urban Development Strategy for Leipzig*. The *INSEK 2030*, finalised in 2018 (Leipzig, 2018b) continues the work by the administration on *the Urban Development Concept for Leipzig 2020* (Leipzig, 2009). The overall vision and goal of the *INSEK* is to ensure Leipzig's sustainable growth; priority fields of action entail that Leipzig: i) ensures quality of life; ii) creates social stability; iii) succeeds in competition and iv) strengthens internationality. Quality of life in the strategy is closely linked to benefits from environmental improvements.

The concept is structured in four parts: First, general information on the current status of the city is presented, including socio-demographic and economic issues (*foundations*). This is complemented by outcomes of stakeholder consultations. Second, *sectoral and cross-cutting concepts* are drawn up (e.g. open space and the environment, housing, culture, sustainable mobility, economy and work, brownfield revitalisation, healthcare). Third, *priority areas and district assessments* are outlined. While main development requirements are defined for all 63 districts, the *INSEK* emphasizes districts (priority areas) which are significant for the whole city and the surrounding region and where attention needs to be paid to either tackling important developmental tasks or reducing structural disadvantages.

These areas identified in *INSEK Leipzig 2030* are based on the priority areas designated in the sectoral plans and often have a specific focus, e.g. industry or green and open spaces. This urban development approach - using priority areas - corresponds to the high need for action in Leipzig as well as the limited financial and human

Figure 1. View from the Weisse Elster river in Leipzig.

resources available, which needs to be used efficiently. Finally, a *strategic vision* summarizes the principles, goals for the city as a whole and priority fields of action for Leipzig's urban development (Leipzig, 2018a).

Implementation and outreach

The *INSEK* is an important basis for the strategic orientation of municipal action, the integrated and multidisciplinary work of the local administration, the district concepts in priority areas, and applications for urban development funding. It addresses citizens' needs and more than 60 sectoral plans, containing overarching aims and priority fields of action for the whole city and for specific areas of Leipzig.

In the process of formulating the strategy, the administration conducted several stakeholder consultations over the course of three years. The consultation included expert interviews as well as an online consultation and multiple workshops and events for the wider population to take part in. The city stresses that stakeholders are also vital to the concept's implementation.

The priority fields of action in the concept have been compiled on the basis of sectoral planning, such as specific urban development plans and other sectoral plans. The spatial strategy of the *INSEK* consists of a) multidisciplinary priority areas (districts), which are significant for the city and where attention needs to be paid to e.g. reduce structural disadvantages; and b) the district strategy, which identified requirements for all 63 statistical districts from a city-wide perspective. For the implementation of the concept, the city is planning to build partnerships with regional actors.

The *INSEK* lays out a strategic approach on how to drive the financial capabilities of the city. These approaches are: raising the business tax, raising the share of income tax through economic growth, making use of synergies across all fields of activities to reduce costs, closely monitoring costs as well as bundling subsidies and municipal contributions. This implies a high level of collaboration between departments in the implementation process. Additionally, the *INSEK* also has a requirement to seek funding from the German government, the government of Saxony and the European Union (Leipzig, 2018a).

To strengthen implementation, the city of Leipzig has begun cooperating with two universities as providers of evidence-based scientific support (Leipzig, 2018b).

Results and achievements

As the *INSEK* has only been adopted in 2018, there are not yet any publicly available results. In the concept, a three year review cycle is mentioned, meaning that the first results will likely be available in 2021 (Leipzig, 2018b). However, a review (Leipzig, 2012) of the previous *Urban Development Concept for Leipzig 2020 (SEKo)* published in 2009 shows that the SEKo has been used as a strategic basis for different technical plans and identifying new relevant topics (such as climate change adaptation, sustainable mobility). The integrated and interdisciplinary working approach became increasingly important and was further developed, in particular by the working group "Integrated urban development", in which all relevant urban development offices are represented.

Case Study 1.2.
Urban Development Concept Berlin 2030

The Urban Development Concept Berlin 2030 (Berlin Strategy 2.0), which was adopted by the Berlin Senate in 2014, aims to address current and future challenges with innovative solutions and to shape the growing city into one that is sustainable, livable, socially responsible and inclusive. The *Berlin Strategy* was developed following a public participation process lasting over a year and serves as a guiding principle and a motivating force for those stakeholders and citizens wishing to involve themselves in shaping the city. The focal point of the city-wide public participation process was the City Forum 2030, a discussion platform using a range of creative analogue approaches accompanied by workshops for gathering views from representatives from the economic and research sectors and civil society (Berlin, 2015).

The Berlin Strategy sets out eight strategies, which encompass the city goals and approaches to the major sustainable development challenges that will face the city between the time of development and 2030. These strategies and respective activities include inter alia:

- *City and green growing together:* connecting and enhancing free space, safeguarding and improving ecological qualities, enhancing the gateways to the city, sustainable water supply management, improving health benefits through green spaces (encouraging physical activity, reducing heat impacts)
- *Laying the groundwork for a climate-friendly metropolis:* directing energy efficient housing stock renewal and new builds, adapting green and other open spaces to the requirements of climate change, launching and promoting neighbourhood-based climate protection and adaptation initiatives etc.
- *Improving accessibility and city-friendly mobility:* making public transport more attractive, increasing bicycle and pedestrian traffic, developing an integrated commercial transport plan

Additional topics include: strengthening the economy with smart knowledge, unleashing strengths

Figure 2. Green areas supporting sustainable mobility, Viktoria-Luise square in Berlin.

Figure 3. Berlin's urban development concept emphasises the importance of urban and green spaces growing side by side to preserve Berlin's quality as green and compact city.

through creativity, safeguarding employment through education and skills, reinforcing neighbourhood diversity and collaboratively shaping the city's future.

The strategy has no legal status. The concepts in the strategy have to be put forward to policy-makers and implemented independently in state law. There is no set review cycle for the *Urban Development Strategy*, yet with changing conditions the strategy can be revised (Berlin, 2015).

Responding to the city's growing population, the strategy was revised in 2016 (*Berlin Strategy 2.0*) to include new focus areas, namely: living, working and open urban society (Berlin, 2016a). The responsibility for coordinating and managing this process lies within Berlin's Urban Development Department. The strategy lists a number of ongoing programmes and initiatives which will enable the implementation of the eight aforementioned strategies. A further revision of the strategy is planned by the new state government during its legislative term.

2. Dedicated urban green planning instruments

A city-wide instrument for planning urban green (and blue) infrastructure can help achieve environmentally sustainable development, while also contributing to climate change adaptation and mitigation. Although often not legally binding, such instruments (e.g. green infrastructure strategy or plan; open space strategy; urban green area management plan; urban landscape strategy; vision for green in the city) provide an important framework for increasing the consideration of NBS in planning and decision-making processes. Key aspects often include: a shared vision for city greening, specific objectives or principles, and strategic priorities for action (WE GI, 2011) as well as specific NBS interventions, outreach and dissemination activities, data tracking and monitoring approaches (including indicators to measure progress), and policy, funding and planning aspects (e.g. assigning responsibilities and budgets for NBS maintenance). By providing a framework for mainstreaming NBS as a tool to reach multiple sectoral goals, dedicated strategies support the enhancement of environmental assets, promote connectivity across a city or region, and benefit local populations through co-benefits for climate change adaptation and mitigation.

Benefits of dedicated urban green planning instruments for NBS implementation::

- Setting a plan that can serve as a reference point for various city departments conducting activities which have the potential to impact urban green and supporting the mainstreaming of NBS across these public bodies
- Creating a common vision for city greening and plan of action to achieve impact, ensuring that individual activities and programmes across municipal departments contribute to this vision in a comprehensive and synergistic manner
- Increasing coherency between different decision-making bodies and processes to optimise the delivery of (co-)benefits from multifunctional urban green areas and NBS (e.g. health and well-being, climate change mitigation, decreased noise, air and water pollution, reduced risk of floods, droughts and heatwaves, sustainable economic growth)
- Raising the awareness of environmental challenges and the potential opportunities for NBS to address these

Given the cross-cutting nature of dedicated urban green planning instruments, their success requires coordinated efforts and collaboration across city departments and between public, private and third sector parties during

both the planning and implementation phases. Consequently, a strategy like this can facilitate new partnerships and empower community members to become more engaged, take on ownership of NBS delivery, management, and maintenance, and shape their local environment. Additional success factors can include: agreeing on intermediate goals and communicating them transparently; networking with surrounding areas and other cities; integrating NBS into overarching informal and formal development strategies (integrated urban development concepts/urban land use planning) (BBSR, 2018). The dedicated strategies of Leipzig and Berlin are outlined below as illustrative examples.

Case Study 2.1.
Leipzig's Open Space Strategy 'Living Green City on the Waterfront'

Motivation and objectives

Leipzig's open space strategy *Living Green City on the Waterfront* (Leipzig, 2017a) is one of several city plans and technical concepts recognizing the importance of diverse forms and functions of urban green spaces and water bodies. It also recognizes the need for a balanced and forward-looking approach towards urban development. The concept of 'double internal development' is a central element of the strategy, highlighting existing potentials like utilising and converting brownfields for developments. Double inner development aims to use land reserves in a structurally meaningful way, while maintaining the supply and usability of open space and developing, networking and qualitatively improving inner-city open spaces. This includes the consideration of wider urban green in decision-making.

Optimizing open and green spaces and water management has multiple benefits, extending beyond climate mitigation and adaptation. Reducing heat through trees and green spaces as well as high water quality improves the health and living standards of the population. Impacts from extreme weather events like flooding could be reduced, thereby reducing possible infrastructure damage and repair costs. Economic benefits can also be created through increased tourism, an influx of a working population, or cultivation.

Implementation

The strategy is funded in part by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety as a precursor to developing a *Green Leipzig 2030 Master Plan*. It follows a clearly stated methodological approach. The Introduction outlines how it fits within the landscape of other related concepts and plans, linking to 14 other policies. Guiding principles and objectives towards 2030 are highlighted in three thematic fields:

Figure 4. Bike path along the Karl Heine Canal in Leipzig.

- *Categorising open spaces*: defines the different open spaces in the city, i.e. all spaces which are characterised by vegetation (green) and/or water (blue), which are not built on and are for the most part unsealed; this theme explores which categories are being looked after by the city and which ones are needing further management for their preservation/development, and what objectives are there for these spaces
- *Securing access to open spaces:* focuses on securing, developing and networking open spaces and making them accessible; considers ecological, economic and socio-cultural aspects (e.g. recreation, human health, inclusion and other ecosystem services)
- *Managing urban green and blue features:* focuses on management issues, as well as special topics like compensation area management and inter-municipal cooperation with surrounding municipalities; this theme also includes medium-term objectives

Each area of activity is analysed and described with regards to its function or utilization, challenges or conflict potentials and outlook to 2030. Some sections also include further indicators, such as financing opportunities and public acceptance.

Leipzig already has a monitoring system in place for its green spaces, which is to be adjusted and improved to adapt to the strategy's indicators. The priorities of the monitoring system are to observe the function and utilization of the open and green spaces and contributions to water management. In addition, statutory monitoring duties for environmental monitoring have to be fulfilled. The city is also investing in a management system to monitor and manage quality aspects, costs and (geo-) data towards the 2030 objectives; this system is to be fully established by 2020. Measures to improve the cross-issue collaboration of actors involved aim to strengthen the implementation of the strategy.

Public participation has a longstanding tradition in Leipzig's development. Due to the diverse requirements of activities for developing open and green spaces and water systems, different participation processes are employed, ranging from workshops to future building exercises to public awareness campaigns. Looking towards 2030, the city is seeking new innovative formats for public participation.

Results and achievements

The Masterplan will be developed with available Ministry funding, building on the experiences and knowledge of *Leipzig's Open Space Strategy* as well as the *Integrated Urban Development Concept (INSEK)* and other previous work on urban development by the city. The aim is to develop a plan on how to build green-blue infrastructure in Leipzig by 2030, which takes the major challenges of climate change adaptation, health, environmental justice, biodiversity and clean mobility into account (Leipzig, 2020a). The stakeholder consultation process for the plan took place in 2018.

Case Study 2.2.
Berlin's Urban Landscape Strategy

The *Berlin Urban Landscape Strategy* (Berlin, 2012), which was adopted by the Berlin Senate in 2011, aims to contribute to sustainable urban development towards 2050 while protecting and increasing the area and quality of urban green spaces. It focuses on reaching the potential of designed green spaces, natural landscapes and spaces made and used by people for socially and environmentally conscious urban development. The strategy centers around three themes:

- *Beautiful city*: develops the city's horticultural inheritance by combining historic parks, urban squares, promenades and redesigned streets to become new open spaces which reduce ecologically burdened neighbourhoods and increase quality of life in densely populated areas

Figure 5. Creative approach to urban gardening on the grounds of the old airport Tempelhof in Berlin.

- *Urban nature*: uses and augments the potential of interweaving the built and natural spaces to enable citizens to experience nature in the middle of the city
- *Productive landscape*: combines agriculture, allotments and subsistence farming with the DIY culture of intermediate users, spatial pioneers, and start-ups to bring Berlin's creativity into the designing of public green spaces

In order to implement the strategy, a number of programs are envisioned along three timelines: 2017, 2030 and 2050. These programs target the restoration and profiling of green areas, development of mixed forests for effective climate mitigation, and planting of 10,000 street trees, amongst other goals. In the period from 2012 to 2015, 10 million EUR were invested in implementing the strategy to, for example, plant 5,000 new street trees and secure drinking water supply and a healthy climate.

The strategy was formulated as a product of several internal coordination rounds between departments and workshops with external experts. However, the Senate did not include a wider stakeholder engagement process to include civil society in strategy's development process. To implement the strategy, the Senate is planning to build alliances through a wide network of partnerships with both internal and external actors. To finance the implementation, the Senate plans to use EU funds foreseen for agriculture, as reforms of these funds will likely include smaller scale landscaping projects.

3. Integration of NBS into sectoral policy plans

Nature-based solutions are increasingly incorporated in plans and strategies addressing specific areas of urban development as "no-regret" solutions that can cost-effectively address diverse urban challenges in parallel. This section presents a number of examples from Germany to show how cities have successfully incorporated the use of NBS and green and blue infrastructure in their sectoral policy plans, based on specific cases of climate adaptation, integrated stormwater management and urban regeneration strategies.

3.1. Climate adaptation plans

NBS are increasingly being implemented as part of local adaptation plans given their "no-regret" nature and ability to deliver multiple economic, social and environmental co-benefits (Frantzeskaki et al., 2019). Nature-based climate adaptation measures in cities include activities aimed at e.g. renaturalising river systems (see Chapter 2.10 "Lebendige Luppe" in the *Catalogue of urban NBS*) and introducing NBS and the enhancement of ecosystem services to adapt to climate risks (e.g. promoting green walls and roofs to improve the thermal comfort of buildings and adapt to increasing heat waves).

In general, planning for large-scale NBS implementation through a city's climate adaptation plan can help cope with increased urban temperatures, flood events and water scarcity by reducing soil sealing, mitigating the heat island effect and enhancing water storage capacity in urban watersheds (Geneletti and Zardo, 2016). Introducing NBS in local climate adaptation strategies additionally helps cities meet their climate mitigation goals (through carbon sequestration and storage) and biodiversity targets.

Benefits of adaptation plans for NBS implementation:

- Creating a comprehensive climate change adaptation strategy can become a valuable approach to mainstreaming adaptation-oriented NBS across different departments and establishing a concerted local response to climate impacts, in light of the fact that climate change is a cross-cutting issue touching on many disciplines and sectors.

- Future climate projections are often associated with high uncertainty when it comes to the exact magnitude and distribution of climate impacts. NBS present "win-win" or "no-regret" adaptation options for municipalities as they offer multiple co-benefits and are cost-effective (EEA, 2019).
- Creating climate change adaptation strategies at the local level allows citizens to participate in creating targeted adaptation strategies that truly reflect local impacts and vulnerabilities and can provide tangible benefits to residents (Geneletti and Zardo, 2016). The process can be used to raise awareness about the benefits of NBS amongst local citizens and foster wider uptake and acceptance.

Adaptation measures using NBS require physical space, which can make them come in competition with other land use options in cities. Local climate adaptation strategies should be thus designed considering other local-level planning instruments. When introducing NBS as adaptation measures into local climate adaptation plans or strategies, it is important to consider and mitigate potential unintended consequences such as gentrification, methane production or providing habitat for mosquitoes and other disease vectors (Frantzeskaki et al., 2019). This also applies to those effects that will only become apparent in the future.

Climate-ADAPT, the European climate adaptation platform of the European Environment Agency and the European Commission, points out two success factors for local climate adaptation strategies: The first is broad collaboration and engagement. Both the cross-departmental collaboration between various departments of the local government as well as the variety of measures to actively include a variety of local stakeholders in the planning and implementation of adaptation actions are critical. The second is strong leadership and championship of adaptation, which is essential to earn a strong position for adaptation on the local agenda (EEA, 2019).

Case Study 3.1.
Berlin's Urban Development Plan for Climate Adaptation

Motivation and objectives

The city of Berlin recognizes the impacts of climate change as a significant threat to its infrastructure and its population's well-being. In response, the Senate has developed a framework for adaptation within its urban development plans (StEP Klima, 2011, followed by StEP KONKRET, 2016), underlined by a scientific, evidence-based adaptation concept (Reusswig et al., 2016), prepared externally by Potsdam Institute for Climate Impact Research (PIK) and the Institute for Ecological Economic Research (IÖW).

The objective of those plans is primarily to keep or increase the standard of living of the city's population in light of climate change. Secondly, the plan aims at building resilient infrastructure as well as effective climate mitigation and adaptation measures. Nature-based solutions are prominently featured across the four fields of action defined in the plan:

- *Bioclimate in populated areas*: building stocks need to be enhanced by albedo or green facades and roofs to tackle heat. A change in materials and building plans are also considered to provide shade and cooling effects. Additionally, courtyards, streets and green spaces need to be adjusted and improved, for instance through preserving and planting new trees.
- *Green and open spaces*: plant and water management are of highest importance for green and open spaces. The plan includes practices like near-natural mixed forests and close-to-nature forestry to build resilience against heat and flooding.
- *Water quality and intense rain*: improving the water management to reduce the risk of flooding and increase water quality can be achieved amongst others through renaturalising riverbanks and lake shores. The use of innovative solutions to purify rainwater are also a possibility.
- *Climate protection*: Besides the installation of renewable energy, the plan points to the carbon storage capability of mores, wetlands, forests and green spaces. Exploiting these opportunities can increase mitigation effects.

Implementation

To achieve the two main objectives of the plan, i.e. achieve a high *wellbeing of the population* and *resilient infrastructure*, the city defines seven targets: reduce the impact of heat on health, minimise impacts of extreme weather events, stabilise the water ecosystem, prevent overflow of the sewage, safeguard recreational areas, improve public transportation infrastructure and keep a functional utilities and waste management system. Each field of action has several specific targets, which are largely based on NBS and underlined by measures to secure their implementation.

In order to show progress on the objectives and targets stipulated in the *StEP* plan, a monitoring system has been put in place. Definitive achievement of the objectives and targets are difficult to measure as they are not quantified, enabling only a qualitative assessment. The results are to be disseminated in reports, which are intended to trigger an ongoing debate including with stakeholders outside the city, such as across city networks. The fields of action in the plan are prioritised according to the highest need for action and those with the highest potential. This might need to be reevaluated in the future to take into account changing external conditions, such as increased impacts of climate change.

The document presents an action plan with twelve flagship projects. Several of these projects use NBS to reach their targets. For instance, one project includes measures to rewet a specific area and thereby support the local water supply, provide a cooling effect and contribute to local biodiversity

Figure 6. Green roofs in Berlin reduce heat island effect and retain rainwater.

conservation. Another project focuses on courtyard gardens, aiming to achieve heat reduction by greening the courtyards, facades and roofs while also improving water infiltration. Yet another project focuses on improving neighbourhood green spaces to reduce heat, improve infiltration, and increase the population's well-being.

To ensure successful implementation of the adaptation strategy, the city recognised which existing instruments can be used or need to be adapted. This includes urban development instruments (subsidies, standards, zoning plans, environmental audits, urban development contracts, competition tendering) as well as landscaping programmes and planning instruments. Those instruments can be used across different fields of action.

The Berlin Senate has also recognised that the understanding and acceptance of the proposed adaptation measures needs to be strengthened in the population to ensure the strategy's successful implementation. The city thus plans to hold an ongoing stakeholder consultation process throughout the whole implementation period. Stakeholders include citizens, businesses, property owners and developers, associations like the association for architects, research and financing bodies. Additionally, the plan aims to learn from other experiences on a regional, national and international level. Using tools for data analysis and using the data in the public discourse are intended to further strengthen implementation.

The plan was updated in 2016 with the urban development plan (StEP Konkret, 2016) due to the rapid population growth and resulting need for action. The main areas of improvement are the interface with other topics and the optimisation of measures, focusing on adapting to heat and water-sensitive urban development. The aim is to strengthen green and blue infrastructure and emphasize the importance of combining both for urban development. The plan showcases best practice examples from local projects and other cities on, for example, the use of blue-green roofs, vaporization patches and shading.

Between 2014 and 2016, the Berlin senate commissioned a *Concept for Adapting to the Consequences of Climate Change in Berlin* (*AFOK* – Reusswig et al., 2016) to scientifically evaluate possibilities to strengthen adaptation efforts and show scenario analysis for 2050 and 2100. Its aim was to build an

evidence-based framework for a comprehensive adaptation strategy combined with the updated urban development plan *StEP KONKRET*. The concept defines the following fields of action: health and protection of the population; buildings and urban development and green spaces; water supply and water management; environment and nature; energy and waste; economy; transportation; tourism; education. According to *AFOK*, the economic benefits of adaptation and natural capital measures outweigh the implementation costs. The report proposes to use its findings to raise awareness of the importance and benefits of adaptation and natural capital to foster citizen support.

AFOK was written by the Potsdam Institute for Climate Impact Research (PIK) and the Institute for Ecological Economic Research (IÖW) on behalf of the Berlin Senate in close collaboration with the departments responsible for *StEP* and the Environment Atlas. To validate the research, stakeholder workshops and interviews were held with experts.

StEP, *StEP KONKRET* and *AFOK*'s implementation has been underlined by the Berlin energy transition law passed in 2016, which pieces together the different strands of climate action in the Senate (Senatsverwaltung, 2017). For adaptation, it states that measures shall be implemented and updated based on scientific evidence and a monitoring shall be put into place (EWG Bln, 2016).

As a monitoring system, *AFOK* proposes three monitoring indicators: the state of the measure, the impact of the measure and the response to the measure. The monitoring system is to be implemented in a flexible manner, as conditions in the city are expected to change over time.

Results and achievements

The three outlined documents provide a comprehensive and legally binding framework for climate adaptation in Berlin which is integrated with other municipal strategies, plans and instruments. To date, there are no publicly accessible monitoring reports or other information on the progress of the implementation of the climate adaptation plans.

Case Study 3.2.
Leipzig's climate change adaptation strategy

The city of Leipzig published its adaptation strategy in 2016. The strategy is intended to inform and support decision-makers in including adaptation aspects in their decision-making processes, especially in future infrastructure projects. The strategy also aims to raise broader awareness amongst the general public, the senate administration and the private sector. The strategy's fields of action are based on the evaluation of a large set of academic research on climate impacts in Germany as well as other cities' adaptation strategies. Based on available evidence, the strategy includes an in-depth overview of likely climate impacts in Leipzig (Leipzig, 2016).

Six fields of action are defined in the strategy: urban planning and buildings; mobility; green spaces and environmental protection; climate adapted water management; health; and civil protection and disaster control. Most of the fields of action include NBS as measures for adapting to climate impacts. To reduce heat in the city, the strategy proposes improving green spaces and increasing tree planting to provide shade. Green spaces are also to be designed to store water in the event of heavy rains and flooding and thereby reduce stress on the city's water absorption capacity. Using native plants is also mentioned for their value in helping to build resilience. The greening of roofs is presented as a measure which can insulate heat

Figure 7. Natural and renaturalised urban watercourses are an important element of Leipzig's strategy for adaptation to climate change.

and store rainwater. Renaturation of streams is further planned to prevent flooding.

In 2014, the Senate conducted a public survey to gather feedback on a list of issues, e.g. knowledge on heat impacts, knowledge on climate impacts, mobility preferences and opinion on climate change. Approximately 5,100 citizens between the ages of 18 to 85 were asked to participate. The evaluation of this survey informed the drafting of the adaptation strategy. One clear outcome of the survey is the need for awareness raising and knowledge sharing on climate-related issues. In response, the Senate has planned further events and publications to tackle this issue (Leipzig, 2016). The strategy, however, lacks concrete steps towards implementation of adaptation measures as well as a concept for monitoring progress and a financing strategy.

3.2. Integrated stormwater management

Integrated stormwater management strategies look beyond conventional stormwater drainage systems and instead adopt a comprehensive water resource protection strategy. To do so, a holistic analysis is undertaken of the entire system to better understand potential impacts in a given urban area; these insights are used as a basis for selecting multiple stormwater management solutions to apply in combination (iWater, 2016). NBS can be included within stormwater management strategies as preventative, structural or adaptive measures (see Table 1).

Table 1 Example applications of NBS as various measures of integrated stormwater management strategies.

Integrated stormwater management measures	Possible application of NBS. The solutions in bold are described in detail in the Catalogue of urban NBS
Preventative measures	Measures to reduce impervious surfaces (e.g. **permeable pavements** and **car parks**) or use of natural features for stormwater management (e.g. green ditches) to disconnect impervious surfaces
Structural measures	Solutions to reduce or delay stormwater flow and/or intercept or remove pollutants; includes various components of sustainable urban drainage systems, such as filter strips, **bioswales**, **green roofs**, **infiltration trenches**, **retention ponds**, bioretention, constructed wetlands
Adaptive measures	Resilient design options for new buildings and streambank protection measures, such as **natural riverbank restoration**

Table 1 reflects the main principles of integrated stormwater management strategies, namely: preventing undesirable situations, such as increases in runoff volume; deploying decentralised structural solutions to retain runoff at the source (cf. Chapter 4.2); and using large infrastructure assets such as e.g. retention basins (iWater, 2015). Curative measures applied to repair damages to ecosystems and infrastructure when other measures have failed or have not been used should be used as a last resort and in combination with preventative, structural and/or adaptive measures.

Benefits of integrated stormwater management strategies for NBS implementation:

- Focusing on addressing the root causes of increased strain on urban stormwater infrastructure (e.g. increased percentage of sealed surfaces, caused by increase of urban density), with NBS often presenting themselves as the most cost and space-effective solutions
- Connecting planning processes for the underground (sewer network) and above-ground systems (e.g. retention infrastructure), providing opportunities to take the topography of each site into account and identify synergies between the above-ground and underground systems as well as NBS and existing and new grey infrastructure in a comprehensive manner

- Bringing together departments responsible for e.g. urban stormwater management, roadside and transport infrastructure and urban green areas and others
- Directing part of urban stormwater management budget towards NBS implementation
- Strategies can be developed in a participatory manner, including the engagement of key stakeholders outside of the municipality, such as private companies. Additionally, the communication component of integrated stormwater management strategies can be used to raise awareness about the benefits of NBS among the general public and businesses (e.g. property developers)

Integrated stormwater management should be a cyclical process beginning with a situation analysis, measure selection and action design (planning phase) followed by the execution of the proposed actions, monitoring and evaluation. The evaluation results should then feed back into the subsequent planning phase.

Effective implementation requires an organisational setup which utilises existing structures in municipal administrations and ensures broad cooperation (e.g. by organising a cross-departmental coordination team) and can benefit from the involvement of and communication with key stakeholders, including those outside of the municipal government (iWater, 2015). A case study of designing and implementing integrated rainwater management in Hamburg is presented below.

Case Study 3.3.
Adaptation of rainwater infrastructure in Hamburg (RISA)

Motivation and objectives

In 2009, the environment and energy department of the city of Hamburg initiated, together with Hamburg water utility (Hamburg Wasser) a project for rainwater infrastructure adaptation (RISA-RegenInfraStrukturAnpassung). The project itself aimed to establish a strategy for sustainable rainwater management for Hamburg in light of the increasing risk of flooding, heavy rain and changing rain patterns. These were to be described in a stormwater management plan that introduces a concept for a decentralized water management system (RISA, 2020) to redirect water into a natural water cycle (HCU, 2011) and protect the city from flooding (HSE and UEB, 2015).

Implementation

The RISA project was divided into three phases: 1) evaluation of the status quo and definition of activity areas; 2) development of a framework and measures to adapt to future challenges; and 3) definition of targets and a long-term plan (UBA, 2016). The project was designed to achieve its aims through innovation and non-traditional approaches (BUE, 2016). Four working groups for future-proof rainwater management were established to ensure the interdisciplinary approach to project tasks, including: urban water management, urban and landscape planning, transport planning and water planning. Additionally, cross-cutting topics such as technology, financing, legal issues and communications were dealt with across all working groups.

Each of the working groups evaluated the status quo in their respective field in order to define the improvements necessary to ensure resilience under future climate scenarios (RISA, 2020). As one of the outcomes, suggestions were made on how to improve the building plan laws according to the needs of integrated stormwater management (e.g. changes in zone designation and land-use planning, environmental planning and sewage systems as well as water infiltration for building areas).

Figure 8. Beach by the Elbe River in Hamburg.

Additionally, RISA recommended introduction of training sessions for building authority employees and financial incentives for private owners and for community open spaces (UBA, 2016).

As a next step, each of the working groups defined pilot projects that were used to test the specific solutions proposed by the working groups as a basis for providing recommendations for wider future applications. Examples of the 23 realised pilot projects include e.g. design of a water infiltration system for a playground (See Chapter 2.3 Rain playground Biberland in Neugraben-Fischbek, Hamburg in the *Catalogue of urban NBS*), development and monitoring of green roofs at a specific site, development of shared use areas in case of flooding, or implementing elements of water-sensitive road construction. The implementation of RISA pilot projects required a strong interdisciplinary approach by all actors involved, from the areas of water management, landscape and urban planning, scientific analysis and engineering.

Moreover, the RISA project analysed and evaluated seven "reference projects", i.e. construction projects (both commercial and residential) implemented in Hamburg developed outside of RISA, but which introduced the principles of integrated rainwater management. An analysis of RISA reference projects was used to show how the different elements of integrated rainwater management can be applied in practice and showcase them as positive examples for other new developments in the city.

RISA has an internet presence for awareness raising and information sharing with citizens (BUE, 2016). The website links to the city of Hamburg engagement portal for urban development, where citizens can engage on the city's future plans (RISA, 2020). Additionally a logo has been developed for the project with the aim of generating recognition value. Flyers and brochures as well as further promotional materials were disseminated to inform about the initiative. In addition to events for expert audiences, the RISA project also organised public and media events, showcasing pilot projects (HSE and UEB, 2015).

Results and achievements

RISA was initially set as a three year project and was extended for another year (BBSR, 2015). The results from the working groups and the lessons learned from the pilot and reference projects were used in the compilation of the Hamburg integrated stormwater management strategy (*Strukturplan Regenwasser 2030*, HSE and UEB, 2015). The concept and its supporting documents are mainly meant for expert stakeholders in public administration, associations and research institutes. Main areas defined in the concept are water management, landscape and urban development. Additionally, the concept describes several fields of activity, which could become more relevant in the future under changing climate conditions as well as urbanization, population and mobility changes (HSE and UEB, 2015).

Areas for optimisation identified in the 2030 concept include: 1) information system and planning guidelines, 2) near-natural local water management, 3) water bodies management, 4) flooding protection, 5) planning and administrative procedures, 6) communications and 7) costs and financing. For each of these areas, the concept proposes several detailed solutions and recommendations and links to experiences from projects. The concept clearly states the need to further refine all areas if necessary due to external changes in the future. The document states that the aims of the RISA project need to be adjusted in the long term (HSE and UEB, 2015).

3.3. Urban regeneration

Urban regeneration aims to improve the physical, social and environmental conditions of an area which has been subject to negative change and is considered vulnerable (Raymond et. al. 2017). It refers to activities such as revitalising degraded areas in cities and bringing abandoned sites back to use. In the context of urban regeneration NBS can generate an array of social, environmental and economic benefits and can be cost-effective as compared to traditional grey infrastructure solutions when considering the delivery of these multiple benefits. For instance, bioremediation of toxic soils at an unused brownfield site and its conversion into multifunctional urban green space can provide opportunities for sustainable urban growth. Attempts to implement NBS for urban regeneration may provide openings for businesses to innovate in the revitalisation of derelict urban and fringe areas (EC, 2015).

Urban regeneration actions and strategies can include nature-based elements such as green mobility corridors that promote more sustainable mobility by opening new bike and pedestrian routes (see Case Study 3.4), publicly accessible pocket parks and green roofs as attractive green spaces for local residents; water retention basins, and green features in school yards and playgrounds (see Case Study 3.3 and Chapters 4.2 and 5), green corridors, urban "ecological zones" or nature-based river restoration projects (see Chapter 2.4 Regeneration of urban green belt in Bielefeld in the *Catalogue of urban NBS*), or new green areas to restore degraded sites or brownfields (see Chapter 2.1 Constructed urban wetlands in Duisburg-Nord in the *Catalogue of urban NBS*). In considering upgrades to urban transport infrastructure, NBS can be included to address stormwater runoff from pavements, roads and areas under the tracks, or upgrade urban furniture (see Chapter 1.6 Green bus stops in the *Catalogue of urban NBS*). In the context of urban regeneration, NBS are also recognised as useful instruments to achieve cities' goals relating to fostering social cohesion, integration and combating social exclusion. Strategies which focus on these benefits often include the promotion of urban agriculture projects to bring different social groups together, help integrate immigrants, create attractive public green areas in poorer neighbourhoods and contribute to the budgets of families that use urban gardens to farm produce for own consumption.

Benefits of urban regeneration strategies and actions for NBS implementation:

- Planned urban regeneration actions can serve as laboratories for innovation, experimentation and testing the environmental, social and economic benefits of NBS for various population groups, especially in cases of wider, integrated or complex application. This in turn can promote further implementation in the future and help to communicate the effectiveness of NBS and their role for sustainable urban regeneration.

- Urban regeneration may require operating simultaneously in the context of currently used, underused and unused land and existing grey infrastructure. NBS offer a solution to connect various uses and spaces and exploit available space more effectively, maximising benefits that stem from given intervention.
- In a situation of conflict between the commercial drivers of urban regeneration and economic and social objectives, NBS can be introduced as a solutions that combine and enhance various objectives in an effective manner.

NBS implemented in the context of urban regeneration should consider linkages between economic objectives, urban ecology, the aesthetic appeal of proposed solutions, and energy and water use at specific sites (Raymond et al., 2017). Potential trade-offs between urban regeneration and gentrification should also be considered in this context to ensure that the planned NBS and their benefits are inclusive and consider the needs of groups at risk of social exclusion.

Successful urban regeneration projects combine top-level governance commitment to action, and cross-departmental cooperation within a municipality with active community participation at the design, implementations and maintenance stages (see Case Study 3.4) (Bianconi et al., 2018). An example of a regeneration project in Leipzig is presented below.

Case Study 3.4.
Urban regeneration in Leipzig – Masterplan Parkbogen Ost

Motivation and objectives

Nature-based solutions are at the heart of *Masterplan Parkbogen Ost*, an urban regeneration strategy aiming to revitalise Leipzig's Eastern district. Amongst other aims, the strategy plans to create a green corridor with bicycle lanes, pedestrian routes and outdoor spaces along a disused railway line. While primarily aiming to regenerate the Eastern district by creating a number of attractive green recreation areas, the strategy will also foster sustainable mobility and increase the district's connectivity to the rest of the city (NATURVATION, 2017).

The masterplan contains twelve targets and six areas of activity. It is set up as a conceptual framework, which intends to be expanded and improved over time. It thus also offers ideas for further activities which could be implemented in the future without setting a tight timeframe and implementation plan for these ideas (Leipzig, 2017b).

Implementation

Many stakeholder groups and initiatives are active in the area, such as environmental groups, social initiatives, sports clubs and cultural initiatives. The masterplan seeks to involve these stakeholders and their knowledge in the regeneration process (Leipzig, 2017b). Leipzig has hosted two citizen workshops to discuss the draft masterplan. Part of the workshops were local inspections of the areas for the masterplan, where citizens could prioritise certain planned activities over others. Additionally, funding and cooperation opportunities were explored and discussed. The city has formulated an answer to the catalogue of 24 issues raised by citizens as part of the citizen dialogue. A large number of local actors, associations, citizens' initiatives and various authorities have been involved in the dissemination of the masterplan.

Cross-departmental cooperation within the administration was the second pillar of stakeholder

Figure 9. Community garden Annalinde in the centre of Leipzig.

Figure 10. Altindenau district in Eastern Leipzig.

engagement. These activities were organized based on the knowledge that including the experts from different departments is crucial for successful and sustainable implementation of the strategy (Leipzig, 2020b).

An implementation strategy forms part of the plan. Here, the city defined key activities and priorities for the implementation as well as further details on the strategic dimensions, stakeholder engagement, requirements for action under planning law, cost structures and a financing strategy. A key to implementation is the strategic prioritisation of areas of action at different points in time (Leipzig, 2017b).

The strategic framework looks at three implementation phases. The conceptual planning of the masterplan includes setting a governance approach for the stakeholder engagement, public awareness campaign and financing of the strategy. Secondly, the operational phase is to monitor the implementation. Finally, the strategy must include a forward-looking element, outlining how the Parkbogen Ost can be maintained at an affordable cost after project funding ends (Leipzig, 2017b).

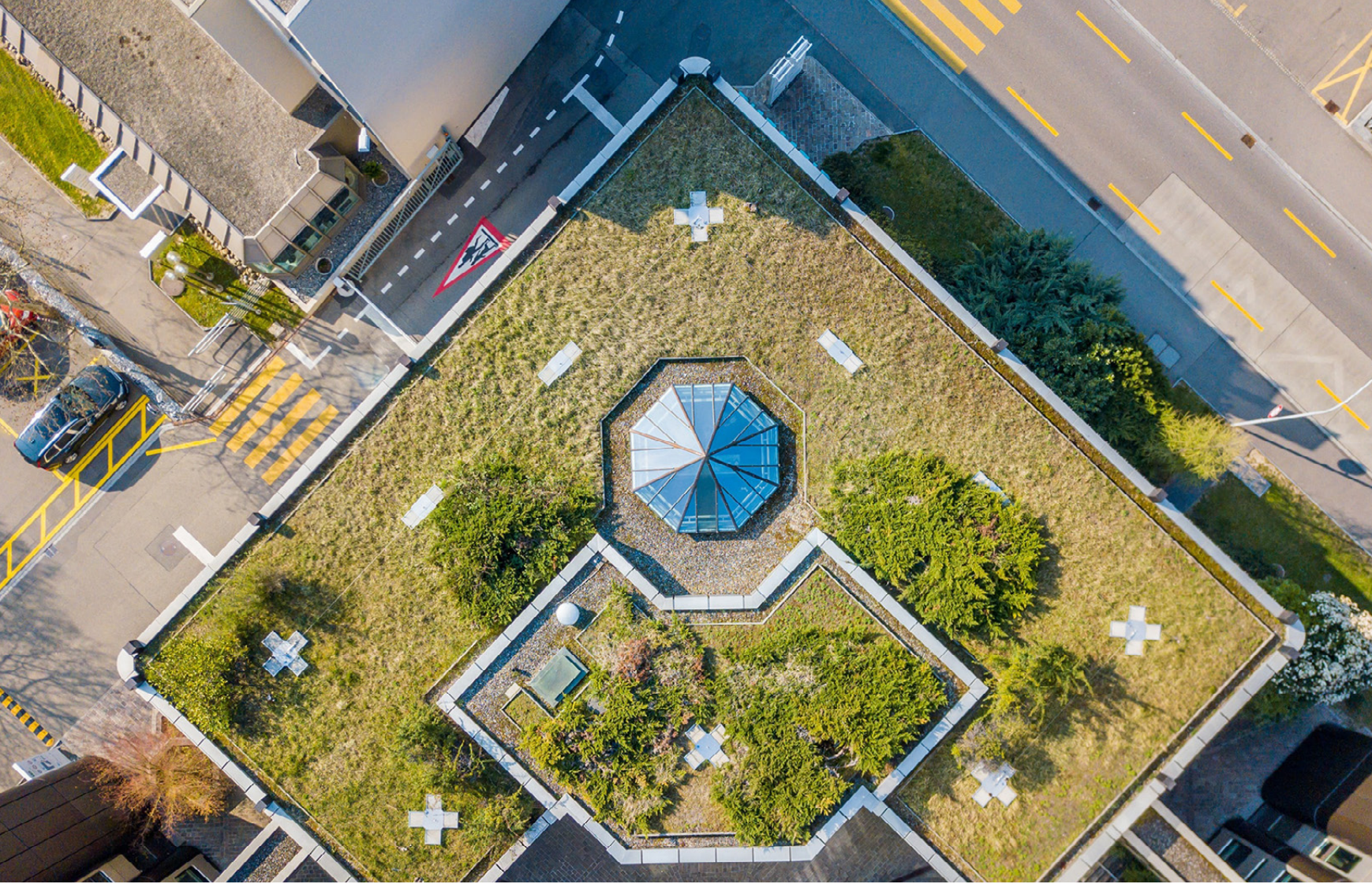
For the implementation, joint cooperation with all stakeholders is considered crucial. Therefore activities included different sets of stakeholders, building ownership and general support of the strategy. An example is the effort of tree planting by residents and other citizens (NATURVATION, 2017). In the future, the city plans to continuously include residents and citizens in the maintenance of the park, for example through tree sponsorships, fundraising activities and other joint initiatives and events (Leipzig, 2017b).

The masterplan's implementation is seen as a long-term project with a duration of around 20 years and a cost of circa 40 million EUR. Financing is expected to be made available through different channels, including the municipal budget, acquisition of third party funding and private funding. The financing strategy outlines which city funds and resources will be allocated to the implementation of the masterplan and which external sources, such as EU funds, will be used (Leipzig, 2017b). The external public funding stems from a national city support scheme - National Urban Development Projects, the European Regional Development Fund (Leipzig, 2020b) and public

funding for tourism infrastructure projects and improvement of the regional economic structure (Leipzig, 2017b).

Results and achievements

The strategy was approved by the Leipzig Senate in 2017 and implemented from 2018 - 2019 (Leipzig, 2020b). It is expected that the masterplan will have positive impacts on several sustainable development goals (SDGs), such as climate action (SGD 15), biodiversity (SGD 13), health (SGD 3) and equity (SGD 10). The city expects several further positive impacts on the general well-being of the city and its residents. These include private funding for further projects, improved cycling opportunities, improved recreational areas and social inclusion (NATURVATION 2017). Furthermore, the successful implementation of the masterplan could lead to Leipzig becoming a model for an ecologic and culturally-diverse city (Leipzig 2017).



4. Specific planning instruments

Land use and spatial planning instruments are the most powerful means by which a city can steer its urban development and ensure that city strategies and objectives are being implemented at a wider level. A diversity of planning instruments are available to safeguard urban areas and their surrounding green spaces, such as green point systems, standards and targets for green space availability, or neighbourhood plans.

4.1. Regulatory requirements for rainwater infiltration

Infiltration is the process by which surface water enters the soil. It also refers to the discharge of rainwater (rain, hail, snow) into the ground via technical infiltration systems. These infiltration systems are used to drain surface water from residential and traffic areas if there is no suitable sewage system or if it has exceeded its capacities for receiving water. The method is also used to counteract reductions in groundwater recharge caused by surface sealing and to mimic the natural water cycle more closely by ensuring that rainwater seeps into the ground close to its occurrence (UBA, 2005).

In Germany, property owners are obliged to implement rainwater retention/infiltration systems if new buildings are constructed and soil is consequently sealed (WHG, 2018, §55). More precisely, rainwater must be collected separately from domestic wastewater in order to either seep or trickle away or be discharged directly into a waterbody or via a sewage system without being mixed with domestic wastewater. Many municipalities introduce a separate wastewater charge to encourage property owners to reduce the amount of rainwater they discharge into the rainwater system (PfH, 2013). The Berlin Water Act (BWG, 2005) requires to infiltrate rainwater on site through the living soil layer. Since 2018 the new regulation Limitation of rainwater discharges in construction projects in Berlin (BReWa-BE, 2018) is in place. Both regulations offer the opportunity to install NBS for rainwater management.

Typical examples of NBS infiltration systems are surface and trough infiltration as well as more technical systems such as shaft infiltration or infiltration pipes (Dresden, 2004). The *Catalogue of urban NBS* includes more information on several NBS for rainwater infiltration, including bioswales, water retention ponds, infiltration trenches and permeable pavings.

Benefits of regulatory requirements for rainwater infiltration for NBS implementation:

- Providing a standardised methodology and guidance for constructing infiltration systems (including NBS), which is applicable to several municipalities
- Taking into account local conditions (e.g. slope, soil characteristics) to identify the most suitable measures
- Establishing a decentralized rainwater infiltration system: rainwater seeps away on site and is not drained offsite, thus preserving the natural local water balance
- Providing property developers with an overview of specific NBS for rainwater infiltration, encouraging the implementation of multifunctional NBS
- Relieving urban wastewater systems, which in turn reduce bottlenecks in the sewage network and the need for rainwater overflows
- Reducing fees for sewage water and the rain run-off
- Long-term prevention of flood events and improved quality of water bodies

Standards for rainwater infiltration should be integrated into environmental and planning regulations as legally binding requirements, where possible. For best results, they should be coupled with financial incentives (e.g. for retrofitting rainwater management measures on existing building structures), guidance documents and advisory services which enable property owners to select suitable measures for their property.

When implementing such requirements, one should bear in mind that rainwater infiltration is not always possible without upstream cleaning as precipitation can rinse pollutants from different areas (e.g. courtyard areas on residential properties that are regularly driven on by cars; courtyards and streets in commercial and industrial areas; main roads; motorways; roof surfaces coated with copper, zinc or lead; or parking spaces with frequent vehicle changes, such as in front of shopping centres or special areas such as truck parking areas). In such cases, rainwater must be pretreated or discharged into the sewage system to avoid the pollutants contained in the water from polluting the soil and groundwater (Celle, 2020). Examples of regulatory requirements for rainwater infiltration across Germany and in Dresden are provided below.

Case Study 4.1.
Regulatory requirements for rainwater infiltration in Germany

Motivation and objectives

Clean water shortages are not commonly seen as a threat in German public discourse. However, climate change is creating more regular water shortages in parts of the country, especially due to changing rain patterns. Some areas in the country are expected to have significantly less rainfall in the future, while other regions are expected to have to cope with an increase in rainfall and stormwater, resulting in floods and pollution (BBSR, 2015). To ensure the availability of high quality drinking water, legal requirements are vital (UBA, 2005). As a centralized infiltration system would not be able to cope with the increasingly high variations in rainwater patterns (Sartorius, 2007), rainwater management infrastructure is needed which utilises natural processes to guarantee local infiltration and enable water re-usage, while also supporting adaptation to heavy rainfall events and controlling the pollution linked to such events. Moreover, the use of rainwater is becoming increasingly important e.g. for irrigation of green areas or toilet flushing. The importance of recycling black and domestic grey water is increasingly considered.

Implementation

Legal requirements for rainwater infiltration can be found in water, soil protection and building regulations. Legal requirements differ between federal states as well as between municipalities. According to the regulations of the federal states, the municipalities are largely obliged to handle sewage disposal. The Federal Water Act (WHG), however, also opens up the possibility for third parties to assume responsibility for the infiltration of rainwater, i.e. the property owners or land users.

A targeted infiltration of rainwater into groundwater constitutes a "discharge of substances into groundwater", in accordance with the Federal Water Act (§ 3 Abs. 1 Nr. 5, WHG). In theory, this requires a permit under water law. A permit may only be issued if "harmful contamination of the

Figure 11. Trough infiltration system in the Rummelsburg district of Berlin. Rainwater is temporarily stored in a permanently green trough, which is then emptied by means of infiltration and evaporation.

groundwater cannot be expected" due to the infiltration (§ 34 Abs. 1, WHG). In practice, infiltration is allowed without a permit in most federal states because it is often assumed that infiltration takes place outside of water protection areas and the rainwater has not been contaminated. In some cases, the exemption is granted directly by law; in other cases, only an authorisation is needed to issue a statutory order.

Some federal states authorise the municipalities to establish in their statutes that rainwater infiltration does not require a permit. However, the regulations under federal state law differ in terms of whether they prescribe infiltration of rainwater or whether they allow it as a variant of waste water disposal. Irrespective of whether a permit is required or not, the protection standards of water law must be fulfilled for any rainwater infiltration cases. The standards are defined by the so-called 'de minimis thresholds', which define the threshold between insignificant input and harmful groundwater pollution.

Infiltration measures can consist of different NBS used in combination, such as a retention pond or a green roof with trough infiltration. In addition to rainwater infiltration measures, there are further rainwater management measures established in Germany that are complementary to infiltration, e.g.:

- unsealing soil and establishing permeable surfaces,
- cleaning contaminated rainwater, and
- retaining rainwater (including green roofs).

Results and achievements:

Not all regions in Germany have the same legal requirements for rainwater infiltration. In some regions, communities can apply for special exemptions; in other regions, communities are responsible for deciding on an infiltration system. Many rainwater infiltration systems in Germany also need to be renovated to adjust to future climatic challenges. Technological advancements are expected to support adaptation to changing weather patterns (UBA, 2005). Innovation and competition in technology for decentralized rainwater management already play a crucial role in Germany. Decentralized systems have the advantage of low upfront investment costs and shorter planning horizons than centralized systems and, as such, are easier to be applied by communities, with lower associated risks. Centralized systems are less capable of adapting to demographic and migration challenges in Germany, such as urbanization, thus decentralized systems can increase flexibility for local communities and regions (Sartorius, 2007).

There are several local initiatives to support rainwater infiltration, such as the RISA project in Hamburg (see Chapter 3.2) or local regulations introduced in Dresden (see Case Study 4.2). The city of Nuremberg, introduced a study for future-proof sustainable rainwater management (Nürnberg, 2016).

In 2015, the Federal Institute for Building, Urban Affairs and Spatial Research (BBSR) published a study on urban heat and water management in German cities, communities and urban regions. One aim was to create acceptance for strategies and instruments to cope with flood risks and increase awareness amongst policy makers, authorities, and the population at large about the need for climate change adaptation measures. Supported by examples from project experiences and expert workshops, recommendations for actions are given. Aspects of water management in the recommendations push for rainwater infiltration systems as an instrument to reduce pressure on the local infrastructure (BBSR, 2015). While it is possible to receive financial support on a local or regional level for rainwater infiltration, there is no national approach to date.

Case Study 4.2.
Requirements and guidance for rainwater infiltration in Dresden

The selection of rainwater systems depends on local conditions (slope, soil type, ground water level). The City of Dresden provides detailed guidance for its citizens to help them choose the right type of measures for their property (Dresden, 2004). For example, suggested measures for a loess-covered terrain are those that increase retention and support evaporation, such as ponds for rain retention and evaporation and cross-linked through-trench elements to reduce water runoff. On the other hand, measures suggested by the city for alluvial and clay-free areas are those that support groundwater recharge and increase evaporation, such as surface and trough infiltration and green roofs.

The guidance presents different measures for water infiltration, including a detailed description of each element, information on suitability, its characteristics (including construction costs) as well as practical guidelines. For trough infiltration, the guidance mentions advantages such as affordability, easy monitoring and suitability for a do-it-yourself construction. Water infiltration can be constructed on plots with sufficient green space or open spaces as accompanying strips of walking and cycling paths, but due to the danger of soil compaction, an intensive surface load is not allowed.

The guidance also includes details on how to calculate a trough infiltration. In order to be able to plan infiltration, the amount of rainwater must be known. Not all of the rain that falls on a surface has an effect on water runoff. With an appropriate design, larger quantities also evaporate. This is taken into account in the calculation of the accumulated rainfall quantities by the runoff coefficient ψ. It is a measure of the runoff behaviour of rainwater from the surface. This value increases the more rainwater flows off. The effective discharge area A_{dis} is determined with the following formula: $A_{dis}=A_{total} - \psi$. The guideline provides an overview of the discharge coefficients of various surfaces. In addition to the effective discharge area, the amount of rainwater produced is determined by the calculated rainfall. Rainfall events are classified according to their duration (T) and frequency (n). Decentralised plants are designed for a heavy rainfall that occurs on average once every 5 years and lasts 15 minutes. This rainfall intensity value is called $r_{(15;0,2)}$.

The size of the infiltration area (A_s) is determined for the calculation of the trough (approximately 1/20 of the connected drainage-relevant area A_{dis}). In order to be able to dimension the trough, the permeability of the subsoil must also be taken into account (factor k_f, permeability value can be taken from tables). The required storage volume of the trough is calculated according to the following formula: $V_s = [\ r_{(T;\ 0,2)} \cdot (A_{dis}+A_s) - A_s \cdot k_f/2\ ] \cdot T$ (Dresden, 2004).

4.2. Green space factors and points systems

Green space factors and points systems are policy instruments to attain desired levels of green and blue surfaces in new urban property developments. They work by scoring different green and blue 'elements' based on their importance for providing ecosystem services or specific functions and using this as the basis to calculate an area-weighted score for a proposed property development (ECNC, 2016). Such systems help to secure blue-green qualities in urban construction and renovation projects.

Benefits of green space factors and point systems for NBS implementation:

- Safeguarding the maintenance of existing and development of new urban green and blue areas at city-wide scale (e.g. by requiring compensation measures to establish green and blue areas if such areas are taken up or sealed by new development projects)
- Providing a ready-to-apply methodology for planners to weigh and value the qualities of green urban areas within new urban developments throughout the city
- Providing property developers with an overview of specific NBS which could be incorporated in planned construction projects, encouraging the implementation of NBS that provide multiple functions and ecosystem services
- Protecting and improving different ecosystem services and functions at city-wide scale (e.g. reducing the urban heat island effect, maintaining soil function and water balance, protecting biodiversity)
- Enhancing the quality of the residential environment through the provisioning of more green and blue infrastructure

Green space factors and point systems can be powerful instruments if they adequately assess, value and explicitly consider ecosystem services and functions. To do so, they need to build on existing ecosystem services assessment frameworks to determine preference weighing and valuation of green and blue structures. Such systems should also allow different types of ecosystems to be factored into calculations and be tested on site to improve their applicability and robustness. Green space factors and point systems are most effective when they become a mandatory part of binding landscape plans or regulations. By applying these to the entire city and its surrounding areas, cities can ensure that all new urban development projects will take greater account of green and blue infrastructure and be more sustainable. An illustrative example from Berlin is outlined below.

Case Study 4.3.
Biotope area factor in Berlin

Motivation and objectives

The Biotope Area Factor (BAF) requires a proportion of the area of new building developments to be left as green space. Established in 1994, the BAF defines ecological minimum standards that become effective in the event of structural changes and new construction projects. The aim is to reduce environmental pollution in inner city areas and to ensure a minimum proportion of green areas in inner-city building areas in order to provide recreational opportunities and maintain ecological functions (BGMR&HCU, 2017a).

The BAF provides developers, architects and designers with clear but flexible guidelines on the area of a plot that must be planted or provide other green space functions (e.g. microclimate improvements, urban cooling, sustainable drainage, natural habitat improvement, and enhanced quality of the residential environment). Specific solutions implemented in the BAF include: greening functional spaces (e.g. bike or bin sheds); planting trees, shrubs or climbing plants to create green walls; introducing green roofs; and paving only on main routes and using permeable surfaces elsewhere.

Implementation

The BAF formula calculates the proportion of an area that needs to be green space, i.e.: *Ecologically Effective Surface Areas divided by Total Land Area*. BAF targets depend on the specific uses of an area. While residential and public areas need to achieve a BAF target of 0.6, commercial, business and administrative areas are required to achieve a lower target of 0.30. If BAF targets are missed, landowner can be required to carry out ecological upgrading measures, as defined by the Berlin Nature Conservation Act (§50), insofar as is reasonable, such as the unsealing of areas.

Different types of green spaces are weighted differently according to their ecological value (see Figure 12). This is based on their evapotranspiration capacity, permeability, rainwater storage capacity, relationship to soil functioning, and habitat provision for plants and animals (Berlin, 2020b). The BAF has a value between 0 and 1, which is determined by the extent to which an area is ecologically active. The factor of 1 corresponds to a biologically active area that is fully permeable and covered in vegetation. The factor of 0 corresponds to sealed terrain that has no ecological function.

The technical basis for calculating the BAF is outlined in the guidance document "The biotope area factor as an ecological parameter. Principles for its Determination and Identification of the Target" (LPB and BGMR, 1990).

Each plot of land can be designed in various ways. In principle, measures that lead to an expansion of the area of vegetation on the ground are given priority. Only then should additional possibilities be utilized, such as the replacement of asphalt and concrete with other surfaces.

In the example provided in Figure 13, new green elements need to be implemented to reach the BAF target. For example some of the asphalt may need to be replaced with vegetation, permeable surfaces and green walls may need to be introduced.

As each new development needs to comply with the BAF targets, the use of regulations has been effective in increasing green cover and green functionality in the inner parts of Berlin. Flexibility of the approach provides significant advantages. BAF is compulsory only in areas where legally binding Landscape Plans are present (16% of Berlin in 21 distinct areas). Construction projects must be notified by the responsible districts at least one month before the start of construction if they fall within the scope of a Landscape Plan (according to §12 Berlin Nature Conservation Act). The implementation of measures that have an impact on the natural balance is usually carried

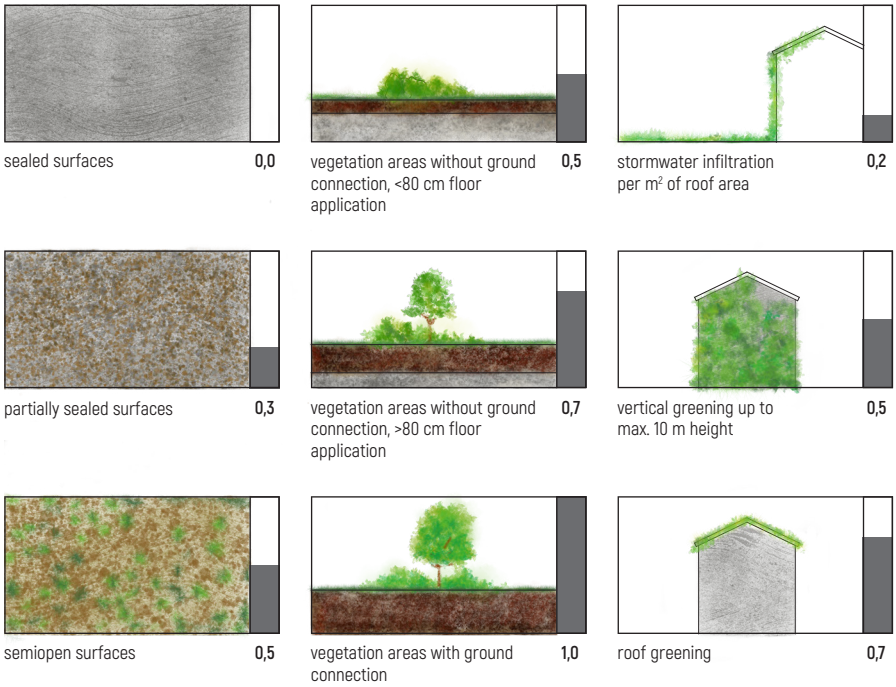
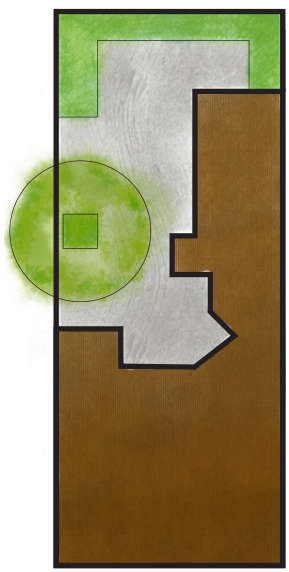


Figure 12. Ecological value of the BAF: Types of land and weighting factor.



Calculation: BAF inventory

Total land area: 479 m²
Developed area: 279 m²
Undeveloped area: 200 m²
Degree of development: 0.59

The courtyard is mainly covered with asphalt. There is gravel with grass coverage on the periphery, and the tree stands in a soil bed that measures 1 m²

140 m² Asphalt	× 0.0 = 0 m²
59 m² gravel with grass coverage	× 0.5 = 30 m²
1 m² open soil	× 1.0 = 1 m²

BAF = 31/479 = 0.06

BAF target = 0.3

Figure 13. Example of BAF calculation (Berlin, 2020).

Figure 14. Green courtyard, part of Hackesche Höfe area in Mitte, Berlin's central district.

out in cooperation with the building owners and landowners (BGMR&HCU, 2017). The Berlin Senate Department for the Environment, Transport and Climate Protection is responsible for the implementation of the BAF, supported by the lower nature conservation authority.

In areas not covered by Landscape Plans the BAF is voluntary and can be used as a guideline for encouraging environmental measures to be incorporated when changes to the existing building structures are proposed (CA, 2014).

Results and achievements

The BAF has been applied in numerous districts with more than 25 BAF Landscape Plans having been prepared to date. In the densely built-up district of Mitte, for example, the natural balance of an area of 7.2 ha was improved by unsealing and establishing green façades and roofs (BGMR&HCU, 2017). The *Berlin's Urban Development Plan Climate* (see Chapter 3.1) has also recently taken up BAF's ideas and demonstrated that this instrument can improve the microclimate situation in the inner city.

4.3. Targets and standards for green space availability and accessibility

Publicly available green and blue areas have the potential to provide multiple services and benefits to citizens. In order to successfully do so, however, a number of criteria need to be met regarding their accessibility, availability, and design. Measurable target values such as green space per capita and green space proportion or availability can help ensure this is successfully accomplished (Syrbe et al., 2018). Introducing standards or binding quantitative targets on green space availability and/or accessibility in policies and strategies can thus be a powerful tool to support the implementation of nature-based solutions and increase the share of green and blue areas.

Benefits of targets and standards for NBS implementation:

- Providing the opportunity to set a political goal or target for NBS implementation, which is easy to communicate and measure
- Binding targets and standards for urban green can ensure that goals are met and citizens have sufficient access and availability of green spaces
- Standards and targets for urban green space accessibility and availability can be easily integrated into urban planning and therewith ensure that green spaces are adequately considered in decision-making processes
- Increasing awareness about the importance of the accessibility and availability of urban green spaces among policy makers, citizens, civil society, business and other actors

Precise specifications for the accessibility, quality and maintenance of green spaces are essential when integrating such instruments in policies. Indicators for urban green spaces can include, for example (Syrbe et al., 2018):

- Green space proportion: green space/total areas in % (using topographical area or remote sensing)
- Green space per capita: green space in m^2/number of inhabitants (using topographical area or remote sensing combined with population data)
- Green space availability: a) area of green space (of minimum size within given distance) in m^2, dived by the number of inhabitants who can access this green space; b) share of inhabitants with access to green space of specified size within given distance (in %)
- Green space metrics: average vegetation height (m), tree canopy proportion (m^3/m^2) or leaf area index (m^2/m^2)

Quantitative targets and standards on green space availability and/or accessibility should be aligned with a long-term vision for the city's development. An example of a target to enhance municipal green spaces in Barcelona is outlined below.

Case Study 4.4.
Enhancing municipal green spaces by 2030 in Barcelona

Motivation and objectives

Barcelona has set the goal to increase municipal green spaces by 1 m^2 per inhabitant by 2030 (against the baseline of 2016) in its 2017 stimulus programme for urban green infrastructure (Barcelona, 2017). This target is the equivalent of 160 ha of new green areas. Currently, the city has a standard of ca. 7 m^2 of green space per city resident. In some districts, the figure is well below the standard, e.g. 1.85 m^2 in Eixample district and 3.15 m^2 in Gràcia. Moreover, almost 70% of public spaces were dedicated to private-vehicle transport, but the majority (83%) of journeys are made by public transport or bicycle. The government in Barcelona decided to pursue initiatives under the slogan "Let's fill our streets with life". Urban green areas are seen as an essential part of such initiatives, providing multiple functions und services to mitigate and adapt to climate change, cope with air pollution, preserve and increase biodiversity and improve health and promote culture (Barcelona, 2017). This target is also part of the city's actions to achieve the objectives of the Barcelona Climate Plan, aiming to reduce greenhouse gas emissions by 45% by 2030 and to turn the city into a carbon-neutral city by 2050. Barcelona seeks to utilise this to fulfil its commitment to the Paris Agreement (Barcelona, 2018).

Implementation

Barcelona's green areas were first identified based on available spatial data, including topographic maps, orthophoto maps, thematic mapping, Normalized Difference Vegetation Index (NDVI), urban plans and other relevant sources. Subsequently, indicators for public green spaces and green cover were derived to calculate the green infrastructure in Barcelona. This approach and its results helped to establish a systematic accountability for green areas and enable the planning, assessment and monitoring of the city's green infrastructure. It also enabled the measuring and monitoring of the connectivity, complementarity of uses, the park's accessibility for the population, the suitability of an area's location for performing social-environmental services, etc. (Barcelona, 2017).

Figure 15. Green infrastructure in Barcelona.

In order to reach the goal of creating 160 ha of new green urban areas, four strategic lines and corresponding actions have been defined. These actions are underpinned with quantity data in hectare for each involved site (parks, neighborhoods, plazas, transport, infrastructure, etc.), namely:

- Increasing the city's green public infrastructure: Actions include creating new public parks and gardens, recovering city block interiors in built-up areas in order to gain new public green area, installing temporary gardens in empty building sites, interventions in roadways to increase green features, greening rooftops, terraces and courtyards and greening walls and dividing walls (Table 2).
- Improving the existing green infrastructure: Actions include e.g. naturalising green areas, increasing the city's biomass, especially in terms of trees and bushes in parks, gardens and public areas, favouring their growth, extending Sustainable Urban Drainage Systems as a solution for regulating water based on natural processes, conserving and improving natural and semi-natural areas, especially open ones and preserving and improving biodiversity in urban sites.
- Stewardship of the general public in increasing and improving green infrastructure: Actions include e.g. promoting the general public's stewardship and shared responsibility in conserving and increasing green infrastructure in parks, gardens and other green areas of the city; promoting ecological agriculture in urban and peri-urban areas and sites; fostering privately-owned green areas through the promotion of vegetable gardens and gardening on balconies, terraces, roof terraces, rooftops, walls and courtyards; fostering the opening of non-municipal green areas to the public; and disseminating knowledge about urban nature and the value of conserving it.
- Studying, planning and monitoring the city's green infrastructure: Actions include planning Barcelona's green infrastructure as a system, including the green corridor network; taking social-environmental services into account; reviewing the areas recognised by planning as leisure areas with potential for increasing the percentage of plant life and permeable areas; completing the study of ecosystem services in Barcelona's green areas for the whole city; and creating an information system on green infrastructure, green areas and biodiversity.

Results and achievements

Recent assessments show that the implementation of stimulus programme for urban green infrastructure and the target to increase municipal green

Table 2 Estimated increases in green infrastructure in Barcelona until 2030

	Increase in green areas (m^2)		
Actions to increase in green areas	2015-2016	2017-2019	2020-2030
Creation of parks and gardens	74,602.24	138,710	833,238
Recovering city block interiors	11,816.41	38,237.11	8,800
Creating temporary gardens in empty building sites	15,946	16,754.16	30,800
Interventions in streets and squares	32,760.46	106,060.46	304,700
Creating green rooftops	-	5,431	22,000
Creating green walls and dividing walls	606.3	3,232	12,100
Total	135,731.41 (13.57 ha)	308,424.73 (30.84 ha)	1,211.638 (121.16 ha)
Total of new green surface area	13.57 ha	44.41 ha	165.57 ha

Figure 16. Green walls in the Maritime Museum in Barcelona.

spaces by 1 m² per inhabitant is well on track. In May 2019, the target to create ca. 44 ha by the end of 2019 was already almost reached. Moreover an area of 3.7 ha (22 areas) have been naturalised and Sustainable Urban Drainage Systems were implemented in 33 areas (Barcelona, 2017).

To support and enforce some of the actions listed above, the city council started promoting green roofs through a dedicated programme. Focus is on actions to activate roofs, terraces and courtyards in existing and newly-constructed buildings and to maximize social and environmental functionality and energy efficiency, turning them into living and green areas. More specifically, the city provides financial assistance for the rehabilitation and renaturation of the vegetation cover, provides citizens with documentation and technical support, fosters the revision of current regulations and develops teaching materials about roofs and terraces (Barcelona, 2019). Moreover, the city published the *Master Plan for Trees (2017-2037).* This plan includes the structuring of greenery actions at new pedestrian streets, squares and superblocks as a strategy to reclaim overtaken public spaces and add new functional and recreational pockets of productive greenery.

Several actions contributed to the 2030 goal to establish 160 ha of new green areas. In addition to creating or extending green parks and plazas, courtyards, green roofs etc., the implementation of superblocks contributes to this development. The main idea is to carry out a functional restructuring of Barcelona to enable people to reclaim public areas that have previously been used for e.g. car traffic and parking, thereby generating a public space full of life. One example is the Poblenou superblock implementation, resulting in 8,600 m² more space for pedestrians (Sustainable Cities, 2016).

4.4. Neighborhood Development Plans

Neighborhood development plans and strategies provide local residents and businesses the opportunity to shape development in their area, including plans for social, economic, green spaces and related construction activities. Such plans enable local communities to develop a shared vision for their neighborhood and link it to broader visions and strategies at the city level, thereby bringing public authorities together with civil society, citizens and businesses.

Neighborhood development plans primarily help to determine where new homes, shops, offices and other developments should be built. They also support the identification, development and protection of important local green and blue spaces. The advantage of a neighborhood-level plan is that it can more accurately respond to inhabitant priorities and local challenges than city-wide plans and ensure that planned developments are in line with inhabitant habits, preferences and daily activities. Such plans can include provisions and measures to preserve agricultural and environmentally sensitive areas, cope with stormwater events, create short commute times between homes and workplaces, allow for easy access to green recreational spaces and foster local social cohesion.

Benefits of a neighborhood development plan for NBS implementation:

- Tailoring the planning and design of NBS and related activities to community needs in a specific neighborhood, responding to their preferences for green and blue spaces
- Offering citizens a powerful opportunity to plan the future of their communities, including the development and management of green spaces
- Joint planning of public authorities, citizens, civil society, local businesses and other actors creates ownership and offer opportunities for the joint management of green spaces, which can also relieve the burden on public administrations
- Driving innovation for positive social change through e.g. the engagement of civil-society organizations at the neighbourhood level to develop 'nested' neighborhood strategies and strengthen urban governance around NBS (Luka and Engle, 2015)

Neighborhood development plans require an appropriate participatory process with local communities; in some cases, participation is ongoing throughout the plans' development and implementation. They also need to be accompanied by adequate financial support and embedded into municipal policy frameworks to ensure their successful implementation. While neighborhood development plans enable a community to achieve different objectives, communities need to first prioritise what they want to achieve and then decide what mechanism will best enable them to accomplish these goals (Luka and Engle, 2015).

Depending on the city governance structures and available resources, the process of developing and implementing such plans can be led by local government bodies or administration. One example of such a programme, coming from Berlin, is outlined below.

Case Study 4.5.
Berlin's neighbourhood management programme

Motivation and objectives

Since 1999, Berlin has run an urban regeneration initiative called the Neighbourhood Management programme as part of the national Social City initiative. This programme adopts a partnership-based approach involving residents, social facilities, businesses, housing associations, local administrations and other stakeholders in combination with voluntary involvement. The programme was set up as an intervention strategy to support disadvantaged neighbourhoods and to stabilise neighbourhoods and strengthen their social cohesion through three areas of work: residential environment, neighbourhood and education (Berlin, 2016b).

Implementation

The neighbourhood management programme supports 34 inner-city neighbourhoods and largescale housing estates in the suburbs with approximately 465,500 residents. There are four types of funding available for projects: action fund, project fund, building fund and network fund. The funding level ranges from a maximum of 1,500 EUR for each action activity down to a minimum of 5,000 EUR for projects and a minimum of 50,000 EUR for building and networks. This support facilitates start-up financing for projects. Co-financing for the neighbourhood management programme comes from the federal urban development programme and the European Regional Development Fund (ERDF) (Berlin, 2016b). Between 1999 and 2019, approximately 472 million EUR was spent on the Social City initiative. Since 1999, the ERDF, federal government and the state of Berlin have spent approximately 140 million, 107 million, and 23 million EUR, respectively, on 42 neighbourhood areas (Berlin, 2019a).

Activities include small greening projects that directly engage the residents. These projects have had a positive impact on social conditions in dense inner-city areas where public space is scarce. Cross-departmental coordination in the administration at district and city level, the private sector actors in a district, associations, institutions and initiatives and the residents work cooperatively on

Figure 17. A citizen science workshop on urban biodiversity and soil health in Berlin's Neukölln district, realized as part of the Neighbourhood Management programme.

Figure 18. Viktoriapark in Berlin plays and important role in providing residents of Kreuzberg district with access to green space.

the projects. Projects are implemented with local partners, residents and resources (Berlin, 2016b).

The neighbourhood management programme seeks an interactive approach with the local community and is seen as being a key pillar of the program. An office and management team are focal points for residents and other stakeholders. Local councils represent the residents and have decision-making power over the funding (Berlin, 2016b).

Results and achievements

An official evaluation of the programme took place in 2007, indicating that the engagement with residents was very successful. Nevertheless, the evaluation also provides recommendations for clearer priority setting in projects and for closer collaboration with all actors (Hanhörster and Reimann 2007).

In August 2019, the initiative celebrated its 20th anniversary with a total of 7,255 projects having been realised (Stadt Berlin, 2019a). A brochure taking stock of the initiatives' achievements reiterates that the integrative approach is a key pillar to the initiative. The structural framework around the initiative has improved significantly over time. The council of residents and the engagement tools for residents have proven successful, yet need to be continuously reviewed and updated to ensure that all residents feel included. Innovation is necessary to improve the chances of long-term success. Current cooperation between departments and across partners need to be reassessed and renewed. Furthermore, there is a definite need to improve the IT systems to ensure seamless budgeting and financing of the initiative and its projects. Overall, the initiative will be extended by another 12 to 15 years, allowing for long-term project planning in the neighbourhoods (Berlin, 2019b). A further evaluation process has been initiated in connection with the programme's 20th anniversary (Berlin, 2019b).

One example of the neighbourhood programme is the "Hidden places – Beautiful courtyards" initiative, which encourages both landlords and tenants to green their courtyards with the help of planners and financial support. This project, which particularly targets low-income residents, showed that increasing the quality of green spaces has led to a positive social impact (Hansen et al., 2017).

5. Financial instruments

This chapter provides an overview of instruments that can be applied by municipal governments to finance or promote the wider uptake of NBS in urban areas. The presented instruments include economic instruments available to municipalities as well as an overview of EU financing instruments (see Annex) that municipal governments can apply for to fund innovative pilot NBS projects. Case studies from Germany show how cities use well-known instruments (e.g. participatory budgets) in an innovative manner to leverage private investment in NBS.

5.1. Tax and fees relief

Tax incentives and fee reductions are most commonly applied to promote the installation of sustainable urban drainage systems and their components to achieve increased on-site infiltration, evapotranspiration or stormwater reuse and reduce inflows into municipal stormwater infrastructure. A reduction in municipal tax rates or municipal fees for waste and stormwater drainage can be used to incentivize real estate owners to install NBS on their property. Incentives and reductions can also be used to promote the creation or maintenance of urban greenery.

Alternatively, a municipality can introduce charges on the use of "grey" infrastructure, thereby reducing their appeal and increasing the incentive to implement green infrastructure. Providing tax and fee reductions may constitute a more attractive solution than introducing new charges and taxes (e.g. for the use of grey infrastructure) which could be met with opposition (Trinomics and IUCN, 2019).

Benefits of tax incentives and fee reductions for NBS implementation:

- Stimulating private property owners to invest in NBS on their property (e.g. bioswales, water retention ponds) based on the prospect of long-term savings through tax incentives and fee reductions. This is particularly relevant in cases where individuals cannot afford investment otherwise, or where the potential benefits of the NBS do not suffice to convince property owners to invest.
- Enabling municipalities to capture the public benefits of implemented NBS which are likely to exceed the lost tax income, e.g. decreased demand on the municipal stormwater infrastructure, decreased flood risk, or decreased air pollution.

Introducing tax incentives or fee reductions require accurate calculations to ensure the instrument is attractive to the target group and correctly reflects

the municipality's avoided costs. In the case of rainwater drainage, municipalities and water utilities can use a property's sealed surface or the size of the area that drains into the sewage system as a proxy for the amount of stormwater the property adds to the sewage network (see Case Study 5.1). The property owners would then receive direct and clear incentives to reduce the size of this surface area.

A tax incentive or fee reduction will not act as intended if the cost of installing NBS outweighs the benefits and savings generated. Municipalities might need to consider awareness-raising campaigns to highlight the long-term saving opportunities and provide guarantees that foreseen incentives and reductions will continue for several years (Toxopeus and Polzin, 2017). A tax incentive programme may accompany a subsidy programme, which serves to reduce the initial cost of NBS installation (see Chapter 5.2). It is important for municipalities to ensure that there are no conflicts between tax and grant schemes. Finally, municipalities need to take into consideration that introducing tax incentives and fee reductions can generate administrative costs related to processing of the applications, including for property inspections and monitoring (Trinomics and IUCN, 2019).

Case Study 5.1.
Imperviousness fee in Dresden

Motivation and objectives

To reduce the amount of rainwater reaching its mixed sewage system, the Dresden urban drainage utility company introduced a number of measures to decrease the amount of impervious surfaces on private properties (Dresden, 2020a). The measures came as a response to the increasing strains on the city's sewage system which have emerged as a consequence of climate change, including resultant droughts and heavy rainfalls. The city of Dresden has had to invest 26 million EUR since 2002 for the protection of its wastewater facilities as a consequence of flooding. About 30% of the costs for the planning, operation and maintenance of the sewage system and wastewater treatment plants are caused by rainwater treatment (Dresden, 2020b).

Implementation

Property owners have to pay an imperviousness fee based on a property's actual imperviousness (1.56 EUR/m²/ year for areas from which rainwater reaches the sewage system). To ensure accuracy, Dresden uses satellite imagery and automated image analysis. Households are informed about how much they have to pay based on a satellite image assessment. If the homeowners disagree with the assessment, they can apply to have it adjusted based on an application. In such a case, the property's infiltration system is assessed based on its dimensions and effectiveness. The infiltration of other surfaces, such as green roofs, can also be taken into account to receive a fee reduction. Additional reductions are available for homes installing rainwater utilisation systems (e.g. for use in toilets, washing machines or garden irrigation) (Dresden, 2020a).

Technical and planning guidelines are made available for new construction and retrofits to inform citizens about reduction factors for different surfaces (Dresden, 2020a). A guideline for the usage

Figure 19. Permeable paving is a valuable and ecological alternative to traditional asphalt pavements.

Figure 20. The intensive green roof of the kindergarten building in a Dresden residential area seamlessly connected to the lawns of the surrounding park.

of rainwater by the city of Dresden suggests options for how private buildings and land can be managed to increase rainwater infiltration. NBS options include green roofs, collecting and using rainwater and property landscaping.

Results and achievements

Between 1995 and 2015, the introduction of an imperviousness fee resulted in the removal of 450 ha of impervious surfaces and a 3,000 million litre run-off reduction per year, despite a population growth of 12% (Ehrenfried et al., 2018). The population of Dresden pays an average of 0.20 EUR per person for 100 liters of waste or rainwater sewage, which is lower than the German average (Dresden, 2020b). More information on regulatory requirements for rainwater infiltration in Germany can be found in Chapter 4.2 and Case Study 4.2.

5.2. Subsidies

Subsidies are used to trigger private investment in NBS, most commonly for NBS attached to private properties like green roofs or sustainable urban drainage systems. As NBS bring benefits to the wider public and not just to the investor or direct user, subsidies serve as payment for delivering the public benefits of the private investment. Subsidies can promote multiple, decentralized investments in NBS which together amount to large-scale deployment of nature-based solutions.

Benefits of subsidies for NBS implementation:

- Promoting private investment on private properties: while municipalities have the opportunity to deploy extensive nature-based solutions (e.g. city-wide reduction of impervious surfaces), they are restricted when it comes to implementing interventions on private properties. Subsidy schemes not only allow for NBS to be implemented on private property, but also mobilize additional private investment in NBS since the funds from subsidies are normally complementary to private finance.
- Easing the burden of high initial investment: despite the high return on investment in the long-term, many investors are hesitant to choose NBS over traditional "grey" alternatives due to the higher initial investment costs. This barrier can be mitigated through subsidies, which make the cost of implementation cheaper for property owners. In return for providing the subsidy and mobilising additional private investment, municipalities reap the benefits of the public services provided by private NBS investments, such as reduced stormwater management costs.
- Mitigating uncertainty: with a low level of awareness and scattered data on the benefits of using NBS compared to grey solutions, private investors are compelled to follow the status quo and select solutions with known returns or profits. Subsidies can partially mitigate the perceived risk associated with NBS and trigger investment in innovative green solutions.
- Payments for the provisioning of public goods: many of the benefits provided by NBS are of a public nature. In the case of green roofs, these include e.g. decreasing rain and stormwater run-off, improving air quality, and conserving biodiversity. Since private benefits alone may not be enough to justify such an investment, subsidies can stimulate private investment to produce public benefits.
- Promoting wide-scale uptake of specific solutions to achieve city-wide benefits: launching an attractive, well-designed subsidy scheme can rapidly increase the rate of investment in a specific solution, which can in turn lead to city-wide benefits that would otherwise not be achievable by individual, dispersed implementation of a given NBS (see Case Study 5.2).

To ensure wide NBS uptake, it is essential that the size of subsidy is attractive for investors and appropriately compensates for the faced uncertainty

and higher initial costs compared to grey solutions. A successful subsidy programme should be accompanied by a public education and outreach campaign, including information on potential savings at the property level to promote awareness and uptake of the subsidy. Standardisation of subsidies, clarification of requirements and simplification of procedures have been shown to encourage more applications (Toxopeus and Polzin, 2017).

NBS can have higher long-term maintenance costs than grey solutions. In such cases, long-term funding (e.g. in the form of tax cuts) may be needed to accompany a subsidy policy and ensure its success. Even where subsidies are granted, implementation costs may remain high for individual citizens, especially where markets for NBS provisioning are not yet developed. In Stuttgart and Basel, the long-term promotion of green roofs with subsidies increased implementation, lowered costs and ultimately made green roofs affordable to the point that the public subsidy was no longer required (Mees et al., 2013). An example of a successful green roof subsidy programme from Hamburg is presented below.

Case Study 5.2.
Green roof subsidy programme in Hamburg

Motivation and objectives

The green roof subsidy programme in Hamburg is part of its city-wide Green Roof Strategy and the overall strategy for sustainable rainwater management. Between 2015 and 2019, Hamburg has provided subsidies for each (private or public) owner that voluntarily decided to implement a green roof (Hamburg, 2020). The refurbishment of existing roofs as well as the implementation of green roofs in new buildings are eligible (EEA, 2016).

The Green Roof Strategy was formulated in response to current and expected impacts of climate change, such as temperature rise and resultant urban heat island effect, change in precipitation patterns and increases in extreme rainfall events. Focusing on green roofs allows the city to increase the amount of high quality green space and permeable surfaces while maintaining the compact urban form of the city.

The city's ambition is to install 100 ha of green roof surfaces by 2020, amounting to 70% of suitable rooftops being covered in green. The guidelines provided by the city also point out the climate mitigation benefits of green roofs, as well as air pollution and noise pollution reduction potential (Hamburg, 2018).

Implementation

Hamburg's subsidies cover 30-60% of the cost of construction, including materials and labor up to a maximum of 50,000 EUR per roof greening measure. The incentive programme is based on the thickness and surface area of the green roof rather than the water retention capacity alone. The subsidy is higher when the investor lives in the building in question and when labor is provided by trained professionals, ensuring a high quality in construction. Subsidies also increase with the thickness of the soil on the roof. A number of minimum standard criteria must be fulfilled for the subsidy to be granted (e.g. minimum 20 m^2 net vegetation area, maximum 30° roof slope, minimum 8-12 cm soil thickness, depending on

Figure 21. Green roofs in Hamburg.

the type of the building) (IFBHH, 2020) Subsidy amounts vary depending on the size of the measure, location (inner or outer city), combinations with rooftop solar arrays and several other aspects (EEA, 2016).

As the green roof subsidy is currently only available until 2020, debates are taking place on whether green roofs should become compulsory for some new buildings and renovations after this date (Schäfer, 2019). The subsidy will likely not be prolonged for these types of buildings. Where green roofs are already required by law (e.g. in nature parks), no subsidies are provided. Moreover, rooftops designed to serve mainly a decoration or renovation purpose but which do not fulfill the stormwater retention function are not subsidized.

The subsidy programme is accompanied by a number of other measures as part of the Green Roof Strategy:

- Fee reduction: Hamburg offers 50% rainwater fee reduction for green roof owners to offset the costs of installation as well as maintenance (Hamburg, 2020). Where green roofs are combined with a rainwater harvesting system which collects rainwater and filters it into greywater that can be used for toilet systems or irrigation, the building can become fully exempt from the rainwater drainage fee (BdF and HH, 2014).
- Legal provisions: implementation of the strategy includes incorporation of green roofs into legally binding instruments such as building law, wastewater law and land-use plans (BGMR and HCU, 2017).
- Promotional campaign: the city implemented a communication campaign online and in public spaces, overseen by a full-time employee dedicated to promoting the strategy. The city is producing a range of informational products for the general public (HCU, 2017).
- University-led research programme: the city cooperates with a local university, which provides scientific support to the strategy's implementation process by evaluating scientific studies on green roofs, collecting data on green roof performance and developing tailored recommendations for construction of green roofs in Hamburg (HCU, 2017).

A stakeholder group including housing estate companies, constructors, landscape architects and urban planners was involved in defining the incentive programme. A total of 3 million EUR was allocated to the subsidy programme, of which 2 million EUR came from the municipal budget and 1 million EUR from the innovation fund of the Senate office (BdF and HH, 2014). 500,000 EUR has been invested from the municipal budget for the promotion, communication, research and regulatory activities surrounding the programme (EEA, 2016). Finally, 300,000 EUR from a German federal funding programme for local adaptation activities was used to pay the salary of the communication officer and university researchers (BdF and HH, 2014).

Results and achievements

The implementation of the programme started in 2014. Between February 2015 and June 2019, 186 applications for funding were submitted and 136 approved. The total approved funding amount, 1.2 million EUR, allowed for creation of 5.3 ha of new vegetation area. The financial means were dispensed from the city's budget, with no external funds. In February 2019 the subsidy programme was extended by a further five years. The extended programme will also include subsidies for constructing green facades.

A key achievement of the programme is increased awareness among citizens and property developers about the ability of green roofs to reduce the heat island effect, cope with stormwater and help adapt to impacts of climate change while providing new, attractive green spaces for the city.

5.3. Participatory budgets

Participatory budgets describe any process which allows citizens to make decisions about how a public budget is spent, either in part or in full. In the context of promoting NBS, a portion of a participatory budget can be dedicated to urban greenery projects or even specifically to NBS or climate protection. This may mean using some of the funds allocated to achieve a specific goal (e.g. low-carbon climate transition) and using participatory budgeting to allocate those funds in order to raise awareness amongst citizens about the specific issue being addressed and increase knowledge about benefits generated by NBS in the process.

Raising awareness and stimulating citizen engagement are among the key motivations behind Lisbon's participatory budget dedicated to climate protection projects in an effort to ensure constant annual investment for achieving the city's greenhouse gas emissions targets. The city wants the participatory budget to act as a catalyst, encouraging private sector investment in such projects and attract additional private sources for adaptation and mitigation. Potential projects include, for example, tree planting to support heat reduction, water capture and storage and cycle lanes. In designing and implementing the citizen climate budget the Lisbon City Council has received support from Climate-KIC (climate-oriented innovation support platform) and South Pole (sustainable finance consultancy) (Climate-KIC, 2019; South Pole, 2019).

Benefits of participatory budgets for NBS implementation:

- Generating new ideas and capturing local knowledge: participatory budgeting allows new ideas proposed by citizens to be captured and acted upon, as a valuable addition to the expert knowledge of the administrations. Citizens can bring an awareness of specific local problems that can be addressed with NBS projects in their neighbourhoods and can use their knowledge and experience to propose solutions that the municipal experts may not be familiar with. Citizen participation can also help the municipal administration to prioritise measures in cases where there are limited funds.
- Fostering acceptance: well-informed citizens that are actively engaged in planning and decision-making process have an opportunity to better understand the benefits of the solutions proposed, which can be particularly useful when introducing new, innovative NBS. This can ensure an increased sense of ownership and can inspire citizens to take part in the maintenance of newly realised projects.
- Understanding of budgetary constraints: Participatory budgets create a better understanding of constraints to municipal budget, helping citizens understand that only a limited number of projects can be realised at any given time.

- Mobilising private investment in NBS: depending on their design, participatory budgets can allow public resources to be channeled into integrated projects, helping secure private resources and contributions from local entrepreneurs and developers and unlocking funding that would otherwise not have been used for NBS, without the additional public funding that became available.

Checking that the NBS which are proposed through such participatory process conform to certain minimum standards can ensure their effectiveness in fulfilling specific goals, such as increasing the accessibility of green spaces to the urban population. This can be realised by, for example, creating a municipality-approved catalogue of NBS which are eligible for funding, including their technical specifications. One example of such guide is the *Catalogue of urban NBS* (Iwaszuk et al., 2019), a publication produced to accompany this guidance document. Such an approach will, however, limit the scope of ideas that can be freely proposed by citizens to those included in the catalogue.

Proposals that can be submitted in participatory budgeting procedures are often one-off projects with a concrete and often short realization timeline of 1-2 years. This limits the possibility of financing larger and long-term projects and raises questions about the maintenance of proposed interventions. However, some cities allow citizens to also make decisions regarding the maintenance and the intensity of care dedicated to specific elements of green and blue spaces in the city (see Case Study 5.3).

Low participation rates in meetings and online processes surrounding participatory budget planning can bring into question the legitimacy of decisions taken through this process. If no efforts are made to promote wide participation (including of under-represented groups) and facilitate access (e.g. providing childcare during the meetings in order to promote the involvement of parents), it is possible that some groups will be excluded from decision-making processes. This in turn can affect the representativeness of the participatory budgeting decisions that are made. Case Study 5.3 presents an example of a successful participatory budget in Berlin-Lichtenberg.

Case Study 5.3.
Participatory budget in Berlin-Lichtenberg

Motivation and objectives

In 2005, the district of Lichtenberg in Berlin became the first municipality in Germany to introduce participatory budgeting (Bürgerhaushalt, 2015). The purpose of launching a very broad participatory budgeting scheme was to involve citizens in budgetary decisions and to foster mutual agreement in policy decisions, leading to effective and fair budgeting, transparency and the education of citizens about financial matters (Lichtenberg, 2019).

Implementation

In the participatory budgeting scheme, citizens deliberate on how to spend the entire discretionary district budget (circa 30 million EUR). For scale, the mandatory expenses of the district that are not subject to the participatory budget amount to 520 million EUR (Participedia, 2019).

The Lichtenberg participatory budget process is recognised as being very inclusive as it offers citizens the possibility to submit their ideas throughout the year through various channels, including neighbourhood dialogues, public meetings, district centres, by post and through the dedicated online platform. Voting on how funds should be spent takes place both online as well as in person on the district-wide voting day. No special outreach efforts are made to engage the citizens in public meetings and online forum and participation is voluntary. To ensure the process is more representative, these approaches are complemented by a household survey of around 10% of the district's population of 250,000 inhabitants to increase the representativeness of results. While the participatory budgeting in Lichtenberg has a representative gender distribution, there is an underrepresentation of younger citizens and citizens with lower education levels (Participedia, 2019). The Lichtenberg district council ultimately decides whether a proposal that has been supported in the voting process is included in the budget. To optimise this process, the council has

Figure 22. Lichtenberg district in Berlin.

Figure 23. With participatory budgeting schemes citizens can provide ideas for green and recreational areas that respond to their needs.

established an advisory committee which holds an annual review cycle to analyse the impacts of the policy. The documentation of the reviews is made publicly available (Lichtenberg, 2019).

The urban areas that the citizens can decide about include public green areas and parks, roadside greenery, playgrounds and care of street trees. Special brochures are prepared to inform citizens about which services are provided under each area of the budget, who stands to benefit from them, what their goals are and the success criteria that should be considered for projects selected under each category. For example, for the "public green areas and parks" category, citizens are told that the budget expenditures should balance the cost spent on 1 m^2 against services provided, such as contribution to climate protection, recreational value, the number of satisfied users and the value of natural area development. Since the Lichtenberg participatory budget covers the district's entire discretionary budget, expenditures cover not only one-off projects but also their long-term maintenance; here, citizens can decide on the intensity of care provided to specific green areas (Lichtenberg, 2019).

The design of the participatory budget procedure means that projects may be decided in a flexible, iterative manner. In one case, for example, a citizen suggested implementing signs prohibiting the feeding of ducks in a local pond in order to prevent pollution and avoid algal blooms. The proposal alerted the city council to the poor condition of the pond and triggered a proposal for restoring the pond and its surrounding park. The design of the improvements was planned in a highly participatory manner. Citizens were invited to contribute to the feasibility study conducted by the landscaping office contracted to do the work, including by participating in an on-site walk to demonstrate different existing uses of the park. The aim of the citizen consultation was to redesign the park in a manner corresponding to concrete usage behaviors of residents and take into account predicted demographic and climate changes.

The participatory budget is included in the district-level administrative law. The district council is legally obliged to provide inhabitants with opportunities for participation and inform them of those opportunities.

Results and achievements

Between 2017 and 2019, circa 20% of the realised proposals correspond to the category of 'environment and nature' (Lichtenberg, 2019). Overall, the proposals made by citizens are of a relatively high quality. Examples of recently realized projects include: revitalization of neglected areas to provide a bee meadow; pond remediation; park revitalization; and tree planting.

About "Climate NBS Polska"

Climate Mitigation through Nature-Based-Solutions in Urban Poland – Fostering Awareness and Capacity (Climate NBS Polska)

The "Climate NBS Poland" project aims to increase the understanding, acceptance and uptake of multifunctional NBS as a cost-effective urban climate mitigation and climate protection measure. By initiating and fostering co-operation and exchange between Polish and German planning, engineering and policy experts, the project seeks to build capacity, knowledge and skills among city officials, municipal staff and landscape planners to enable the conceptual and technical design and implementation of NBS.

To this end, the project includes the following activities and outputs:

- producing two publications: *Addressing climate change in cities: Catalogue of urban nature-based solutions* and *Addressing climate change in cities: Policy instruments to promote urban nature-based solutions*;
- developing tailored guidance and policy recommendations to promote urban NBS adapted to the reality of Polish cities and local governance;
- setting up a targeted capacity-building programme for the project's end-users including an online course, training events across Poland and a study visit to Germany;
- fostering the development of a Polish network of NBS experts and working closely with a number of Polish cities, such as Poznań, Kraków, Wrocław and Warsaw.

This project is part of the European Climate Initiative (EUKI). EUKI is a project financing instrument by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The EUKI competition for project ideas is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. It is the overarching goal of the EUKI to foster climate cooperation within the European Union (EU) in order to mitigate greenhouse gas emissions.' This publication is complemented by a guide on policy instruments that can be used to foster NBS uptake in Polish cities.

The opinions put forward in this catalogue are the sole responsibility of the author(s) and do not necessarily reflect the views of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Annex: EU Financing programmes

Financing Instrument	Types of NBS-related measures and projects that are supported
European Agricultural Fund for Rural Development (EAFRD) https://ec.europa.eu/regional_policy/en/policy/what/glossary/e/european-agricultural-fund-for-rural-development	Non-productive investments to achieve agri-environment-climate objectives; investments in preventive actions to reduce the consequences of natural disasters, adverse climatic events and catastrophic events; afforestation and creation of woodland; establishment of agroforestry systems; prevention and restoration of damage to forests; investments improving the resilience and environmental value and mitigation potential of forest ecosystems; agri-environment-climate payments; supporting agricultural practices that make a positive contribution to the environment and climate.
Cohesion Fund and European Regional Development Fund (ERDF) https://ec.europa.eu/regional_policy/en/funding/cohesion-fund/ https://ec.europa.eu/regional_policy/en/funding/erdf/	Direct allocations to biodiversity, nature and green infrastructure and investments in flood protection, water purification or renovation of buildings; more than 100 INTERREG programmes under ERDF's European Territorial Cooperation goal (cross-border, transnational, maritime and interregional) that fund GI projects in several countries.
Natural Capital Financing Facility (NCFF) of the European Investment Bank https://www.eib.org/en/products/blending/ncff/index.htm	Projects generating revenue or cost savings based on the provision of environmental goods and services (e.g. water management, air quality, forestry, recreation, pollination and increased resilience to the consequences of climate change), such as green roofs/facades, ecosystem-based rainwater collection/ water reuse systems, flood protection and erosion control.
European Fund for Strategic Investments (EFSI) and EFSI II regulation https://www.eib.org/en/efsi/index.htm	Sustainable (cross-border) projects, particularly those contributing to climate targets of the Paris Agreement and the transition towards a more resource efficient, circular and (near) carbon neutral economy (including e.g. upgrading of public spaces and services such as sport facilities, public parks, open spaces, commercial areas, smart housing and sustainable urban development projects).
LIFE programme https://ec.europa.eu/easme/en/life	Technical assistance projects; preparatory projects (capacity building/ pilot projects); and integrated projects (large-scale, regional or transboundary projects) which strengthen the ability of ecosystems to provide ecosystem services, further the knowledge base, increase effectiveness and uptake of GI, and/or prioritise restoration activities.

Horizon 2020 https://ec.europa.eu/programmes/horizon2020/en	Research activities underpinning the deployment of EU-level NBS projects (e.g. scientific research on ecological processes, development of tools for NBS/green infrastructure (GI) mapping and assessment) and innovation actions (e.g. the development of new, innovative NBS or innovative approaches to GI implementation); co-funds projects implementing GI through NBS and restoration as well as related research activities.
European Maritime and Fisheries Fund (EMFF) https://ec.europa.eu/easme/en/european-maritime-and-fisheries-fund-0	Projects supporting the protection and restoration of marine biodiversity and ecosystems and compensation regimes in the framework of sustainable fishing activities (e.g. the management, restoration and monitoring of NATURA 2000 sites affected by fishing activities; the rehabilitation of inland waters in accordance with the Water Framework Directive)

References

AFOK, 2016. *Anpassung an die Folgen des Klimawandels in Berlin – AFOK, Zusammenfassung*. Stadt Berlin, Senatsverwaltung für Umwelt, Verkehr und Klimaschutz.
https://www.berlin.de/sen/uvk/klimaschutz/anpassung-an-den-klimawandel/programm-zur-anpassung-an-die-folgen-des-klimawandels/

Berlin, 2009. *Elements of sustainability – Ecological building in Berlin.*
https://www.stadtentwicklung.berlin.de/bauen/nachhaltiges_bauen/download/bausteine_der_nachhaltigkeit_en.pdf

BReWa-BE, 2018. *Begrenzung von Regenwassereinleitungen bei Bauvorhaben in Berlin.*
https://www.berlin.de/senuvk/umwelt/wasser/regenwasser/de/Hinweisblatt-BReWa-BE.pdf

BWG, 2005. *Berliner Wassergesetz.*
https://docplayer.org/23887675-Berliner-wassergesetz-bwg.html

Barcelona, 2017. *Government measures: Stimulus Programme for the city's urban green infrastructure*. Ajuntament de Barcelona; Ecology, Urban Planning, Infrastructures and Mobility.
https://ajuntament.barcelona.cat/ecologiaurbana/en/what-we-do-and-why/urban-greenery-and-biodiversity/green-infrastructure-impetus-plan

Barcelona, 2018. *Climate Plan 2018–2030*. Ajuntament de Barcelona; Ecology, Urban Planning, Infrastructures and Mobility.
http://ajuntament.barcelona.cat/ecologiaurbana/ca/que-fem-i-per-que/energia-i-canvi-climatic/pla-clima

Barcelona, 2019. *Living Roofs and Green Covers.* Ajuntament de Barcelona; Ecology, Urban Planning, Infrastructures and Mobility.
https://ajuntament.barcelona.cat/ecologiaurbana/en/what-we-do-and-why/green-city-and-biodiversity/living-roofs-and-green-covers

BBSR, 2015. Überflutungs- und Hitzevorsorge durch die Stadtentwicklung Strategien und Maßnahmen zum Regenwassermanagement gegen urbane Sturzfluten und überhitzte Städte. Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR) im Bundesamt für Bauwesen und Raumordnung (BBR), Bonn.
https://www.bbsr.bund.de/BBSR/DE/Veroeffentlichungen/Sonderveroeffentlichungen/2015/DL_UeberflutungHitzeVorsorge.pdf?__blob=publicationFile&v=3

BBSR, 2018. *Grün in der Stadt: Internationale Beispiele für grüne Städte zum Weißbuchprozess*. ARGE Urbanizers, Berlin.
https://www.bbsr.bund.de/BBSR/DE/FP/ExWoSt/Forschungsfelder/2015/weissbuch-gruen-in-der-stadt/downloads/gids-kurzexpertise-internationale-beispiele.pdf?__blob=publicationFile&v=3

BdF and HH, 2014. *Mitteilung des Senats an die Bürgerschaft, Einzelplan 6 Behörde für Stadtentwicklung und Umwelt. Gründachstrategie für Hamburg – Zielsetzung, Inhalt und Umsetzung*. Bürgerschaft der Freien, Hansestadt Hamburg.
www.buergerschaft-hh.de/parldok/dokument/44644/einzelplan_6_behoerde_fuer_stadtentwicklung_und_umwelt_gruendachstrategie_fuer_hamburg_zielsetzung_inhalt_und_umsetzung.pdf

Berlin, 2012. *Strategie Stadtlandschaft Berlin: natürlich urban produktiv*. Berlin Senat, Senatsverwaltung für Stadtentwicklung und Umwelt.
https://nbn-resolving.de/urn:nbn:de:kobv:109-opus-128986

Berlin, 2015. *Berlin Strategy. Urban Development Concept Berlin 2030*. Berlin Senate, Department for Urban Development and Environment.
https://www.stadtentwicklung.berlin.de/planen/stadtentwicklungskonzept/download/strategie/BerlinStrategie_Broschuere_en.pdf

Berlin, 2016a. *Berlin Strategie 2.0*. Berlin Senate, Senatsverwaltung für Stadtentwicklung und Umwelt.
https://www.stadtentwicklung.berlin.de/planen/stadtforum/download/5stadtforum/SenStadtUm_BerlinStrategie2.0.pdf

Berlin, 2016b. *Information on the Berlin Neighbourhood Management Programme*. Stadt Berlin, Senatsverwaltung für Stadtentwicklung und Wohnen.
https://www.stadtentwicklung.berlin.de/wohnen/quartiersmanagement/download/qm_flyer2016_en.pdf

Berlin, 2019a. *20 Jahre Berliner Quartiersmanagement in Zahlen und Fakten*. Stadt Berlin, Senatsverwaltung für Stadtentwicklung und Wohnen.
https://www.stadtentwicklung.berlin.de/wohnen/quartiersmanagement/download/aktuelles/kurzinfo_20_jahre_quartiersmanagement_in_zahlen_und_fakten.pdf

Berlin, 2019b. *20 Jahre Berliner Quartiersmanagement. Bilanz und Perspektiven für die Soziale Stadt*. Stadt Berlin, Senatsverwaltung für Stadtentwicklung und Wohnen.
https://www.stadtentwicklung.berlin.de/wohnen/quartiersmanagement/download/aktuelles/broschuere_20_jahre_quartiersmanagement.pdf

Berlin, 2020a. *Berlin Digital Environmental Atlas*. Senate Department for Urban Development and Housing, Berlin.
https://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/edua_index.shtml

Berlin, 2020b. *Biotope Area Factor (BAF)*. Senate Department for the Environment, Transport and Climate Protection, Berlin.
https://www.berlin.de/sen/uvk/natur-und-gruen/landschaftsplanung/bff-biotopflaechenfaktor/

BGMR and HCU, 2017a. *Grüne Innenstadt: Biotopflächenfaktor*. Urbane Freiräume: Qualifizierung, Rückgewinnung und Sicherung urbaner Frei- und Grünräume, BGMR Landschaftsarchitekten, Berlin, HafenCity Universität, Hamburg.
https://www.hcu-hamburg.de/fileadmin/documents/Professoren_und_Mitarbeiter/Projektentwicklung__-management/Forschung/Urbane_Freiraeume_Steckbrief_Berlin_Biotopflaechenfaktor.pdf

BGMR and HCU, 2017b. *Hamburger Gründachstrategie*. Urbane Freiräume: Qualifizierung, Rückgewinnung und Sicherung urbaner Frei- und Grünräume, BGMR Landschaftsarchitekten, Berlin, HafenCity Universität, Hamburg.
https://www.hcu-hamburg.de/fileadmin/documents/Professoren_und_Mitarbeiter/Projektentwicklung__-management/Forschung/Urbane_Freiraeume_Steckbrief_Hamburg_Gruendachstrategie.pdf

Bianconi, F., Clemente, M., Filippucci, M. and Salvati, L., 2018. *Regenerating Urban Spaces: A Brief Commentary on Green Infrastructures for Landscape Conservation*. TeMA – Journal of Land Use, Mobility and Environment, 11(1), 107–118.
https://doi.org/10.6092/1970-9870/5216

BUE, 2016. *Gemeinschaftsprojekt RISA zur Entwicklung eines zukunftsfähigen Regenwassermanagements, RegenInfraStrukturAnpassung*. Behörde für Umwelt und Energie, Stadt Hamburg.
https://www.hamburg.de/risa/

Bürgerhaushalt, 2015. Participatory budgeting in Berlin-Lichtenberg: a complex, multi-channel process. Bürgerhaushalt, Bundeszentrale für politische Bildung, Bonn.
https://www.buergerhaushalt.org/en/best_practice#n1834

CA, 2014. *Berlin Biotope Area Factor – Implementation of guidelines helping to control temperature and runoff*. Climate ADAPT, European Climate Adaptation Platform.
https://climate-adapt.eea.europa.eu/metadata/case-studies/berlin-biotope-area-factor-2013-implementation-of-guidelines-helping-to-control-temperature-and-runoff

Celle, 2020. *Regenwasserversickerung*. Stadt Celle, Umweltschutz.
https://www.celle.de/Rathaus/B%C3%BCrger-und-Unternehmensservice/Regenwasserversickerung.php?object=tx,2727.2.1&ModID=10&FID=2727.9.1&NavID=2727.233&La=1&ort=&sfwort=1

Climate-KIC, 2019. *Lisbon Climate Citizenship Commitment: integrating climate action projects into a city's Participatory Budget*.
http://local.climate-kic.org/wp-content/uploads/2019/02/Factsheet_CFL_LisbonGreenPB.pdf

Dresden, 2004. *Mit Regenwasser wirtschaften*. Landeshauptstadt Dresden, Umweltamt.
https://docplayer.org/43179846-Mit-regenwasser-wirtschaften.html

Dresden, 2020a. *Zum Umgang mit Niederschlagswasser*. Stadtentwässerung Dresden.
https://www.stadtentwaesserung-dresden.de/service/grundstuecksentwaesserung/mit-regenwasser-wirtschaften.html

Dresden, 2020b. *Die Abwassergebühr. Getrennte Gebühren für Schmutz- und Niederschlagswasser. Wofür zahlen Sie Ihre Abwassergebühr?* Stadtentwässerung Dresden.
https://www.stadtentwaesserung-dresden.de/service/abwassergebuehren.html

EC, 2015. Towards an EU Research and Innovation policy agenda for Nature-based Solutions and Re-Naturing Cities, Luxembourg: Publications Office of the European Union.
https://ec.europa.eu/programmes/horizon2020/en/news/towards-eu-research-and-innovation-policy-agenda-nature-based-solutions-re-naturing-cities

ECNC, 2016. *Method Factsheet – Blue Green Factor*. OpenNESS, ECNC: European Centre for Nature Conservation.
https://oppla.eu/product/2006

EEA, 2016. *Four pillars to Hamburg's Green Roof Strategy: financial incentive, dialogue, regulation and science*. Climate ADAPT, European Environment Agency.
https://climate-adapt.eea.europa.eu/metadata/case-studies/four-pillars-to-hamburg2019s-green-roof-strategy-financial-incentive-dialogue-regulation-and-science

EEA, 2019. *Urban Adaptation Support Tool*. Climate ADAPT, European Environment Agency.
https://climate-adapt.eea.europa.eu/knowledge/tools/urban-ast

Ehrenfried, L.M, Vietz, G. and Whiteoak K., 2018. *Incentivising stormwater management in cities and suburbs*, Water e-Journal 3 (1).
https://watersource.awa.asn.au/environment/built-environment/incentivising-stormwater-management-in-cities-and-suburbs/

EWG Bln, 2016. *Berliner Energiewendegesetz*. Berlin Stadt.
http://gesetze.berlin.de/jportal/portal/t/x7q/page/bsbeprod.psml?pid=Dokumentanzeige&showdoccase=1&js_peid=Trefferliste&documentnumber=1&numberofresults=1&fromdoctodoc=yes&doc.id=jlr-EWendGBErahmen&doc.part=X&doc.price=0.0#focuspoint

Frantzeskaki, N., McPhearson, T., Collier, M.J., Kendal, D., Bulkeley, H., Dumitru, A., Walsh, C., Noble, K., van Wyk, E., Ordóñez, C., Oke, C. and Pintér, L., 2019. *Nature-Based Solutions for Urban Climate Change Adaptation: Linking Science, Policy, and Practice Communities for Evidence-Based Decision-Making*. BioScience, 69 (6), 455–466.
https://doi.org/10.1093/biosci/biz042

Geneletti, D. & Zardo, L., 2016. *Ecosystem-based adaptation in cities: An analysis of European urban climate adaptation plans*, Land Use Policy, 50, 38–47.

Hamburg, 2018. *Dachbegrünung. Leitfaden zur Planung,*
https://www.hamburg.de/contentblob/10603292/c6eb1f159c491cfd8c7188f77bodd277/data/d-leitfaden-dachbegruenung.pdf

Hamburg, 2020. *Green Roofs*.
https://www.hamburg.com/residents/green/11836394/green-roofs/

Hanhörster, H. & Reimann, B., 2007. *Evaluierung der Partizipation im Rahmen der Berliner Quartiersverfahren unter besonderer Berücksichtigung der Aktivierung von Berlinerinnen und Berlinern mit migrantischer Herkunft*. Stadt Berlin, Senatsverwaltung für Stadtentwicklung; Deutsches Institut für Urbanistik.
https://www.stadtentwicklung.berlin.de/wohnen/quartiersmanagement/de/evaluation/download/bericht_evaluierung_partizipation.pdf

Hansen, R., Rall, E., Chapman, E., Rolf, W. and Pauleit, S. (red.), 2017. *Urban Green Infrastructure Planning: A Guide for Practitioners.* GREEN SURGE.
https://www.e-pages.dk/ku/1340/html5/

HCU, 2011. *Integration dezentraler Regenwasserbewirtschaftung in die Hamburger Bebauungs- und Genehmigungsplanung: Analyse und Handlungsschwerpunkte. Ein Zwischenbericht*. HafenCity University, RISA.

HSE and UEB, 2015. *RISA Strukturplan Regenwasser 2030, Ergebnisbericht des Projektes RISA – RegenInfraStrukturAnpassung*. Hamburger Stadtentwässerung AöR (HSE) und Behörde für Umwelt und Energie (BUE), Hamburg.

IFBHH, 2020. Hamburger Gründachförderung.
https://www.ifbhh.de/foerderprogramm/hamburger-gruendachfoerderung

Iwaszuk, E., Rudik, G., Duin, L., Mederake, L., Davis, M., Naumann, S. and Wagner, I., 2019 Addressing Climate Change in Cities. Catalogue of Urban Nature-Based Solutions. Ecologic Institute, the Sendzimir Foundation: Berlin, Krakow.
https://www.ecologic.eu/17229

iWater, 2015. *ISWM measures and approaches*. iWater project, City of Turku, Environmental Division.
http://www.integratedstormwater.eu/sites/www.integratedstormwater.eu/files/final_outputs/6.9._iswm_measures_approaches.pdf

iWater, 2016. *Integrated stormwater management*. iWater project, City of Turku, Environmental Division.
https://www.integratedstormwater.eu/sites/www.integratedstormwater.eu/files/iswm_guidelines_2.pdf

Leipzig, 2009. *Leipzig 2020. Integriertes Stadtentwicklungskonzept (SEKo)*. Stadt Leipzig, Dezernat Stadtentwicklung und Bau.
https://static.leipzig.de/fileadmin/mediendatenbank/leipzig-de/Stadt/02.6_Dez6_Stadtentwicklung_Bau/61_Stadtplanungsamt/Stadtentwicklung/Stadtentwicklungskonzept/SEKo_Pdfs/SEKo_BlaueReihe_50_Web.pdf

Leipzig, 2012. *Integriertes Stadtentwicklungskonzept (SEKo) - Umsetzungsbericht 2012*.
https://static.leipzig.de/fileadmin/mediendatenbank/leipzig-de/Stadt/02.6_Dez6_Stadtentwicklung_Bau/61_Stadtplanungsamt/Stadtentwicklung/Stadtentwicklungskonzept/SEKo_Pdfs/Umsetzungsbericht_2012_nternet.pdf

Leipzig, 2016. *Klimawandel – Anpassungsstrategien für Leipzig*. Stadt Leipzig, Amt für Umweltschutz.
https://www.leipzig.de/fileadmin/mediendatenbank/leipzig-de/Stadt/02.3_Dez3_Umwelt_Ordnung_Sport/36_Amt_fuer_Umweltschutz/Publikationen/Klimaschutz/Klimawandel_Anpassungsstrategien.pdf

Leipzig, 2017a. *Lebendig Grüne Stadt am Wasser - Freiraumstrategie Der Stadt Leipzig*. Stadt Leipzig.
https://www.leipzig.de/news/news/freiraumstrategie-der-stadt-leipzig-vorgestellt/

Leipzig, 2017b. *Masterplan Parkbogen Ost*. Stadt Leipzig.
https://www.leipzig.de/fileadmin/mediendatenbank/leipzig-de/Stadt/02.6_Dez6_Stadtentwicklung_Bau/64_Amt_fuer_Stadterneuerung_und_Wohnungsbaufoerderung/Projekte/Flyer_Broschueren_PDFs/Parkbogen_Ost/Parkbogen_Ost_Masterplan.pdf

Leipzig, 2018a. *INSEK Integrated Urban Development Concept for Leipzig 2030. Strategic Vision and Urban Development Strategy.* Stadt Leipzig.
https://static.leipzig.de/fileadmin/mediendatenbank/leipzig-de/Stadt/02.6_Dez6_Stadtentwicklung_Bau/61_Stadtplanungsamt/Stadtentwicklung/Stadtentwicklungskonzept/INSEK_2030/INSEK-Leipzig_2030_Broschure_engl_Fassung_Teil_1.pdf

Leipzig, 2018b. *Beschlussauszug. Stand der Realisierung am 28.06.2018, Ratsversammlung vom 31.05.2018*, Ö5.5 Integriertes Stadtentwicklungskonzept Leipzig 2030 (INSEK). Stadt Leipzig.
https://static.leipzig.de/fileadmin/mediendatenbank/leipzig-de/Stadt/02.6_Dez6_Stadtentwicklung_Bau/61_Stadtplanungsamt/Stadtentwicklung/Stadtentwicklungskonzept/Leipzig-2030_Beschluss_Gesamtfassung.pdf

Leipzig, 2020a. *Masterplan Grün.* Stadt Leipzig.
https://www.leipzig.de/freizeit-kultur-und-tourismus/parks-waelder-und-friedhoefe/masterplan-gruen/

Leipzig, 2020b. *Parkbogen Ost – von Bahnflächen zum grünen Aktivband.* Stadt Leipzig, Stadtteilentwicklung/Stadterneuerung.
https://www.leipzig.de/bauen-und-wohnen/stadterneuerung-in-leipzig/stadterneuerungsprojekte/parkbogen-ost/

Lichtenberg, 2019. *Bürgerhaushalt Lichtenberg.* Bezirksamt Lichtenberg von Berlin.
https://www.buergerhaushalt-lichtenberg.de/

LPB and BGMR, 1990. *The Biotope Area Factor as an Ecological Parameter. Principles for Its Determination and Identification of the Target.* Landschaft Planen and Bauen and bgmr Landschaftsarchitekten, Berlin.
https://www.berlin.de/sen/uvk/en/nature-and-green/landscape-planning/baf-biotope-area-factor/principles-for-its-determination-and-identification-of-the-target/

Luka, N and Engle, J., 2015. *Neighborhood Planning for Resilient and Livable Cities.* Montréal's Green, Active and Healthy Neighborhoods Project, The Nature of Cities.
https://www.thenatureofcities.com/2015/11/18/neighborhood-planning-for-resilient-and-livable-cities-part-3-of-3-montreals-green-active-and-healthy-neighborhoods-project/

Mees, H.L.P., Driessen, P.P.J., Runhaar, H.A.C. and Stamatelos, J., 2013. *Who governs climate adaptation? Getting green roofs for stormwater retention off the ground.* Journal of Environmental Planning and Management, 56 (6), 802–825.
https://dspace.library.uu.nl/handle/1874/281206

NATURVATION, 2017. *Parkbogen Ost: creating a green / park belt in Leipzig.* NATURVATION – nature – cities – innovation, Durham University.
https://naturvation.eu/nbs/leipzig/creating-green-park-belt-leipzig

Nürnberg, 2016. *Zukunftsweisender und nachhaltiger Umgang mit Regenwasser.* Stadtentwässerung und Umweltanalytik, Stadt Nürnberg.
https://www.nuernberg.de/imperia/md/sun/dokumente/sun/regenwasser.pdf

Participedia, 2019. Participatory Budgeting in Berlin-Lichtenberg. The University of British Columbia.
https://participedia.net/case/12

PfH, 2013. Naturnahe Regenwasserbewirtschaftung für nachhaltigere Städte. Professur für Hydrologie, Universität Freiburg.
http://www.naturnahe-regenwasserbewirtschaftung.info/index.php?page=gesetzeslage

Raymond, C.M., Berry, P., Breil, M., Nita, M.R., Kabisch, N., de Bel, M., Enzi, V., Frantzeskaki, N., Geneletti, D., Cardinaletti, M., Lovinger, L., Basnou, C., Monteiro, A., Robrecht, H., Sgrigna, G., Munari, L. and Calfapietra, C., 2017. *An Impact Evaluation Framework to Support Planning and Evaluation of Nature-based Solutions Projects.* EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas. Centre for Ecology and Hydrology, Wallingford.

Ruesch, M.A. and Wagner, M., 2015. *Participatory Budgeting in Germany: Citizens as Consultants.* Bürgerhaushalt, Bundeszentrale für politische Bildung, Bonn.
https://www.buergerhaushalt.org/sites/default/files/German_PB_final_engl1.pdf

Reusswig, F., Becker, C., Lass, W., Haag, L., Hirschfeld, J., Knorr, A., Lüdeke, M.K.B., Neuhaus, A., Pankoke, C., Rupp, J., Walther, C., Walz, S., Weyer, G. and Wiesemann, E., 2016. *Anpassung an die Folgen des Klimawandels in Berlin (AFOK).* Klimaschutz Teilkonzept. Hauptbericht. Senatsverwaltung für Stadtentwicklung und Umwelt, Sonderreferat Klimaschutz und Energie (SRKE), Potsdam – Berlin.
http://www.pik-potsdam.de/~luedeke/lit/afok_endbericht_teil1.pdf

RISA, 2020. *RISA – das Gemeinschaftsprojekt zur Umsetzung einer zukunftsfähigen Regenwasserbewirtschaftung in Hamburg.* RISA – RegenInfraStr StructurAdjustment, Hamburg.
https://www.risa-hamburg.de/hintergrund-ziele/

Sartorius, C., 2007. Zukunftsmarkt Dezentrale Wasseraufbereitung und Regenwassermanagement. Fallstudie im Auftrag des Umweltbundesamtes, Fraunhofer-Institut für System- und Innovationsforschung, Karlsruhe.
https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3454.pdf

Schäfer, S., 2019. *Flop-Strategie in Hamburg Kommt jetzt die Gründach-Pflicht?* Hamburger Morgenpost.
https://www.mopo.de/hamburg/flop-strategie-in-hamburg-kommt-jetzt-die-gruendach-pflicht--32984796

Senatsverwaltung, 2017. *Klimaschutz, Ein Energiewendegesetz für Berlin.* Berlin Stadt.
https://www.berlin.de/sen/uvk/klimaschutz/klimaschutzpolitik-in-berlin/energiewendegesetz/

South Pole, 2019. *Lisbon's City Finance Lab-backed green participatory budget awarded 5 million EUR budget for next cycle.*
https://www.southpole.com/news/lisbons-city-finance-lab-backed-green-participatory-budget-receive-5-million-budget

StEP Klima, 2011. *Stadtentwicklungsplan Klima, Urbane Lebensqualität im Klimawandel sichern.* Stadt Berlin, Senatsverwaltung für Stadtentwicklung.
https://www.stadtentwicklung.berlin.de/planen/stadtentwicklungsplanung/download/klima/step_klima_broschuere.pdf

StEP KONKRET, 2016. *Stadtentwicklungsplan Klima KONKRET, Klimaanpassung in der Wachsenden Stadt.* Senatsverwaltung für Stadtentwicklung und Umwelt, Berlin.
http://www.stadtentwicklung.berlin.de/planen/stadtentwicklungsplanung/download/klima/step_klima_konkret.pdf

Sustainable Cities, 2016. *The implementation of the Superblocks programme in Barcelona: Filling our streets with life.* The European Sustainable Cities Platform.
http://www.sustainablecities.eu/transformative-actions-database/?c=search&action_id=agvjqhrc

Syrbe, R.U., Hou, W., Grunewald, K. and Mathey, J., 2018. How green are our cities? Green space provision in urban areas [in:] Grunewald, K., Li, J., Xie, G.I, Kümper-Schlake, L. (Eds.), Towards Green Cities: Urban Biodiversity and Ecosystem Services in China and Germany, Springer, 86–100.

Trinomics and IUCN, 2019. Approaches to financing nature-based solutions in cities. Working document prepared in the framework of the Horizon 2020 project GrowGreen.
http://growgreenproject.eu/wp-content/uploads/2019/03/Working-Document_Financing-NBS-in-cities.pdf

Toxopeus, H. and Polzin, F., 2017. *Characterizing nature-based solutions from a business model and financing perspective.* Utrecht University and Naturvation.
https://naturvation.eu/sites/default/files/news/files/naturvation_characterizing_nature-based_solutions_from_a_business_model_and_financing_perspective.pdf

UBA, 2005. *Versickerung und Nutzung von Regenwasser. Vorteile, Risiken, Anforderungen.* Umweltbundesamt, Dessau.
https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/2973.pdf

UBA, 2016. *RISA – RegenInfraStrukturAnpassung.* Umweltbundesamt, Hamburg.
https://www.umweltbun7desamt.de/themen/klima-energie/klimafolgen-anpassung/werkzeuge-der-anpassung/projektkatalog/risa-regeninfrastrukturanpassung

WE GI, 2011. *West of England Strategic Green Infrastructure Framework.* West of England Green Infrastructure Group.
http://www.westofengland.org/media/216918/gi%20framework%20020611.pdf

WHG, 2018. *Wasserhaushaltsgesetz* vom 31. Juli 2009 (BGBl. I S. 2585), das zuletzt durch Artikel 2 des Gesetzes vom 4. Dezember 2018 (BGBl. I S. 2254) geändert worden ist
http://www.gesetze-im-internet.de/whg_2009/WHG.pdf

Wüstemann, H., Kalisch, D. and Kolbe, J., 2016. *Towards a national indicator for urban green space provision and environmental inequalities in Germany: Method and findings.* Humboldt-Universität zu Berlin.
http://sfb649.wiwi.hu-berlin.de/papers/pdf/SFB649DP2016-022.pdf

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