



nature-based urban innovation

NATURVATION

project

INTERNATIONAL COMPARISON OF NATURE-BASED SOLUTIONS PROJECT REPORT

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Led by Durham University, NATURVATION involves 14 institutions across Europe working in fields as diverse as urban development, innovation studies, geography, ecology, environmental assessment and economics. Our partnership includes city governments, non-governmental organisations and business. We will assess what nature-based solutions can achieve in cities, examine how innovation is taking place, and work with communities and stakeholders to develop the knowledge and tools required to realise the potential of nature-based solutions for meeting urban sustainability goals.



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EXECUTIVE SUMMARY

The four-year NATURVATION project (2016-2020), funded through the EU Horizon 2020 Programme, seeks to map and analyse existing experiences and practices in the use of nature-based solutions (NBS) to understand what enables NBS innovations and ultimately use this knowledge to inform policy and practice. One of the tasks of the project was to analyse the processes, mechanisms and tools which support or hinder nature-based innovations and their systemic integration. This report explores the dynamics and politics of urban NBS innovations by comparing governance arrangements, public participation, financing mechanisms, innovation patterns and social impacts associated with the emergence and deployment of 54 NBS interventions grouped in a number of physical domains in 18 cities worldwide.

The 18 cities covered in this report include NATURVATION's six partner cities (Barcelona, Győr, Leipzig, Newcastle, Malmö, and Utrecht), six non-European cities (Boston, Cape Town, Melbourne, Mexico City, Tianjin, and Winnipeg) and six other European cities (Athens, Dublin, Edinburgh, Montpellier, Munich, and Sofia). The cities and their NBS were systematically selected based on criteria and methods developed by WP4 convenors to ensure the representation of diverse urban and environmental conditions, while also taking the diversity of ecological domains and aspects of innovation into account.

What are the key characteristics of the 54 NBS studied in 18 cities?

Data allows the characterisation of NBS based on the ecological domain they belong to, the challenges they address, the type of organisation initiating or responsible for overseeing their implementation, the ways citizens are engaged and social and environmental justice issues related to these. Some of the key characteristics are:

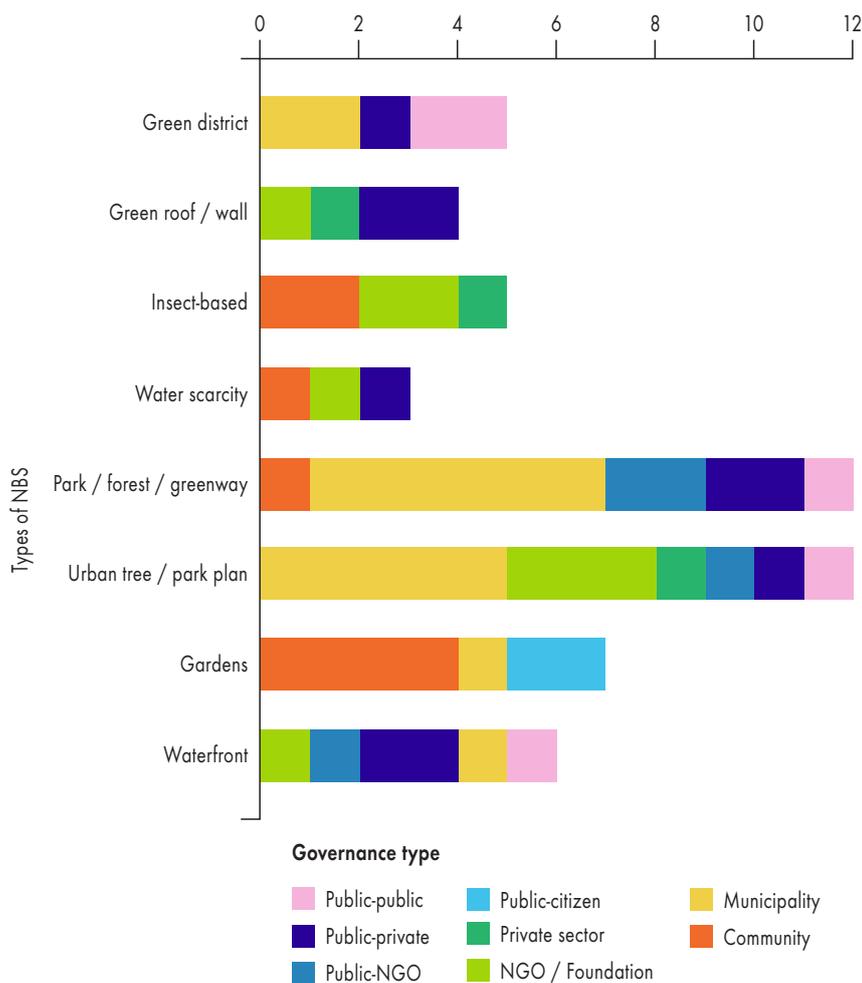
Ecological domains. The NBS studied here are grouped into eight physical domains: 1) strategies, 2) parks, 3) ecodistricts, 4) urban gardens, 5) green roofs, 6) insect-oriented interventions, 7) waterfronts and 8) measures addressing water scarcity. Almost half of the NBS fall into the categories of strategies (12) or parks (12); urban gardens also represent a larger group (8) in comparison to the other categories, which generally accommodate four to six NBS each.

Claimed aims in addressing urban sustainability challenges. The NBS studied here mostly address challenges related to conservation, (i.e. green space, habitats or biodiversity protection),

health and well-being, and climate change and climate resilience, but many of the initiatives are also related to increasing attractiveness through land use or urban development. Yet the environmental gains of grey-infrastructure based NBS could be offset by the ecological imprint of the associated building works.

Governance arrangements and public participation. Municipality-led NBS is still a dominant governance type, however jointly-implemented NBS by governmental and non-governmental actors emerge in a variety of domains. Municipalities are typically in charge of strategies and parks, while community gardens and insect-oriented initiatives are mostly managed exclusively by non-governmental actors. In this vein, most NBS have minimal public participation, often in the form of volunteering, educational and technologically-oriented tools, void of co-creation elements or deeper forms of dialogue between expected or projected beneficiaries and the implementing actors.

Social and environmental justice concerns. When Nature-Based Solutions are directed to green-deprived neighbourhoods or socio-economically vulnerable groups through the deployment of participatory methods, they tend to contribute to urban environmental justice. At the same time, while greening contributes to better quality of life and health in these neighbourhoods, such “beautifications” might also cause gentrification, especially if there already is such a trend in the area.



What enables NBS implementation?

Nature-based solutions emerge in complex institutional and governance structures enabled by different arrangements of actors, finances and policy – independently of the physical type of NBS.

NBS as a response to challenges. Some of the NBS studied here indicate that NBS emerge as novel responses to a multitude of challenges cities encounter. As opposed to previously-applied single-objective practices, we see an increasing recognition of NBS' multi-functionality, for instance, through the multiple claimed aims assigned to many of the NBS studied here. This also indicates a growing awareness of the potential of NBS in addressing sustainability challenges, which are often systemically linked.

Collaborative arrangements. There is a broad variety of actors, networks, institutions and intermediaries (often) from multiple disciplines, sectors and policy arenas working together on the design, development and implementation of the NBS studied here. These collaborative arrangements provide an opportunity to develop and maintain knowledge continua in different disciplines, across sectors and time horizons. When NBS emerge under hybrid (public-private) governance modes, economic reactivation and attracting capital can be prioritized over enhancing ecological and social benefits. Some of the common contradictions concern transparency, accountability, justice and democracy, particularly regarding the way that costs and benefits are distributed over time

Financing, policy and the key role of municipalities. Besides collaboration and knowledge continua, diverse sources and novel mechanisms of finance are shown to be critical for the implementation of NBS. In this vein, the prominent role of municipalities has several important aspects. NBS are often financed through municipal budgets and local policies frequently drive NBS implementation. Finally, municipalities often undertake iterative urban NBS experiments, although austerity contexts sometimes interfere with their capacity to fully intervene in the urban fabric.

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1. INTRODUCTION

Nature-Based Solutions (NBS) can help meet urban sustainability challenges by providing multiple benefits across a range of social and environmental challenges, including climate regulation, biodiversity and ecosystems loss, resource efficiency (Eggermont et al. 2015) and urban resilience (Kabisch et al. 2016). For instance, blue spaces (lakes, ponds, drains & wetlands) can provide stormwater regulation together with opportunities for recreation and biodiversity preservation (Madre et al. 2014; Pataki et al. 2011; Gill et al. 2007). Permeable surfaces and rain gardens can reduce pressure on urban drainage systems, lower heat island effects and reduce flood risks. Urban trees and forests improve air quality, sequester carbon dioxide, reduce energy use, and contribute significantly to the reduction of heat island effects (Emmanuel and Loconsole 2015; Hardin and Jensen 2007; Akbari 2002). Moreover, urban parks deliver public health and wellbeing benefits (Barton et al. 2012; Tzoulas et al. 2007; Maas et al. 2006; Gascon et al. 2016), while community gardens are associated with enhanced access to food, nutrition, physical activity, mental health, better community relations and overall community resilience (Barthel et al. 2015; White 2011; Wakefield et al. 2007). Notably, one of the key expectations of NBS deployment is their contribution to innovation, economic growth and job creation (Nesshöver et al. 2017).

Yet, in spite of the list of benefits anticipated from NBS, their adoption is far from widespread. Deeper comparative and transdisciplinary analysis of the multiple social impacts and values of NBS in terms of governance, finance and public participation is required to overcome the systemic conditions that currently limit the cultural change required for their adoption. In this vein, this report delves into the processes, mechanisms and tools which support or hinder nature-based innovations and their systemic integration. Overall, this report explores whether NBS can reconfigure the interests of policymakers, stakeholders and community groups while systematically integrating NBS into business-as-usual decision-making practices. The analysis of the dynamics and politics of NBS in cities undertaken here covers 54 interventions in 18 cities worldwide. In particular, it compares the governance arrangements (actors, institutions, partnerships, processes supporting NBS), dynamics of public participation, innovation patterns and social impacts associated with the emergence and deployment of NBS in a number of physical domains, cities and contexts. The report concludes with a discussion of the critical factors that affect the wider and deeper distribution and positioning of NBS.

This comparative report is part of a series of related outputs providing insights into unlocking NBS potential in the fields of

innovation (Taking Action for Urban Nature: Innovation Pathways Directory), governance (Taking Action for Urban Nature: Growing Effective Governance Solutions), finance (Taking Action for Urban Nature: Business Models Catalogue for Urban Nature-Based Solutions), and public participation (Taking Action for Urban Nature: Handbook for Citizen Engagement). This report is organized as follows: *Section 2* describes the methodological approach. *Section 3* contains the main findings of this report, cross-case analyses among 54 NBS organised into eight main sub-sections along a number of ecological domains (NBS types). The emergence of each NBS type is first described, followed by specific governance and public participation arrangements, aspects of innovation and wider socio-environmental impacts. *Section 4* discusses the constraints and enabling circumstances that need further thought for wider systemic NBS integration. *Section 5* concludes the report.



This report is a comparative analysis to extract key insights about the emergence and trajectories of different types of NBS, while reviewing their socio-environmental impacts, governance, finance and public engagement schemes, including aspects of innovation and contestation. To this end, the current report covers a total of 18 case cities, 12 in Europe and six in other regions. In each city, three specific NBS are examined, which provides a dataset of 54 NBS worldwide. In-depth case study analyses have been undertaken in each of the cities to frame the local context. Next, the NBS have been compared across all cities and domains along a number of uniform categories.

The case-study research in all 18 cities and respective NBS has been undertaken following a rigorous *Case study and comparative analysis protocol*. This protocol outlines the steps and provides guidance about the research themes and questions to pursue in each case study, together with the criteria for city and NBS selection, and the specific process required for data collection and analysis. This process resulted in preparation of a total of 18 working papers. The present report is an in-depth analysis of this material.

The general goal for selecting the cities and NBS has been to achieve a diversity of NBS domains, variety in the type of urban challenges addressed, different technical and social innovations in NBS, diversity in the forms of governance, finance and public participation arrangements, demonstration of key trends with respect to the effective implementation of NBS, and consultation with local stakeholders. Through this process, the following study cities were chosen: Athens, Barcelona, Boston, Cape Town, Dublin, Edinburgh, Győr, Leipzig, Malmö, Melbourne, Mexico City, Montpellier, Munich, Newcastle, Sofia, Tianjin, Utrecht, and Winnipeg.

The research themes and associated questions used for data collection and analysis include NBS intervention histories, impacts and implications, their governance and structural conditions, patterns of public participation, contestations and innovations. Certainly, the extent to which these questions are addressed in each particular case varies according to the specific nature of the NBS and the local context.

Data collection has been based on several pillars. First, analysis of key policy/strategy documents, media and grey literature

for each city was conducted. This embraced official and semi-official sourced materials, elaborated by public, business and community organizations, consultancies, think tanks, newspapers, blogs, social media, and websites. Second, a list of key informants for all NBS were selected and semi-structured interviews were conducted. At least 15 semi-structured interviews were conducted for each city, all recorded, and then either transcribed or distilled into detailed field notes. In that manner, in-depth expertise was extracted from key informants from policy and public domains, businesses, utilities, civil society and community groups. In six cities, mobile labs were used, whereby a mixed group of researchers and practitioners conducted in-situ analysis by collecting primary and secondary data on NBS interventions, enabling a rapid, multi-perspective assessment of the issues being encountered in the field, which also provided space for dialogue and debate.

Analysis for each city was based on how much the initial research questions were addressed in the interviews, either through discourse analysis or classification and coding techniques. This data has been written up in 18 working papers, which are the basis of this report's analyses. Data analysis for this report has been done iteratively through a mix-methods approach. First, thematic analysis was used as an entry point for comparative analysis using six research themes: history, governance, participation, impacts, contestation and innovation. To facilitate the thematic cross-case analysis, a comprehensive spreadsheet was created to synthesize and sum up key findings for each NBS based on the six research themes. The entries for each category were supported by guiding questions to synchronize responses (see Appendix 2). Secondly, Grounded Theory was used to identify emerging patterns and trends across cases, i.e. by close reading of the working papers. Section 3 of this report was elaborated using the former method, while section 4 was produced through the Grounded Theory approach.

To conduct purposeful cross-case analysis, inspired by Eames (2013), we have pulled together data on: (1) 'what' is governed (i.e. the physical domain and its emergence), (2) 'who' is involved in the process of governance (i.e. key actors, public participation), (3) 'why it is governed', or 'what is the aim/expected impact' of the NBS, and (4) 'how' the NBS is governed and implemented, with special focus on actors' responsibilities in the different phases of NBS, the role of municipalities (mostly in terms of decision-making power and financing, eventual experimentations and reflexivity of the governance process). Furthermore, the extent of innovation has also been reviewed, with special attention to the type of innovation in relation to the above four categories. To operationalize this framework, categories were developed for each aspect (see Appendix 1). Section 3 reveals how these different aspects intertwine and influence the development and implementation of NBS across NBS types and cities.

Section 4 is a more synthetic discussion which partly builds upon the social and environmental justice aspects of the NBS deployment and partly explores enabling factors for NBS innovation. The former aspect has been developed using an urban political ecology lens (Heynen et al. 2016), focusing on how much the studied projects could claim inclusivity, participativeness, and creation of shared forms of wealth. The latter draws upon innovation system theories, in particular the recently-developed Nature-Based Innovation System Framework (van der Jagt, *in press*).



The main findings in this section are organized around eight NBS typologies, as the qualitative comparison of the initiatives within the same domain provides the most functional and applicable insights. To this end, the patterns of emergence, governance and participation, the expected and observed impacts and the aspects of innovation are the categories on which this comparison has been built. Governance has been understood in a wide sense here, including an analysis of the set of actors, ownerships, partnership arrangements implemented to initiate and maintain projects, as well as of the forms of community participation and civil engagement achieved and manifested. Detailed information on the NBS studied below is available in the form of snapshot reports, and in a summary report of the working papers produced for each case-study/city (Sekulova & Kotsila 2018).



3.1 PLANS AND STRATEGIES FOR URBAN TREES, FORESTS AND PARKS

The analysis in this section builds upon plans and strategies for urban trees, forests and parks in Athens, Barcelona, Cape Town, Leipzig, Malmö, Melbourne, Munich, Newcastle and Sofia.

3.1.1 NBS emergence

Many of the municipal-level NBS plans feature street trees and urban foresting. The municipal tree strategies studied within Naturvation are all designed, led and extensively funded by the local administrations. The strategies in Malmö and Leipzig are still in progress, or about to be formally adopted, while Melbourne's strategy has been in place since 2012. All tree plans emerge with common concerns in terms of tackling air pollution, climate change (especially extreme weather events), and increasing densification associated with growing populations, while aiming to increase health, wellbeing and biodiversity through greenery. Their targets vary according to their particular socio-political environments and geography. While Malmö and Leipzig committed to planting 1,000 trees, Melbourne aims at 3,000 trees per year. In Leipzig, tree-planting efforts concentrate on two major roads, aiming to increase their attractiveness and eventually their socio-economic viability. In contrast, Malmö and Melbourne aim for a more dispersed canopy covering over 25% (Malmö) and 40% (Melbourne) of the cities by 2040. The latter two plans, building on ecological knowledge and research, further accentuate the importance of soil moisture, species diversity and tree vitality. Melbourne for instance, aims to have no more than 5% of any single species on its streets.

One factor that marks the emergence of effective tree plans is the tension between densification and the need/call for greenery, often seen in the local administration as a collaboration or a conflict between different departments with competing responsibilities, e.g. between infrastructure regulation and greenery. One of the obstacles to further tree canopy expansion reported for Leipzig and Barcelona is the increasing pressure on land, and hence space for housing and social infrastructure such as schools or social centres. In Leipzig, street-tree planting is especially challenging in residential areas where slots for vegetation have not been much integrated into the design of existing infrastructure, resulting in competition with other uses such as traffic, parking lots, or underground pipes and cables.

A number of plans and strategies seek an elusive balance between biodiversity preservation, climate regulation and socio-economic activities. Munich's Climate Adaptation Strategy is related to the urban tree programs listed earlier, emerging after a series of floods and heat waves in the city, but also responding to the densification process associated with

ATHENS: Hellenikon Metropolitan Park

This park is part of a larger private sector driven development project planned to start operations in 2018. Being the largest in Europe (approx. 200 ha), the park promises to provide Athens with a much-needed ecological boost, spanning an important portion of the site of the former Hellenikon International Airport. The planned project aims to boost greenery and create high-quality spaces while minimizing the natural resources used, protecting and enhancing local ecosystems. This development carries immense political and economic importance, as it fulfils an obligation toward Greece's creditors. Despite long struggles from self-organized civil groups and academics who supported the development of a sustainable open public park for all Athenians, the plan proposed by the development company is problematic due to the extent of grey infrastructure development both within and around the park, the privatization of public and natural (coastal and forest) grounds, and also due to its vagueness regarding ecological and sustainability aspects. There have been a number of alternative projects articulated but their political possibility remains limited.

BARCELONA: Special Plan for the Protection of the Natural Environment and Landscape of Collserola Mountain (PepNat)

The Collserola Natural Park is an approximately 8,000 ha forested area in the hilly Northern fringes of Barcelona. The park is jointly managed by a consortium of public actors, including the Catalan government (Generalitat de Catalunya), the Barcelona Provincial Council (Diputació de Barcelona), the Metropolitan Area of Barcelona (AMB) as well as all adjacent municipalities. The new Special Plan for Protection of the Collserola Natural Park (PepNat) is currently under formulation. The plan is being devised to address Collserola's new status as a NATURA 2000 site, responding to the challenge of preserving biodiversity while providing mostly recreational ecosystem services to the population in its highly-urbanized surrounding areas.

CAPE TOWN: Environmental Education Trust

The Cape Town Environmental Education Trust (CTEET) is a non-profit environmental education organization that seeks to improve both the inclusiveness of urban nature reserves and the effectiveness of biodiversity conservation by connecting nearby disadvantaged and racialized communities with municipally-owned nature reserves. Cape Town forms part of a UNESCO World Heritage Site called the Cape Floristic Region Protected Area, which includes nearly 20% of Africa's flora in 0.5% of its area. 17 nature reserves within Cape Town protect some of the area's biodiversity, but structural inequality has typically barred many disadvantaged communities from accessing recreation opportunities within reserves. To tackle the challenges of both biodiversity protection and extremely high unemployment levels, CTEET takes a crèche to career approach by offering youth environmental education in nature reserves in partnership with the City of Cape Town, job skills training in the conservation sector, and employment in roles like conservation monitors. In this way, conservation in Cape Town takes a more inclusive approach that offers opportunities to marginalized communities.

LEIPZIG: Urban Tree Program

The program is part of the city's climate change actions led by the city administration. It includes tree planting schemes in response to calls by environmental NGOs and citizens for more green in the city as well as to political pressures to improve air quality and reduce noise. It aims to plant 1,000 new street trees per year, mostly along major roads, and the establishment of new urban forests. Furthermore, it has a tree-adoption feature through which citizens can donate to tree-planting activities. The program is further envisioning the development of pedestrian- and cycle-paths as corridors among parks and green spaces.

MALMÖ: Tree Strategy

Malmö's recently-proposed Tree Strategy aims to increase biodiversity, create a comfortable climate, establish conditions to improve citizens' physical and mental health and help to preserve the city's cultural history (municipality driven). It also aims to change attitudes towards trees, whereby trees are to be seen as our common resources, not an obstacle in city development. The strategy sets concrete targets and responsibilities for tree management on different municipal stakeholders, but it also aims to involve larger landowners. These targets and responsibilities are linked to concrete budget posts, which makes the strategy transparent and operationalizable. The strategy's vision is to become one of the world's largest arboretums.

MELBOURNE: Urban Forest Strategy

The City of Melbourne's key overarching and most high-profile green space strategy is the Urban Forest Strategy (UFS). It is a central part of an innovative overarching policy framework of the City of Melbourne based on an ecosystem approach to climate adaptation. The strategy aims to adapt the city to climate change, mitigate the urban heat island effect by bringing inner-city temperatures down, create healthier ecosystems, become a water-conscious city, and engage and involve the community. The UFS seeks to protect against future vulnerability and to provide a robust strategic framework for the evolution and longevity of the urban forest in Melbourne. It also underpins the city's aim to create healthy ecosystems for people and nature; it has been developed along these lines and it is being implemented in intensive consultation with citizens.

MELBOURNE: Urban Forest Fund

The City of Melbourne launched the Urban Forest Fund (UFF) in May 2017 to provide financial support to new greening projects on privately-owned land which entails 75% of the total land area. Projects include green spaces, tree planting, vertical greening and green roofs. The UFF currently has AUS\$1.2 million in seed funding and the City of Melbourne's aim is to increase this through contributions from organisations and individuals either as supporters or as partners. Under the public-private partnership scheme, the UFF aims to increase the amount of green infrastructure across the city area by fund-matching greening projects dollar for dollar.

MELBOURNE: Green Your Laneway Program

The City of Melbourne, through the Urban Forest Strategy, has a comprehensive plan for greening major streets and precincts, but not smaller laneways. Across the municipality, laneways occupy a ground area of 60 ha, with a further 150 ha of vertical space. The Green Your Laneway Program investigates the opportunity for lanes to be greened to provide shading and local cooling, improved aesthetics and local amenities, ecological benefits, health and well-being while increasing landscape permeability and hence flood mitigation and passive watering. The programme started in 2014 and 4 lanes are selected for greening each year (AUS\$1.8 million). From growing vertical gardens, to planting trees and creating pocket parks, the laneways have enormous potential to become the city's backyards. Citizen engagement is one of the key features of this program.

MUNICH: Greening Office

The Greening Office is part of a non-governmental organization (NGO) called Green City. It aims to increase awareness and engage citizens and the private sector in implementing greening measures on private plots across the city. Green City was founded in 1990 by a handful of dedicated citizens with the goal of creating a people-friendly green Munich; today it is the biggest environmental organization in Munich. The NGO is supported by the City Council as part of its climate protection program. The Greening Office, created with co-financing from the city of Munich, offers free-of-charge expert knowledge and advice on green walls, green roofs, and other issues relevant for greening private lots. By doing so, it not only facilitates the implementation of private greening, but also increases awareness of and supports climate adaptation.

MUNICH: Climate Adaptation Strategy

The Climate Adaptation Strategy (2016) is a great example through which the challenges and importance of creating organizational structures and knowledge for integrating NBS in comprehensive and detailed planning can be demonstrated. In 2013, the city council put adaptation on the agenda and employed a climate adaptation manager in the environmental department. In 2014, an organizational structure was established to support the development of the strategy. It comprised a steering and a working group, both including various units and levels of decision-makers. The strategy includes a total of 26 mostly green or blue multipurpose measures, aiming to counteract expected temperature rise, heat waves and more frequent heavy rainfalls, while increasing health and well-being. The city council has provided separate funds for implementation of the measures and has instructed the departments to document the implementation status.

NEWCASTLE: Business Plan for Newcastle's Parks

Newcastle City Council's budget for parks has been cut by 90% between 2010 and 2017. In 2017, a public consultation was run on the proposed transfer of operations, delivery and maintenance of parks and allotments from the City to a new Charitable Trust. The plan, which was still in the approval phase as of 2017, stipulates that the land remains owned by the City Council, while the Trust should generate additional revenue to maintain the parks through the sale of multi-functional services. Continuing to maintain parks as a public service was not considered an option within this business plan in the light of budget cuts. (public-NGO partnership)

SOFIA: City Forest Plan

The City Forest Plan is envisaged as a community tree park in Sofia targeting the biggest environmental challenge of the city, air pollution. The intervention is an undertaking of a non-governmental organization and relies solely on citizens' engagement in terms of tree planting and maintenance. The intervention unfolded after the leading NGO, together with other NGOs, initiated the candidature of Sofia as a European green capital. Through planting trees on neglected urban land and restoring green eco-corridors that allow fresh air from the mountains to reach the city, the intervention is expected to improve the air quality, reduce carbon emissions and also provide a place for recreational activities.

its urban growth. It is however wider in (planning) scope; it embraces a total of 26 measures, which are intended to counter temperature rise, heat waves and heavy rainfalls, while improving health and well-being. The plan puts a strong emphasis on NBS, such as open green spaces, rooftop gardens, (large) trees, and blue areas.

A management plan struggling with similar issues is the Special Plan for the Protection of the Natural Environment and Landscape of Collserola Mountain – an 11,000 ha park and protected area within the metropolitan area of Barcelona. Initiated by adjacent municipalities and regional authorities, the plan aims to strike the difficult balance between providing various forms of ecosystem services (such as recreational activities and habitats/biodiversity preservation) through zoning schemes with different levels of intensity.

Austerity and post-crisis politics force a profound reconfiguration of urban NBS, affecting their planning and management. The interventions discussed here happen in contexts of austerity, state absenteeism and (post)-crisis politics. One of these is the transformation of the former Hellenikon airport in Athens into a multi-functional development that includes a 2,000,000 m² area with green elements, including a park. The park is planned to span one third of the area, while the remaining zone is destined for residential and commercial buildings, including shops and a casino. In 2011, this property was included in a list of public assets that were to be capitalized as a means of helping the Greek state to recover from economic crisis. In fact, the current plan for a Metropolitan Park was negotiated and developed as a means of compliance with the conditions set by the international creditors of the Greek state. Importantly, initial plans envisioned the entire area as a recreational metropolitan public green zone, potentially the green lungs of Athens. Yet, in face of the crisis it was sold off (or 'assigned') to a financial fund which allowed for land speculation and substantial construction in the zone.

Another NBS in this group, which needs new sources of funding, is Newcastle's parks. After the municipal budget for park maintenance was cut by over 90% as part of austerity implemented by the British government, the city council looked into new approaches to financing public green areas. The proposed business plan envisions the creation of new and diverse revenue streams, especially those built on commercial activities in city parks, and the engagement of citizens as volunteers for the maintenance of the green zones.

Lastly, Sofia City Forest is an NBS led by Bulgarian civil society groups, very much in the planning phase, envisioned to be implemented through private donations. The major contribution of the City Hall to the forest's establishment is to engage with the search for ways to accommodate the civil initiative – and to an extent public demand for cleaner air. The city is thus looking for a potential citizen-led park that meets current regulations. The municipality has no explicit intention to finance the establishment of urban parks, or to adopt climate change adaptation measures in the city.

The emergence of these three interventions can be seen as due to 'state failures' where NBS are inserted or converted into profitable ventures or managed through so-called civic governmentality, within a neoliberal economy (Lemke 2001).

Certain plans emerge in response to the increasing need of citizens to plan and undertake greening activities in their neighbourhoods and homes (mostly in the Global North) and to make urban nature, including nature reserves, accessible and rewarding for disadvantaged communities (mostly in the Global South). Two NBS within this category are promoted as educational initiatives: the Cape Town Environmental Education Trust and Munich's Greening Office. The former was founded in 2001 to increase social inclusion of low-income and racialized communities in Cape Town's nature reserves, while the latter is an NGO advising citizens, building owners, and private companies on how to green private spaces to help confront climate change. The Greening Office started as a volunteer-based organization aiming to make Munich greener and less car-choked, eventually growing into an NGO with 25 staff members receiving public and private funding. The Environmental Trust, on the other hand, brings children to nature reserves so that they can develop an intrinsic connection to nature. It also offers career development pathways for adults from disadvantaged and racialized communities, based upon the idea that nature conservation could only succeed when people from areas near nature

reserves feel that these offer them socio-economic opportunities and livelihood support. The Green Your Laneway Program in Melbourne also aims to involve communities in neighbourhood greening activities, but in contrast with the other two NBS, it is initiated and managed by the City of Melbourne in selected laneways, which are not covered by other greening plans, such as the Urban Forest Strategy or Urban Forest Fund.

3.1.2 Governance and public participation

Most of the plans and strategies for urban trees, forests and parks are municipally driven or emerge in partnership with the municipality.

Although many of the strategic plans are municipally driven, NGOs frequently emerge as initiators and stewards.

NGOs often act in collaboration with municipalities and/or citizens, either as initiators of the NBS or as potential partners taking over and managing the NBS after a municipal initiative. Grupa Grad, the local NGO in Sofia, carries out proactive visioning, planning, coordination and fundraising for the NBS. The principal role that NGOs play in plans is also apparent in the Environmental Education Trust (Cape Town) and Greening Office (Munich). While the Educational Trust in Cape Town can use municipal resources, including municipal office space and nature reserves, their education and training activities are funded through homeowner conservation associations, education program participation, donations and government funding. Alternatively, the Greening Office is an independent operation under a well-established NGO, which mostly relies on annual funding from the municipality. This implies that the municipality can predetermine its activities in a way that may conflict with the NGO's strategies and outreach approaches. In the case of Newcastle's parks, the municipality is the initiator of a business model aiming to transfer responsibilities to a charitable trust responsible for funding and maintaining the urban parks. Funding there is expected to come from self-financing by sale of services (such as funeral sites, mini-golf courses, cafes, and retail outlets) or from a large endowment. As the implementation of this new business model for Newcastle parks is still pending, the maintenance of the park is being subsidized by the public health budget.

While greening plans traditionally fall under municipal jurisdiction, there is an emerging trend to engage private actors and funding in their deployment.

Both Melbourne's Urban Forest Fund and Leipzig's Baumstarke Stadt are municipal initiatives, which very early in the process engaged with private actors. The Urban Forest Fund specifically targets businesses, developers, property owners to undertake greening measures, such as green roofs, walls, tree planting and rainwater collection on private grounds. This fund is envisaged as a public-private partnership, where municipal funding is matched with private money either through 'partnering' (i.e. matching 50% of the cost needed), - or 'supporting' (i.e. donations, seed funding). In the Baumstarke Stadt, citizens can donate a minimum of €250 for tree planting, which resulted in 5,000 additional trees on top of the Urban Tree Program. Melbourne's Green Your Laneway Program also falls within this category, focusing on potted plants, pocket parks, green walls and vertical gardens in combination with green roofs. Both the Forest Fund and the Green Your Laneway Program complement the Urban Forest Strategy by targeting private or semi-private land that are not covered by public land policies. The re-development of Hellenikon in Athens is the only initiative financed and managed entirely by private developers, which had severe, mostly negative, implications for the initial greening scope and ambitions of the NBS.

Although the role of municipalities is crucial in all of the cases, their commitment and responsibilities vary largely.

In Malmö, the Streets and Parks Department is the main actor responsible for the implementation of the Tree Strategy, and at the same time it seeks more collaboration with other municipal departments and large land owners (e.g. real estate companies, or the Swedish Church). Collaborations are often used as a strategy to overcome both the internal tension between competing departmental aims and the external tension related to land-use priorities. While Malmö's Tree Strategy aims for municipal funding and collaboration with larger land owners, the City of Leipzig directs its attention to citizens' support. In Baumstarke Stadt, as part of the city planning program, citizens can adopt a tree through a minimum donation. In

this sponsorship scheme, the municipal tasks of financing and maintenance are combined with private funding.

Likewise, citizens and laneway communities are important actors in Melbourne's Green Your Laneway Program, where the municipality facilitates bringing together many different stakeholders, private and public land owners, designers, architects, engineers, local residents and businesses in designing and envisioning their neighbourhood. This is largely implemented through the Participate Melbourne webpage and the assistance which the city provides to property owners in the form of information on required permissions, maintenance and compilation of planting tips (including suggested species) for selecting adequate plants to thrive on the site.

The Special Plan for the Protection of the Natural Environment and Landscape of Collserola Mountain (Barcelona) is another example of a municipal role as initiator, land and resource provider. The plan was initiated and is now jointly managed by the park office, adjacent municipalities and regional authorities. As it is beyond the jurisdiction of municipal departments, the metropolitan region is responsible for formulating and putting together the plan and conducting the consultative process around it.

Successful strategic plans require diverse forms of collaboration from inter-departmental to external engagement with the wider community. Melbourne's Urban Forest Strategy and Munich's Climate Adaptation Strategy (CAS) are both powerful overarching municipal plans. Yet, their design and implementation have taken different pathways. The Urban Landscapes, Policy and Design Branch in the City of Melbourne involves federal, state and local governments, leaseholders, and environmental sector leaders, research and educational institutions, artists, industry forums, businesses, schools and developers in an effort to educate, inform, manage and enhance urban ecology across the city. The implementation of the Urban Forest Strategy of Melbourne has several interrelated programs (e.g. Capital Tree Planting Program, Urban Forest Health, Urban Foresters) addressing aspects of a healthy urban ecosystem, each with dedicated budget posts and active citizens' engagement from design to maintenance. The City of Munich on the other hand has kept the CAS as an inter-departmental process, with thematic working groups, including various units and levels of decision makers. The climate protection manager works toward the integration of climate adaptation measures in a decentralized manner and at all planning levels. The process is financed through governmental funds for climate change adaptation, established in 2014 by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Thanks to this integrated institutional process, the adaptation strategy is well-grounded in the municipal departments' ongoing work to make it easier to implement and sustain. Yet in contrast to Melbourne's Forest Strategy, the citizens of Munich have never been considered as critical contributors to these strategic documents.

Public participation associated with tree strategies tends to occur in the form of non-conflictive, or educational events, promotion of online tools and nomination of sites for greening. Malmö's Tree Strategy provided for educational activities, involving citizens in developing and updating the city's tree register. Citizen involvement is however regarded as a challenge in terms of the resources invested and the efficiency of participation. In contrast, Leipzig's Urban Tree Program organized several participatory events for the establishment of the draft concept, when suggestions for possible locations were gathered. Reports from NGOs, however, state that the total inventory of 57,000 trees along the streets of Leipzig could be almost doubled. Yet this was not considered in the Tree Program.

The City of Melbourne also sought civil engagement through local forums and online feedback, using place-based storytelling to engage the community in discussions around renaturing and climate resilience. Local authorities committed significant resources to community engagement, including online applications such as the i-Tree Eco tool. The inputs collected by the community are reported to have contributed to the development of the strategy. Likewise, the city's Urban Forest Fund targets citizens and property owners interested in greening their property and inviting them to contribute to the fund. The Green Your Laneway Program, on the other hand, has been passing through a public consultation phase where sites were nominated, followed by comprehensive criteria (elaborated by the municipality), eventually leading to the selection of four laneways that received funding for greening. The public did not participate in the selection process, nor were issues of inclusivity and

marginalization considered as potential criteria for inclusion among the list of winners.

Technical plans and (green) strategies often reach the public at an advanced stage of their development or in formats that are not easy to digest. The public participation in the preparation of plans - be it for management such as Collserola in Barcelona, or climate adaptation as in the case of Munich - started with a version designed by experts in the field, which was then presented to the public with little or no prior information on its content. In Barcelona, citizens were invited to comment upon the initial drafts through a series of meetings, where – despite the inclusive small group format – the topics to discuss were pre-decided by the organizers, which obstructed effective participation according to key informants.

Similarly, in the case of Newcastle, formal consultations solely focused on the proposal to implement a new business model for city parks despite citizens' and community groups' request that parks were funded by the city as public goods, or despite their concerns that the new business model could lead to creeping privatization and commercialization of the parks. This is related to civil groups' concern that the charitable trust that is proposed to run the parks may not be democratically accountable. Nevertheless, the financial performance of the new park business model was the primary criterion for evaluating its success or failure considered by the city.

Likewise, in Hellenikon (Athens), citizens had 30 days to read a 2,500-page technical document prior to public consultations, which even architecture experts claimed was hard to process, let alone citizens without special expertise. In the planning phase of the project, with the election of a new government in Greece in 2015, a team of architects from the Technical University of Athens had been asked to contribute. Yet, even at that point, there was little room for influencing investors in terms of changing the key features of the development and associated park. Some of the points that changed in the initial proposal included an agreement to increase connectivity of the park with surrounding municipalities and to prioritize its construction in the timeframe of the project.

Furthermore, citizen engagement often depends on and is related to the interest and goodwill of the individual(s) coordinating the plan, for example in Munich's Climate Adaptation Strategy, Barcelona's Collserola Park, and some of the urban tree plans. Climate plans, for example, are generally considered to be too technical to engage citizens at an early or intermediate stage. The design of the Climate Adaptation Strategy in Munich involved mostly internal stakeholders, with their own inter-institutional power structures and pre-existing institutional epistemologies.

Lack of trust poses a serious impediment to effective public participation in NBS. The contextual distance between civil groups and municipalities, or the historical background of civil (un)cooperation and pre-existing contestations influence participation processes. Lack of trust sometimes makes municipalities reluctant to genuinely engage with civil groups (see e.g. Munich, but also elsewhere). A key impediment for public participation in larger NBS plans and management documents is the lack of trust, or the perceived sense that a proposed plan would go ahead regardless of consultation responses, particularly visible in the cases of Newcastle's parks, Barcelona's Collserola Park, and Athens' Hellenikon. Issues of privilege, or who could afford to volunteer and participate in NBS consultations and managements are another factor that leads to low turn-out rates. As noted in the case of Newcastle parks, participants in the public consultations and potential volunteers who could help with the maintenance of the park came mostly from affluent areas.

Related to the issue of trust are poorly-designed public consultation strategies which often result in low participation rates. Ineffective communication strategies designed by local administrations (for reasons like insufficient resources dedicated to announcement), play a key role in how well citizens are informed about the participative process and consultations. For example, the turn-out rate in Barcelona has been relatively low given the scale and extent of the population using Collserola Park.

Finally, **there are cases when participation is actively avoided by the designers** of interventions, especially evident in

Hellenikon (Athens). The planning process was described as 'secretive', based on fictional negotiations, or without providing citizens with a means to engage, so that the expected financial gains of the project are not compromised. One of the results of this minimally-participative process was that the publicly-accessible green space in Hellenikon did not increase, leading two professors of architecture who led the negotiating committee to resign soon after the consultations.

3.1.3 Aspects of innovation

These plans and strategies are typically social innovations, experimenting with institutional structures, altering roles and responsibilities of various actors and testing new ways of financing implementation and maintenance activities. The emergence of engaging private actors as financiers in traditionally municipal responsibilities can be seen in different ways in Leipzig's tree projects, Melbourne's forest fund and Newcastle's proposed business model for park maintenance. In other NBS, such as Melbourne's Forest Strategy and Green Your Laneway Program, the city is experimenting with different ways of community engagement in different phases of the NBS. Furthermore, the Green Your Laneway Program uses community engagement to further experiment with different urban spaces and the potential roles of different actors in these new spaces. The Climate Adaptation Strategy in Munich is a good example of experimentation with institutional structures inside the municipality. A new structure was developed in 2014 to support the CAS, including an inter-departmental steering committee and a thematic working group, both including various units and levels of decision-makers, and a climate adaptation manager coordinating the implementation of climate adaptation measures. Similarly, the City of Malmö also tries to create new ways of working in the Tree Strategy to better reflect shared responsibilities (among different municipal departments and larger collaborating property owners) over common resources (i.e. trees). This is achieved by linking specific goals and activities to specific budget posts and making actors responsible for different activities. This makes the Strategy more concrete, transparent and interpretable for different actors.

In addition, some of these cases demonstrate reflexive governance. The City of Melbourne, for instance, engages citizens in various ways in its strategic policy document development, including the Urban Forest Strategy, in the name of citizens' health and wellbeing. The Green Your Laneway Program is a good hands-on example of back-and-forth negotiations with local communities and local businesses in NBS development from design, through implementation to maintenance. The strong interconnectedness among the different policy documents, reflecting citizens' wishes, images and visions on the development of their city further strengthens the reflexivity of Melbourne's governance style.

3.1.4 Expected and registered impacts

Measurable impacts are hard to obtain due to sporadic evaluations, attributability or simply recent initiation. In most of the NBS that concern plans, it is hard to speak of impacts as implementation is still underway or pending. However, there are indications and predictions of expected environmental, social and economic impacts and their implications. Most NBS of this type aim to provide regulating services (including air quality improvements, noise reduction, carbon sequestration, flood regulation), supporting services (including habitat preservation) and cultural services, (environmental education/awareness, recreational and social benefits, aesthetic landscapes), while generally contributing to public health and accessibility of green spaces.

Overall, even if some part of the NBS is implemented, measurable impacts were hard to obtain as projects are either too new or evaluations are only sporadic and partial, often lacking baseline data. Measuring impact is difficult when the time horizon needed for impacts to be felt is too long, i.e. Malmö's Tree Strategy, Munich's Greening Office educational and awareness-raising objectives. Attributability is often challenging, as it is difficult to measure the singular impacts of one intervention vs. other factors, i.e. the impact of trees in Malmö's Tree Strategy or the role of Munich's Greening Office in the emergence of

projects around greening and climate adaptation.

The overall (environmental) impact of plans together with the grey infrastructure tied to them is often neglected and requires further exploration. NBS plans typically encompass an array of actions with a large geographical reach, making it difficult to assess their overall environmental impact, especially when grey infrastructure elements are attached or required for their deployment. In Hellenikon (Athens) and in Tolka Valley Park (Dublin), grey development funding was needed for the NBS to realize its full potential. In other words, ambitious nature-based plans are often tied to grey development, something often not considered when measuring impacts. This is the case with NBS, which are expected to attract further grey development by making neighbourhoods more liveable and attractive - see Sofia's City Forest, Melbourne's Green Your Laneway Program, Leipzig's Urban Trees project and Dublin's Liberties Strategy. In some plans economic development is part of the NBS' aims, while others do not take it into account when evaluating impacts. In that way, the assessment of environmental/ecological impacts is often limited to the intervention itself, i.e. how many trees will be planted, but fails to consider changes that transcend the NBS either in time and space.

Socio-economic impacts of plans are blurry. Plans promise multiple benefits, and thus gain popularity and support, but often remain vague about how such measures will be implemented, neglecting implementation difficulties or discrepancies. Hellenikon Park claims features of sustainable water management, enhancement of the natural local environment (streams) and human comfort (shading, acoustic barriers, reflective materials), but it is noteworthy that none of these are specified in detail (where, how many) and there is no legally-binding mechanism to ensure implementation of these features takes place. Similarly, while the projected expectations of new jobs are high (75,000), the type and longevity of projected employment is not described or evaluated. In turn, other economic impacts that affect society more generally are overlooked, such as public land privatization. Another example is the case of Collserola Management Plan, where the development (or not) of the park's fringes, potential gentrification, and the regulation of existing illegal housing have not been clearly addressed in the current versions of the Plan. In Newcastle, important savings are expected from the newly envisaged parks management plan, but inequalities due to the limited ability of deprived neighbourhoods to mobilise volunteers and raise funding through commercial services in their parks are not taken into consideration. New concepts and ideas are often introduced but these are not well digested by all stakeholders, giving rise to questions about their implementation and potentially-contested impacts, i.e. the proposal for "adaptive management" in Collserola's PepNat, or for co-management in some of the initiatives of the Liberties Greening Strategy in Dublin.

Citizen engagement scales up the positive impact of plans and strategies. In the case of Melbourne's Urban Forest Strategy, a reflexive co-governance approach, with face-to-face workshops, e-governance and continuous co-creation, fostered rights and responsibilities of citizens as urban ecosystem managers. For projects to address the practical and institutional complexities that large-scale greening involves, collaboration with multiple state authorities and support from (or formation of) non-profit organisations proves beneficial. NBS that focus on education and awareness raising through citizen and grassroots engagement (i.e. Cape Town's Environmental Education Trust or Munich's Greening Office) produce noticeably positive public reactions and implementation follow through. Similarly, positive impacts are seen where novel environmental ideas and practices are key features of the NBS.



3.2 PARKS, URBAN FORESTS AND GREENWAYS

Analysis in this section builds upon parks, urban forests and greenways in Barcelona, Boston, Cape Town, Dublin, Edinburgh, Leipzig, Montpellier, Sofia, Tianjin and Winnipeg.

3.2.1 NBS emergence

Two out of the seventeen parks and greenways studied here emerged as a result of private ownership or donation. Vrana Park in Sofia, previously owned and maintained by the Bulgarian royal family opened to the public after it was donated to the local municipality. Unlike other urban parks in Bulgaria, it is only open during weekends and has a small entrance fee which the municipality collects to help fund its management. Having been a private, fenced, no-go zone for more than 50 years, the 97.5 ha park now hosts rare flora and fauna, together with well-preserved wilderness areas, also accessible through guided tours. Critical junctures here concern the buildings within the park, which are still owned by the royal family. In a somewhat similar fashion, the Stavros Niarchos Foundation in Athens developed a cultural centre with multiple features, including a green zone on a derelict area, and handed it over to the Greek state in 2017. The donation was however accompanied by very strict conditions on management of the building, including high operational costs.

Returns from residential development are reported to trigger park and greenway emergence in two NBS studied here. Dublin's Tolka Valley Park, especially in its second phase, was initiated by the park department and tied to funding from housing developments on the lower South side of the park. Initially the Tolka pond was aimed at providing an amenity for lower-income residents living around the park. Yet, with the financial crisis and public funds drying up, the envisioned users of the park were the upper-class residents of the real estate that helped raise the funds for its establishment. Similarly, the Two Rivers Urban Park in Cape Town (still in the planning phase) straddles public (land) ownership and private (housing) development. The NBS would involve the redevelopment of an industrial area in Cape Town and a degraded river into a green space with new housing whose siting is the subject of ardent negotiations, not the least because this area is very close to a business district.

The chronic lack of green space and civil mobilization around are key drivers for the emergence of new parks. Grassroots mobilization around the uneven distribution of green space calls the attention of local municipalities to bring nature back to particular neighbourhoods. This movement gave rise to Dublin's Liberties Greening Strategy and its two emblematic parks: Weaver and Bridgefoot St. Parks. Notably, these parks emerged in the aftermath of the Irish economic crisis when real

BARCELONA: Passeig de Sant Joan Green Corridor

The redevelopment of the 'Passeig de Sant Joan' (2010-2015) promenade into a green corridor is a project initiated by the City to increase ecological and social connectivity within the city. The particular measures involve the widening of sidewalks at the expense of car lanes, where rest areas and playgrounds were installed while planting native tree species and shrubs of various heights, low on water demand and rich in diversity. The semi-green pavement controls for runoff waters, retains less heat and has a cooling effect associated with the evapotranspiration from vegetation.

BOSTON: Porous Alley

The Porous Alley (in Public Alley 543) is a demonstration project to explore the feasibility of using porous pavement to increase groundwater recharge and to reduce flooding and water pollution. The alley is in the City's Groundwater Conservation Overlay District, and has been identified as an area where a low water table threatens building foundations. Drainage from the alley flows into a combined sewer, contributing to overflows and pollution during heavy rainstorms. Heavy rain can lead to ponding in the alley or localized flooding. The Porous Alley consists of a 66 foot long, 10 foot wide section of porous asphalt in the middle of the alley, with a coarse gravel storage area beneath it, creating 425 cubic feet (nearly 3,200 gallons) of water storage. Project goals include cleaning and filtering polluted runoff to prevent it from entering the Charles River and recharging groundwater levels to reinforce the structural integrity of nearby buildings. (public-public partnership)

BOSTON: East Boston Greenway

The East Boston Greenway is a shared-use path and park in East Boston located along the path of a former railroad (Conrail Line). The greenway connects several significant open spaces in East Boston, including Piers Park, Memorial Stadium, Bremen Street Park, Wood Island Bay Marsh and Belle Isle Marsh. When completed, the line is expected to be 3.3 miles long. The Greenway operates at the neighbourhood scale as a backyard for young children to safely ride bikes and play. It also operates at the city scale, enabling connections to transportation. As each additional segment comes on line, the Greenway will become a great recreational asset and amenity at a more regional scale. (public-NGO partnership)

CAPE TOWN: Two Rivers Urban Park

Proposals are being negotiated that would see an industrial area in Cape Town and degraded river and green space area redeveloped into a mixed use, mixed income development – with green space rehabilitated into a park. Two Rivers Urban Park is at the confluence of the Black River and the Liesbeek River. This geography is a suitable metaphor for Cape Town; the Liesbeek River runs through affluent neighbourhoods as it snakes down from Table Mountain to the ocean and has been substantially rehabilitated through the work of the privately-funded Friends of the Liesbeek organization. The Black River, on the other hand, runs through disadvantaged and racialized suburbs in the Cape Flats and has been substantially altered to accommodate outflow from a wastewater treatment plant. At Two Rivers Urban Park, the rivers meet. Public participation processes have exposed contestation about the appropriate scale for development and how that would impact access to and aesthetic appreciation of the park. Several proposals have been developed for what the site should be, including from external consultants, government agencies, academic think tanks, and grassroots community mapping, all of which propose different relationships between development and the park. These proposals, as well as the rehabilitation of several sections of green space and the rivers highlight questions of different values for nature, of gentrification and economic development, and of public participation in planning NBS. (public-private partnership)

DUBLIN: Liberties Greening Strategy - Weaver Park and Bridgefoot St. Park

The Liberties Greening Strategy seeks to improve the recreational amenities of the Liberties Local Area (municipality driven). Two of the most significant new green spaces are (1) Weaver Park and (2) Bridgefoot St. Park. Weaver Park has been built on a 0.6 ha area in the Liberties aiming to address the lack of green space in the area and to provide a place for recreational activities such as skateboarding and community events. The creation of Bridgefoot St. Park - instead of further housing development - was approved by local authorities as a response to years of campaigning by local residents in the area. The park will include lawns, flowers, trees, furniture, lighting, allotments, a community garden, a terrace, a playground, and more - all built on former derelict land.

DUBLIN: Tolka Valley Park - Wetlands and Greenway

The development of a four-kilometre greenway and off-road cycling route, linking Glasnevin Finglas with Ashtown, with three integrated constructed wetlands is a significant green infrastructure project for Dublin. The municipality driven NBS is a continuation of the successful 'integrated constructed wetlands' intervention which was created in 1999 as a novel way of treating the polluted incoming waters of the Finglaswood Stream. The Greenway was a project aiming to add 20 hectares of newly-developed parkland to the city, connecting neighbourhoods and offering ecosystem services to a newly-built complex of apartments south of the park. After big biodiversity benefits from the first constructed wetland system, including the return of salmon to the river, the second phase aimed at enhancing habitat diversity, new wetland ponds to be planted, with aquatic and marginal vegetation, new hedgerows, thousands of trees and seven hectares of wildflower meadow. Control of invasive species, such as Giant Hogweed and Himalayan Balsam, was also planned as part of the on-going management policy.

EDINBURGH: Little France Park

Little France Park is a multi-stakeholder initiative to develop new parkland for the local community of Craigmillar, as well as the staff of the adjacent hospital and research campus (under construction). Craigmillar is a socio-economically disadvantaged neighbourhood and the park aims to improve interactions between professionals working in this area and the local community, as well as their health and well-being, in part through the implementation of an active travel route through the area. In addition, as part of Edinburgh's green belt, it connects green spaces and habitats. However, land use at the site is contested, with different municipal departments having different objectives. The original area designated for park development was larger, and land has been sold off to construction companies. To avoid further fragmentation of the green space, the Parks and Greenspaces department of the city has initiated a public-private partnership, which is led by the Edinburgh and Lothians Greenspace Trust.

LEIPZIG: Green Spaces in East Quarter

This intervention comprises several schemes aimed at revitalising one of the city's most structurally disadvantaged, yet most culturally vibrant areas. It involves invigorating the area through the redesign, extension and new development of parks, the greening and communal use of vacant plots, the establishment of new urban forests, setting up new communal gardens, and the planning and partial implementation of a green corridor for cyclists and pedestrians. This community driven NBS covers three different case studies: 1) Querbeet communal gardening project, 2) Bunte Gärten intercultural gardening initiative and 3) Parkbogen Ost green mobility corridor.

MONTPELLIER: Green and Blue Urban Network

In 2006, the City of Montpellier started to develop a plan for green structures in the municipal area, which has been further developed and it is still in progress as of 2018. The state and the city share the €446,000 cost of the NBS, respectively contributing 52.8% and 47.2%. The initiative includes mapping and studying green areas in the city with a focus on biodiversity, defining its value to counterbalance ongoing urbanization pressure and to create links between green and blue infrastructure. Rivers, including the large Mosson and Lez, are largely integrated in the Green and Blue Network Project. The aim of this municipality driven NBS is to improve the living environment of the people of Montpellier, to connect natural spaces to improve the functioning of urban ecosystems, and promote the movement and maintenance of plant and animal species in urban areas.

SOFIA: Vrana Park Museum

Vrana Park Museum was once a summer residence of the Bulgarian royal family and had a strict no-visitor policy for years. The creation of the park started in 1903 and for over 40 years an ensemble of 821 tree, shrub and grass species were planted on less than 100 ha. Dozens of unique plants from all over the world were brought to Vrana; the landscape design includes gardens, alpineums (rock gardens), conservatories and a lake with lilies created in 1909. The giant water lily is one of its most impressive plant species. After the estate was given back to the successors of the royal family, they partially donated it to Sofia municipality and in 2013 the 'Vrana' park-museum was opened to visitors. Due to its rare species, well-preserved wilderness and historical significance, the park enjoys great interest from tourists and locals as well as from scientists as a biodiversity hotspot.

TIANJIN: WUQING DISTRICT - Integrated green and blue infrastructure

The Wuqing District is a rapidly-developing suburban district, north of the downtown core, housing about 1 million residents. The area has a rich ecological environment consisting of four larger rivers, seven smaller rivers, two water reservoirs, and one of the most important forest reserves of Tianjin. The district meets the requirements of the national 'Garden City' standard with over 36% green coverage. In 2014, the area was selected to be a pilot national ecological demonstration area; over €500 million was invested into blue and green infrastructure projects, and the third China Green Expo was organized here (2015). Some highlights include the 2.53 million m² North Canal Suburban Park which combines camping, entertainment and wetland areas where over 72,000 trees were planted, and the South Lake Area that combines business, recreational, residential, and ecological areas, including three islands. (municipality driven)

WINNIPEG: Community-based renaturalisation

Over a dozen public areas of Winnipeg have been turned into wildlife habitats by communities, supported by the municipal Naturalist Team and a network of change agents. Northeast Pioneers Greenway: through the effort of local communities, the abandoned railway tracks were revitalized, and turned into a bike path and no-mow-zone along an 8 km strip. Henteleff Park: this 160,000 m² riverside area was turned from a market garden into a diverse riparian forest by local communities, who planted over 6,000 trees in the last decade, and created an interpretive education centre to highlight the park's deep historical roots. Bishop Grandin: a network of natural prairie habitats, public pathways, community gardens, and naturalized stormwater retention ponds along the Bishop Grandin Boulevard tying together local communities. Wildwood: local communities have planted thousands of trees, restored prairie grasslands and the riparian forest. Transcona Community Bioreserve: a 45 ha former wood preservative treatment facility was turned into a bioreserve used by cyclists, dogs and walkers.

estate development was sluggish. These are relatively rare cases where urban space is rezoned from grey (earmarked for housing) to green (dedicated to parks), made possible by bargain-priced land. In contrast, the Little France Park, which is in an advanced planning stage and part of Edinburgh's green belt, faces severe pressure from real estate developers. Acting as a corridor between existing green amenities, Little France Park has a high potential to become a recreation zone that promotes social cohesion, yet its future is to be decided within the negotiation process between different municipal departments and interests. Unlike developments in Dublin, the local community in Edinburgh is (allegedly) split on 'greening' versus 'building' strategies for the zone. The Department of Parks and Greenspaces is actively seeking the establishment of the Little France Park as an active travel route with strong biodiversity features and an improved sense of place. In this particular case, the parks department initiated a multi-actor partnership for the establishment of the park, which was eventually taken up by a non-profit trust. This trust has been working to gain local people's support for turning arable land of low perceived quality into a park. The park is still awaiting approval amidst increased pressure from real estate developers in its southern section.

Four of the community-initiated parks emerged from opposition to housing and infrastructure development or industrial pollution. A range of community-driven renaturalisation projects in Winnipeg emerged in opposition to housing developments (for example the Henteleff park), or as a result of citizen campaigns to turn polluted areas into bio-reserves (the Trascona Community Bioreserve), or after intense lobbying by citizen groups concerned with the decline of green space (see Bishop Grandin Greenway).

In the emblematic Boston Greenway case, the rail-to-trail program led to conversion of an abandoned railway dumping site into a green corridor with a multi-use pathway and a linear park. The greenway emerged due to pressure from local non-profit organizations and communities in East Boston, which had historically suffered from noise and expansion of Logan Airport. In the 1960s, the proposed runway extension led to the demolition of Wood Island Park and the eviction of a number of citizens. Today, the Wood Island Park is a cluster of sports fields wedged between the airport highway access ramps.

Former rail corridors are popular locations for new parks or greenways. This is especially the case with Boston's Greenway, Winnipeg's Northeast Pioneers Greenway and Parkbogen Ost in Leipzig. The case in Leipzig focuses on developing unused railway tracks as an arch-shaped, green mobility corridor running along the perimeters of Leipzig's East Quarter, hoping to raise the profile of the area. The corridor consists of existing and proposed green spaces such as parks, communal gardens, urban forests, green classrooms, landscaping projects and garden colonies. Winnipeg's Northeast Pioneers Greenway is an abandoned 8 km railway that has been turned into a bike path through the effort of local communities.

Greening along roads or inter-park connections emerge from long-term municipal planning, coupled with regional/national strategies. The greening of Passeig de Sant Joan in Barcelona aimed to increase ecological and social connectivity within the city in the framework of the municipality-led Green Corridors Plan. The particular measures involved the widening of sidewalks at the expense of car lanes, where rest areas and playgrounds were installed while planting diverse drought-resistant native trees and shrubs. The semi-green pavement reduces runoff, retains less heat and provides active cooling via evapotranspiration from vegetation. In contrast, the green corridors project in Montpellier, aiming to enhance cycling and running connectivity between parks and natural spaces, was initiated due to a national regulation but was neglected when national and regional priorities changed.

The Porous Alley in Boston is another NBS tied to roads, mostly involving the installation of porous asphalt to increase the permeability of pavement and underground water storage. In this case, the measure has mixed funding from the Massachusetts department of Environmental Protection and the City of Boston as a testing ground for new green technology. The greening of Cuiheng Road in Wuqing District (Tianjin) also entailed the installation of green belts in the form of trees along roads that connect existing parks, or zones that combine greening (leisure and recreation areas) with high-end business zones (South Lake, Nahhu, Wuqing District, Tianjin) – although this time with a clear push from the state.

State-initiated new parks are mostly a Chinese phenomenon. The establishment of 'ecological parks' is a formal requirement of local governments in China, (see North Canal Suburban Park, Wuqing District). In these new parks, greenery, recreation, culture, sports and commercial functions are sought. Yet, it is mostly in leading economic zones such as the Wuqing District where integrated green and blue infrastructure is actually being implemented.

3.2.2 Governance and public participation

In most of the cases, municipalities have key functions in governing parks and greenways. Their roles and responsibilities vary across cases from taking full ownership of the NBS by being the *landowner, initiator, manager and funder* (Passeig de Sant Joan, Liberties Greening Strategy) through having *limited decision-making power* due to other pressures and other actors' interests, such as housing development or land ownership (Little France Park, Tolka Valley, Porous Alley, Two Rivers Urban Park, Sofia's Vrana Park), or being a higher-level initiative, where the municipality functions as an executor only (Green and Blue Urban Network Project, Wuqing District). In some cases, the municipality is present as a landowner, but the NBS is mostly driven by NGOs and/or citizens (see Winnipeg's renaturalisation and the East Boston Greenway). In Parkbogen Ost, for instance, the city is committed to the project with administrative and organisational support, inclusion in planning processes, plot management systems and compensation measures.

The roles within municipalities are often divided so that while the local/district government initiates and leads the process, the funding comes from the city council's central budget or regional/national authorities. The Passeig de Sant Joan (Barcelona) is one example of such a governance structure. District governments and local offices are also key in developing and maintaining a close relationship with the local community and bringing local needs and interests to the table to be shared with higher-level decision makers, as in the case of the Liberties Greening Strategy (Dublin).

In Edinburgh, the City Council, as sole landowner, manages Little France Park, and participates in planning, policy- and decision-making, while a trust has been created to match the city council budget with funding from a variety of actors. At the same time, the park has been 'attached' to a real estate development in the area, so that it could benefit from the premiums on land prices associated with the adjacent BioQuarter, which might limit its potential as a recreational corridor. Another example where park development is closely connected to real estate development is the Tolka Valley in Dublin. The first project was fully driven, designed and executed by the Dublin City Council, while the second was outsourced to a landscape architecture office, where real estate developers were key players in decision making, although still funded by the Parks Department and the National Transport Authority.

As is typical for governance of water-management measures, the Porous Alley in Boston is a shared responsibility between local and regional authorities. In this case the City of Boston Public Works Department, Charles River Watershed Association and Boston Groundwater Trust are responsible for implementing green infrastructure, i.e. low-impact storm-water management techniques in the area, funded by the Massachusetts Department of Environmental Protection (60%) and the City of Boston (40%).

Municipalities, as land owners, are starting to share maintenance responsibilities with other actors, as seen in the case of the East Boston Greenway. After the ownership of corridors was transferred to the City of Boston, the maintenance was distributed between various public agencies. At the same time the Friends of East Boston Greenway is the local association that oversees and organizes regular clean-up and planting activities to improve the greenway. Similarly, the municipality of Sofia inherited the ownership of Vrana Park from the royal family and is responsible for its maintenance. As funding for its management comes from the (limited) municipal Parks and City Gardens' budget, voluntary maintenance work, in-kind donations and sales of entrance tickets (to access the park) are sought as additional source of income. In Cape Town's Two Rivers Urban Park, the lead actor is a planning firm that was awarded the tender for the park's development, while

the Department of Transport and Public Works manages the land owned by the province. Here the municipality's role is limited, similar to the Winnipeg case. In Winnipeg's community-based re-naturalization the municipality's role was restricted to initial mapping of natural areas and the maintenance of the segments of the multi-use trails on municipal property. Funding, however, is secured by the community through smaller grants from different levels of government and donors.

Municipalities act as executors in predominantly state- or nationally-financed parks and greenways. The Green and Blue Urban Network project in Montpellier is based on a national scheme (SCOT, Schéma de Cohérence Territoriale), which sets boundaries between spaces for urbanization and natural and agricultural areas. It is legally binding and translated to the municipal level as the PLU (Plan Local d'Urbanisme) with its realization falling under the responsibility of the Directorate for Landscape and Biodiversity. Similarly, a strictly top-down initiative, the Wuqing District in Tianjin, has programs and plans derived from a clear national political agenda. The 13th national Five-Year Plan (2016-2020) provides a guiding framework, based on national political goals, such as the construction of an ecological civilization. The national agenda is translated into urban policy and programs, and local five-year plans are enacted by municipalities, municipal districts, and municipal bureaus in a hierarchical governance structure. Each project has to fit into this plan to gain political support and funding. If given approval, planning and implementation is coordinated by district bureaus, which subcontract tasks to private companies. Public participation is largely absent in this process. NBS are embedded in environments where decisions are considered to be the domain of national and local governments and their associated expert committees and implementation follow strict top-down logic.

Other top-down and more-technical projects, where NBS are not particularly visible (or are dispersed across a larger area) feature little or sporadic public participation. For example, in Boston's Porous Alley, which was initiated by regional authorities, participation was limited to informational meetings, without elements of co-creation or co-design. Another case of minimal citizen involvement in planning and implementation is Montpellier's Green and Blue Urban Network. The design and execution of the Passeig de Sant Joan green corridor (Barcelona), for example, was not informed or highly influenced by the involvement of neighbourhood groups. While informative and consultative gatherings targeting interested stakeholders were organized under the guidance of local district authorities, neighbourhood associations spoke of a poor information and communication process prior to the events where the design of the green corridor was launched.

NBS featuring biodiversity preservation frequently rely on volunteers as a core public participation strategy. In Sofia's Vrana Park, citizens participate directly with voluntary contributions to maintenance, such as making bird houses, providing seeds, and donating and planting trees. Likewise, since pollinators are an attractive means for engaging citizens with conservation activities, the John Muir Pollinator Way in Scotland is reported to attract the interest of volunteers.

New parks where multiple interests need to be balanced are often reported as having unsatisfactory or mechanistic participatory processes. For example, the Two Rivers Urban Park (Cape Town) had consultant-led co-design workshops in 2016 which were rendered unsatisfactory by the way in which participation was limited. As a response, a group of landowners, the neighbourhood association and NGOs formed an alternative process and created an alternative scenario for the development of the NBS. This alternative scenario contrasts with the development vision of the local and provincial government. In the former, access to open space and densification at the edges is prioritized, while in the latter, density and access to housing, transportation and economic opportunities are sought more ardently. In Edinburgh's newly-developed Little France Park, active public participation has been weak. Consultations organized by housing development companies revealed conflicting perspectives on the future development of the area. While some people supported the development of real estate on the "barren, low-quality land", others favoured of new woodlands. Overall, what seems to be taking place is that land that is intended to become a "quality green space" by the Parks and Greenspace Department, while receiving competing applications for residential planning by construction companies that are gaining traction with local community.

The above two NBS differ further in how **diverging visions of nature reflect diverging types of participation**. In Edinburgh's Little France Park, existing nature is considered barren and unattractive and renaturing/rewilding is promoted by the parks departments in the local municipality, while in Cape Town, the municipality is more concerned with developments where greening is imagined and deployed as a means of making the place safe, attractive and prosperous. While the former vision of nature (and parks) has stirred little participation, the latter is associated with fervent debates and civil engagement.

Vacant lots trigger community engagement, which in turn can be a key driver for the emergence of NBS. Dublin's Liberties Strategy has been largely shaped by public mobilizations, especially around urban gardens. The occupation of vacant lots by the local community paved the way toward the creation of "formal" green spaces in the Liberties neighbourhood. The design of the Weaver Park, for instance, has been advised by the ideas, needs, and demands of the local community, whose guidance has contributed to conceiving the parks. Likewise, civil engagement in the renaturalisation activities in Winnipeg is a key driving factor for NBS emergence and maintenance. Participation there ranges from the organization of clean-ups, installations and tree-planting in the Bishop garden, to rewilding and gardening activities in Northeast Pioneers Greenway, Armstrong's Point and Wildwood. In Henteleff Park (Winnipeg), for instance, neighbourhood residents contribute their expertise as lawyers, accountants and land managers and regular maintenance work.

Access to participation is often biased toward legally-established groups. The permeability of public participation, or the very decision about who can advise the design and functionality of NBS, is at times biased toward legally-established groups, as in the case of Bridgefoot St. Park in Dublin. Municipal approaches that seek to actively involve citizens in the design and implementation of NBS, such as the Liberties Greening Strategy, reveal tensions between rigid institutional structures for park management and flexible governance structures, such as in community gardens. For example, whereas planners intended to include urban community gardeners that had occupied the land in Bridgefoot St. Park (Liberties), tensions arose when negotiating the terms of this involvement. On the other hand, demands that were clearly community-driven and only concerned particular types of infrastructure, (as in the case of a skater-friendly area within Weaver Park), were more easily "digested" and realized by the city council's planning authorities.

Another example is Tolka Valley Park (Dublin), where socially-marginalized communities living north of the park did not get direct or close-by access to a re-developed green space due to the safety concerns of residents from well-off neighbourhoods located closer to the park.

Historical episodes of losing green space or environmental conflicts in general promote strong civil involvement in NBS. The East Boston Greenway is an example of a genuine grassroots development, where local residents advocated with city agencies to realize their vision of converting an abandoned railway track into a green amenity for the community. The Friends of East Boston Greenway are strongly involved in the management and stewardship of the NBS. Notably, participation there is very much grounded in the historical fights against the noise and impacts of expansion of a nearby airport and the associated uprooting of Woodland Island Park. The movement there is known as the Maverick Street Mothers who organized a community blockade using baby carriages to stop construction and delivery trucks on Maverick Street (East Boston) in the 1960s. Environmental conflicts in the Cape Town and Mexico City NBS cases show a similar trend.

3.2.3 Aspects of innovation

Parks, urban forests and greenways carry elements of both social and technical innovations, yet one innovation is often the prerequisite of the other. Boston's Porous Alley, for instance, was explicitly claimed as a testbed for the efficacy of a new green technology. Porous asphalt was applied in streets and alleyways to recharge groundwater levels, in turn reinforcing the structural integrity of nearby buildings, while cleaning and filtering runoff to prevent pollution of the Charles River. The project provided the city and relevant stakeholders the opportunity to learn by doing, but also enabled the

monitoring and evaluation systems necessary to systematically test the technology's efficacy in a Boston-specific setting. The importance of collaboration between numerous municipal departments, including those responsible for utility lines, parking, and construction project management, are highlighted here.

Similarly, incremental technical and ecological innovations took place in Boston's East Greenway and Dublin's Tolka Valley Park. In Tolka Valley, for instance, biodegradable matting was used to protect riverbanks from erosion and invasive weeds and to allow native willow trees to take root. The matting is made from hemp and when the willows become established it breaks down into compost, leaving no residue. In Boston's Greenway, an innovative action was to re-use or upcycle existing waste materials in construction. The community advocacy for open space, including community buy-in, has been a key driver to create a collective vision of converting an eyesore into an amenity for the neighbourhood, which was also grounded in sustainable design. This NBS has further experimented with collaborative governance forms, such as allocating different responsibilities to different stakeholders, e.g. maintenance of different segments of the greenway relies on different actors, while the overarching coordination is in the hands of a local community group.

Besides Boston's Greenways, there are a growing number of community-led initiatives in this category, such as Leipzig's Parkbogen Ost and Winnipeg's various renaturalisation projects, which feature social innovations in terms of how people organize to collectively care for green spaces. In Bishop Grandin Greenway (Winnipeg), for instance, members of the local community organized to restore and re-wild a communal green space. The three stormwater retention ponds were naturalized with prairie vegetation and several community gardens were built along the Greenway, both with raised and in-ground beds, free of herbicides and pesticides. The process resulted in the creation of an active-living venue for people to enjoy and to increase public awareness, appreciation, and knowledge of the area's natural and historical value.

3.2.4 Expected and registered impacts

The socio-environmental benefits of the parks, urban forests and greenways studied here are enormous. Yet we cannot claim these fully match pledged expectations. The positive impacts that are commonly expected from this key type of NBS concern regulating services (air quality regulation, noise reduction, carbon sequestration, flood regulation, water purification through wetlands), wildlife habitat, cultural services (recreational, social and aesthetic improvements) and health benefits (as is the case with green plans above). We detect many impacts of the NBS studied here. More pleasant walkways and thoroughfares **encourage people to walk and spend time outdoors** (in all examples). **Mobility is increased** by green cycle ways (i.e. Boston's Greenway, Montpellier's Green and Blue Urban Network Project, Tianjin's green and blue infrastructure, Barcelona's Passeig de Sant Joan, Leipzig's Parkbogen Ost). **Vandalism and antisocial behaviour are reduced** (i.e. Tolka Valley Park and The Liberties Greening Strategy in Dublin; Roerplein in Utrecht). Bringing nature into the city has positive effects in **reducing depression and illness**, and enhancing **biodiversity awareness and environmental values**. The benefits of trees and greening in general have in some cases been assessed in economic terms, such as savings caused by removing pollution, storing carbon and providing shade and cooling. Other economically-measurable benefits stem from **diverting water from the sewer network** which **decreases the risk of flooding** and reduces costs and energy use for wastewater treatment, (Liberties Greening Strategy, Dublin).

Citizen engagement scales up the positive impact of the NBS. Whereas many of the parks and greenways welcome the active participation of citizens as stewards, we see differences in the emerging impacts depending on how citizens are involved in each project. In Sofia, Vrana Park is managed by a state company while welcoming the voluntary work of citizens for its maintenance. Citizen involvement can help overcome financial shortfalls and create a sense of responsibility and care for urban nature. However, it only serves as 'assistance' for urban nature management, rather than participation in its governance. When, instead, citizens are actively engaged in shaping urban nature, we see impacts varying from biodiversity and habitat creation to increased awareness, appreciation, and knowledge of the area's natural and historical value (e.g.

Winnipeg's community-based initiatives: greenways, parks, re-naturalised spaces).

When new and refurbished parks and greenways are tied to stimulating the local economy, gentrification is likely to take place. Parks and greenways often improve the profile of unprivileged areas by better connecting them to hubs of economic activity (i.e. Two Rivers Park in Cape Town; Little France Park in Edinburgh; Tolka Valley Park in Dublin, East Boston Greenway). Little France Park, for example, is bounded by the BioQuarter and the Royal Infirmary on the west side, and a residential area on the east side. It is hoped that the park will provide connectivity between the two areas, attracting staff members to visit, live and use amenities in the disadvantaged Craigmillar district, thus contributing to its regeneration. However, this might also cause gentrification.

Indeed, greening-related benefits (cooler microenvironments on hot days, space for relaxation, pond sanitization, reduced noise) are better distributed when NBS are in disadvantaged areas (e.g. more accessible for those living in dense social housing estates with little green space, for instance around Tolka Valley Park, or the Liberties, in Dublin). At the same time, many NBS – mostly green and blue corridors that connect economic hubs, are saddled with unrealistic expectations of boosting economic growth, which might also conflict with the environmental objectives of the projects (Hickel & Kallis 2019). Tolka Valley Park (Dublin), for example, is expected to increase connectivity between socially disadvantaged neighbourhoods on the Finglas side and more elite residents on the Dublin side. However, socio-cultural differences are stark and reflected in the different ways the park is being used (an informal division of the park's areas according to socio-economic group). In East Boston, the Greenway is feared to accelerate the gentrification of a currently diverse and predominantly Hispanic part of Boston. The Liberties Greening Strategy (Dublin) aims to connect the city in terms of tourism, which is similarly expected to impact real estate prices and the character of an already gentrifying neighbourhood. Other examples of incentivizing economic growth in neighbourhoods through green infrastructure include Montpellier's Green and Blue Urban Network, Barcelona's Passeig de Sant Joan, and Tianjin's Wuqing District – Integrated green and blue infrastructure.

Safety issues influence NBS design and thus to some extent shape their environmental impacts. The creation of natural spaces that are also safe is a great concern in many of the studied contexts. In Cape Town's Two Rivers Urban Park, for example, safety was considered as a factor when debating whether to develop the NBS or not. In areas where crime, anti-social behaviour and illegal activities are proliferating, the creation of dense natural environments (like non-landscaped and undeveloped parks) often causes concerns or claims about safety. This might either promote the green development of previously unmanaged land (e.g. Tolka Valley Park), or shape decisions about the level of wilderness in an area to be converted into green infrastructure, where perceived safety is often prioritized over biodiversity.



3.3 DISTRICTS WITH FLOOD-ALLEVIATION OR OTHER GREEN MEASURES

Analysis in this section builds upon districts with flood-alleviation or other green measures in Malmö, Montpellier, Newcastle, Utrecht and Tianjin.

3.3.1 NBS emergence

Natural features are increasingly associated with sustainable drainage systems, applied for flood alleviation measures in most of the eco-districts explored within Naturvation. These features include open spaces, natural wetlands, water channels and retention ponds. A common characteristic of all eco-districts is that they aim for climate resilience and climate adaptation; this aim is typically coupled with increased attractiveness and enhanced health, well-being and recreational opportunities. Leidsche Rijn, for example, has a sustainable closed-circuit water system with natural wetlands, bioswales, pumping stations and permeable paving which filters stormwater organically. Augustenborg uses a sustainable drainage system with (engineered and natural) open water channels, retention ponds, trenches, ditches, wetlands, and sunk parks. Only the surplus water is directed into the conventional sewer system. Likewise, the Brunton Park Flood Alleviation Scheme in Newcastle incorporates flood defence walls, an underground storage tank, a surface water storage basin and embankment and diversion of the Ouseburn river. Parc Marianne, uses a local multi-functional park as a retention basin to channel off river overflows. In these cases, the projects were initiated because the leading actors - mostly public bodies - acknowledged that certain challenges were increasingly affecting the city (or part of it) and they were willing to undertake action in this direction. The NBS were favoured for their perceived multi-functionality. Malmö, Utrecht and Newcastle are places where NBS were chosen over grey solutions because they were more aesthetic, cost-effective, resource efficient and suitable for dealing with several sustainability issues at once.

Eco-districts are typically large-scale interventions, requiring long-term planning and a constellation of diverse actors who have internalized the benefits of nature-based solutions. The increasing exposure to floods and in some cases the perceived need for housing development, have been key triggers for the emergence of ecological districts with specific flood-prevention measures. Moreover, the flood alleviation schemes in several of the cases have enabled new developments and made housing and construction more sustainable, liveable and hence attractive. This especially goes for the cases of Newcastle, Utrecht, Montpellier, and Tianjin. This process takes place in different ways: either by the delivery

of surface water drainage within a housing development, or by creating aesthetically-appealing features in the new developments, and also by providing leisure and recreation opportunities to nearby residents.

3.3.2 Governance and public participation

The constellation of actors involved in governing eco-districts is diverse, typically including multiple municipal departments often in collaboration with other public and/or private actors. The governance modes of eco-districts range from municipality-driven to public-public and public-private partnerships. The extent of collaboration among municipal departments varies; there is however a noticeable trend toward more collaboration recognizing the benefits of integrated approaches when working with complex development projects intended to bring multiple benefits to the area and its residents. The engagement of specialised experts, such as the project office and water task force in Utrecht and the project manager in Malmö, seems to be central to the success of these NBS.

In these governance structures the role of municipalities varies. **Municipally-driven initiatives typically employ project managers or create teams dedicated to the eco-district project.** Augustenberg Ecocity has been initiated by multiple municipal actors and committed individuals, some of whom are municipal employees, and when governmental funding was provided for the plans, a project manager was employed by the district administration for this specific task. At the same time, Leidsche Rijn was initiated, facilitated and managed by a project office, with its own director and councillor, created inside the municipal structure for this specific project, with different groups working on different aspects of the development. One of these groups was the water system task force. In both cases, this internal municipal organization contributed to the projects' success. However, while Malmö struggled with decision making being more-or-less dependent on established municipal processes, the Leidsche Rijn created a project office which simplified the decision-making process and made it relatively independent, in turn adding legitimacy and transparency, and facilitating pioneering activities. A risk of handling eco-districts on a project basis is lack of continuity in management and maintenance activities, which might impact public participation and innovation, especially if responsibilities for these activities are not forwarded and allocated through time.

In public-public partnerships, several public actors are involved with different tasks and the municipality can either have a strong managerial role (Ouseburn Catchment Sustainable Drainage System, Newcastle) or a weaker operational role overlooked by the central government (Tianjin Ecocity). In Newcastle, the Brunton Park Flood Alleviation Scheme allocates the responsibilities among multiple actors. The City Council manages the entire planning process and is responsible for flood risk across the city. Groundwork (a non-profit organization) manages the NBS, while the Northumbrian Water and Environment Agency manages surface water and river flood risk. In Tianjin's complex top-down governance, the different high-level committees are responsible for different functions (see below), with a strong influence on local policy and business, while the local government follows higher-level decisions.

In *public-private partnerships*, such as Montpellier's Parc Marianne, the NBS is governed through land price control, whereby the municipality bought the land through a tendering procedure, which was run by a semi-public company (SERM), and sold in parcels to developers. Importantly, development plans had to stick to local zoning regulations (ZAC) on design, water and energy.

All cases underlined the key role of a combination of existing or new policies at different levels in realising sustainable development through delivering NBS. Both national policies and bottom-up or nationally-inspired local policies regularly support NBS implementation. Compliance with water-quality standards (e.g. Newcastle, Utrecht), sustainability principles, environmental objectives and policies promoting these (e.g. Malmö, Montpellier) clearly facilitated and sometimes provided an extra policy push for action. In the Utrecht case, for instance, the 1972 national water pollution regulations and the national discourse on environmental sustainability and clean water, motivated by the Club of Rome's Limits to Growth report, found fertile ground among the Leidsche Rijn development decision makers. Similarly, the Rio Summit

MALMÖ: Augustenborg EcoCity

Augustenborg EcoCity is the collective name for a program to transform a run-down neighbourhood into a socially, economically and environmentally more sustainable and attractive place to live (1998-2002). Augustenborg EcoCity is one of Sweden's largest urban sustainability projects; its transformation started at the end of the 1990s and continues today. Measures of the four-year municipality driven redevelopment project include an open stormwater management system, green roofs and walls, re-planning of gardens and parks, and urban gardens. Augustenborg benefitted from funding from the governmental Local Investment Program for Sustainable Development and strong agency of individuals engaged with the area. One of the key success factors of the project is the continuous and conscious collaboration with stakeholders and the involvement of residents.

MONTPELLIER: Parc Marianne Ecodistrict

This new district consists of red, grey, green and blue infrastructure: housing, business, a college, a public square, cultural equipment, a park, retention basin, protected woodland, and a green corridor along the river. As an ecodistrict, it addresses several of the sustainable development goals, such as climate action for adaptation, resilience and mitigation and environmental quality, including air quality, waste management and water management. Green structures of the project are designed for flood alleviation. Parc Marianne also aims to respond to the strong demand for housing, promoting social mixing and functions in the neighbourhood, as well as improving mobility and public transport networks. Parc Marianne has been developed, in a public-private partnership, on 40 ha over the period of 2010 – 2018 for a construction cost of €110 million. The project has been awarded the 'EcoQuartier 2011' prize in the category of 'global ecological approach'.

NEWCASTLE: Ouseburn Catchment Sustainable Drainage System

A range of sustainable drainage schemes (SUDS) have been taking place along the Ouseburn river that flows through the urban, suburban and semi-rural areas of Newcastle. These schemes include: i) the Ouseburn River Restoration Project and ii) Brunton Park Flood Alleviation. The river restoration is being delivered by the Groundworks charity and is funded by the Environment Agency. Newcastle University also provides some funding and monitoring of the river and impacts of the project (public-public partnership). Activities focus on the upper sections of the river including re-meandering, silt traps, widening and working with landowners to reduce runoff. The Brunton Park Flood Alleviation Scheme was completed in 2016 by Northumbrian Water, the Newcastle City Council and the Environment Agency. This scheme includes attenuation ponds, new water-dependent habitats, such as wet woodland and willow, 400 metres of channel re-alignment, and a new 250 metre flood wall.

TIANJIN: Ecovalley of the Sino-Singapore Tianjin Ecocity

The Sino-Singapore Tianjin Ecocity is a flagship government-to-government project between Singapore and China (public-public partnership). The construction started in 2008 with a vision to transform the original barren land into "...a thriving city which is socially harmonious, environmentally-friendly and resource-efficient" on 30 km² for ca. 350,000 residents on the coast of the Bohai Sea with an investment of ca. €6.5 billion. So far, an 8 km² start-up area has been completed, housing 70,000 residents. Relevant measures include soil replacement and regeneration, air pollution control, smart monitoring, and several innovative green and blue infrastructure interventions. The core concept of the Master Plan is the development of smaller residential 'eco-cells' that form eco-neighbourhoods with community functions. The four large residential districts, and the central 'eco-core' district are all connected with an extensive green and blue infrastructure network called the 'ecovalley' that has a fishbone structure. The area is a key pilot project in China's national 'Sponge Cities Project'.

UTRECHT: Leidsche Rijn Water System

The Leidsche Rijn is a sustainable closed-circuit water system including natural wetlands, bioswales, pumping stations and permeable paving which filters stormwater organically. The system is an integral component of the Leidsche Rijn municipality driven urban development project providing about 30,000 new homes between 1997 and 2025, the largest such project in the country. The main goal of the project is to provide clean and clear surface water with benefits for neighbourhood quality, biodiversity and recreation. The dedicated task force of the Leidsche Rijn project involves Utrecht province, Utrecht municipality, Vleuten de Meern municipality and the water authority (De Stichtse Rijnlanden) who coordinated plan implementation until 2011.

and the Local Agenda 21 have been powerful impulses for the Swedish government to create a Local Investment Program for Sustainable Development, which was one of the main financial sources for the Augustenborg Ecocity.

Securing funding has been fundamental to initiate and develop eco-districts, but the soundness of financial planning and the diversity of funding sources and their management structures vary a lot across this type of NBS.

In Newcastle, while the NBS is managed by a non-profit organization, funding comes from multiple sources, primarily the Environment Agency (£180,000), but also from Groundwork NE & Cumbria, DEFRA, and Northumbrian Water Ltd., a private water utility company for the Newcastle region. In Malmö, despite the strong desire for change, the project did not start until state funding was allocated and channelled through the different departments of Malmö municipality. This required close departmental collaboration - in this case between the district administration, service department, waterworks, municipal housing company, as well as collaboration with the initiators, including local businesses, industrial estates, local schools, and citizens. While Augustenborg relied on public funding and strong municipal leadership, Leidsche Rijn could partially pass the cost to developers who paid a premium on land prices. In both cases, EU funding further supported the project advancement. Similar to Utrecht, in Montpellier the municipality sold parcels to developers and regulated their actions through zoning.

Tianjin's Ecocity is a strictly top-down government-to-government cooperation between China and Singapore, with several public actors involved from the two collaborating countries and governed through different committees. The Sino-Singapore Ecocity Administrative Committee is responsible for the administration and construction. The Joint Working Committee oversees the project and sets key milestones. The consortium of the Sino-Singapore Tianjin Ecocity Investment and Development Co. is the master developer, while the Singaporean National Parks Board is planning the Ecovalley itself. The funding is channelled through this top-down structure and thus closely correlates with the fixed responsibilities allocated across the governance structure.

Most newly-developed districts that incorporate NBS measures lack comprehensive participation processes.

Citizens are normally provided with information (on various technical parameters) either through information panels, demonstration projects, educational activities or public consultations - as in the cases of Utrecht's Leidsche Rijn, Newcastle's Brunton Park Scheme, and Montpellier's Parc Marianne and Tianjin Ecovalley). More interactive forms of engagement or co-creation are however missing from the public participation landscape. When participatory processes are initiated and conducted in a mechanistic, 'tick-the-box' style, out of duty rather than of interest, the results are usually disappointing for both developers and end users or beneficiaries - as demonstrated in the Parc Marianne ecodistrict. Moreover, the lack of professional staff with sufficient time is often the bottleneck in orchestrating citizen participation. Yet, achieving deeper forms of community engagement proves beneficial, as demonstrated by the greening measures undertaken in Augustenborg. Here, the commitment of local residents was especially important for the intervention's success and the city administration pursued their engagement consistently, non-formally and creatively, in part by employing some community members in the waterworks.

3.3.3 Aspects of innovation

Districts with flood alleviation measures are often framed as hybrid or socio-techno-ecological (or systemic) innovations, where a combination of ecological and technical solutions requires some kind of a governance, knowledge or economic intervention. These cases experiment with nature in combination with technologies and technical systems which often requires novel governance structures, collaborations, actors' involvement and streams of funding. However, these cases also show that realising and maintaining these NBS has strongly relied on expert knowledge and assistance, for example, through planning groups, interdisciplinary teams or amateur or professional individuals. These knowledge actors have been identified as researchers, technologists, municipal officers, NGOs, and local residents. Water cleaning in Utrecht, and cleaning and slowing the water flow in Malmö both heavily relied on technological and ecological knowledge to integrate grey and green infrastructures.

Initiatives led by public bodies or co-led with private partners are likely to produce infrastructural and systemic innovations. This might be explained because these types of innovations require larger mobilisation of resources – experts, budgets, techniques and materials – for their implementation. These innovations call for new integrative and interactive implementation

processes allowing joint project management, collaboration among municipal departments, involvement of different expert groups and in some cases the consideration of social values. As discussed above, Augustenborg is an example which went through extensive and creative public participation experimenting with different pathways of citizen engagement.

Districts with flood alleviation, based on our studied cases, are typically driven by a combination of interdependent variables, such as agency, leadership, financial support, policy and multiple place-based factors. Strong professional leadership by enthusiastic and influential individuals associated with strategic discourses and long-term visions for urban transformation and environmental sustainability characterize most of the cases, and are most apparent in Malmö, Newcastle and Utrecht.

Furthermore, **some of these cases trigger policy innovation** (policy learning). In Malmö, the municipal stormwater policy was developed in conjunction with the Augustenborg Ecocity project. As the project went on, it could incorporate learning and experiences from previous and current open stormwater management systems, such as Augustenborg. Based on the trials and failures in both the technical systems and social practices, such as collaborative management and organizational structures, it could update water management guidelines.

3.3.4 Expected and registered impacts

Higher water quality and resilience to flooding are the key benefits of the studied eco-districts. The variety of measures, technologies and infrastructure that this type of NBS includes yield environmental benefits ranging from flood alleviation, to provision of recreation opportunities, thermal performance, energy savings, biodiversity enhancement, more sustainable mobility options, and in some cases (e.g. Newcastle's SUDS in the Ouseburn Catchment) long-term remediation of mining impacts. Few projects have quantified impacts, but in Malmö's Augustenborg Ecocity, carbon emissions and waste generation decreased by 20% and waste leaving the area shrank by 70%. The design features of Leidsche Rijn - abundant space for surface water and ecological banks - allowed for creating wide, robust water canals and buffers with ample access to sunlight and wind, which is crucial to maintaining high water quality and visual attractiveness. In the case of the Ecovalley in the Sino-Singapore Tianjin Ecocity, a complete remediation of soil and water bodies was undertaken, significantly improving their quality.

Serious social justice concerns exist in NBS, especially around issues of exclusion. Accessibility is often jeopardized due to the attractiveness of NBS' integration in nature and sustainable technologies, thus making them appealing and affordable only to upper- and middle-class residents. The lack of social welfare policy that would reserve some new housing for lower-income residents causes ecodistricts to reflect and perpetuate existing inequalities rather than curb them. In Montpellier's Parc Marianne, for example, park-side real estate costs twice as much as housing next to the boulevard. Moreover, unaffordable housing and NBS that provide adaptation or resilience to extreme weather events like flooding combine to cause **climate gentrification**. Affluent urban populations are better protected from risks resulting from climate change and less wealthy and usually longer-term residents face greater climate-related risks (e.g. Newcastle's Ouseburn Catchment Sustainable Drainage System). In Tianjin, although 10% of the planned housing is supposed to be affordable, there is little prospect for blue collar jobs as the proposed industries within the ecocity are mainly high-tech and creative. Although 20% is planned for public housing, Caprotti, Springer and Harmer (2015) suggest that its cost would remain beyond the reach of middle-class residents.

The context in which NBS are situated is highly important. Augustenborg's rental housing structure, where the housing company (MKB) is partially municipally owned, rental prices are negotiated by the renters' association and adjusted to MKB's rental prices, which has prevented gentrification. Yet placing new eco-districts outside existing dense urban environments means that most current urban residents will not benefit much from them. Flood prevention or CO² capture benefits arguably transcend the location of each NBS, yet siting ecodistricts on new semi-exclusive terrains can contribute to climate and health

gentrification (Heynen et al. 2006).

Citizen engagement augments the positive impact of NBS. Similar to observations of the impacts of parks and greenways, active involvement of citizens and citizens' organizations also shapes NBS outcomes in flood-control NBS. Prioritizing community needs and resistance against developers' interests leads to eco-districts with better social outcomes. Malmö's Augustenborg Ecocity, has seen (i) turnover of tenancies decreasing by 50%, (ii) unemployment falling from 30% to 6%, (iii) participation in elections increasing from 54% to 79%, (iv) migration away from the area reduced from 28% to 10%, and (v) housing being provided to elderly people. People's active and continuous involvement there has led to more sustainable/renewable energy initiatives, car-pooling, and the emergence of environmental start-ups.



3.4 URBAN AND POCKET GARDENS

Analysis in this section builds upon urban and pocket gardens in Athens, Barcelona, Dublin, Győr, Leipzig, Utrecht and Winnipeg.

3.4.1 NBS emergence

Many urban gardens emerge in contexts of austerity and crisis when real estate development slows and municipal land remains unused. The concept of Barcelona's 'Pla Buits' (Catalan for 'blank plans') emerged from the Spanish real estate crisis, when the City Council granted a number of vacant sites to civil initiatives for short-term use (about three years). In the first phase (2013-2016), nine out of the fourteen sites were developed as urban gardens. The plots were selected by the City Council. Local groups organize, govern and manage the activities in each of the spaces. Espai Germanetes, one of the Pla Buits gardens, emerged from political and community-based mobilizations of autonomous collectives, partly in response to the systemic lack of public green space in the Eixample district. The garden currently occupies only one-tenth of the barren land initially reclaimed by the community, the rest being programmed for construction of a school and retirement homes. The Illa dels Tres Horts, another Pla Buits garden, in the Sants-Montjuic district, is a social urban garden project propelled by a number of local civic associations, including ones that target socially vulnerable groups. Over time the garden was cared for by local families, partly since the area has little open public green space for children to play. Parents saw the garden as a safe place to meet that promotes sustainable values, introduces children to the process of cultivation, and is a healthier alternative to shopping malls or entertainment parks.

In Athens, derelict municipal land was turned into organic gardens under varying organisational structures, but in all cases with strong municipal involvement. An exception is the Marousi collaborative gardens, which was initially designed and funded by a tobacco company.

In contrast with Barcelona and Athens' gardens, Dublin's enjoyed less support from the City Council in their initial stages. The urban gardens located on the future premises of the Bridgefoot St. Park (Dublin) emerged on housing estates demolished

in the middle of the last century due to their poor conditions. Yet, with the economic crisis the site remained vacant for a long while. Facing continuous bureaucratic and legal obstacles these gardens were initiated by a community development NGO, and then re-initiated by an ad-hoc community project. Eventually the city council opened up to discussing a new co-management scheme.

Some urban pocket parks emerge through reflexive governance processes between City Councils and local community members, where citizen support and involvement is a requirement for the garden's deployment.

Roerplein is a pocket park in a residential area of Utrecht. It is financially supported by the municipality but emerged from citizen consultations during the development of the Neighbourhood Green Plans. Community interest in the garden grew through the involvement of a social entrepreneur who facilitated the design of a green square, using a range of communication strategies and techniques including interaction with local school children. The pocket garden has been designed and implemented through back-and-forth exchanges between citizens and the municipality with the social entrepreneur acting as a mediator. This mediation triggered the emergence of a self-organized team of local citizens supervising and maintaining the plot, which in turn helped other goals to surface, such as improving social cohesion and safety.

Urban gardens with strong social (educational, cultural and therapeutic) objectives emerge purely as citizen-lead initiatives, using 'free', 'derelict' or 'temporary' spaces.

The Querbeet garden in Leipzig, dating from 2012 was initiated by a small group of gardening enthusiasts who negotiated temporary use of a vacant plot. The garden is envisioned as a sustainable communal terrain, managed through cooperation and democratic self-governance. Its members seek an active engagement with community politics, local and global food provisioning, and environmental education and protection. The group collaborates with a local club of young people and a refugee home providing space for garden-based interaction between local and immigrant residents. Relationships with refugees however have been difficult due to their temporary residency, which is a feature of the German asylum system. The Querbeet garden, like the pocket park adjacent to the Germanetes urban garden (Barcelona), had to vacate their original plot to make room for a new social building. This development reflects the current priorities of Leipzig City placing refurbishment and building of schools and childcare centres high on the agenda. The dilemma of "more schools versus more green space" is thus present both in Barcelona and Leipzig.

In a similar approach, the Bunte Gärten (Leipzig) aims to provide a safe and supportive space for refugees in Leipzig's East Quarter. It was revived and extended in 2015 by a small group of citizens partly in response to nationalist, anti-immigration protests in town. Like in Querbeet, a major challenge for the project is the creation of a long-term network of refugees and other users.

Food for Good is another social urban garden example in Utrecht, launched in 2012 in a multi-ethnic neighbourhood blighted by high unemployment, antisocial behaviour, and health-care deprivation. The garden is run as a bottom-up project managed among non-for-profit social and environmental foundations/groups that support socially- and economically-vulnerable people by engaging them in gardening work. Being a therapeutic space for social service users, the project uses a derelict area free of charge. Its launch was financially supported through private grants, limited sales and contributions from social care institutions. Yet, the financial situation of the garden is uncertain, and local management capacity is limited, making its future unclear.

A distinct and notable example of self-managed community-based green spaces are Winnipeg's dozen urban gardens in the disadvantaged Spence Neighbourhood, and edible community spaces along the Cumberland Corridor designated for indigenous communities. The associated projects are self-governed nature-based spaces for educational, therapeutic and social inclusion purposes. These include a healing village and knowledge centre, managed by and dedicated to women (healing and empowerment). These NBS tackle issues of systemic poverty, violence and unhealthy lifestyles in spaces that reflect the indigenous people's cosmology, hence emphasizing the therapeutic importance of connection to the land and the creation of safe environments where ancestral healing methods can be applied.

School gardens survive mostly thanks to the efforts of enthusiastic teachers amid institutional lapses. The school gardens in Győr re-emerged after a long period of oblivion, especially during the Soviet era when the green-tech revolution changed approaches to planting and growing food. The techniques and approaches used in Győr school gardens are diverse. In some of these university students are trained on how to organize and maintain the gardens using ecological agriculture approaches as optional credit courses. In others, elementary school student groups plant, maintain, harvest, collect seeds under the supervision of teachers. Although established on institutional grounds, legal or public incentives for the development and maintenance of school gardens are largely absent. The gardens emerged and flourished thanks to motivated teachers and parents.

3.4.2 Governance and public participation

Urban and pocket gardens are typically community-driven initiatives, with varying support from the municipality. Plots and cultivation are always managed by the beneficiaries, while the role of the municipality varies from a pure land provider to a financier or decision-maker. In some cases, following the development of the garden activities, this role has changed over time. In other cases (Athens, Barcelona, Dublin), the plots are selected by the City Council and local groups organize, govern and manage the activities in each of the spaces. In all the cases, maintenance activities are taken care of by usually-volunteer citizens, sometimes with municipal support (Roerplein, Utrecht) and expert knowledge, provided by foundations, volunteers or the municipality. Expert knowledge and involvement are key assets for the development of these gardens – both in terms of agricultural skills (e.g. Utrecht's Food for Good, Winnipeg's Indigenous Community Gardens), and public participation processes (Barcelona's Pla Buits).

Athens differs from the above cases due to its very strong municipal involvement in urban gardens in terms of funding, coordination and, in some cases, design. Internal city council politics determine the approach, access rights, land availability, financing and management of these gardening schemes resulting in varying governance structures. Its strong role in Athens means that in all cases the municipality chooses management structures. One common structure is rotating plot assignment to different individuals with a municipal representative in charge of any socio-cultural issues that emerge (Agios Dimitros garden). Another structure is creating circular islands for shared cultivation among 4-5 families to enhance collaboration and solidarity (Marousi gardens). Here, beneficiaries were chosen based on socio-economic indicators of vulnerability, good gardening practices and communitarian relations.

The changing role of municipalities during the NBS' lifetime is related to the extent of citizen engagement and funding sources. Utrecht's urban gardens (Food for Good, Roerplein) and Barcelona's Pla Buits are examples of this pattern. Roerplein and some of the Pla Buits began with strong municipal involvement. In fact, Pla Buits was an initiative of the city council, in which a number of vacant sites in the city – along with services, such as electricity, land clearance, monitoring, and an instructor for participation – were granted to civil initiatives, although with each initiative retaining its autonomy and members often contributing money and labour. Similarly, Roerplein was implemented within the framework of the municipal Neighbourhood Green Plans to promote public participation in urban development, offering funding to realize citizens' ideas for greener neighbourhoods. Here, maintenance is a shared responsibility between a self-organized group of neighbours and the municipality: while citizens do the maintenance work, the tools and materials are provided by the municipality. In the Food for Good project, the municipality withdrew after providing the land and a start-up grant (from the Spatial Development Department). Later on, the garden was supported or financed by foundations, social care organisations, NGOs and commercial activities such as renting meeting rooms or selling produce to local restaurants.

Municipal support for urban gardens is commonly insufficient. This is clearly seen in the temporary use rights of the Querbeet garden in Leipzig and Pla Buits in Barcelona. The Querbeet garden is envisioned as a sustainable communal terrain, managed through cooperation and democratic self-governance. These rights were provided by the city under

different schemes, such as the 'plot management system', 'plot register', or 'temporary use agreement' in combination with funding for the reconstruction of Eastern Leipzig from federal, national and EU schemes (e.g. Urban Reconstruction East, Social City, National Projects for Urban Construction, Improvements in Regional Economic Structures, ESF, and EFRE). In Winnipeg, the city administration set conditions (Community Gardening Policy) in return for free land use, including requirements for the community groups to bear all costs related to gardening. Strong neighbourhood leadership (the Spence Neighbourhood Association) partnered with businesses and organizations to support community garden development with in-kind contributions, including volunteer hours, and training by skilled indigenous gardeners. In general, though, municipal involvement is much weaker (or non-existent) in urban gardens with educational, cultural and therapeutic aims.

Similarly, strong citizen leadership and minimal municipal involvement was found in Győr's school gardens, **which have strong community-based, bottom-up, self-governance dynamics**. Dedicated teachers frequently initiate and coordinate initiatives with expert knowledge and some financial support from the Foundation of Hungarian School Gardens.

Municipality roles in urban garden projects are not limited to initiating, providing land and making decisions about plot allocation and management. In Athens, in the case of Agios Dimitros garden, for instance, they further support the activities of the garden by encouraging 20% of production to go to a municipal social grocery store. In addition, farming families claim that they can save up to €150 per month by not having to buy vegetables from the grocery store.

Urban and pocket gardens are highly experimental, strongly influencing their long-term performance. The experimental features range from space management and cultivation methods (Athens, Winnipeg), through environmental education (Győr) and therapeutic activities (Food for Good in Utrecht, Winnipeg), to different land use schemes, such rights to use private land for mutually-beneficial communal projects (Leipzig), and forms of maintenance (Roerplein in Utrecht).

Some of these NBS have also been governed through reflexive processes of continuous dialogue between the municipality and citizens. This is not surprising as citizens are key actors in the implementation and maintenance of these gardens. For instance, the Roerplein pocket garden has been designed, implemented and maintained through continuous communication and knowledge exchange between citizens and the municipality, which in turn supports NBS continuity.

Urban gardens indeed experience a governance continuity challenge for multiple reasons. The Bunte Gärten (Leipzig), for instance, faced numerous obstacles and frequent relocations, making it difficult for refugees to dedicate time and effort to the project. Other challenges for this particular garden concerned how open it should be to a diverse range of temporary users, bringing us back to the point of members' commitment and continuity. Continuity is one of the challenges Dublin tried to address when designing a co-management scheme for the Bridgefoot St. Park. Only legal entities (NGOS, community development groups and other legally-standing organisations) are recognized in participatory decision-making, whereas individual or ad hoc volunteer groups are less visible and heard.

Participation, volunteering and self-management drive the very existence of most urban gardens studied.

Participation in public urban gardens, however, commonly struggles to sustain itself over time. In Illa dels Tres Horts, the Tarpuna cooperative (working on social inclusion through urban and peri-urban agriculture) was instrumental to creating an urban garden attracting a diverse group of members (mostly other organizations). Already in the first year of implementation many of the organizations involved did not engage consistently with the project. Eventually, members of the local community, predominantly families with young children, gradually organized and took over most of the plots in the garden, giving a more participatory character to the project. Likewise, the Food for Good urban garden in Utrecht was established by a number of associations working toward social inclusion (Foundation De Wending, Stadsbrug (City Bridge) and environmental protection (Utrecht Natuurlijk). The project is attended by users of various social services as well as by volunteers, and guided by a professional head gardener (responsible for planning and implementing field works) and a rehabilitation program officer (following up with and monitoring the service users). The functions of the head gardener and

ATHENS: Municipal Gardens - Marousi and Agios Dimitrios

Municipally-assisted community gardens started to appear in Athens in 2012, with the objective of providing relief for vulnerable groups (i.e. unemployed, retired, low-income, single-parent and large families), strengthening social solidarity and mental health. The users practice organic gardening and keep most of the produce, at the same time increasing soil fertility and reducing erosion. 20% of the food is donated to the municipal food bank. In Marousi, in 2012, the first garden was split into 35 individual plots for beneficiaries. The second was realised through a donation courtesy of Japan Tobacco International and designed by the specialized landscape company Ecoscapes. This was based on a collaborative model, where multiple beneficiaries work on shared plots with a single type of product, and share the yields. In Agios Dimitrios, the initiative started in 2012 with 45 plots and has kept a very high participation rate, declaring multiple cultural, social and habitat benefits.

BARCELONA: Pla Buits Urban Gardens

The 'Pla Buits' Plan, or Plan for Urban Vacant Lots with Territorial and Social Involvement, is an initiative for urban space co-management fostered by the City Council aiming to involve civil society in defining, installing and managing activities of different types in unused spaces across all city districts. The cases studied include: 1) "Illa dels Tres Horts", a social garden in Sants-Montjuic district, initiated by a non-profit cooperative working for sustainability, social justice and equality of opportunities, and 2) "Espai Germanetes", a project proposed by a neighbourhood association in the highly-urbanized Esquerra de l'Eixample district, which acts as a place to meet, dialogue and grow food.

DUBLIN: Liberties Greening Strategy - Bridgefoot St. Park

The Liberties Greening Strategy seeks to improve the recreational amenities of the Liberties Local Area. Two of the most significant new green spaces are (1) Weaver Park and (2) Bridgefoot St. Park. Weaver Park has been built on a 0.6 ha area in the Liberties aiming to address the lack of green space in the area and to provide a place for recreational activities such as skateboarding and community events. The creation of Bridgefoot St. Park - instead of further housing development - was approved by local authorities as a response to years of campaigning by local residents in the area (public-citizen partnership). The park will include lawns, flowers, trees, furniture, lighting, allotments, a community garden, a terrace, a playground, and more - all built on former derelict land.

GYÖR: School Gardens

The School Gardens of Győr cover a set of interconnected grassroots initiatives that are implemented by teaching and learning communities. Although earlier school gardens fell victim to development and neglect in the 20th century, the modern school garden movement has grown rapidly since 2013 due to its recognized value in current pedagogical movements and potential role in education for sustainability. There are approximately a dozen school gardens in Győr, one of which also plays a prominent role in the initiation and coordination of the school garden movement at a national level.

LEIPZIG: Green Spaces in East Quarter

This intervention comprises several schemes aimed at revitalising one of the city's most structurally disadvantaged, yet most culturally vibrant areas. It involves invigorating the area through the redesign, extension and new development of parks, the greening and communal use of vacant plots, the establishment of new urban forests, setting up new communal gardens, and the planning and partial implementation of a green corridor for cyclists and pedestrians. This community driven NBS covers three different case studies: 1) Querbeet communal gardening project, 2) Bunte Gärten intercultural gardening initiative and 3) Parkbogen Ost green mobility corridor.

UTRECHT: Food for Good Community Garden

Food for Good is an organic community driven vegetable garden on public land providing social care to vulnerable people with support needs. Sustainable food cultivation is used as an instrument for building community and employability skills, ultimately leading to societal reintegration. The garden includes six main food-growing plots, a greenhouse, a wild nature zone with a pond, a green buffer strip with trees and shrubs circumventing the land, a number of cabins and sheds including a meeting room, kitchen and office, a patio, a herb garden, a bread digester used by a partner organization to generate biogas and beehives.

UTRECHT: Roerplein Pocket Park

The Roerplein pocket park is an example of a Neighbourhood Green Plan project. Neighbourhood Green Plans are an initiative of Utrecht municipality to support the bottom-up 'greening' of neighbourhoods (public-citizen partnership). Citizens can propose a variety of often quite small-scale plans that enhance the neighbourhood by means of green spaces, social cohesion and thereby community identity. At the Roerplein, a public square was transformed into a green square by way of a participatory process, assisted by a social entrepreneur. The project aims to reduce heat stress, enhance social cohesion and the attractiveness of the neighbourhood, promote biodiversity and support recreation.

WINNIPEG: Indigenous Nature-Based Solutions

Winnipeg has a 6,000-year history of indigenous habitation, and is currently home to Canada's largest urban indigenous population. The city has a large ethnic chasm, rooted in history, and intertwined with the highest rates of poverty and violent crime of any Canadian city. There are several downtown neighbourhood community groups, such as the Spence Neighbourhood Association and the West Broadway Community Organization that use vacant urban space for the benefit of indigenous communities, and encourage communities to maintain green spaces, 'tot lots', and a network of community gardens. There are also small indigenous 'healing lodges' for building community resilience, and a nurturing community living environment through providing support to women, developing collaborative, innovative social enterprises and a knowledge centre that forms partnerships with indigenous and non-indigenous experts.

the rehabilitation coordinator in Illa dels Tres Horts are performed by one person, paid by Tarpuna.

Although community participation in the initiation of Győr's school gardens was minimal, maintaining momentum required supportive institutional management and a large community of volunteers, donors and other supporters with dedicated teachers initiating and coordinating various garden-related activities.

Collaboration with municipalities can be both empowering and disempowering for urban gardens. The municipally-supported urban gardens (e.g. Barcelona, Athens) have triggered much civil interest and engagement, empowering community members and individuals interested in gardening to cultivate and self-organize. At the same time a number of conflicts related to participation surfaced. In Espai Germanetes, Barcelona, the initial community group that fought for the social and green recovery of the entire 5,000 m² barren area split over whether to accept the municipality's proposal that allocated only 500 m² of the total space to formally become a garden under the Pla Buits scheme. In Athens, final decision-making and rule-setting was in the hands of the city councils. One example from Athens concerns the municipality of Marousi, where many individuals who could not maintain a good level of cultivation, or were reported to be irresponsible and unable to fulfil tasks due to physical or psychological problems, were restricted from the scheme, even if they were intended beneficiaries from socially vulnerable groups.

While enhancing the attractiveness and vitality of neighbourhoods, urban gardens seem to be perceived as less important 'green infrastructure' by urban planners and private developers. The Querbeet garden in Leipzig seeks to engage long-term members from diverse backgrounds. It was encouraged by the municipality to use vacant space and thus help enhance the attractiveness and vitality of the city, until the land was reclaimed by developers. The garden was forced to find an alternative plot using an 'innovative' temporary use agreement scheme to negotiate usage rights for communal projects on privately-owned sites for ten years. Yet the period of low investment interest passed and this second location is now also targeted by builders. The garden collective then had to find a third location, manoeuvring again between distinct interests and public agencies. Due to the uncertainties over usage rights that the group faces, Querbeet began using raised beds that can be lifted and moved. Local connections are however, less mobile and take time to establish. This has made it difficult for the group to recruit new members with repeated relocations.

The NBS dedicated to healing, education and empowerment owe their success to their highly participative organizational models. This is especially visible in the Indigenous Nature-Based Solutions in Winnipeg, but also for the Cape Town Environmental Trust. Winnipeg's Indigenous NBS deal with structural conditions of inequality and segregation through the use of urban gardens, spaces for ceremonies, and a healing village developed in collaboration among elders, NGOs, victims of abuse and supporters. The project was initiated, planned and implemented solely by indigenous people.

3.4.3 Aspects of innovation

Urban and pocket gardens mainly carry elements of social and ecological innovations, experimenting with space use and management, different governance structures and cultural activities. Derelict areas in Athens and Barcelona provided a good opportunity for the municipalities to allocate these spaces to different citizens' gardening activities. This action further called for experimenting with not only space use, but also space governance, which has played out differently in the two cities. In Athens, the different governance forms emerged through municipally-led processes (top-down). In Barcelona although land allocation was initiated by the municipality, each project has autonomy to self-govern, which played out in a collaboration where different partners contribute different types of resources. In Leipzig, the municipality is experimenting with different land-use schemes for urban gardening projects. The local residents and garden enthusiasts who initiated these NBS aimed to create shared spaces for cultural recreation and social bonding under democratic self-governance, which primarily relies on the commitment of local residents. In Dublin, the Bridgefoot St. Park also experiments with both space and

space management. The park's design incorporates space for allotments (municipally-assigned cultivation spaces) but also for community gardening, which is envisaged to be co-managed by citizens and the municipality. The design also includes a play area, an open square for events and performances, a lawn area and a possibility for a community or municipality-run café or open-air cinema.

These gardens carry significant elements of cultural innovation. The Bunte Gärten, for instance, has supported interactions with refugees coming in to the city. Winnipeg and Győr are other examples innovating with culture and ecology through therapeutic activities and indigenous cultivation methods (Winnipeg) and through introducing gardening into daily life through the activities of schools, coordinators and parents (Győr). As one school garden coordinator emphasized, "there are no mistakes in our garden - only experiments" (Katona 2017). In Winnipeg, urban gardens are co-managed by a group of various citizens' organisations, engaging approximately 60 indigenous gardeners to maintain the plots – often supported by professionals who participate in part for free, out of their own personal interest in community well-being and NBS.

In Utrecht, both initiatives experiment with types of governance, the share of responsibilities and resource allocation. In Roerplein, the combination of municipal funding, the engagement of an experienced intermediary facilitating participatory processes, and the shared NBS management were all found to be innovative. In addition, this was supported by an innovative policy framework (Neighbourhood Green Plans), which mandate public participation by involving locals in maintenance, especially in neighbourhoods which are relatively deprived of green space. The Food for Good project, being a citizen-NGO initiative, more heavily depended on voluntary work, self-employed staff and secure funding. Strong leadership and collaborations (networks, partnerships) with local stakeholders have been crucial to continue this initiative.

3.4.4 Expected and registered impacts

Strong social and cultural benefits. Quite uniquely and especially in comparison with other NBS, urban gardens are places of engagement, stewardship and proximity to nature. Urban gardens are particularly impactful in terms of social and cultural benefits while also increasing green space and biodiversity in cities. While most gardens provide quality food to those who cultivate and the wider community, they also serve educational (Győr's school gardens) and healing purposes (gardens of the Clan Mothers Turtle Lodge Healing Village, Winnipeg). These correspond to the declared aims of urban and pocket gardens, which are associated with improvements in health, well-being, social inclusion and awareness. They help people connect with natural processes, learn about sustainable growing practices, connect with the local community and create safe, creative and restorative environments that can also be nuclei of cultural and political activity. Many of the studied urban gardens addressed specific social challenges. In the municipally-supported gardens of Athens, 20% of the produce goes to poor families, while those who get access to the plots are also socially and economically vulnerable people. In one of Barcelona's Pla Buits gardens and in Utrecht's Food for Good, projects were based on the idea of involving vulnerable people, acting as a reintegration and education ground for those at risk of social exclusion. Both succeeded in becoming places of diversity and co-existence. In Leipzig, urban gardens in the East Quarter contributed to social cohesion, refugee integration, well-being and health, among other social benefits.

Gardens are also perceived as quieter, cooler and better shaded, offering relief from the density of the city. In Utrecht's community-managed green park (Roerplein), vandalism reduced after residents began transforming and maintaining this space. In Winnipeg's Clan Mothers Turtle Lodge Healing Village, cultivation spaces provide food and habitat for birds and other species, while constituting gathering places for the neighbourhood and being directed, designed and managed by indigenous people.



3.5 GREEN BUILDINGS, ROOFS AND WALLS

Analysis in this section builds upon green buildings, roofs and walls in Athens, Dublin, Edinburgh, Malmö and Montpellier.

3.5.1 NBS emergence

The green roofs and walls are the least frequent NBS studied here, partly due to the more complex requirements – in terms of finance, infrastructure, and motivation on the part of developers. The personal engagement of building owners and their capacity to dedicate funding and recuperate the initial investment are key factors that mark the emergence of green roofs. The requirement of specific expert knowledge (ecological, technical, practical) throughout the different phases of the intervention, from design to development and maintenance, is a common facet of green roofs and walls.

Green roof and wall projects routinely underestimate the management efforts needed, making them difficult to commercialize or afford. Most green roofs and buildings with vertical gardens hence emerge in a context of a strong drive and financial support from the local municipality, as we have seen in Malmö and Montpellier, or a powerful donor, as in the SNFCC case in Athens. This could be part of the reason why these types of NBS have received little financial or practical evaluation so far. The walls of the Château le Lez in Montpellier, for example, were not vegetated, contrary to initial plans, due to poor maintenance of the irrigation system. This said, green roofs, walls and aquaponic installations are often chosen for their expected biodiversity and aesthetic benefits.

3.5.2 Governance and public participation

Most green roofs and buildings with vertical gardens tend to have diverse governance modes, depending on which context they have emerged in, what purpose they serve and for whom. Municipal leadership, policy and financial support (both cases in Malmö), a private funder (Athens SNFCC) or enthusiasts (Montpellier's Château le Lez) seem to be key to implementing such projects. When funding is not available, maintaining continuity requires additional resources and pre-agreed responsibilities. In the Square Metre for Butterflies project, the co-leading NGO is responsible for planning and implementation, contractors are responsible for maintenance and the initiators provide in-kind contributions, such as

time, knowledge, etc. In each case, ecological knowledge seems to be a crucial issue. In the Dublin aquaponic project, for instance, it has been solved by employing someone to help train students, monitor, maintain, and keep records on the operation of the project. This is especially important given the claimed goals of conservation, increasing biodiversity and enhancing neighbourhood attractiveness.

Municipalities are rarely the only key actors in this domain; when they are, there is a strong institutional setting.

The SNFCC, for instance, stands on public land managed by the SNFCC SA, whose board is appointed by the Greek government, under the authority of the Ministry of Finance, Culture and Education. According to a special law signed as an agreement between the two parties (SNF, the Greek State), the government has to comply with certain conditions, or else the SNF maintains the right to withdraw its donation. At the privately-initiated Château le Lez, local zoning regulations set requirements on the design of the green building. In Malmö, both NBS have been initiated and run by the municipality, in collaboration with several municipal departments and external stakeholders. In Augustenborg, the homogeneous land and building ownership in the area strongly facilitated the decision-making, implementation and maintenance of green roofs on a larger scale.

Overall public and citizen participation in roof-top gardens and green buildings is limited or non-existent,

partly because roofs are often not publicly accessible. This is particularly visible in Montpellier's Château le Lez or Dublin's Belvedere aquaponic project. Participation in these types of projects either happens by encouraging staff training or by providing sporadic access for students and professionals and an enhanced view for tenants in all seasons, which also increases customer value (BiodiverCity-Koggen, Malmö). In cases of residential green roofs, such as in Malmö, citizens' interests are represented through the local housing company. Citizens' viewpoints are usually collected through surveys, informal and formal dialogues and previous experience channelled through the housing company. Citizen engagement in new developments, however, is often low (BiodiverCity-Koggen in Malmö, Little France Park in Edinburgh). Developers are rather concerned with the satisfaction of the end user, or particular clients. Public participation was also scant in the rooftop-based Square Metre for Butterflies project in Edinburgh. Apart from the staff associated with the management of pollinators or plants in specific green roofs, projects see little citizen engagement.

Augustenborg's Green Roof Institute, with its almost 10,000 m² green roof atop municipally-owned premises, aims to address the low level of public participation, and was established in conjunction with Augustenborg Ecocity as a green element of the sustainable drainage system. The Institute's large green roof area serves as a testbed for experimenting with different types of green roofs and vegetation, but also accepts thousands of visitors annually with educational and knowledge-development purposes.

3.5.3 Aspects of innovation

Green roofs and buildings are often featured as ecological and physical innovations in combination with elements of technological and/or social innovation.

The creation of green space is one of the main drivers of their emergence, while management and maintenance remains a challenging issue. This calls for novel governance arrangements with a focus on knowledge and management continuity. One of the most publicly- visible NBS with ecological innovation features is Montpellier's Château le Lez, where the architect's explicit aim was to create the first nature-inspired building in the city, 'the building that grows', whose walls are surrounded by plants to further inspire green building design and designers. Similarly, Athens' SNFCC carries innovative architectural characteristics: a photovoltaic canopy and a green roof-like artificial hill. Unlike many green structures, this one is publicly accessible.

As opposed to Montpellier, the two cases in Malmö are more robust ecological and technical experimentations. They test different types of vegetation, maintenance practices and soil structures (intensive green roofs) in relation to building structures

ATHENS: Stavros Niarhos Foundation Cultural Centre

This NBS was previously a parking lot left over from the 2004 Olympic Games. The Stavros Niarhos Foundation Cultural Centre (SNFCC) restored the site's lost connections with the city and the sea through a 170,000 m² landscaped park with a building. It is the first large-scale sustainable public building in Greece. The construction includes an artificial hill beneath which the Greek National Library and the Opera are located. The space hosts a range of educational and cultural activities which have so far been provided for free, including gardening courses, lectures and workshops on environmental and botanical topics, as well as environmental activities, such as tree identification. It also claims flood-regulating functions with embedded storm water infrastructure, air quality improvement and shade provision, among others. (public-private partnership)

DUBLIN: BELVEDERE COLLEGE - Urban Aquaponics Farm

The Belvedere College Urban Farm was started by the school in collaboration with the 'Urban Farm' start-up. It was and continues to be run by students with the help of trained personnel. It started as a combined greenhouse aquaponics/hydroponics facility serving as a testing ground for researching sustainable farming practices, providing education and practical experience on the topic to students, and being part of a collaborative food network in the local area. Winning the Zayed Future Energy Prize in 2016, the school upgraded the so-called GROWlab, and currently maintains the aquaponics system. The school is considering integrating the lab as part of its curriculum, using the system's functions to teach topics such as chemistry, physics, mathematics, environmental science and sustainability.

MALMÖ: BiodiverCity

BiodiverCity is a three-step project run by Malmö municipality (2012-2017). The aim of the project is to increase biodiversity by developing new products, services and processes, contributing to a vision of a green, attractive and healthy city. Over the implementation phase of two years, almost 30 different green structures have been established in different parts of the city including urban biotopes, green roofs, green walls and mobile plant systems. These green structures were designed and implemented in multi-disciplinary working groups through collaborations among ecologists, landscape architects, scientists, entrepreneurs and building developers from different private and public organisations, including Malmö municipality, the regional administration of Scania, research institutes, universities, building owners and developers. These permanent demonstrations serve as a basis for evaluation, learning, and dissemination of innovative solutions for urban greenery. In this study, we investigated the Koggen building in the new development area of Western Harbour and its intensive green roof implemented by the one of the partnering building owners.

MALMÖ: Augustenborg Ecocity

Augustenborg Ecocity is the collective name for a program to transform a run-down neighbourhood into a socially, economically and environmentally more sustainable and attractive place to live (1998-2002). Augustenborg Ecocity is one of Sweden's largest urban sustainability projects; its transformation started at the end of the 1990s and continues today. Measures of the four-year municipality driven redevelopment project include an open stormwater management system, green roofs and walls, re-planning of gardens and parks, and urban gardens. Augustenborg benefitted from funding from the governmental Local Investment Program for Sustainable Development and strong agency of individuals engaged with the area. One of the key success factors of the project is the continuous and conscious collaboration with stakeholders and the involvement of residents.

EDINBURGH: Square Metre for Butterflies

This project was launched by Royal Botanic Garden Edinburgh and the Butterfly Conservation Trust in 2016 to create a green network of rooftop habitats for threatened butterflies in Edinburgh. The aim is to get partners to plant at least one square meter of each of the following plant species: bird's-foot trefoil (*Lotus corniculatus*) for common blue butterflies, sheep sorrel (*Rumex acetosella*) for small copper butterflies, and common rock-rose (*Helianthemum nummularium*) for northern brown argus butterflies. Sites have been selected in close proximity to the species' caterpillar plants on some of Edinburgh's hills. The project has an education component, training staff in butterfly identification and also acts as a demonstration project to increase support for rooftop greening.

MONTPELLIER: Château le Lez

This private initiative of a building that grows was built in 2000 and followed the local specifications for the area (Z.A.C des Berges du Lez), tackling the challenges of urban density and lack of nature. The building is situated on the banks of the Lez River not too far from the city centre. It is one of the first green buildings in Montpellier, now serving as a model for green buildings being built after 2000. The building is 75 meters long, has seven floors and 62 flats with a total cost of €3.2M. Its walls are made of gabions, wire baskets containing dry stones, whose base made of large blocks of stones that degrade upwards. The facades are colonized by plants that inhabit the interstices of the rocks. The watering system is located between the joints of the panels to nurture the plants, and the balconies are equipped with flower stands for climbing plants. The building enhances the aesthetics of the neighbourhood.

(e.g. roof inclination). Besides other actors, in both cases, the Green Roof Institute plays an important role in providing facilities for the physical testbeds, knowledge and education enabling ecological knowledge continuity. Furthermore, these projects have also experimented with governance practices, partly through the collaboration of a multitude of public and private actors working together in multidisciplinary teams on the design, implementation and maintenance phases of the NBS. In BiodiverCity-Koggen, the housing company, as one of the collaborating actors, provided the roofs of its rental building for testing new processes and products to improve urban ecosystem services, increase biodiversity, re-create the local flora, improve aesthetics and reduce maintenance. One of the main outputs of this NBS is a novel maintenance plan, including new ways to maintain green structures, biodiversity and how to pass knowledge on to staff responsible for maintenance.

Similar to Malmö's Koggen, Edinburgh's Square Metre for Butterflies is an incremental innovation, to enhance mostly pre-existing green roofs to provide better conditions for butterflies and other pollinators. In both cases, organisations engaged in a process of active learning to increase confidence, capacity and competence in green infrastructure.

3.5.4 Expected and registered impacts

The cultural services from green buildings, roofs and walls are increasingly prominent. Cultural services of this type of NBS include aesthetic appreciation, inspiration for culture, art & design, and connection to nature through adding elements of the local landscape and ecology. Some roofs or buildings include small garden plots, enhancing educational activities around food provision and increasing well-being associated with frequent contact with nature. Some also include beekeeping and honey production (see in the category of insect-oriented NBS), thus increasing pollination services. Expected impacts also include raising the awareness of the urban residents about the potential benefits of NBS in the city.

Green roofs and walls are expensive to maintain. Green buildings often face a cost-related dilemma of combining natural elements and functions with large-scale grey architecture. They mostly involve architectural innovation, but due to their high demand for expert knowledge, their construction and maintenance are expensive, which is reflected in the elitist character of who can afford to live in them (e.g. Château le Lez, Montpellier). Green buildings that are not residences also present financial challenges which affect the organizations buying or renting them (e.g. SNFCC, Athens). This is a crucial factor when considering NBS sustainability and the distribution of costs and benefits. Namely, while innovative financing can kick-start a project, high maintenance costs are often borne by taxpayers (SNFCC, Athens). In general, maintenance of this type of NBS proved a challenge for all green buildings studied (e.g. BiodiverCity-Koggen in Malmö; Belvedere College in Dublin).

Apart from direct environmental benefits (increased biodiversity, water savings, energy efficiency) the range and broadness of cultural impacts of green buildings depends on where they are built. The Belvedere College roof serves as a laboratory for sustainability education and experimentation for students at a private school. In the case of SNFCC, Athens, the green roof of an underground library and parking garage is part of a public park, and therefore offers aesthetic and recreation benefits to a much wider public. As a green/sustainable building, it offers energy savings and other benefits to the organizations it hosts. However, in both cases, the costs of construction and maintenance proved prohibitive for scaling-up such interventions for the broader public (public schools or other public spaces/buildings) without the involvement of private actors. Both this project and the less costly Square Metre for Butterflies project in Edinburgh were enabled by donations or grants from non-for-profit organizations, or some sort of partnership between public and non-public actors.



3.6 INSECT-BASED INTERVENTIONS

Analysis in this section considers insect-based interventions in Edinburgh, Győr, Newcastle and Sofia.

3.6.1 NBS emergence

Insect-oriented initiatives are a recent and growing trend. All projects explored here are private undertakings, led either by large corporations, such as Audi in Hungary, conservation trusts, like the John Muir Pollinator Way and Square Metre for Butterflies in Edinburgh, or enthusiastic individuals. The Audi factory in Győr covers a 5,167,366 m² semi-urban area, 76% of which is green space “on-hold” until the factory complex expands its productive capacity. As part of its display of corporate social responsibility, the factory dedicates substantial amount funding to the management of native species, undertaking bio-indicator monitoring, carbon dioxide absorption research, and environmental education (including beekeeping). In 2015, the factory purchased six hives with 270,000 bees which were installed in indigenous Pannonian sandy grasslands. The bee colonies produce between 200 and 240 kg of honey yearly, branded and sold as Audi Hungaria Premium Honey. The bee colonies are well visited by public officials and educational groups, including the Audi Hungaria School.

Other bee-based interventions studied are the installation of hives at St. John Church and the University of Newcastle by the BeeSoc collective. Both ventures emerged between 2013 and 2017. In the former, a member of the congregation established and attended the bees, while supported by the Newcastle beekeeping community, largely funded through charitable events. The introduction of aromatic and bee-friendly plants enhanced the churchyard. In the latter case, members of the University of Newcastle Student Union installed the hives and formed a student group interested in beekeeping practices. A specific feature of Newcastle’s urban beekeeping is advanced digital hive monitoring equipment, which was donated by a private business (Arnia).

The Sofia beekeeping initiative is semi-private, and semi-citizen based. The small business was formed by two individuals in 2015, and promotes top bar hives, which are less efficient at producing honey, but very effective for beekeeping (and breeding). These hives have a window through which the development of the colony can be observed. The business sells the top bar hives complete with bees, delivery, settlement, work clothes and accessories, and a year of guidance. The initiative, which has fostered the installation of a number of beehives on roofs in Sofia, is gaining popularity and has an active following on social media.

EDINBURGH: John Muir Pollinator Way

The John Muir Pollinator Way was implemented by Buglife, a non-profit organisation dedicated to achieving sustainable populations of bugs necessary to sustain other forms of life, to create a network of bug-friendly green space along an already existing walking and cycling route, the John Muir Way. The 215 km route runs from coast to coast, passing through Edinburgh. In several municipalities, including Edinburgh, the potential sites of improvement, e.g. schools, parks, public places, and churchyards, have been mapped. Mapping and first steps of implementation have been done together with citizens and other local stakeholders.

EDINBURGH: Square Metre for Butterflies

This project was launched by Royal Botanic Garden Edinburgh and the Butterfly Conservation Trust in 2016 to create a green network of rooftop habitats for threatened butterflies in Edinburgh. The aim is to get partners to plant at least one square meter of each of the following plant species: bird's-foot trefoil (*Lotus corniculatus*) for common blue butterflies, sheep sorrel (*Rumex acetosella*) for small copper butterflies, and common rock-rose (*Helianthemum nummularium*) for northern brown argus butterflies. Sites have been selected in close proximity to the species' caterpillar plants on some of Edinburgh's hills. The project has an education component, training staff in butterfly identification and also acts as a demonstration project to increase support for rooftop greening.

GYŐR: Beekeeping at Audi

This beekeeping project is located at the Audi Hungaria factory. It is a privately-funded medium-scale (€100,000-150,000) project, including aspects of ecosystem management with native species, awareness raising, and education for sustainability through beekeeping. Audi Hungaria started beekeeping activities in 2015, and the core initiative is now complemented by pollution-reduction research that uses bees as bioindicators, awareness raising and sensitization of employees, education of school children through interactive workshops, and honey branding.

NEWCASTLE: Beehives in the City Centre

Honeybees are being kept at a number of locations in the city centre including church roofs, university sites and a retail store. Resources for the operation have been mobilized through the beekeeping community – through grants and membership fees at the university student union and through charity events and donations at the church. The Urban Observatory, a project based at the University of Newcastle, provides urban beekeepers with new technologies enabling the health and productivity of beehives to be monitored.

SOFIA: I Have a Bee

The 'I Have a Bee' initiative offers a sustainable and long-term solution to the pollinator decline. The initiative was started up by three enthusiasts in 2015, who provide new 'top-bar hives' targeted for hobby beekeepers. These new 'amateur-type' hives do not require the care of a professional beekeeper, which makes hobby beekeeping a more convenient and attractive recreational activity. These top-bar hives can be installed in backyards and terraces. The start-up package includes: beehive, delivery, bee family, settlement, work clothes and accessories, instructions and one year free of charge professional counselling.

There are two insect-based NBS in and around Edinburgh initiated and implemented between 2015 – 2017, which create and restore habitats either on rooftops (Square Metre for Butterflies), or along a 215 km long-distance travel route across the densely populated central belt of Scotland (the John Muir Pollinator Way). The former project, run by the Royal Botanic Garden together with the Butterfly Conservation Trust, consists of small patches of caterpillar food plants installed on the roofs of office buildings. The latter is an initiative by an NGO (Buglife), to conserve pollinators and support the services they provide to agriculture while bringing nature closer to people.

3.6.2 Governance and public participation

The initiatives studied here are mostly driven by non-governmental organisations (NGOs or foundation) or communities.

Building partnerships with a clear division of responsibilities among implementing actors is key in most insect-oriented NBS, especially when funding is limited. The two insect-based NBS in Edinburgh and surroundings are both in the initial phase now and have so far been managed and financed by the Royal Botanic Garden together with the NGO

Buglife (John Muir Pollinator Way) and the Butterfly Conservation Trust (Square Metre for Butterflies) respectively. The John Muir Pollinator Way was initiated and implemented by the NGO. The start-up grant came from the Central Scotland Green Network Trust (an independent charity partly funded by the Scottish Government), which was mostly used to cover the costs of mapping. Scottish Natural Heritage (government funded) provided funding for public engagement that accompanied the mapping exercise in the first 10 sites. The second phase was funded by a Greggs Foundation Environmental Grant. As the Way crosses land owned by local authorities, businesses, environmental organisations, farmers and community groups, working in partnership was crucial to establish the pollinator route. Partners at sites are envisaged to help both with in-kind and occasional financial contributions for maintenance.

In the Square Metre for Butterflies project, the Botanical Garden is partnering with the Butterfly Conservation Trust (NGO), which is also helps planning and implementation through providing resources (time, knowledge, materials, plants). In addition, various partners and companies, e.g. suppliers of materials and green roof components, provide in-kind contributions to the NBS. The Scottish Wildlife Trust plays a background role in championing the project within political arenas and watching over its continuation.

The Newcastle Beekeeping Society is not only an exemplary case of the importance of partnership building, but also of the resources that can be mobilized by the beekeeping community when funding is limited. Different units and communities of the University of Newcastle have taken up very specific roles in beekeeping activities. The BeeSoc student organization at the University of Newcastle was explicitly formed to take over beekeeping from Go Volunteer, a team within the Student Union that was previously responsible for it. For BeeSoc, several grants were provided by the Student Union and a membership fee was charged. This enabled purchase of materials and additional expenses. The Estates Department of the University of Newcastle is responsible for finding a site for beehives on campus, while the Urban Observatory, a research initiative based at the university, is monitoring beekeeping by deploying sensors in the beehives. At St. John's Church, the initial investment was raised through charity events, and it was expected that the maintenance costs would be covered through honey sales. (As this turned out not the case, the church congregation donated the additional resources.)

Audi's undertaking beekeeping as a large corporation is unique among these cases in terms of its stable financing. Still, collaboration, as in the other cases, is key for project advancement. The project is run by the company's Environmental Management Unit on an earmarked budget from the Facility Management Unit and the Bioindicator Project. This is run together with the Forest Faculty at the University of Sopron, who analyse pollutants based on samples from the honey, beeswax and pollen collected at the site. The maintenance of the beekeeper's shack, the beehives, and nearby areas is subcontracted to external companies.

In Sofia, two community members founded the organization 'I Have a Bee.' The founders are the main decision-makers and financiers of the project. Citizens can get involved by purchasing a beehive with bees. Additional services can be requested: delivery, installation, work clothes and accessories and one year of free professional advice.

Notably, **the role of municipalities in insect initiatives is less relevant**, with the exception of Newcastle, where the municipality launched a Bee Steering Group that developed a Beekeeping Strategy in 2011. Even though these initiatives were cancelled and the group disbanded in 2011, these initial steps by the city council triggered several activities around the city, such as installing bee boxes, changing flowers to more bee-friendly species, and engaging with schools to promote awareness. For a brief period, Newcastle was known as a "UK's most bee-friendly city". The social relationships that were formed and maintained enabled beekeepers in the city centre to pick up this thread and establish Bee Steering Groups. As a result, several beehives were set up in the centre by different community actors.

The city council's actions were important for the NBS kick-off in Newcastle. In Edinburgh, the city council enabled the later development of the John Muir Pollinator Way, for instance, by adapting meadow maintenance regimes - in line with their

efforts of re-naturalising parks and green spaces – and participating in site implementation with five local authorities and several Friends of Parks groups. The local authorities are even less involved in the city's other NBS (the Square Metre for Butterflies). Here, authorities mostly provide the Botanic Garden with resources (staff salaries) to implement green innovations to reach the environmental and landscape development goals of the city. To reach these goals, the Botanic Garden, as the initiator and manager of the NBS, is engaging with other public and private actors.

Public participation in NBS focusing on urban hives, and initiated by single individuals, and smaller (or larger) businesses largely focuses on organization of educational activities, events and field trips and the sale of marketable products.

3.6.3 Aspects of innovation

Insect-based interventions often carry elements of social and technological innovations. Urban beekeeping has turned into a space for experiments with forms of smart urban development, such as monitoring of hives, learning and experimentation, and data-sharing orientated toward biodiversity protection and environmental education.

In Newcastle, new beekeeping practices have been introduced through the use of advanced digital hive monitoring equipment, which was developed by the Urban Observatory and Arnia, and provided for free to bee-keepers. The long-run monitoring of hives leads to conservation-related learning, and enables beekeepers to more effectively and efficiently look after their hives. In Győr, beekeeping is also monitored, and key performance bio-indicators are analysed by the University of Sopron. These bio-indicators, based on the analysis of the honey, beeswax and pollen, can show pollutants and thus enhance long-term environmental knowledge. The approach of using bio-indicators (bees) to monitor pollution has started to spread to other companies. A German supermarket chain, in cooperation with the University of Sopron, has launched its own beekeeping bioindicator across several locations in Hungary. There is also a discussion around the possibility to transfer the full-day beekeeping program, which was developed for educational purposes at the Audi site, to other schools.

3.6.4 Expected and registered impacts

The insect-based NBS have contributed to enhancing the biodiversity and aesthetic value of local landscapes. They have also been reported to increase environmental awareness and stewardship through educational activities and active citizen involvement. In some of the cases, these initiatives can act as a way to improve access and connection to nature for disadvantaged neighbourhoods and youths (e.g. John Muir Pollinator Way in Edinburgh).

Maintenance costs are not too high for this type of NBS, but still projects are not viable without funding. Insect-based NBS, similar to green buildings, are often enabled by donations or grants from non-profit organizations, or a partnership between public and private actors, such as the Square Metre for Butterflies project in Edinburgh, which is operating on donations.

Urban beekeeping is growing, yet detached from global ecosystem disruption. Beekeeping as a form of “helping” and “owning” nature at the same time, has grown in urban environments not only driven by clearly educational or environmental goals, but also as a hobby that can be learnt and practiced (Sofia’s “I Have a Bee” initiative), and potentially generating income by selling honey as the outcome (as in Sant John’s Church in Newcastle, or Audi’s factory in Győr). Beekeeping initiatives raise the greater question of generating and evaluating impacts in a detached manner. Beehives, for example, as a metaphor of “nature”, contain natural mechanisms and functions and their existence benefits ecosystems and agricultural production by increasing pollination. It is perhaps indicative of how easily beekeeping is adopted - an urban trend that is

creative, fun, and “doing the right thing” in terms of sustainable practices - but is also detached from the reasons why there is a decline of those pollinators today (pesticides, etc.). Audi’s beekeeping project earns profits for conservation programs and raises awareness around biodiversity, while it is situated within a car factory with expansion plans on a protected natural ecosystem.



3.7 WATERFRONTS AND RIVERSIDES

Analysis in this section builds upon initiatives at waterfronts and riversides in Boston, Dublin, Győr, Leipzig, Munich, Tianjin and Winnipeg.

3.7.1 NBS emergence

Many of the waterfront NBS studied are large-scale, long-term, costly initiatives, often initiated by state actors.

In the Moson-Danube estuary (Győr) the sinking of the river (resulting from floods in the Danube) obstructed ship and boat traffic and led to the accumulation of branches on riversides while drying adjacent areas. The technical direction undertaken by the municipality and the Transdanubian Water Directorate was to narrow the river bed, through steeper paved banks, and install a flood gate system to regulate water levels. The Isar river, on the contrary, in the frame of the Isar Plan, was restored to its original shape after having been “tightened” in a narrow concrete corset. This restoration gave the river more space to move and regain its original features. The Isar Plan also included rewilding measures for the river landscape. These two interventions have applied entirely different approaches to transform riverscapes to improve “aesthetically unpleasing landscapes”. In both cases, one of the major drivers for changing the riverside was the need for flood protection and making better use of the river areas for leisure and recreational activities. It is yet to be discussed how “the natural” has been conceived in narrowing and partly paving a river bed.

Another smaller-scale and less energy-intensive river restoration is the alluvial forests of Leipzig around the Luppe river. Deepening and straightening the river bed and tubing of streams in earlier decades lowered groundwater levels, removing the forest’s water basis and damaging biodiversity. The intervention aimed to bring back water flows through mill brooks and new canals, eventually enhancing wetlands and the natural resilience and biodiversity of the area. The renaturing of the river was a joint initiative of local municipalities (the Northern part), supported by an environmental organization (NABU), which contributed to the maintenance and cultivation of an amphibian habitat (in the southern section of the river). Another approach to the construction of wetlands is illustrated by the Tolka Valley Park (Dublin). There, soil and water pollution caused by illegal dumping and industrial/landfill leakage was tackled by creating an integrated wetland to slow down floods and absorb polluted urban runoff waters. The wetland is fed into an ornamental pond connected with a river (used extensively for fishing).

The Ecological Wetland Park in Tianjin Harbour is also artificially created, though much larger, approximately 630,000 m².

BOSTON: Waterfront Initiative

The Waterfront is an initiative of a local philanthropic foundation (Barr Foundation), which is consciously trying to fill a gap in current public climate planning efforts in Boston seaside areas. It aims to combine historic preservation and climate planning with a focus on reinforcing place identity. The Waterfront Initiative has been awarded over \$9 million to date since its start in 2016, focusing on providing exceptional parks and accessible open spaces, engaging and reflecting a full range of Boston neighbourhoods and their residents, enabling responsible development that is attentive to the public's interest, and addressing the critical need for resiliency and adaptation to climate change.

DUBLIN: Tolka Valley Park - Wetlands and Greenway

The development of a four-kilometre greenway and off-road cycling route, linking Glasnevin Finglas with Ashtown, with three integrated constructed wetlands is a significant green infrastructure project for Dublin. The municipality driven NBS is a continuation of the successful 'integrated constructed wetlands' intervention which was created in 1999 as a novel way of treating the polluted incoming waters of the Finglaswood Stream. The Greenway was a project aiming to add 20 hectares of newly-developed parkland to the city, connecting neighbourhoods and offering ecosystem services to a newly-built complex of apartments south of the park. After big biodiversity benefits from the first constructed wetland system, including the return of salmon to the river, the second phase aimed at enhancing habitat diversity, new wetland ponds to be planted, with aquatic and marginal vegetation, new hedgerows, thousands of trees and seven hectares of wildflower meadow. Control of invasive species, such as Giant Hogweed and Himalayan Balsam, was also planned as part of the on-going management policy.

GYÖR: Moson-Danube Project

The Moson-Danube Project is a publicly-funded, large-scale blue infrastructure intervention implemented between 2012 and 2015 in the densely populated urban core of Győr. The project includes river regeneration along 125 km, the reconstruction of urban riversides, ecosystem restoration of backwaters, freshwater habitats and several islands, as well as installation of concrete riverbanks, a floodgate and strengthening the river network of Győr.

LEIPZIG: Post-industrial Waterscapes

Leipzig has a lot of woodland within close reach, some very close to the city centre, connected to residential districts. This NBS, in a public-NGO partnership, focuses on the re-naturation of the Luppe River ('Lebendige Luppe'), which entails measures to enhance biodiversity and to (re)establish semi-natural habitats. Other features include reopened mill brooks, reflooding, and re-natured rivers together with their surrounding alluvial forests. This NBS is an attempt to rehydrate the area, which has suffered from drainage through canals, industrial and tourism use.

MUNICH: Isar Plan

The Isar Plan is the renaturation process of the Isar river. In 1995, financed by Munich municipality and the region of Bavaria, a multi-stakeholder project group was initiated to plan for the renaturation of the Isar river in Munich by transforming it from an artificial canal bed into a more natural shape and function. The three main objectives were improved flood control, increased biodiversity and improved recreational opportunities. The construction started in 2000 and was finished in 2011 having restored 8 km of the river at a cost of €35 million. The Isar Plan provides an excellent example of how diverse organizations and citizens can work together for an agreed and multi-beneficial outcome with regional impact, leading to reduced flood risk, improved water quality, the ecological recovery of a semi-natural riverside area, and the provision of a recreational area in the heart of the city.

TIANJIN: Ecological Wetland Park in Tianjin Harbour

Wetlands cover over 7.4% of Tianjin's area (875 km²) and the municipality is engaged in large-scale wetland protection projects. As an industrial pioneer, the China-Europe Advanced Manufacturing Industrial Park developed the Tianjin Harbour Economic Area - Ecological Wetland Park in 2010 on about 630,000 m² with an investment of €34 million, financially supported by the Asia Development Bank (public-private partnership). The artificial wetland area has three distinct functions: 1) wastewater treatment of the industrial park to minimize wastewater and pollutant discharge into the Bohai Bay, 2) ecological restoration to increase biodiversity (as a result, the areas now hosts over 120 species of wetland plants), and 3) increase the liveability of the area by providing space for leisure and recreation, thus making residential life more attractive in a rapidly-developing industrial district that is embedded into the manufacturing and logistics capacity of the largest port of North China.

WINNIPEG: Seasonal river use

Winnipeg, lying at the confluence of the Assiniboine and Red Rivers, is experiencing a renaissance in the use of its waterfronts, while facing highly variable water levels and devastating floods limiting riverside development and activities. The more than half of the 240 km privately owned waterfront further limits development possibilities and neighbourhood access. Nevertheless, significant public and private investments were made in public spaces along downtown rivers, and there is active public consultation on challenges, opportunities, and potential future directions. The winter use of the river has gone through an unprecedented change in the last 10 years, organized by a private company (The Forks North Portage Partnership), that began to operate the Guinness World Record-holding longest naturally frozen skating trail on the rivers. The winter river offers skating, curling, cycling, walking and cross-country skiing, with unique, community-designed warming huts, a restaurant on ice, art exhibitions, and other cultural events. The frozen riverbeds also function as mobility pathway connecting otherwise distant neighbourhoods during the winter months.

It is a state venture funded by the Asian Development Bank. The Wetland Park was reclaimed from the sea, and developed with the aim to facilitate wastewater treatment, biodiversity and eventually the liveability of nearby areas, thus attracting a skilled workforce.

The other two interventions in this category that share a number of features are both located in **North America**. The waterfront initiatives in Boston and Winnipeg emerged from joint multi-stakeholder efforts to enhance the accessibility of either the seafront (Boston), or the riverside (Winnipeg). In Boston, the key drivers of the NBS are the need to achieve higher climate resilience reduce inequality and improve access. The latter has especially been in focus, as lower income and minority residents perceive the waterfront as unwelcoming, “private looking” and too expensive. The Winnipeg initiative, on the other hand, is features 240 km of privately-owned waterfront, devoid of neighbourhood access. In Boston, inclusivity is sought through creative and participatory planning and the development of greenways and artistic installations facilitating access to the waterfront. In Winnipeg, the frozen river is used in the winter for community-based events, sports, art, recreation and social innovation as a way of enhancing cohesion between neighbours and neighbourhoods that are normally separated by the water. Both initiatives are initiated and funded by private actors and foundations – the Barr Foundation in Boston and the Forks North Portage Partnership in Winnipeg.

3.7.2 Governance and public participation

Most of the waterfront initiatives are governed through different types of partnerships, in which the initiating and/or leading state actor partners with other public, private or non-governmental organizations. As water bodies often cross municipal borders, regional authorities play a key role in these projects, besides their municipal counterparts. The collaboration between these two actors is therefore crucial for the success of waterfront NBS. Although the municipality and the Northern-Transdanubian Water Directorate (Győr) and the Bavarian Water Management Office (Munich) coordinated their respective waterfront development projects, funding came from different sources. While the Moson-Danube NBS was funded through and supported by the European Union Framework Directive, the Isar Plan was funded through the Bavarian State (55%) and the City of Munich (45%). In the latter case, shared funding came with shared responsibilities and collaboration among a variety of actors. The Isar Plan’s interdisciplinary project group included representatives from several municipal departments, consulting experts, and an alliance with the largest environmental NGOs in Germany representing interests of various citizen groups.

Similarly, renaturing the Luppe River in Leipzig is also a joint implementation with national funding. Following the recommendation of the Federal Agency for Nature Conservation, the local municipalities and an environmental NGO joined forces in the implementation process after having started to work separately on different parts of the river. While Leipzig and one of the downstream municipalities are the main coordinators bearing responsibilities for implementation in the southern fraction of the river, the NGO is responsible for the northern-section rewilding and for environmental awareness campaigns (together with the associated public outreach).

One of the largest undertakings in this domain is the Ecological Wetland Park in Tianjin Harbour, which is a state-backed top-down public-private partnership, in which the Ministry of Finance signed an agreement with the Asian Development Bank to create a green development fund together with the local government. The NBS involves a multitude of actors from different industrial sectors and governmental levels. The role of the local government entails the ownership of the industrial park, facilitation of the project and the funding of the park and its maintenance.

Waterfront initiatives with private leadership and funding also emerge from joint multi-stakeholder efforts, in which individual engagement of project leaders and community members is crucial for the development of the NBS. The initiatives in Boston and Winnipeg aim to enhance accessibility of either the sea-front or the riverside, enjoy private

funding through the Barr Foundation (Boston) and the Forks North Portage Partnership (Winnipeg). Although the Forks is a publicly-owned corporation, it acts as a private undertaking. In the absence of municipal and regional responsibility in the winter time, the Forks gradually took over managing the frozen river with the agreement of the city. Interestingly, when the river is navigable its management falls under the responsibility of the federal government and when it is frozen, there are no governmental jurisdictions or claims over it. This, and some private funding, has opened a window of opportunity for a multitude of entrepreneurial initiatives on the frozen river surface.

Boston's waterfront initiative was also a response to the lack of public leadership in the city's waterfront planning. The rapid construction in a South Boston waterfront neighbourhood where "more than €1.3 billion worth of apartments, condos, storefronts, and office space is under construction" prompted the Barr Foundation to start the Waterfront Initiative (Kim 2018). The Waterfront Initiative initially supported organizations in harbour planning, designing waterfront parks, and climate resilience efforts along the Boston waterfront. However, it has more recently started to focus on social equity and public engagement across more vulnerable neighbourhoods around waterfront issues, dedicating one full-time staff member for the initiative.

The type of approach to public participation applied by the project initiator is central for the successful integration and inclusion of multiple concerns, including social justice, in its deployment. The approaches to public participation in these cases are strongly related to the types of governance used. In Tianjin, public participation was a cultural and institutional no-go zone, while in Győr (Moson-Danube) and Munich (Isar), public participation has been approached in conventional or formal ways. In Hungary, this entailed state-led community surveys and forums, and in Germany, internet platforms, brochures, site visits, workshops, media, round tables, discussions and interviews were used. The results of both processes and the extent to which public participation outcomes have been taken into consideration in the final project design and implementation differ. Local groups in Győr report that accessibility to the river for specific groups (like fishermen) has become less frequent and comfortable. Alternatively, in Munich the consideration of citizen opinion helped identify the optimal 1.5 km for the urban river re-wilding section that brought back the alpine character of the river, while enlarging its banks, keeping flood meadows and existing vegetation and providing better access for different community groups.

Large-scale river re-scaping NBS are still riddled with narrow technological visions, where participation is tailored toward the needs of the establishment. In the Leipzig Luppe River re-wilding intervention participation is generally driven by the close involvement of an environmental organization (NABU), focusing on the environmental education aspects of the project and leading a small part of the project. In this case it is unclear whether any effective type of public participation took place in the design of the intervention, given civil groups' reservations about the success of the scheme. Environmental organizations report that the Neue Luppe Canal flowing through the alluvial forest between Leipzig and Halle lies too low, causing low groundwater levels that negatively affect the local ecosystem, and so advise its comprehensive transformation. The city of Leipzig, however, did not seem open to consider such a possibility. According to NGOs' reports, the city has excluded expert opinions from different stakeholders, including NABU, precluding knowledge co-creation and the participation of civil society in strategic decision-making. The formal participation process furthermore did not provide opportunities to discuss different options, but rather requested comments only on the option chosen by the city. Moreover, changes in the rewilding proposal were not communicated early on. Interviews with NGOs indicate that more successful rewilding measures could be achieved if the City of Leipzig and regional authorities were to drop technical flood protection measures that most likely favour the local water supply companies. Reports on the participative process with the Győr waterfront are another illustration of narrow or overly-technical visions by public agencies which have been difficult to influence by non-institutional actors.

Waterfront access initiatives run by private actors and foundations frame participation around charitable and leisure activities. Participation in the Boston and Winnipeg waterfront projects was largely enacted through funding racially and ethnically diverse organizations (by the Barr Foundation in Boston, for example) and community-driven shaping of a skating trail, building of snow sculptures, and the overall provision of open space for enacting creative ideas by neighbours

from different sides of the river (in the Forks North Portage Partnership of Winnipeg).

3.7.3 Aspects of innovation

Waterfronts and riverside NBS are very diverse in the types of innovation they represent. All studied initiatives are **ecological innovations, in the sense of creating new spaces with a multitude of aims benefitting diverse actor groups.** In addition, some of the cases have restoration among their main goals. The most apparent of these is the Isar Plan in Munich, which explicitly and systematically integrates ecological elements even in the most technical river restoration segments, to re-create the alpine character of the river in a strictly urban setting and increase biodiversity. Another experiment, literally with the physical space, is Tianjin's butterfly-shaped wetland park integrated with the water treatment process and the 'sponge city concept', according to which at least 75% of the rainfall is collected, stored and reused in the area.

Experimenting with multifunctional physical structures often requires new ways of governance, which we can see in most of these initiatives. Seasonal freezing of the river and the absence of legal responsibilities for this enabled The Forks in Winnipeg to search for and initiate new ways of governance, funding, collaboration of actors, engagement of locals, and allocation of responsibilities to run winter activities. Similarly, the Barr Foundation in Boston, although a more established organisation, recognised the benefits of community engagement and began constituency building within different governance settings for its different initiatives. Its goal was to strengthen the public realm around Boston Harbour and facilitate more inclusive and resilient waterfront development, contrary to the more traditional development on the southern end. Waterfront initiatives in Munich and Leipzig also experiment with governance structures that have not been tested earlier. One of the crucial factors that made the Isar Plan possible was bringing together actors from different sectors and disciplines in a working group to implement the plan, in which close cooperation and trust developed between different municipal departments, regional authorities and other private and community actors. This new cooperation and governance constellation were needed for the successful planning and implementation of the project. Another way of collaboration was developed in Leipzig over the responsibilities for redeveloping the Luppe River. In this governance structure, a workable division of tasks and physical spaces was negotiated between the municipality and an NGO to work together under common funding from the Federal Agency for Nature Conservation.

Some of the waterfront initiatives have become spaces for learning, both within and beyond the project. The Isar Plan, for instance, has been implemented in several stages with the idea to learn from one stage or site to another. The first stage was a pilot project to gain more experience with this type of river restoration. The construction work was planned between October and April (1999-2000) when the discharge from its mostly-frozen alpine watershed is low and recreational use is less. The first lessons on the river's behaviour during the high discharge season could be then collected after the summer when the pilot stage has experienced both natural and social pressures. Since the pilot, the Isar became a best practice example for river restoration, receiving many national and international visitors to exchange experiences and enhance knowledge development about nature-based solutions.

Similarly, Tianjin's wetland gets regular visitors, mostly from other provinces and local governments, to learn about the technical and organizational details of the NBS and about the 'sponge city' concept this site is experimenting with.

3.7.4 Expected and registered impacts

Prevailing socio-cultural benefits. Typically-expected impacts (and generally claimed aims) for this type of NBS include flood regulation, improvement of water quality (water treatment in case of wetlands), increased biodiversity, and cultural benefits such as increasing accessibility and attracting people to previously unused or of limited reach areas. Business

opportunities are also created as spaces for sports and leisure (see for example Winnipeg's seasonal river use).

As most of these NSB reconfigure blue access points or whole blue areas into more ordered and managed ecosystems, they are also considered as culturally beneficial for creating amenities for people to use. This has had a number of positive cultural and social impacts, such as normally-separated neighbourhoods coming together in the winter on the frozen Forks River for community-oriented events, including festivals and winter sports.

In some cases, certain ecological benefits have been compromised. In Győr, for instance, antiquated river-restoration plans were not publicly negotiated and thus ignored important new approaches for resilience and climate adaptation in such ecosystems. In Winnipeg's Seasonal river use NBS, new cultural and related economic values were created through the developments, but this caused significant changes to the physical structures of the riverfront and the floodplains.

Social justice is an important concern in gentrification-prone areas. Whether NBS will have negative or positive social justice impacts seems to be closely connected to how initial project aims and values are defined, but results show that waterfronts in general are prone to gentrification. Waterfront regenerations that aim to create new spaces for business and leisure frequently become elitist for their attractive locations with high demand. Weak social housing or rent control regulations result in waterfronts that reflect privilege and the intersection of social and racial inequalities. This was seen in Boston, where population in the Seaport District is only 3% black and 89% white, with a median household income of nearly \$133,000, (the highest in Boston). In a very different case, the Isar river restoration plan, which was based on values of biodiversity and civic engagement, succeeded in delivering such outcomes and offering an accessible amenity that serves a large number of residents. Yet even there, the price of nearby housing is increasing. Similar is the case of Tianjin's Ecological Wetland Park, which managed to increase biodiversity and ecological benefits such as wetland water purification, but at the same time constitutes a selling point for real estate developers building elite residencies.



3.8 MEASURES TO DEAL WITH WATER SCARCITY

Analyses in this section cover measures dealing with water scarcity in Cape Town and Mexico City.

3.8.1 NBS emergence

Water scarcity is a central theme in developing country NBS explored within Naturvation. Ensuring water availability through the removal of invasive species in Cape Town, or replanting grassland, facilitating water discharge and encouraging water-friendly chinampa agriculture in Mexico City, are some key physical features of the NBS we studied in less-developed countries. Two of these NBS, Water Funds in Cape Town and Mexico City, were initiated by the same NGO, mostly as a result of state failure to sustainably manage the local water system. Its multi-actor framework involving businesses, academia, state actors and civil society seems to have provided a new format, which is arguably more transparent and trustworthy, and hence more apt for accessing funding and initiating action than formal municipal/state structures. The Water Forest initiative in Mexico City is another multi-actor initiative encompassing 237 km² of the most vital watersheds of the city. It emerged from the need to develop and implement a regional water conservation strategy for Mexico City. Some of the measures there include restoring pastures, installing biodigestors for local waste treatment and stimulating changes in agricultural practices through the reduction of pesticide use. In all cases, the particularities of the local socio-political contexts strongly influence the trajectories of the NBS. Concerns with inequality are thus eminent features of their planning and deployment. **As an illustration, one of the facets of successful water access NBS is the integration of concerns about justice and gender into their design and operationalization.** This is especially evident in the Cape Town Atlantis Water Fund – Aquifer Clearing Pilot Project where community members, mostly women, have been the main protagonists of change.

3.8.2 Governance and public participation

Most NBS in this domain are initiated and often led by NGOs and grassroots groups, each characterized by a unique constellation of actors and allocation of roles. The Water Forest initiative in Mexico is managed by Conservation

CAPE TOWN: Atlantis Water Fund – Aquifer Clearing Pilot Project

Cape Town experienced severe drought from 2015 to 2018 and the city came close to running out of water. One pilot project seeks to increase the water supply to Cape Town by removing invasive plant species, which are thought to remove millions of litres of water from the catchment area annually and use significantly more water than indigenous species. A pilot project run by The Nature Conservancy is removing invasive species from the area that recharges the Atlantis Aquifer, the largest aquifer supplying Cape Town. The initiative also acts as a job creation and training program by employing teams from nearby disadvantaged communities to do the plant clearing work. Importantly, the pilot project feeds into the creation of a Water Fund for Cape Town, which in the form of a public-private partnership, will convene various levels of government, industry representatives and other stakeholders to find new ways to fund and coordinate wider efforts to clear invasive plant species as a water supply strategy.

MEXICO CITY: Water Forest

This NBS aims to develop and implement a regional conservation strategy to provide water and ecosystem services to Mexico City, the State of Mexico, and Morelos. More specifically, the Water Forest seeks to identify common objectives that encourage participation, integration, and coordination and strengthen water resilience for the megalopolitan region. Led by the Conservation International Mexico, various entities, i.e. states, municipalities, local communities, civil society organisations, and academics, have come together over the past ten years to collaborate in the initiative, which covers an area of about 250 km² and encompasses the most vital areas of the watershed for absorbing rainfall and recharging aquifers. It seeks to protect and restore ecosystems and sustainable livelihoods in ways that range from changing local agriculture practices to instituting new national policies. Activities on the ground are complemented by a movement-building exercise to engage key actors around the concept of the Water Forest and encourage them to integrate it into their own agendas. The initiative enjoys considerable support from business leaders and state governors of the megalopolis who have proclaimed the Water Forest an issue of national security.

MEXICO CITY: Water Fund

The Mexico City Water Fund was initiated by the Nature Conservancy Mexico on behalf of the Latin American Water Funds Partnership and in partnership with other organisations (2015). It is now managed by a new non-profit organisation 'Por el Agua de la Ciudad de México' (For the Water of Mexico City). A key aspect of water funds is that they attract funding in an organised and transparent manner from large water users, such as drinking water and sanitation operators, irrigation districts, hydroelectric plants, and foundations. The Water Fund aims to help reduce the imbalance of the aquifer and promote a positive long-term water balance. At the same time, these actions will have a number of benefits, including lower subsidence, mitigation and adaptation to climate change, and protection of biologically-significant sites. The Fund has just initiated its first pilot project to protect and enhance regional ecosystem features, while strengthening water security and regulating the water cycle in the city.

MEXICO CITY: Boroughs of Xochimilco and Tlahuac

The 'chinampa' cultivation method associated with this area is highly productive and has a positive effect on water-related ecosystem services serving Mexico City. Unfortunately, this social-ecological system has been deteriorating for some time. Many years of unsuccessful institutional efforts have encouraged local actors to pursue small practical initiatives in support of chinampa cultivation. These normally involved academic activists, producers and concerned residents creating value-added markets while also trying to connect citizens with producer and place through, for example, 'Community Supported Agriculture' with basket delivery, a 'Sunday Market' near a popular recreational facility in Xochimilco, and 'Sales of Produce' combined with ecotourism and educational programs for schools. This community-led initiative can be seen as an urban agriculture project but it is more importantly an effort to use traditional food cultivation practices as a pathway to ecosystem restoration and social-hydrological resilience.

International Mexico, an NGO, but in essence it is driven by a committed individual, who collaborates with a wide range of people, communities and organizations. There are 115 formal supporters of the initiative, some of them taking on more leadership than others. The Water Forest is unusual in that it is organised on the scale of the megalopolis and needs support from federal and state governments – not the least in form of legal designation and protection. At the same time, it is important that the initiative does not come across as top-down to not undermine the power of local communities. In fact, it is the indigenous communities' practices that are said to have sustained the still-functioning ecosystems to date.

The initiatives supporting traditional cultivation methods (Xochimilco, Tlahuac) are characterized by alliances between activist academics and traditional cultivators. The groups formed to support initiatives in Xochimilco include producer cooperatives and civil associations housing and/or supporting producers (*chinamperos*) with the involvement of researchers interested in ecosystem restoration.

The Water Funds in Cape Town and Mexico City were initiated by the Nature Conservancy and rely on multiple stakeholders, including businesses, academia, actors from state agencies and civil society, but in contrast to the other initiatives currently they both seek private-sector financing. Interestingly, the involvement of municipalities differs in these two cases (see below).

Water funds function as financial mechanisms to channel investments from associated organizations to projects that meet collectively-agreed priorities. The main idea behind these mechanisms, in Cape Town and Mexico City, is that these funds function as independent legal entities. In both cases, the Nature Conservancy initiated the process acting as an intermediary to catalyse cooperation and to unlock financing, particularly from the private sector. In Mexico City, the newly-formed NGO for Water in Mexico City already manages the fund. In Cape Town, the intention is that the Nature Conservancy will step back after the fund has reached maturity, including an established governance structure, a stable business model, and engaged stakeholders who jointly sit on a board and fund projects to clear water catchments of invasive species. In both cases, private partners with intense water use have already been approached, such as beverage companies, breweries, water bottlers, and other private actors with interest in sustainable water management, such as insurance companies, the financial sector, utilities and other government entities. In Cape Town, for instance, the Coca-Cola Foundation donated \$150,000 (~€130,000) to the Atlantis Water Fund. Alternatively, In Mexico City, the local government provided initial funding, and all partners contributed to the implementation cost of the first landscape conservation pilot project (587.76 ha), in Topilejo, which cost around 27.1 million pesos (~€1.164 million). This pilot includes 'active' (i.e. restoration of degraded land) and 'passive' (i.e. preservation of areas in a good state) conservation limiting the growth of agricultural production with the goal of maintaining and improving infiltration and recharge. It also includes productive reconversion (201.53 ha) for the development of agricultural activities compatible with maintaining forest cover, which facilitates infiltration and recharge, economic viability, and landscape-quality improvements. The budget is shared 50-50 between For the Water of Mexico City who manages the Water Fund and the Mexico City Secretariat of Environment. The transparency and credibility of this new governance structure seemingly allow for easier access to funding for future actions.

The role of municipalities in these initiatives varies a lot from the municipality being the **key decision-maker** (Mexico City Water Fund), through the provider of **legal designation and protection** (Mexico City Water Forest) to potential collaborator in grassroots initiatives in Mexico City to create sustainable livelihoods and to restore ecosystems. In the Mexico City Water Fund, the local government is a key player as a decision-maker, funder and implementer with emphasis on engaging the private sector and utility managers with interest in sustainable water management. For the city's Secretariat of Environment, the Water Fund is among other things an opportunity to bolster its beleaguered Conservation Land and address the city's water challenges while securing ecosystem services. The Water Forest, however, despite important municipal support, has understated the City's role in the field, so that the NBS does not come across as a top-down approach in the eyes of local communities – undermining their power over local land and practices. Importantly, both the Water Fund and Water Forest have been incorporated into the city's Resilience Strategy, which not only situates these NBS within an integrated policy framework, but also facilitates partnerships and financing, in turn reducing silos and increasing information exchange.

The dozen grassroots initiatives in Xochimilco, Tlahuac, and Milpa Alta for traditional cultivation practices located on heritage sites called for the attention of different authorities. The city's Secretariat of Environment, in collaboration with the Ministry of Housing and Urban Development, are to create a Master Plan to resolve the current situation of regulatory confusion and contradiction that undermines protection efforts. In conjunction with the Master Plan, the city's Resilience Agency, the Autonomous Metropolitan University and the Deltares Group (a Dutch company with water expertise) are developing a Water Resilience Strategy for the Heritage Zone and identifying a portfolio of measures to protect and restore the Xochimilco water system. An interesting component of this effort is the planned implementation of an Open Data platform that will ensure that the extensive research being carried out is available to other initiatives, including other planning processes in the future, acknowledging that plans come and go and that more effort should be made in helping them to build on one another.

We see a new role of nature conservation organizations emerging in these initiatives. Either they act as

intermediaries catalysing cooperation and unlocking financing, particularly from the private sector (Water Funds), or they manage the development and implementation of NBS with the help of other collaborating individuals, including members of local communities, subsistence farmers, NGOs, academics, and government officers (Water Forest). The role of academia becomes pertinent in the grassroots initiatives in Xochimilco (Mexico City), which are mainly based on alliances between activist academics and traditional cultivators (*chinamperos*). *Chinamperos* have a strong cultural connection to the place and to traditional practices of chinampa cultivation, which help maintain a functioning ecosystem. Recognizing this, conservation organizations support them in maintaining good practices, and facilitate access to markets that will allow them to make an adequate living.

Public participation and strong community appeal are the mechanisms or principles that tend to enable NBS dealing with water scarcity. Strengthening community relationships and trust where perceptions of widespread corruption are an obstacle is key to realizing NBS in developing countries. The interventions in Mexico City and Cape Town point to the key role of engaging community members in leadership roles in preservation and stewardship activities, especially through grassroots initiatives that help restore local ecosystems (i.e. *chinampas* cultivation in Xochimilco).

The success of the Atlantis Water Fund Pilot Project (Cape Town) is bound to the targeted engagement of women who were employed and trained in water preservation and invasive species removal from catchments. Empowering women to become change makers in local communities with an enhanced sense of being stewards of the natural environment is one of the reported successes associated with the project. Likewise, in the Mexico City Water Forest the direct engagement of local communities was fundamental for carrying out the project, as they are (often) the collective owners and guardians of extensive land in contexts of weak law enforcement. Local communities are hence the developers, defenders and the enforcers of sustainable livelihoods where NBS can thrive, for example through convincing local producers of nopal cactus and avocados to change cultivation practices and use less agrochemicals, thus protecting aquifer water quality.

Unlike many NBS in industrialized countries, where achievement of green aesthetics is a key aspiration, The Water Forest, Xochimilco and Atlantis projects are all deeply embedded in the basic needs of the local population - access to water and secure livelihoods. **Work around these types of NBS is entangled with issues of sustaining and transforming livelihoods in contexts of high inequality, where employment goes hand in hand with enhancing the provisioning and regulating functions of local ecosystems** (Cape Town, Mexico City).

3.8.3 Aspects of innovation

NBS addressing water scarcity typically aim for institutional change, and depending on the socio-political context conservation and/or better livelihoods, bringing along ecological and social innovation. In these NBS, we encounter experimentation with different governance structures, financing mechanisms and ways of stakeholder engagement. The Water Funds in Cape Town and Mexico City are excellent examples of governance innovation, where new financial mechanisms are tested through new institutional arrangements. The Water Fund model is one that has been used by the Nature Conservancy around the world. The model is flexible and so can be adapted to new locations, but the consistency of the approach and the involvement of the same intermediary supports successful innovation in new places. The Water Funds, besides acting as novel governance bodies to facilitate investment in nature-based solutions, also play important intermediary roles by developing shared visions across agencies and organizations and by changing political dynamics. In this role, they are trusted, transparent and well-defined entities, creating a new space for interaction and rethinking basic assumptions about water.

In Cape Town, the model has not only enabled downstream water users to invest in land conservation and restoration upstream, but has also promoted technological innovations by seeking to enhance groundwater recharge through catchment

clearing. The project works with researchers to study the actual water supply impacts. Furthermore, this innovation's economic component takes a social enterprise approach to create locally-run businesses in contrast to the current inconsistent and sporadic hiring practices in South African invasive plant clearing projects. A key aspect of this approach is education, skill development and stewardship. In Mexico City, an important additional innovation is tracing water pathways to calculate the full costs for different water uses and users, providing a tool and means to properly price water.

The other two NBS in Mexico City are building on **close collaboration with locals using cultural values and traditions to make agriculture understood as a path to ecosystem restoration and social-ecological resilience**. While the Water Forest recognizes regional ecosystem connections by operating at the megalopolis level, the dozen traditional cultivation initiatives with local producers are very site specific, enjoying exclusive collaboration among limited groups of actors. The Water Forest, on the other hand, works with a very broad range of stakeholders in recognition that everyone from small communities to state governments needs play a role in governing and protecting the Water Forest. It redefines the role of land as a producer of water (Water Forest), repurposing nature rather than developing new technologies. At the same time, it is traditional in that it harks back to ancient understandings of vegetation's role in providing water and calls on indigenous communities to sustain their traditional practices. The case of Xochimilco is another example of social innovation, provoking change in societal values, practices and their understanding.

3.8.4 Expected and registered impacts

When watershed conservation is coupled with community involvement, positive impacts are manifold. These projects aim to improve water cycling with natural methods. They not only increase water access and availability, but also improve carbon capture, air filtering, temperature regulation, habitat and food production, among others, by involving different types of green areas and economic activities.

NBS to provide services, especially in water-scarce environments, are systematically challenged by unsustainable water consumption and unequal water access which in turn depend on political power or socio-economic status. In Cape Town's Atlantis Water Fund Pilot Project, groundwater extraction and construction of new dams has significant environmental impacts, which the project seeks to reduce through the removal of invasive species. The NBS involves disadvantaged communities in conservation, as structural inequality has typically barred many of them from accessing both nature reserves and job opportunities. Water scarcity is sometimes viewed as a global problem that needs far-reaching infrastructural solutions, but these NBS examples show the benefits of working with and for local communities.

When watershed conservation combines community involvement and sustainable job creation (such as the water-preservation businesses in Cape Town), the impact is multi-faceted. In Cape Town, it is said that savings on future water treatment and desalination alone could offset much or all of the cost of watershed conservation, while social enterprise approaches followed in the pilot project demonstrated potential to create locally-run businesses. Similarly, the Water Forest in Mexico City working with various actors at different levels seems to be a key element in its success, as does the personal approach to building trust and relationships. In Xochimilco, Mexico City, provisioning and regulating services (water supply and purification, flood regulation) and cultural and economic benefits accrue through support of traditional livelihoods of *chinampa* agriculturalists.



4. DISCUSSION

The following section generalizes the earlier analyses, delving into the barriers and enablers of NBS. Here, the naturebased jargon and practice are situated in debates around green growth, multi-functionality, gentrification, justice and green-washing. The discussion further engages with the different visions of nature implied in the NBS studied, and their relative dominance in public debate. Overcoming these multiple barriers is an open question which hinges upon the type of enablers that NBS require. Building on innovation system theory, we list a number of conditions that could drive systemic, just, ecologically sustainable and genuine integration of NBS in urban life and policy.

4.1 CONTESTED ISSUES EMERGING AROUND NBS

4.1.1 NBS-pledged multi-functionality as a double-edge sword

One type of contradiction that arises when comparing the conceptualization and implementation of NBS comes from the multi-functional expectation of ecological, social and economic benefits from NBS. The question of whether NBS can fulfil these three promises emerges in many of the interventions. Urban gardens, for instance, are considered exemplary for how they can combine social and environmental benefits. However, their ability to offer social benefits sometimes conflicts with the environmental benefits, such as providing ecosystem services and green space. The municipal urban gardens in Athens, for example, aimed for high productivity (increasing social benefits of food distribution and environmental benefits of green space) requiring intense and timely participation. This led to exclusionary behaviours toward vulnerable individuals who lacked the capacity to engage at the required frequency or intensity. In Leipzig's East Quarter, the communal gardening project Querbeet set goals of active engagement with social issues such as community politics, local and global food provision, environmental education and environmental protection. These, however, required infrastructure for holding cultural activities which undermine flood control because it covers a significant percentage of otherwise undeveloped land, and thus limits the overall water-retention capacity.

When the visions and promises of an NBS are built on sustainability principles, which have been transparent, negotiable,

inclusive and flexible, the conflicts between economic, environmental and equity objectives can be prevented. Malmö's Augustenborg Ecocity received political, administrative, technical and residential support early on, which prevented major contestations around it.

Entrenchment in grey infrastructure and greenwashing

Related contradictions concern whether NBS can provide enough regulatory services (air quality, noise reduction, temperature regulation, carbon storage) if other aspects of urban life and production patterns (i.e. car usage, industrial pollution) remain the same. In other words, while some social, ecological and economic benefits accrue from NBS, whether they can be considered the most socially, ecologically and economically efficient solution to specific urban challenges is uncertain. For example, in Barcelona's Passeig de Sant Joan, while the existing intervention does address some ecological and social challenges by offering water-permeable sidewalks, it does not reach the level of green space and social interaction that a 'rambla' design arguably would. More importantly though, if the main challenge in the district is the lack of green leisure space and over-use of cars, it might be addressed with an automotive ban, pedestrianisation and tree planting in some main streets or quarters. At the Győr Audi factory, the ecological and social-cultural benefits of its beekeeping project could be weighed against the environmental costs of industrial development on Natura 2000 protected ecosystems. Other examples include the Parc Marianne in Montpellier versus city-scale challenges, Munich's Green Office against a city-wide car-dominated infrastructure, and beekeeping and education in Newcastle versus addressing causes of bee population declines. It is thus the politics of struggle between different needs and demands that can compromise sustainability targets that city governments are pursuing.

Moreover, important contradictions arise when NBS are attached to green-field development presumed to be necessary. In Cape Town's Two Rivers Park project, the main disagreement concerned whether there should be any development in what is now a mixture of industrial area, degraded riverscape and vacant green space. Habitat loss might exceed gains in implementing an NBS such as an eco-district. The premise upon which such interventions are built is that new grey infrastructure and urbanization are needed. Whereas new eco-districts exhibit promising sustainability and climate change adaptation results, they almost use a "blank page" approach where new developments are designed for "empty" spaces (i.e. Utrecht's Leidsche Rijn water system, or the flood alleviation scheme created for the properties on the Brunton Park estate in Newcastle). In Newcastle, replacing mature woodland with 'executive homes' makes sustainable urban drainage system in future residential developments a form of **green- or nature-washing**. Where construction of districts with sustainability features destroys existing biodiverse ecosystems or compromises plans for less urbanized areas, nature-based solutions could become a contested term.

Viability of green growth

Another challenge is whether NBS that are funded, owned or partly supported by private institutions can serve the public interest of social welfare and just social and environmental outcomes and remain under public scrutiny. It is often the case that NBS "market" themselves as low-risk and/or high-profit to attract capital investments. In Melbourne, costs and risks of the Urban Forest Strategy were not easily accepted by private developers and land managers. The skills and knowledge deficits related to the implementation of green infrastructure lead to wide divergence in cost estimates for installation and maintenance, limiting uptake as developers and land managers are unwilling or hesitant to risk cost overruns. Similar hesitation was observed in Melbourne's Urban Forest Fund and Malmö's BiodiverCity project, where questions arose about the cost of NBS lack of responsibility or budget assigned to any party for maintenance.

Competing land-use interests impede the full realization of NBS, especially large-scale conservation or ambitious plans for watersheds and city greenbelts. These competing interests often result in political decisions to de-prioritise biodiversity protection or enhancement in cities, which is deemed as a less profitable or less popular option. Merging or combining uses (i.e. agro-natural, green/grey, etc.) has been attempted but presents challenges. In Montpellier's Green and Blue Network, for example, urban agriculture has replaced biodiversity priorities and NBS are envisioned as part of the creation of new

economic areas. In Athens, the plan for Europe's biggest urban park at the former Hellenikon airport has been ridden with controversy as only 500 acres of the 200 ha development is earmarked as "park". Furthermore, 16% of those 500 acres is projected to contain grey infrastructure, surrounded by elite real estate and touristic developments, which were considered key to revitalize the national economy. Other examples of conflicts between economic returns and biodiversity gains were recorded for Mexico City's Water Forest, Cape Town's Environmental Education Trust, the Moson-Danube Project in Győr, Munich's Isar Plan, Barcelona's plan for Collserola, Munich's Greening Office, Tianjin's Ecocity and the new parks management model in Newcastle.

A related question concerns the flawed belief that densification-driven urban growth and greening could go together. Intense construction and further infrastructure development in urban zones further compact the soil, reducing trees' ability to grow and expand their root systems. One of the obstacles to the further expansion of the tree canopy in Leipzig and Barcelona was the tension between densification and the need for greenery, the increasing pressure on land, and hence space for housing and social infrastructure such as schools or social centres. In Leipzig, street-tree planting is especially challenging in residential areas where slots for vegetation have not been integrated much into the design of the existing infrastructure, competing with other uses such as traffic, parking lots, or underground pipes and cables. The Leipzig Tree Program was further challenged by a counterproductive decree which simplified the process of cutting down trees on and around construction sites. With the expansion of the city, former fallow land with trees was rapidly converted into built-up terrains.

In Malmö's Ecocity project, open canals and ponds competed with new developments and urban densification. Similar tensions between urban sprawl and "re-naturing" appear in the Tree Strategy in Malmö, in Melbourne's Urban Forest Strategy, the city-wide tree planting in Leipzig, as well as the Leidsche Rijn project in Utrecht. In Boston's Greenway, newer developments actually blocked access to green space without new access points being created. Armstrong's Point community-led initiative in Winnipeg struggled to save the last native riverbank forest in the downtown area from privatisation into expanding residential areas and parking lots.

Greening, equity and justice

Contestations also arose in BiodiverCity over public access versus public funding: if the greenery is not accessible to all, why would it be financed from the municipal budget? To deal with economic risks, NBS are often governed by hybridized arrangements or special legal agreements. In Winnipeg's Seasonal river use NBS, The Forks North Portage Partnership (FNPP) is publicly owned but acts like a private development corporation, and enjoys substantial independence. Whether successful in delivering services or not, this has implications for how priorities are set and what level of transparency exists when public areas are governed according to market rules and logic.

In Utrecht's Food for Good, pressure is placed on project participants to devise a business plan and generate their own revenue. In Newcastle's new park management plan, emphasis on making urban nature a venue for quick returns has compromised social and ecological benefits. In some cases, this pressure has led to creating exclusive NBS products that rely on the buying power of the potential beneficiaries. Such is the case of Montpellier's Building that Grows, or to some extent also the housing projects of Parc Marianne district. In Belvedere College (Dublin), the innovative environmental education method developed through aquaponics also only benefits the school's (elite) students with limited impact on the wider society of Dublin.

Prioritizing the various benefits and services that an NBS can offer, and thus shaping its final design and impacts is a function of whose visions, needs and voices are included in the negotiations prior to and during NBS implementation. The uneven representation of different visions reflects wider tensions and inequalities that exist in society, and which are often concealed behind a universal characterisation of benefits as "social". In Boston, the Waterfront Initiative's largest challenge was to grasp and satisfy all the different needs related to the function of a new waterfront. Similarly, Collserola's PepNat in Barcelona aims to regulate the use and management of a Natura 2000 forest surrounded and permeated by urban developments. It attracts

a variety of visitors with different expectations, demands and political/economic power. In Winnipeg, the success of the Seasonal river use NBS drives demand for flood-control measures that would allow waterfront access in the summer flood period, but would negatively affect upstream communities.

Green gentrification

Contradictions and related contestations frequently arise from residents and social movements worried about negative consequences of successful NBS implementation. Green spaces might provide safer and more pleasant places to meet and relax, and can enhance the pride of place for local residents, especially in disadvantaged neighbourhoods, contributing to better life quality and health. But neighbourhood beautifications or improvements might also cause or accelerate gentrification (tourism, speculation - e.g. Barcelona, Boston, Dublin). These initial green improvements are then counteracted by their negative long-term effects: degrading social networks and losing a sense of belonging among long-standing neighbours. In Leipzig, stimulating economic growth and enhancing the attractiveness of the city through property development while providing affordable housing, sufficient and high-quality social infrastructures, preventing the marginalisation of populations in poorer neighbourhoods, protecting natural and semi-natural habitats and retaining accessible communal green spaces ranked high on the list of diverging interests that interview partners saw as difficult to reconcile (Green Spaces in East Quarter, Leipzig). In Montpellier's eco-district, 30% of housing is social but this is located outside the park. Long-standing middle-income residents thus cannot afford housing that most directly benefits from the park's ecosystem services. In Tianjin, there are concerns about increasing housing prices in the Ecocity (a proposed reduction from 50% to 20% affordable housing). Another cost related to neighbourhood liveability is the change that green areas can bring when capitalized into economic opportunity, as has been the case in Barcelona's Passeig de Sant Joan (affordability and type of new bars/restaurants that benefit from the project) or Melbourne's Green Your Laneway Program (issues of noise due to busy cafes with outdoor tables). In these cases, long-term residents might not be forced outright to leave the neighbourhood, but bear the negative impacts of NBS interventions.

4.1.2 Different visions of nature

Another set of challenges is the different visions of nature implied and enacted in the NBS. Such visions can vary and clash, especially in cases of large-scale consolidated and potentially highly biodiverse green and blue areas like urban and peri-urban parks, forests and waterfronts. A central question here concerns whether nature serves anthropocentric functions or is valued as pristine and biodiverse. The types of nature required for biodiversity and pollinators, for example, might clash with the manicured type of nature commonly installed on green roofs or in pocket parks. Some pollinator-attracting plants are perceived as unkempt or untidy, hence unsuited to the aesthetics of particular enterprises (see Square Metre for Butterflies in Edinburgh).

A related question concerns the type of anthropocentric functions that get prioritized and the way these communicate or enforce neoliberal and growth-based city models. For example, contestations arise in Leipzig around whether or not an urban park (highly accessible and with much grey infrastructure) should be turned into a forest with a stricter protection regime. Similar trade-offs are being discussed in the Plan for the management of Collserola (PepNat) under formulation in Barcelona. The park is surrounded by urban areas while being a NATURA 2000 site. Other examples include the Moson-Danube Project in Győr where the river has been channelled and straightened through a concrete corset versus the Isar River in Munich, which was re-wilded, restoring its natural meandering geography.

In many cases, traditional grey solutions are promoted or preferred over more 'nature-based' ones, not only because they might offer more services/functionality, but also because they provide profit for development companies. In the Moson-Danube Project, for example, environmentalists contested the need for riverbed narrowing as unnecessary and unsuitable for flood adaptation. Yet a grey square, adjacent to the riverfront in Győr, was promoted over more green space as being

more suitable for holding events. Likewise, in Cape Town's Water Fund, one important point of contestation has been whether solutions should focus on grey infrastructure only or incorporate greener elements of NBS. The importance of catchment clearing was contested (within the local municipality) as too costly, even at the height of the drought crisis, because of a focus on achieving quick wins.

With the neoliberal trend in urban governance, private owners of green land often have the power to impose their vision of nature to integrate their "stakes" into a planned NBS (i.e. golf course owners in Newcastle's Brunton Park Flood Alleviation scheme). International organizations, local institutions and local communities also carry and advocate for very different visions of urban nature. Such clashing views can be deeply engrained in histories of racism, exclusion, and dispossession. The Cape Town Environmental Education Trust, for example, aimed to increase environmental consciousness of unprivileged groups around conservation while also opening some opportunities for work in the field. But lack of housing and lack of access to safe water and food shaped the perceptions and livelihood priorities of the urban poor, eventually challenging conservation efforts. Similarly, indigenous communities, which were focal actors for the Water Forest initiative in Mexico City but were not consulted or included enough from the beginning, ended up contesting the grounding and validity of the this NBS.

Finally, evidence draws attention to how clashing visions of nature hinge on cultural and socio-political context. Clashing demands between green/blue areas and development of real estate, parking, or shopping malls, might indeed reflect the interests of economic elites versus the desire of local residents for more green space. But it is often the case that demands for more jobs, housing, schools, parking etc. versus more nature-driven visions and needs are widespread and cut across class and other socio-cultural characteristics (Cape Town's Two Rivers Urban Park, Athens' Hellenikon, Győr's Moson-Danube project; Cape Town Environmental Education Trust; Melbourne's Urban Forest Fund; Barcelona's Germanetes Pla Buit garden, urban gardens of Leipzig's East Quarter). These often reflect deeper issues of socio-economic inequalities or lack of state support, which NBS alone cannot address (i.e. lack of public schools or social housing, or limited access to safe water).

In Mexico City's Water Fund project, the public contests the idea of putting a price on water, although this would arguably improve its sustainability. This is due to values linked to indigenous cultures, socialist opposition to water privatization and a history of low pricing, widespread inequalities, clientelism, and poverty. Again, in Mexico, culturally-specific practices (like informal ownership) are seen as obstacles to the implementation of Xochimilco's traditional cultivation as an ecosystem restoration practice, but deeper issues of land abandonment or conversion to housing or greenhouses are core to understanding the challenges of this NBS implementation. Culturally-persistent views of what urban nature should look like can also stand against re-naturing efforts, as in the case of Winnipeg, where community-initiated renaturalisation faces resistance (in Bishop Grandin Greenway and Northeast Pioneers Greenway). Some people continue mowing instead of allowing re-naturalisation because naturalized landscapes appear visually unattractive to them and are perceived to accumulate more garbage. In Dublin, passive versus active recreation demands for Tolka Valley Park reflect existing class divisions in the surrounding areas.

4.1.3 Neoliberalism and democracy: private profit versus public welfare

When NBS emerge under hybrid (public-private) governance modes economic reactivation and attracting capital can be prioritized over enhancing ecological and social benefits. Some of the common contradictions concern transparency, accountability, justice and democracy, particularly regarding the way that costs and benefits are distributed over time. It is widely observed that funds and new technologies become available faster through innovative financing schemes that involve private investments in NBS management. However, accountability, transparency, and civil engagement in such projects are not always well defined or communicated to the affected public. The SNFCC, for example, is a donation from a non-profit foundation to the Greek state under a specific legal framework. The conditions to which the Greek government agreed,

however, have been contested in terms of the economic burden incurred to the public sector and the actual benefits (for the National Library, Opera and the general public). Initiatives that are predominantly motivated by private actors often focus on innovativeness and investment returns rather than on social welfare and equity in access. The Boston Waterfront is funded and managed by a non-profit organization but is located on public land. However, many of its amenities and benefits are not benefitting/reaching low- to mid-income people as its design and character is considered non-welcoming and not affordable. In Montpellier's eco-district, profit was made from housing built on public land with direct access to nature, bought at a fixed price but then re-sold on the free market (with profits of over 50%). Social housing included in the NBS did not enjoy as much access to green infrastructure and a fair housing model was discarded for fear that the apartments would have a lower market value.

Many of the contradictions of neoliberal logic and concerns compromising ecological or social goals for economic ones are seen to be tied to public-private partnerships or hybrid governance models that are common for enabling NBS implementation. Newcastle's new parks management model, for example, is based on a charitable trust as a social enterprise but acts outside democratic accountability. The Hellenikon Metropolitan Park (Athens) emerged in the context of economic crisis and was a result of pressure for exploiting public property through privatization and investment attraction. As a result, an extremely valuable land resource was offered at a very low price to international investors and developers, with highly questionable benefits for the Athenian/Greek public. In Mexico City, the Water Fund is being developed in collaboration with private partners/investors, with little transparency about their responsibilities over a common public resource.

4.1.4 The durability of innovative NBS

Another conflictive issue concerns the durability, maintenance or longevity of NBS, especially when projects hinge on temporarily available land, resources, or expertise. In Malmö's BiodiverCity, implemented or planned innovations suffered from the lack of different resources, including ecological/technical/practical knowledge and experience with green infrastructure, particularly with maintenance and clearly defined responsibilities for assuring NBS sustainability. Another innovative NBS which requires specific technologies and faced maintenance challenges was Boston's Porous Alley. The John Muir Pollinator Way project not only required specific maintenance techniques, but was also challenged by difficulty to secure long-term funding as most environment-related proposals have a lower priority in public budgets and are only short term. Urban community gardens also suffer from being "eternally informal", despite their combined socio-environmental benefits and durable educational and environmental awareness impact. Barcelona's Pla Buits gardens are challenged by short time frames, while school gardens in Győr suffer from similar time and budget restrictions. In Winnipeg, the SNA community gardens, for example, are faced with the threat of displacement as they stand on public residential land, and thus could be developed when and if the city decides to. High land values and development pressures often do not allow cities to assign permanent locations to urban community gardens, especially within dense cities.

4.2 INNOVATION ENABLERS FOR DIFFERENT NBS TYPES

The NBS studied here through the lenses of innovation system theories show that a 'successful' innovation in the context of urban NBS and sustainability transitions rely on a system of actors, networks, institutions and infrastructures facilitating its development and diffusion. More specifically, the combination and the intensity of certain enabling conditions define the development of NBS (van der Jagt et al., in press). Building on the Nature-Based Innovation System Framework (van der Jagt et al., in press), in this section, we discuss key drivers of NBS innovation, in relation to the eight types of NBS studied in this report. These key drivers entail (1) agency, (2) discourse and vision, (3) policy paradigms, (4) governance structures and collaborative arrangements, (5) learning, (6) resources and (7) place-based factors.

4.2.1 Agency: leadership, power, commitment

Agency, the capacity for action that individuals and organizations take to influence the development of nature-based solutions, is an important element in all NBS types. These actions are key as they influence actions of other actors through, for instance, different partnership models or community engagement.

Often driven by change-agents, (employees of) organizations demonstrate leadership and power in NBS development and uptake. In Munich, for instance, the newly-employed and highly-committed climate manager has driven the implementation of the Climate Adaptation Strategy and related blue and green measures. Similarly, in Malmö, in all three cases, we find the role of engaged individuals – often from municipal or private organisations – being critical in the development of NBS. Mexico City's Water Forest has also been initiated and driven by a committed individual. Moreover, the development of many of the green roofs and insect-oriented initiatives rely on small enthusiastic groups, not least because of the need for continuity in ecological knowledge and management efforts.

In agreement with the literature (e.g. Brown et al. 2013; Hendricks & Calkins 2006), we also see a new role of **non-profit organisations and enterprises emerging in these initiatives**. Such examples entail the Nature Conservancy taking the lead in developing water funds in Mexico City and Cape Town or an environmental NGO, in collaboration with the municipality, driving the development of the Luppe riverside in Leipzig. In Utrecht, a social entrepreneur has played a key role in implementing green measures in the Roerplein neighbourhood, while in Winnipeg, the Forks Partnership has taken responsibility for winter activities and enhancing accessibility among scattered neighbourhoods on the frozen river.

Municipalities' commitment to, or agency in NBS mainstreaming is also reflected in local sustainability initiatives (Bayulken & Huisigh 2015) and **internal institutional arrangements** (Brown 2008). Examples of the latter are the placement of one landscape architect in each urban development project team in Munich, the project teams specifically created for the implementation of eco-districts or the interdepartmental collaboration that emerged in Malmö, which has grown to be a common practice there in the past two decades. Commitment also manifests itself in public pressure on existing systems for service provision (Ferguson et al. 2013). Athens, Barcelona and Leipzig are also examples of municipal commitment for urban gardening in the form of land (or users' rights) provision.

A consistent political vision (Bai et al. 2010), in parallel with the introduction of new forms of plans and strategies, policy and policy frameworks also exemplify institutional commitment to sustainability (in some cases more than others). The City of Melbourne has been particularly illustrative in this respect.

4.2.2 Discourse and vision

While agency plays a key role at individual and group levels, collective worldviews do so at the societal level. **Discourses and visions of urban sustainability** such as 'eco-districts', 'green roofs' or 'urban gardens' often translate into norms of action, which in turn **can build up the 'social momentum for change'**. Augustenborg Ecocity in Malmö is an obvious example of how the sustainability messages of the Rio Summit (1992) have created a political vision in Sweden, which was put into action on the national policy agenda by creating the Local Investment Program for Sustainable Development to support sustainable urban transition at a district level. The top-down vision, in this case, met the bottom-up needs expressed through strong agency and created a moment of change. As seen in this case, discourses and visions are closely linked to other innovation enablers, including agency, policy, learning and place-based factors. Similar worldwide discourse, such as the 'sponge city' concept being implemented around the world, has facilitated its uptake in Tianjin, China. Discourse can also create a status quo. While policies of the City of Melbourne mirror and benefit from the emerging concepts of 'resilient cities' and 'healthy cities', the public discourse around green roofs – often perceived as costly, unsafe and high-maintenance

(Hendricks & Calkins 2006) – currently undermines their upscaling. This said, as shown earlier in the discussion section, clashes between different visions of nature (nature as community-based, or nature as unkempt) could easily clash with NBS as orderly/grey-infrastructure based innovation.

4.2.3 Policy paradigms

Discourses and visions interact with different policies, which directly or indirectly steer sustainable practices, stewardship, financing and public engagement to enhance nature-based solutions.

Interestingly, some of our cases are ahead of their time in terms of policy compliance. In Malmö, both BiodiverCity (2011-2018) and Augustenborg Ecocity (1998-2002) were developed in parallel with Malmö's Environmental Program (2009-2020) and the local stormwater policy (2000). The latter benefited a lot from the practical experience gained in the Augustenborg open stormwater system. The Isar Plan (2000-2011) in Munich started before the relevant European water-related directives, such as the European Water Framework Directive (2002) and the Flood Risk Management Directive (2007), came into effect. However, these were claimed to further support ecological water engineering, flood protection and climate change adaptation measures.

As we have found, individual organisations, such as Audi in Győr, Hungary can also promote NBS development – in this case through applying bioindicators by analysing beeswax for air quality performance – within their internal strategies and policies (also in Brown 2008).

The City of Melbourne's **integrated and holistic policy framework with a long-term vision**, however, is a relatively new undertaking; it accounts for broader perspectives, such as regional dynamics, while considering multiple political, financial and local aspects of urban planning. In addition, it is data-driven and builds on extensive consultation. These conditions – in addition to having specific policy documents for individual NBS, such as the Urban Forest Strategy and Urban Forest Fund – have been crucial for effective policy implementation and the delivery of high-quality NBS (also in e.g. Bayulken & Huisingsh 2015; Haaland & van den Bosch 2015; Mees et al. 2013; Young 2011).

As has been previously shown (e.g. Schilling and Logan 2008), the development of **parks, greenways, eco-districts and urban gardens have been strongly influenced by local (environmental) regulations, land marketing (e.g. vacant lots for urban gardens) and zoning** allowing or limiting activities of land users (e.g. communities provided by land-use rights by the municipality), landowners and private developers. In addition, **communicative and (alternative) financial instruments, especially when combined, enhance NBS development** (Mees et al. 2013; Schilling & Logan 2008). The different types of water and forest funds (Mexico City, Cape Town, City of Melbourne), creation of trusts and partnerships (The Forks in Winnipeg) and donations for e.g. tree planting (Leipzig) are different alternative financing mechanisms.

4.2.4 Governance structures and collaborative arrangements

Policy paradigms are strongly influenced by governance structures, i.e. the actors involved and the distribution of decision-making power and responsibilities across stakeholders, and their different collaborative arrangements (e.g. networks, partnerships, participation). This has an impact on whether actors have a strategic overview, potential budgets and capacity for collaboration, which in turn determine NBS development.

As our cases show, **NBS emerge in complex institutional structures**, which are often challenged by the fragmentation of responsibilities and insufficient capacity to integrate diverse voices in the design phase. This often leads to NBS discontinuity

or ineffective attention to issues of justice in the lack of long-term and balanced agency. The cases in Malmö (Tree Strategy), Mexico City (Water Fund) and Newcastle (parks), for instance, demonstrate some attempts to overcome issues of blurry authority by better clarifying responsibilities and coordinating actions across municipal departments and/or organisations. Furthermore, governance structures also influence institutional capabilities for collaboration and learning in this domain, which are two enablers of NBS innovations that are essential to overcoming challenges of fragmentation across scales and between sectors (also in e.g. Bulkeley et al. 2016; Kabisch et al. 2016; Muñoz-Erickson et al. 2016; Wolfram 2018).

Collaboration – in professional networks, different types of partnerships, and the form of citizens' engagement – is becoming an increasingly dominant NBS practice. **Collaborative arrangements often carry multiple benefits** for a variety of actors, including knowledge development, learning, and experimentation, but also resource mobilisation and reflexive policy practices. The Urban Forest Strategy and its related actions in the City of Melbourne or the BiodiverCity project in Malmö, for example, bring together researchers, policy makers, businesses and local communities to co-create urban nature-based innovations in demonstration projects, facilitating knowledge development and mobilising agency and resources, while contributing to the further development of urban policies. In addition, the City of Melbourne's public participation model contributes to more inclusivity in planning and decision-making process, while providing better understanding of the city as a socio-ecological system which was also found as an additional benefit of working in partnerships (also in Ernstson et al. 2010).

Cape Town's Environmental Educational Trust and Győr's school gardens confirm previous findings that partnership working is conducive to organisational commitment (see in Brown 2008), trust building (see in Muñoz-Erickson et al. 2016) and learning (see e.g. Muñoz-Erickson et al. 2016; Wolfram 2018).

Urban gardens, for instance, in Utrecht and Barcelona are illustrative examples of how partnerships enable experimentation (see also in McCormick et al. 2013; Kabisch et al. 2016). The possibility of rethinking regulation and rules is another positive implication of partnerships (Farrelly & Brown 2011), as shown in the case of Augustenborg (Malmö), where experimentation with ways of collaboration and with physical structures was undertaken.

Private actors, especially housing associations, developers, land owners and investors are particularly important actors to build collaborations within urban NBS (Kabisch et al. 2016). The conditions and quality of the collaboration strongly determine the trajectory of the NBS, as in Athens' Cultural Centre, Cape Town's development project, Malmö's green roof NBS and Melbourne's Urban Forest Fund.

The empowerment of civil society is becoming particularly important in the implementation phase of nature-based solutions, especially in cities with high levels of private landownership (see also in Young 2011). As our study shows, through bottom-up NBS, most importantly urban gardens and water scarcity measures, citizen engagement has a great potential to improve the public support of sustainability interventions, and ultimately bring about sustainability transformations.

4.2.5 Learning: education and training, research, experimentation, monitoring and evaluation

Education and training raise stakeholders' awareness of the multiple benefits of sustainable solutions (Hendricks & Calkins 2006; Young 2011). Most of the **urban gardens and insect-based interventions explicitly aim for community education**, but we also find educational activities in some parks. In certain gardens, learning activities target otherwise neglected or unheard groups, such as children (Győr), immigrants (Leipzig) or indigenous people (Winnipeg). Cape Town's Environmental Education Trust, for instance, focuses on school children to create local environmental stewardship while incorporating job skills training for adults in low-income communities to create continuums in urban nature conservation.

Plans and parks also feature organisational learning. In Munich, new organizational structures and processes had been established for mainstreaming climate mitigation, which consisted of an interdepartmental steering committee, thematic working groups and specially-employed staff (i.e. climate managers). This structure, which was more-or-less replicated for mainstreaming climate adaptation, also allowed for intersectoral and interdepartmental learning.

This study also touches on the **role of research, monitoring and evaluation in supporting decision-makers** in the assessment of current urban challenges and finding potential solutions to these, not least in urban planning and governance (see e.g., McCormick et al. 2013; Young 2011). The first pilot project of the Water Fund in Mexico City, for instance, builds on extensive research into the operation of the natural and artificial water system and related costs. Likewise, the City of Melbourne's Urban Forest Strategy is a scientifically-vetted policy framework, building on extensive international, national and local research, including, for instance, the digital mapping of greenery in Melbourne City, complemented by local community knowledge.

Knowledge actors have been identified as key players in many of the studied NBS. Academics played an important role in re-introducing *chinampero* cultivation in Mexico City through bringing together scientific ecosystem restoration techniques and knowledge of contemporary (online and offline) markets. Munich's Isar Plan and Climate Adaptation Strategy have also been developed and implemented in collaboration with academic partners. Practice and science were interwoven in all three NBS studied in Malmö, where interdisciplinary working groups, including researchers, were also key drivers of NBS design and implementation.

Research and evaluation help to improve and refine nature-based interventions (Naylor et al. 2012). This process is often influenced by place-based conditions and can help tackle a range of topics, including assessing and monitoring local ecological qualities (e.g. different aspects of bee monitoring in Győr or in Newcastle, urban biodiversity assessment in Munich's Isar Plan), social qualities (e.g. job-creation potential in Cape Town's Environmental Education Trust), or citizen preferences for NBS interventions (e.g. Melbourne's Green Your Laneway Program). There are multiple challenges, however, around monitoring and evaluation. If it is not done properly, it can easily undermine the commitment of other stakeholders (see also in Zhang et al. 2012), as happened in some of the measures in the BiodiverCity project. It can also lead to limited comparison among NBS (Bayulken & Huisinigh 2015), which can in turn limit learning and development potential. Furthermore, some social and environmental benefits are difficult to quantify (e.g., cultural ecosystem services, e.g. Ferguson et al. 2013; Kabisch et al. 2016). We have encountered this in most of the NBS studied here.

While education and research improve understanding of the multiple benefits of NBS among different stakeholders, **experimentation** (also called learning-by-doing) **contributes to the development of new forms of governance approaches**, intertwined with social learning where multiple actors are involved and values are questioned and redefined (see also in e.g. Brown et al. 2013; Wolfram 2018). Experimentation with governmental structures can be found across all types of NBS, but are clearly demonstrated by, for instance, the water funds of Cape Town and Mexico City and the urban gardens and pocket parks of Utrecht. The Water Fund in Mexico City has also broadened the spectrum of potential solutions to the water challenge faced by the city while influencing the political discourse around water pricing and increasing investments in NBS innovations.

Municipalities often play a prominent role in iterative NBS experiments, from initiators to evaluators, which also provides a message of support to other actors involved. One typical way of municipal learning found in this study is city-to-city learning, where cities share best practices by observing NBS elsewhere, learn about their pros and cons, and potentially adopt them. City-to-city learning has been reported from amongst others Munich's Greening Office, Malmö's Tree Strategy, and Melbourne's Urban Forest Strategy.

4.2.6 Resources: knowledge and human capital, financial factors, technologies

The presence and adequate use of different resources further enable nature-based innovations. Our study supports the claim that the technical implementation and maintenance of green roofs or urban trees heavily relies on a **local ecological and climatological knowledge continuum** (Hendricks & Calkins 2006; Zhang et al. 2012). Urban gardens (see e.g. Barcelona, Utrecht and Leipzig) and NBS addressing water scarcity (see e.g. in Mexico City and Cape Town) show how important it is to adapt NBS to socio-ecological and socio-cultural contexts (Naylor et al. 2012). Information on current NBS (e.g. quantity, distribution and quality) across the city, such as the urban tree mapping in the City of Melbourne and Malmö or Munich's climate maps, leads to better-informed decisions on where to implement measures and invest resources (Haaland & van den Bosch 2015). Maintaining the knowledge continuum is facilitated by previously-discussed enablers, such as learning and collaboration.

Technology development is another important condition for certain types of NBS, including districts, waterfronts, riverside flood alleviation measures, and advanced multi-functional biodiverse green rooftops. In these cases, we can often observe an increasing interaction between technological and ecological knowledge. As transaction and financial costs of these technologies can still be high, their mainstreaming is often limited, as is currently the case with the uptake of green roofs in the City of Melbourne.

The presence of diverse financing and/or sound financial planning is also a key to the success of nature-based interventions. Although today, institutionalized spending, grants and subsidies are reported to be the most common financing for nature-based solutions (Bayulken & Huisingh 2015; Mees et al. 2013; Zhang et al. 2012), our study shows the emergence of new types of financial mechanisms, such as forest and water funds (City Melbourne, Cape Town, Mexico City), in parallel with new types of governance structures, such as trusts, partnership works and the increasing involvement of community and private resources.

4.2.7 Place-based factors: the built environment, natural processes and resources, societal processes, cultural frames of reference

Place-based factors strongly influence the availability and scope of nature in cities and the functioning of nature-based innovations. **NBS are developed in close relation to the built environment**, either attached to or situated between grey, green and blue structures, which consequently affects the functionality of NBS (Kabisch et al. 2016). Cities with low-rise development (e.g. Malmö) are more suitable for green roofs given easier rooftop accessibility and less space occupied by building infrastructure (Zhang et al. 2012) than in high-rise neighbourhoods (e.g. City of Melbourne). The development of open stormwater management would not have been possible in Augustenborg (Malmö) without the proximity of the Rise river and the pre-existing 'park city' structures, which provided enough space and new opportunities for redeveloping green spaces with new multifunctional features complemented with blue structures. In other NBS cases, the availability of vacant spaces made it feasible to establish alternative greening (Haaland & van den Bosch 2015), such as temporary and/or movable urban gardens in Leipzig or abandoned train tracks in Boston with added values of recreational activities and improved mobility. In both cases, the intervention was shaped by and contributed to the further shaping of local identities and the sense of place.

Natural processes, such as plant productivity which is influenced by local soil and climatic conditions, **are also important considerations when planning green infrastructure**. Recent green plans, forest and tree strategies explicitly build on the knowledge gathered on these processes, see e.g. the Urban Forest Strategy of the City of Melbourne, Tree Strategy in Malmö or the Climate Adaptation Strategy's climatic maps in Munich.

Societal processes, such as urbanisation or tourism, similarly **influence nature in cities, while giving rise to multiple**

contestations. While increasing population growth and mobility may degrade qualities of nature, it could also prompt the demand for it, for instance by stimulating processes of revitalization (McCormick et al. 2013). The renaturalisation of the Isar River in Munich demonstrates how citizens' need for access to the river created more space for recreational activities, which in turn resulted in further environmental degradation, for instance, in terms of littering and increased human presence causing habitat disturbance. Public health, poverty and employment issues have also triggered NBS development and associated contestation.

Finally, we have also found that **local cultural frames of reference**, such as aesthetic preferences, consumption habits, entrepreneurship, levels of trust, or artistic activities, also **influence the development and diffusion of all types of nature-based innovations** (see also in McCormick et al. 2013; Wolfram 2018; Young 2011).



5. CONCLUSIONS

Nature-based solutions emerge in complex institutional and governance structures (Mguni et al. 2015; Wolfram, 2018). The present study confirms this pattern, independently of the type of NBS. Similar to previous findings (e.g. Brown 2008; Ferguson et al. 2013; Muñoz-Erickson et al. 2016), we see a broad variety of actors, networks, institutions and intermediaries (often) from multiple disciplines, sectors and policy arenas working together on the design, development and implementation of NBS. These kinds of collaborative arrangements provide an opportunity for developing and maintaining a both a vertical and horizontal knowledge continuum in different disciplines and across sectors. Besides collaboration and knowledge continuum, diverse sources and/or novel mechanisms of finance are shown to be a critical condition enabling the success of NBS. Furthermore, this study highlights the prominent role municipalities often play in iterative urban NBS experiments, yet austerity contexts interfere strongly with their capacity to intervene profoundly in the urban context.

The impacts of NBS like blue spaces, parks, urban forests, greenways, urban gardens and permeable surfaces are multiple and well-established (Eggermont et al. 2015). Our findings generally agree with what has been found in the literature on urban blue spaces, permeable surfaces, trees, forests, parks and community gardens. The new aspects and findings that this report highlights concern something we could term "attention to the process of NBS design and implementation". In other words, although the socio-cultural impacts of most NBS have to do with processes that follow the implementation of NBS (enabling recreation, cultural events, or strengthening local communities), 'process' itself can also be part of the impact as social gains accrue during NBS planning and design when local stakeholders are engaged (as in the examples of Melbourne's Green Your Laneway Program, Munich's Climate Adaptation Strategy, the Leipzig Post-industrial Waterscapes project which brought city officials into dialogue NGOs). The extent that such gains reach the multiple groups and places that might be affected depends upon the way participation is understood and implemented in each case. In this regard, it is important to distinguish NBS plans that consider a limited fragment of the population as stakeholders (elites, businesses), from those aiming to involve and serve the wider public. When nature-based solutions are directed to green-deprived neighbourhoods or socio-economically vulnerable groups through the deployment of participatory methods (Liberties Greening Strategy, Dublin; Malmö's Tree Strategy, East Boston's Greenway, Utrecht's Food for Good, Leipzig's East green spaces), they tend to contribute to urban environmental justice. This is not only because amenities are distributed better in the city, but also because the very process of consultation can bring out new and valuable voices, views and values. In this sense, we can also argue that processes of contestation and resistance against unwelcome NBS projects (such as the Hellenikon

Metropolitan Park) also constitute learning experiences and boiling pots of negotiation and learning around urban nature and alternative ideas of it.

In that vein, urban and community gardens often provide a space for multi-cultural and multi-ethnic encounters, for care or specialized attention for vulnerable individuals. This is not a service easily stipulated by eco-districts, large urban parks, or greenways. Yet, it is these particular NBS (urban gardens) that end up being in the most precarious state, facing reallocation, having an uncertain economic future, or running low on volunteers' time (see Germanetes in Barcelona, Food for Good in Utrecht, and Querbeet in Leipzig). The NBS interventions explored here further point to the increasing social and healing role of derelict urban land and the spaces for co-creation and interaction with nature in various contexts around urban gardening. Yet, urban gardens are considered to be less prestigious and thus less durable in comparison with the all other green interventions.

Another highlight is that in lower-income countries and indigenous community contexts, NBS pertaining to water scarcity seem to be highly pertinent, mostly since these (projects) are deeply embedded in the basic needs of the local communities, especially with respect to access to water and hence ensuring (healthy) livelihoods. Gender and female empowerment is another aspect given more space in the design and implementation of various NBS based in these contexts.

Regarding participation and NBS governance, the type of attitude, approach and dedication through and with which consultations are undertaken is central to (partially) achieving a certain degree of multi-functionality and inclusivity. The active involvement of the public from the beginning, or in the very conceptualization phase, is crucial for positive impacts to be manifold and contradictions minimized, especially in large-scale NBS such as waterfronts, parks, green ways and eco-districts.

That said, the ambitious nature of NBS is what makes them inherently and inevitably contradictory in the multiple ways that we have described. The scale of NBS projects emerges as one critical aspect to consider in the context of democracy and neoliberal governance. As visible in the Leipzig's East Quarter Urban Gardens and elsewhere, smaller-scale initiatives can be negotiated in a more direct fashion, i.e. with lower-than-city authorities and citizen groups, requiring fewer procedural/bureaucratic steps and involving more transparent and direct interaction between officers and the public. The same holds for Edinburgh's Square Metre for Butterflies, and Winnipeg's Community-based renaturalisation initiatives. Large-scale projects, however, often face problems related to ecological connectivity versus institutional jurisdiction. In the case of the Water Fund in Cape Town, for example, much of the land located in important water catchments falls outside city limits. In Collserola's management plans, there are nine municipalities surrounding the mountain, with different stakes and interests. Complex projects such as the Augustenborg Ecocity and BiodiverCity in Malmö, or Munich's Climate Adaptation Strategy, struggle to democratically coordinate the multiple actors and to manage an efficient dialogue and cooperation. In these cases, cross-departmental collaboration could contribute to overcoming challenges but require significant time and a commitment to democratic decision making to be integrated in NBS planning.

Another key finding is the special attention that needs to be given to the maintenance and longevity of NBS, especially when projects rely on temporarily-available land, resources or expertise. Ensuring long-term funding is a common hindrance not only for community and pocket gardens. Green innovation does not come without a high cost. Eco-buildings, facades and permeable surfaces, for example, also tend to have higher maintenance costs than originally stipulated.

We could also observe that NBS with hybrid public-private governance modes, where economic returns and access to financing are central to the project, are gaining momentum, especially in contexts of economic austerity. Yet, prioritizing economic returns often goes at the cost of its social (accessibility, justice, transparency, accountability) and ecological (biodiversity and global impact) benefits (as seen in the cases of Newcastle parks, Hellenikon in Athens, Urban forest in Sofia, and Little France Park in Edinburgh). Notably, the above-mentioned research poses a challenge to the alleged or expected

multi-functionality of NBS. One of the salient expectations from NBS deployment is their contribution to innovation, economic growth and job creation (Nesshöver et al. 2017). Yet a central and re-occurring question in our study concerns how benefits are weighed against the social costs associated with the NBS implementation and its aftermath. Gentrification (including climate gentrification), lower accessibility and exclusion are some of the likely companions of larger-scale greening projects, especially where funding depends on returns on investment in property and higher charges on land.

The different visions of (urban) nature found in the contexts of NBS implementation are often hinged to different histories and socio-cultural contexts, clashing interests and uneven power relations between various stakeholders. One concern that stands out upon comparing all interventions is the type of problems that NBS solve. The creation of a “natural” appearance of an intervention that diverts a river-bed onto the fairway of the golf course as a means of reducing the flood risk for nearby households and eventually enhances the attractive features of the golf course fits under the Nature-Based Solutions framework. Stated differently, heavy modifications of river-beds that aim to foster the attractiveness and value of grey infrastructure, which are then manicured to fit a particular green aesthetic are not the most sustainable features and interventions, from a biodiversity, ecological or political ecology perspective. A relevant further question is whether Nature-Based Solutions can actually conceal interventions whose entire package, grey infrastructure included, is ecologically disruptive rather than amiable. Caution is needed to ensure sacrificing green space and biodiversity does not take place under the guise of NBS, and whether sustainability is not addressed too narrowly. This implies reviewing the premises upon which NBS are conceived: are they sustainable when compared to traditional grey infrastructure or no intervention at all? In other words, could NBS enhance or make grey infrastructure such as new housing developments more attractive? Furthermore, parks, greenways and corridors could make heat waves more bearable or improve local air quality, but would not offset or reduce the sources of climate change and atmospheric contamination. Likewise, multiple beekeeping initiatives cannot offset the negative impact of pesticides on insects. There seems to be a limit to what NBS can achieve on their own. A relevant discussion to therefore consider is whether curative or preventive approaches are actually sought when implementing NBS at scale.

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APPENDIX 1

ECOLOGICAL DOMAINS AND SUB-DOMAINS INCLUDED IN THE QUESTIONNAIRE

(1) 'What' is governed, i.e. list of physical domains and their emergence:

- 1) Plans and strategies for urban trees, forests and parks
- 2) Parks, urban forests and greenways
- 3) Districts with flood-alleviation or other green measures
- 4) Urban and pocket gardens
- 5) Green buildings, roofs and walls
- 6) Insect-based interventions
- 7) Waterfronts and riversides
- 8) Measures to deal with water scarcity

(2) 'Who' is involved in the process of governance, actor constellations and public participation?

- a) Municipality-driven
- b) Public-public partnership
- c) Public-private partnership
- d) Public-citizen partnership
- e) Public-NGO partnership
- f) NGO / Foundation-driven
- g) Privately-driven
- h) Community-driven

(3) 'Why is it governed', 'what is the aim' and the impact of the NBS in relation to the physical domain and governance. These categories have been developed based on the claimed aims of each NBS projects.

- Increase accessibility: access to nature
- Decrease vulnerability: livelihood, access to food, decrease poverty, social integration, safety
- Increase economic attractivity: increase aesthetics, better living environment, create economic activities, job creation, transit & connectivity, revitalization

- Decrease air pollution
- Education: training, awareness raising
- Climate resilience & climate change adaptation: flood prevention, climate planning
- Enhance health & recreation: enhance well-being, increase cultural activities
- Water security: water quality, water quantity
- Conservation: natural conservation, cultural conservation, biodiversity, environmental protection, habitat preservation, healthy ecosystem
- Institutional change: create new processes, develop new strategic frameworks, generate revenue in new ways, testing (technology), new ways of engaging citizens (e.g. in spatial planning)

(4) 'How' is the NBS governed and implemented, with special focus on actors' responsibilities, role of municipalities, financing, experimentation and reflexivity. In addition, the emerging types and aspects of innovations have been explored in each ecological domain in relation to the emergence, aims, governance structures, and public participation in the NBS.

These innovation types include (Bulkeley & Raven 2017):

- A. Ecological / physical innovations: a) the creation of new natural spaces, b) maintaining and managing existing green and blue spaces and c) restoring ecosystems and their functionality to deliver a wider range of ecosystem services and benefits.
- B. Social innovations: a) policy innovation referring to new (or significant changes in) in public policy frameworks, b) economic innovations referring to new (or significant changes in) governance frameworks and/or arrangements, c) innovations generating different types of knowledge, d) economic innovation referring to new (or significant changes in) economic frameworks or modes of operation and e) cultural innovation referring to new (or significant changes in) cultural frameworks.
- C. Technological innovations: a) product innovation, b) process innovation and c) infrastructural innovation.
- D. System innovations: innovations leading to systemic changes in both social (values, regulations, attitudes etc.) and technical (infrastructure, technology, tools, production processes etc.) dimensions and, most importantly, in the relations between them.

APPENDIX 2

GUIDING QUESTIONS PER RESEARCH THEMES FOR FILLING IN THE COMPARATIVE EXCEL TABLE FOR THE 54 NBS IN 18 CITIES

I. INTERVENTION HISTORIES

1. What is the physical NBS? (Describe the NBS based on the ecological domains, see Sheet 'Ecological Domains')
2. How did the NBS intervention emerge? (The below sub-questions can help to specify this generic question)
 - what is the aim of the NBS?
 - who initiated the NBS?
 - what is its timeframe?
 - who are the envisioned users?
3. What sustainability challenges (the city facing with) does the NBS aim to address?

II. NBS GOVERNANCE

1. What are the institutional arrangements through which the NBS is implemented?
 - who are the involved actors?
 - how are responsibilities and / or decision-making power distributed among actors / institutions?
2. Which policies have been important for governing the NBS? (See also 'Policy typology' and 'Governance modes' for further analysis)
 - how did these policies come about / what motivated them? (if there is info)
3. What are the financial arrangements through which the NBS is governed?

III. PUBLIC PARTICIPATION IN NBS

1. What are the institutional arrangements in terms of citizen engagement, partnership or other stakeholder participation that have supported the emergence and implementation of the NBS in the city?
2. At what stage were citizens or community members involved? (NBS stages can be divided into e.g. appraisal, visioning, planning, designing, implementing, maintaining and evaluating)
3. Which participatory methods were used? (Describe the participation, use sheet 'Participatory methods' for further analysis). Please additionally describe the level of involvement (use sheet 'Participatory methods')
4. How was participation enabled?
 - how was access to participatory processes shaped?
 - if, what obstacles to participation were encountered?
5. How (if) were the results of public participation (at instances or continuous) incorporated in the implementation of the NBS?

IV. NBS IMPACTS AND IMPLICATIONS

1. Which targets have been achieved in relation to addressing sustainability challenges and to what degree?
 - what are the main environmental impacts, e.g. water, ecosystems, biodiversity, soil, air quality? (if any)
 - what types of (ecosystem) services are expected to be provided by the NBS? (See ESS examples on sheet 'Ecosystem Services')
2. What have been the socio-political implications of the realisation of this NBS?
 - who are the beneficiaries of the NBS? (e.g. which areas of the city benefit from the NBS? who are the envisioned vs actual users?)
 - who (which stakeholders) were excluded and at which stages? Why and with what impacts / outcomes?
3. What have been the economic implications? (if any).
4. Other implications - not mentioned above?

V. CONTRADICTIONS AND CONTESTATION AROUND NBS INTERVENTIONS

1. What contradictions have emerged among the different visions around the NBS intervention and around their multi-functional promises (e.g. between economic, environmental and societal objectives)?
2. What were the main institutional and practical challenges the NBS has encountered?
3. How were these challenges negotiated and resolved (or not) throughout the NBS's lifetime? (NBS's lifetime or NBS stages can be divided into appraisal, visioning, planning, designing, implementing, maintaining and evaluating)
4. How has the NBS intervention been contested in society and which groups (if any) resisted it?

VI INNOVATION VERSUS TRADITIONAL APPROACHES WITHIN AND AROUND NBS INTERVENTIONS

1. In what sense has the NBS intervention involved innovation? (See sheet 'Innovation Types' for guidance)
 - if there is a mention on learning and / or knowledge innovation, please include it here: what forms of learning have taken place within the NBS intervention, and by whom?
2. What has drive the innovation? (See sheet 'Innovation Drivers' for clues)
3. To what extent is the NBS intervention being replicated within and outside the city?
 - if there has been any replication, what type was it and by whom?



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