Nature Based Solutions Projects Implementation Handbook

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Case studies retrieved from the Nature4Cities Implementation Model Database

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Executive Summary

Nature Based Solutions (NBSs) are actions inspired or supported by nature to simultaneously address urban challenges regarding climate change, availability of resources, environmental quality, and socio-economic issues at different and interconnected scales. NBSs can be diverse, ranging from e.g. urban forests, greening gardens to composting and renaturing riverbanks. The planning and implementation of NBSs can be quite challenging because they are solutions that intervene in highly complex socio-ecological systems, and require the bundling of expertise between different sectors and disciplines (social, environmental and economic).
Practitioners who work on climate adaptation and mitigation on a day to day basis are not necessarily familiar with NBS. Or when they are familiar with the concept, the experience with implementation of NBSs is lagging behind**. Nature4Cities** has developed a knowledge repository and various tools that enable practitioners in the uptake of NBSs in various ways. This handbook builds on the work done for the Nature4Cities project. It is particularly suited for government officials, practitioners and project coordinators working in the public domain who are not that experienced with NBSs.

The handbook is divided in three sections. The first section contains case study examples retrieved from the Nature4Cities Implementation Model Database. These cases are categorised in three main themes: rainwater management, parks and green residential areas and urban ecological networks. These themes furthermore respectively reflect different scales of NBS interventions: object, neighbourhood and city scale. Each theme is described following four aspects:

- Why is an intervention needed?
- What kind of NBS is applicable?
- Who is the key actor?
- How is the planning and implementation process organized?

Under the fourth question, the *how*? subsection, we describe the case study examples according to their governance approach, that is: government-led, co-creation and private sphere initiative. The case study presentation covers a broad variety of areas and approaches that are meant to inspire practitioners with practical examples that enables them to explore which NBS might be suitable for their context.

The second section presents Nature4Cities tools that can be used for the potential uptake of NBSs. The tools presented in this handbook are particularly suitable for the early stages of the planning and implementation process and enable practitioners to make the step from being inspired to taking action.

In the last section we briefly explain the aspect of social acceptance of NBS and the need to create internal and external support for NBS project implementation. In addition, we suggest next steps cities can take to gather support and build capacity to implement NBS in their context.

	Readers guide		
	Section 1 (chapter 2-4)	**Section 2 (chapter 5)**	**Section 3 (chapter 6)**
What does it offer?	Case studies on: ▪ Excess rainwater (chapter 2) ▪ Parks and green residential areas (chapter 3) ▪ Ecological networks (chapter 4) The why, who, what and how of the urban challenge, followed by case examples.	Introduction to available tools at the Nature4Cities platform	Capacity building for the implementation of NBS
When?	Ideation phase of an NBS project or development of a climate adaptation and mitigation strategy	Ideation phase and initial stages of the planning and implementation process	Planning and implementation phase
How to use it?	The reader can browse the case examples, select a specific NBS typology (thematic) or a governance approach.	The reader is guided through the different tools based on the questions and/ or knowledge gap this person has.	Building blocks for the creation of internal and external organisational support.

1 Introduction

In the recent years renaturing cities with Nature Based Solutions (NBSs) has gained a lot of attention. Nature Based Solutions are actions inspired or supported by nature to simultaneously address urban challenges regarding climate change, availability of resources, environmental quality, and socio-economic issues at different and interconnected scales. NBSs can be quite diverse, ranging from e.g. urban forests, greening gardens to composting and renaturing riverbanks. A substantial knowledge base with a diversity of tools, methods and handbooks has grown over the last couple of years. The European Commission has played in important role in promoting NBSs by aiming to position the EU as leader in 'Innovating with nature'. The EC has launched a wide range of **projects and actions** leading to the development of knowledge, tools and actions to establish sustainable and resilient societies.

The implementation of NBSs is challenging due to the fact that they intervene in highly complex socio-ecological systems of which the responses are uncertain (Nesshöver, 2017). The planning and implementation processes often involve collaboration between multiple stakeholders with different backgrounds, coming from different disciplines and sectors, bringing together diverse knowledge and different perspectives on what the problem definition is and which solutions are appropriate. The predominant view that NBSs should furthermore be implemented in a co-creative process involving citizens and other stakeholders, makes it even more challenging. Research and the development of implementation tools and strategies are therefore crucial to enable practitioners in the uptake of NBSs. **Nature4Cities** (N4Cs) contributes to this research base with **the Nature4Cities platform** (forthcoming 2020/ 2021) offering a rich variety of tools and methods, among which a knowledge repository, NBS databases and various assessment tools. This handbook builds on the work done for the Nature4Cities project, presenting a selection of tools suitable for the early stages of NBSs planning processes.

1.1 Why this NBS project implementation Handbook?

An analysis of case studies, collected in various NBS-databases (e.g. OPPLA, Urban Nature Atlas and the N4Cs Database), has shown that the majority of NBS projects are implemented by local governments through either a 'traditional public administration approach' (45%) or a 'new public management approach' (21%) (Egusquiza, 2018) which implies that overall, local governments are key actors in the implementation process of NBSs. Besides the leadership role in the uptake of NBSs, these localities have a strong impetus to take action especially since cities are the most densely populated, highly polluting areas in which climate change is affecting the lives of an increasing number of people. Hence, cities are at the same time an important space for sustainable innovation and a 'locus for action' (Nevens, 2013). However, cities do not automatically become 'actors' in this transition, and when they do, the policies adopted are not always sufficient to guide the necessary accelerated change towards sustainability (Olazabal, M. and Pascual, U., 2013).

Whether or not cities choose to act on the impact of climate change has, to a certain extent, to do with the experienced sense of urgency. In some regions of the world the grave impact of climate change is already felt on a daily basis, but most regions experience incremental changes such as increasing dry and hot summers, increased storms and cloudbursts. The deeper impact on biodiversity, human health and the quality of life (e.g. access to food, clean water, clean air) which has an impact at a slower pace, becomes visible only at the mid and long term. This results in a lack of urgency to act, especially when there are more pressing issues in the present that steer decision-making. Whereas climate change has a long-term cycle with postponed effects, politics is characterised by these short-term cycles. This tension between short- and long-term thinking has a crucial impact on climate adaptation and mitigation policies and pathways to sustainable cities, as depicted in figure 1.

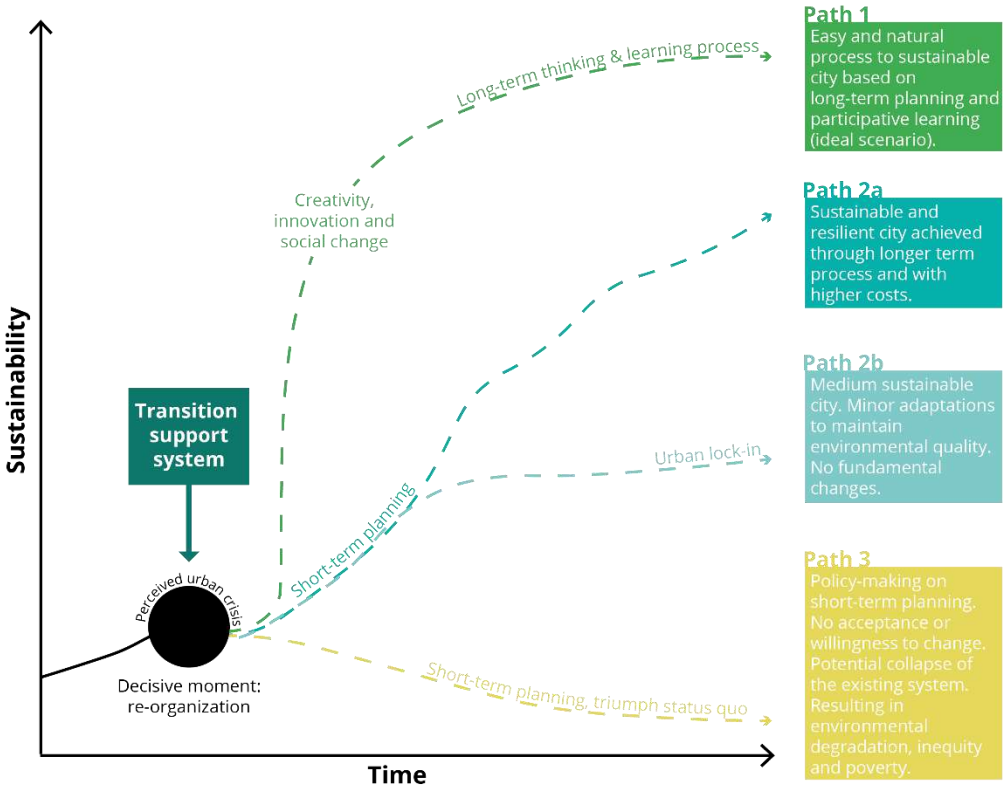


Figure 1: Urban Sustainable Transition

The stronger the focus on the short-term in which a 'business as usual' approach is predominant, the greater the risk to create a lock-in situation in which adequate measures to prevent the grave impact of climate change on the longer term are not adopted in time. To prevent a lock-in situation on the mid- and longer term, it is important that cities shift their focus and start reorganising their coping strategies to deal with the impacts of climate change. However, due to a lack of knowledge, skills and capacity cities need support to transition.

1.2 For whom is this handbook?

This handbook is particularly suitable for those practitioners who are not yet that experienced with Nature Based Solutions and are seeking to find out if NBSs could be a solution that fits their context and the challenges they are working on. Especially for those policy makers who are at the early stages of developing climate adaptation and mitigation policies in which they are dealing with uncertainties concerning the budget, knowledge, capacity. In addition, the handbook assists in deciding on the governance approach that fits in each socio-political context of decision-making. Participation and co-creation are the dominant approach according to the literature (Haase 2017; Nesshöver 2017; Raymond 2017; Wamsler 2017) but what the case examples illustrate is that the governance approaches used in NBS projects are quite diverse and very much context dependent.

This handbook is developed for government official, practitioners and project coordinators responsible for NBS projects, in particular for those working in the public domain

1.3 What does this NBS projects implementation Handbook offer?

Distinguishing Decision Support Tools (DSTs) from Process Support Tools (PSTs) contributes to the categorization of the tools available and to understand on what level these tools offer support. DSTs support decision makers in making better-informed decisions, whereas PSTs support practitioners in the organizational process. The availability of a variety of DSTs and PSTs is especially important because practitioners experience different types of problems throughout the planning and implementation process of NBS (and in developing climate change adaptation policies more general), resulting in different needs at different stages of the policy process.

DSTs play an important role in steering the content of a decision. They inform practitioners at three different levels:

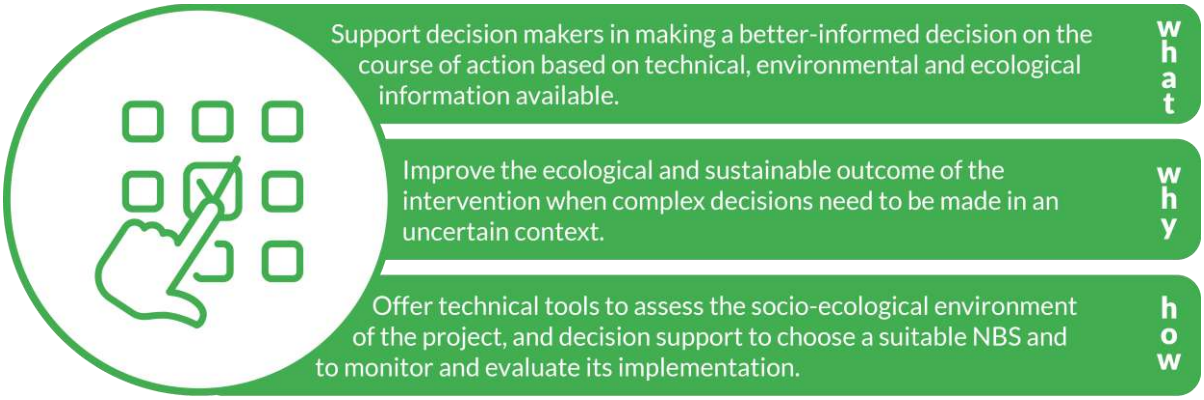


Figure 2: Decision support tool (DST)

In addition, the PSTs enable practitioners to reflect on the organisational aspects of the decision-making process to develop policies and implement them. This also concerns three different levels:

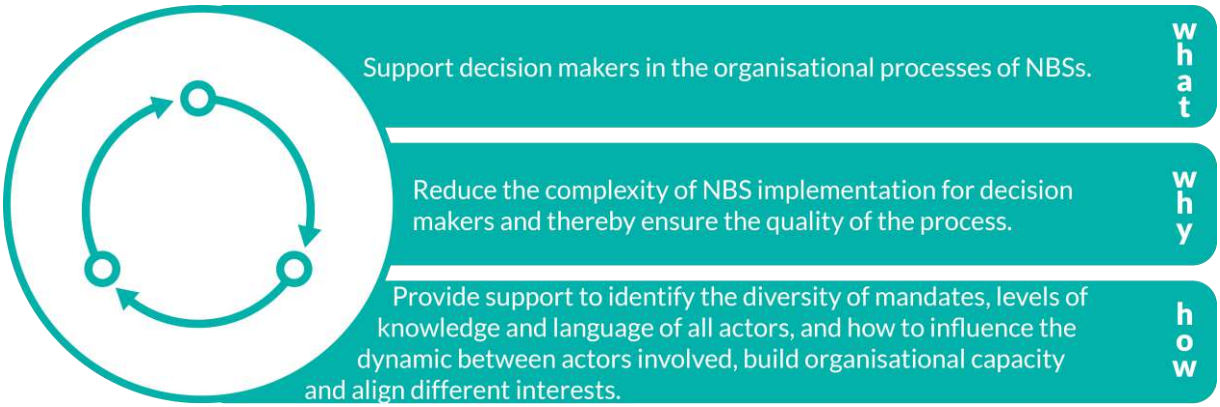
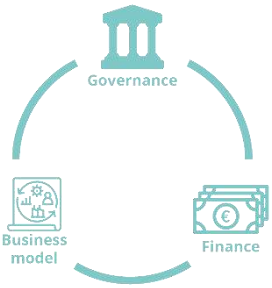


Figure 3: Process support tool (PST)

In the last couple of years, the knowledge base on NBS has increased significantly, especially due to European Commission projects. A number of handbooks have been developed:

Think Nature	The Think Nature handbook offers a basic encyclopaedic introduction to NBSs, it touches upon a broad range of, but less in-depth, aspects of NBSs. It is neither a PST nor a DST.
Connecting Nature	The Connecting Nature handbook contains an NBS Busines Model (BM) canvas complemented with a how-to-use guidebook. The BM-canvas is developed for the early stages of NBS planning as a tool to communicate, plan, identify new partners and explore financial resources. The handbook can be characterized as a DST.
Connecting Nature	A second Connecting Nature handbook is on Reflexive Monitoring and co-production (forthcoming). This handbook supports in the monitoring and evaluation of co-creative NBS implementation processes, and is a PST.
Naturvation	Atlas & Business Model Catalogue is a DST that describes the value proposition, value delivery and value capturing of different NBS models for a selection of cases.
GrowGreen	Catalogue of NBS Financing Approaches is a literature review exploring financial resources to invest in Green Infrastructure (GI) and NBS and can be considered as a DST.

The abovementioned handbooks cover a broad range of topics regarding NBS. These handbooks are very rich and form an important theoretical base for further the implementation of NBS, describing the technical and conceptual aspects in detail. What this Nature4Cities handbook brings in addition to the already existing variety of material, is that it offers a systematic presentation of case examples in which the governance, financial and business models are illustrated. This handbook thereby seeks to bridge the gap between NBS theory and practice by presenting tangible examples connecting the tools developed for the Nature4Cities project to case examples. The categorization is such that it allows practitioners to understand how similar types of NBSs can be approached in a different manner, e.g. using different financial and governance approaches. This can support them to reflect on what would work in their own context.



This handbook offers a decision support tool (DST) in the sense that it presents a broad variety of cases that inspire practitioners to replicate. The handbook furthermore offers process support (PST) by guiding the reader through the several Nature4Cities tools that have been developed

1.4 Method: Why, what, who and how

This handbook offers an accessible and easy to understand guide for practitioners responsible for climate adaptation and mitigation policies in municipalities. There are four core questions that need to be addressed at the beginning of the planning process:

Why is an intervention needed?

What kind of NBS is applicable?

Who is the key actor?

How is the planning and implementation process organized?

The answers this handbook offers are twofold: on the one hand case examples and on the other hand the Nature4Cities tools. Together these provide a combination of decision support and process support offering both inspiration as well as actionable advice for practitioners in policy and planning for NBS at municipal level. Both sections can be read independently which allows the reader to choose the reading order.

The first section (chapter 2 – 4) of the handbook zooms into case examples drawn from the **Nature4Cities Implementation Model Database**. These cases are structured on three different scales: object, neighbourhood and city scale associated respectively to three different types of solutions: excess rainwater, parks and ensuring the continuity of ecological networks. Each type is detailed in a dedicated section. This classification is based on **the NBS explorer** developed by Nature4Cities. In each section the four abovementioned questions are answered (why, what, who and how). The four core questions correspond with the **Nature4Cities Implementation Model Database pre-selection tool** (forthcoming).

Figure 4 depicts the outline of the case descriptions in section 1.

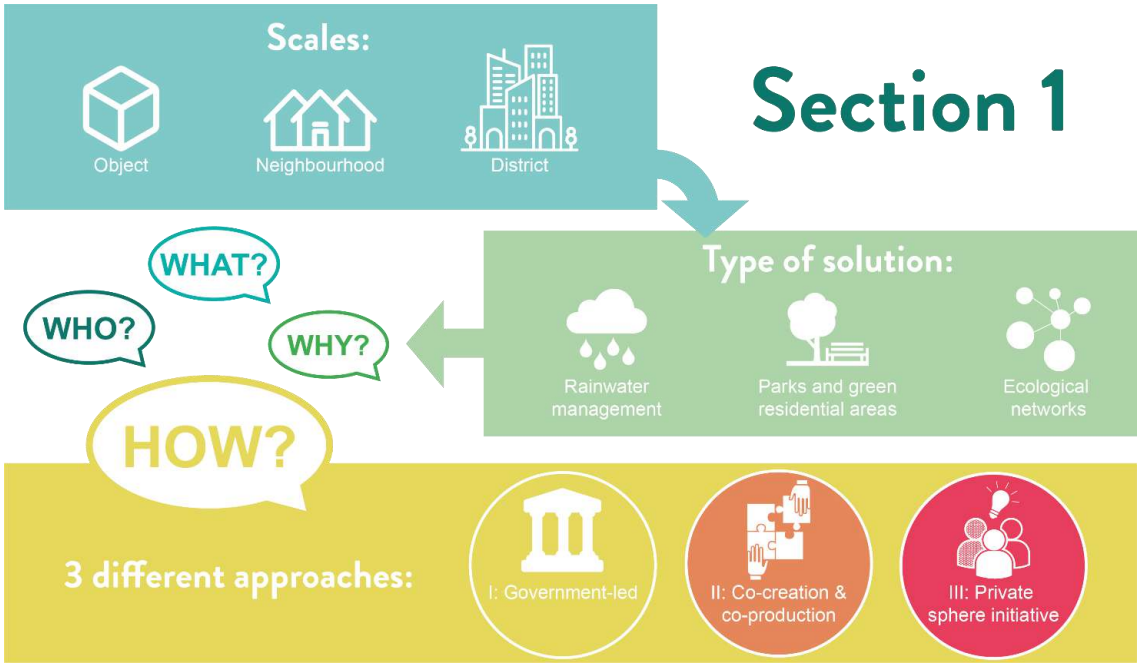


Figure 4: Categorization of case examples

The specific case descriptions loosely follow a similar format. Besides, the cases are visually supported by a small infographic, indicating the urgency, the budget, the means of financing and the complexity of the project. A legend of this infographic is depicted in figure 5. The corresponding circle is coloured in the infographic.

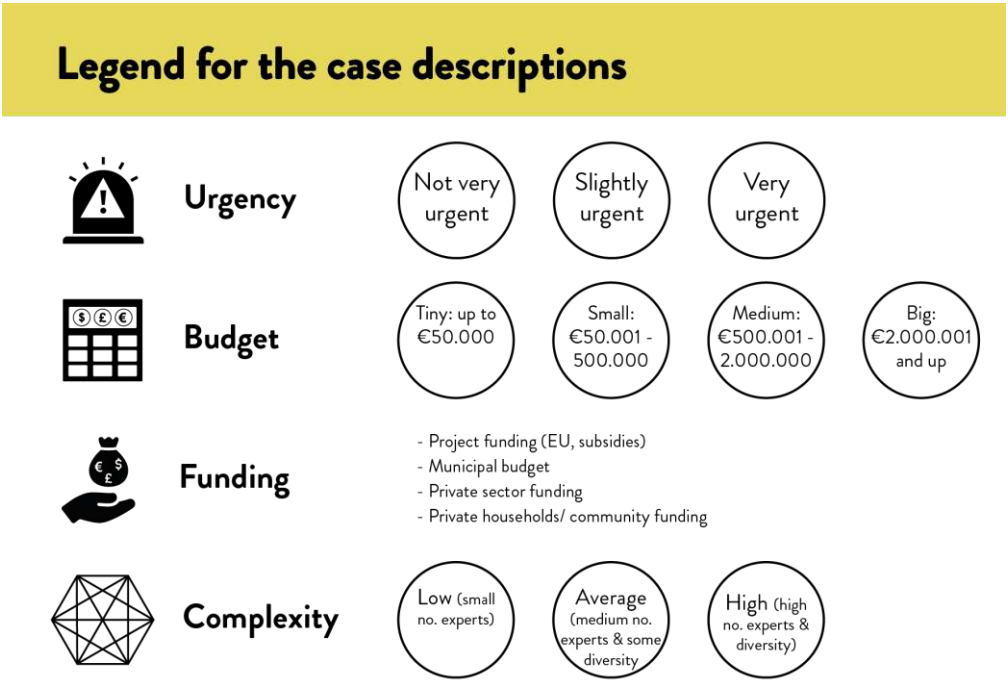


Figure 5: Legend for the case descriptions

The case examples in itself do not offer one-fits-all solutions for practitioners because NBSs are not simply a copy paste exercise. What works well in one situation may deliver undesired effects in another context. Therefore, the second section (chapter 5) of the handbook guides the reader through the Nature4Cities tools that are available at the Nature4Cities platform. It explains how the tools work as a process or decision support tool. Next, based on a set of questions and/or perceived knowledge gaps, it is shown how these tools can be of use in planning and implementation processes.

Besides the two core offerings of the handbook, the case examples and the Nature4Cities tools guidance, the last section (chapter 6) briefly reflects on the next steps cities needed to take to develop their own sustainable climate adaptation and mitigation strategy, the challenges faced in the decision-making process (trade-offs that are part of the decision-making) and building capacity to create social acceptance and support for NBS interventions.

2 Rainwater management

2.1. Urban Challenges

Many European cities experience serious water management problems in the occurrence of heavy rainfall and cloudbursts. Sewage systems overflow, streets, squares and parking lots are submerged and lower-lying houses and storage facilities face the risk of flooding. These events disturb public life and inflict economic damage. Increased soil sealing in urban areas is a major factor causing problems in urban water management. Soil sealing is a common low-budget, low-in-maintenance option adopted to develop public infrastructure. Paving private gardens has become a trend amongst home owners and private land owners as well. Tackling the problem of urban water management is therefore both a public and private issue. There are several small-scale strategies that can be adopted to deal with excess water. Combined together these small interventions can have a large-scale impact and thereby avert large scale infrastructural measures in the urban water management system.

2.2. Nature Based Solutions

Climate adaptation strategies should focus on water quality and water management. NBS interventions could be used to protect the quality of valuable water resources and groundwater recharge. Moreover, greening the infrastructure in and around water (which implies the removal of grey infrastructure such as dams and grey riverbanks) allows for more biodiversity. The creation of impervious surfaces both on the ground (e.g. swales, unsealed and planted car parks) as well as on objects (e.g. green roofs) also has a positive effect on water runoff. Other types of actions, such as taxation and regulation on soil sealing, have proven to be successful as well.

In the following section we present a selection of NBSs for water quality and water management. The **NBS Explorer** at the Nature4Cities platform allows to browse other case examples.

2.3. Governance

Urban water management is a complex system that involves many actors and scales, both governmental and non-governmental, as well as technological aspects and ecological factors which are interlinked and co-dependent. Governments carry an important responsibility in managing the urban water cycle because most water issues occur in public space. The most common approach is to carry out large-scale infrastructural interventions in which the government governs projects from a traditional public administration approach, taking up sole responsibility and being financially responsible for the necessary investments. The department tasked with urban water management can involve other departments in the planning process, for instance the health department (health risks due to sewage), infrastructure and traffic (flooding of parking lots and roads), or from the social domain (housing). Hiring external expertise is also very common, in particular for an environmental and ecological assessment of the problem, as well as expertise to develop innovative technological solutions. Collaboration with other local stakeholders, private land owners and residents is relatively new, because governments realise that part of the solution to deal with flooding events lies in the hands of private actors. In most cities high percentages of ground is in private ownership or use. New approaches need to be adopted to involve private owners taking small scale actions on their private grounds (Keremane, G., 2017). The government can exert influence over privately owned land by adopting regulations and laws, raise taxes or provide subsidies, nudging or by offering support.

2.4. Three different governance approaches to rain water management

2.4.1. Government-led

Water management interventions through the implementation of NBSs by public sector actors in the public domain are relatively straightforward, given that public authorities are considered as the ‘owner’ of public space, or the (financially) responsible body. Physical interventions in the public space can be relatively minor such as creating green strips, using permeable paving and special tiles. In some of these cases specific types of citizen participation was used, but mainly in the form of public consultation.

Green strips and ecological parking lots along the river bank

Rotterdam. Source: Stichting Milieunet

Rotterdam

Overview Rotterdam, the Netherlands

Urgency	○ ● ○
Budget	● ○ ○ ○
Funding	Project funding & municipal budget
Complexity	● ○ ○

Rotterdam, Netherlands

In the Netherlands the local municipality of Rotterdam used permeable tiles, permeable grass strips and vegetation to green parking lots, sideways and pockets. The municipality used these small scale NBS interventions as a way of dealing with the impact of river tides, and by doing so, Tide Park Rotterdam was created.

The programme was government-led and concentrated on a particular area at two riverbanks (Nieuwe Maas and Nieuwe Waterweg) that create an increased flooding risk in times of heavy rainfall as a consequence of climate change. The small green strips that are created by the NBS offer space for recreational activities. A number of governmental and semi-governmental bodies were involved to implement the NBS, such as the national government (Ministry of Infrastructure and Water), associations, water authorities, municipalities and the Province of South Holland, as well as an environmental organisation.

Financing

The NBS was financed by the national, regional and local government and Europe (LIFE). Due to the combination of small scale, low cost interventions and lower maintenance costs, the overall budget was relatively low.

Ober-Grafendorf, Austria

The DrainGarden in Ober-Grafendorf has been developed to mitigate the increasingly frequent heavy rainfall events that lead to flooding of residential areas, damaging private and public property. The combination of plants and pebbles creates a layered surface with high water permeability and high storage capacities, with on top of that a positive impact on the microclimate. With necessary modifications, the rainwater management system can be tailored to other situations, such as green roofs, car parks, and private housing.

The project was initiated by the mayor of Ober-Grafendorf with the support of the municipal council. The project was executed by the long-term gardening service provider of the municipality and with the expertise from the University of Natural Resources and Life Sciences, Vienna, and the consultancy firm Zenebio GmbH, who developed the smart rainwater management system. Due to spatial planning laws in Austria, the project was subject to stakeholder participation and public consultation, but this was limited because the project was implemented in an underdeveloped area with hardly any inhabitants.

Financing

The system allows the municipality to avoid investment costs for construction of additional sewage pipes as well as regular operational costs for maintaining the sewerage and operating pumping facilities and thus has considerable cost advantages, both over the short and the long term.

The cost of the substrate for one cubic metre is about 100 euro. Depending on the choice of plants, the cultivation cost ranges from two euro /sqm for seeding to several thousand euro/sqm for planting large woody perennial plants. A budget of 65.000 euro was available for the process management and support services co-funded by the EU through the C3-Alps project Capitalising Climate Change Knowledge for Adaptation in the Alpine Space programme.

Green strips

Ober-Grafendorf

Overview Ober-Grafendorf, Austria

Urgency	○ ● ○
Budget	○ ● ○ ○
Funding	Project funding
Complexity	● ○ ○

Taxation schemes

Foto Funda (Roosendaal)

A relatively new strategy to prevent soil sealing is the introduction of a taxation scheme. This can either be the introduction of a ‘tile tax’ which increase the amount of household municipal taxes when the percentage of tiles in the household garden is too high (AT5, 2020; Rietkerk 2016). This strategy is most common and accepted in Belgium and Germany. In the Netherlands some experiments have taken place but have led to public debate which resulted in a reward structure rather than a financial ‘punishment’. Instead of taxing local residents that remove tiles from their garden, these people receive a reduction in their sewage charges (Hendriksma, M., 2018).

Earmarking local taxes (such as tile taxes) and parking fees for green infrastructure (GI) or NBS investments can be useful as a revenue to co-finance GI and NBS projects (Baroni, 2019).

2.4.2. Co-creation and co-production

Heavy rainfall and flood events affect both public and private property and spaces. Streets, household basements, living rooms and other properties can be damaged due to limited drainage capacity of the sewage system and soil. Investment in increased sewage capacity is expensive and does not always create sufficient capacity for peak events. Interventions in the public and private domain are also necessary to limit the decrease in soil sealing (Rietkerk 2016). The government has however a limited number of tools to intervene in the private domain. Exerting influence through regulations, laws and taxes is one approach that is sometimes used, but other initiatives aim to cooperate with private actors (households and private sector) through programmes, small interventions or strategic action.

Cloudburst Management Plan, Copenhagen, Denmark

There are several projects aimed to green gardens. One is the Cloudburst Management Plan, a mixed method approach to combat the impacts of cloudbursts. The plan is actually a bundling of 300 interventions, varying in size and character. Some are grey interventions, such as stormwater roads and pipes that transport water towards lakes and the harbour, detention roads for storing waters. Some are green solutions such as detention areas to store very large volume of waters (i.e. parks that could turn into lakes during flood events), green roads to detain and hold back water in smaller side streets. The programme will be carried out in the next 20-30 years based on a prioritisation system. Land-owners, private sector actors and households can choose to opt in.

The Cloudburst Management Plan is developed by the City of Copenhagen in coordination with Kobenhavns Energi (Copenhagen Energy), the City of Frederiksberg, Frederiksberg Forsyning (Frederiksberg utility company) and neighbouring local authorities who lead surface water and waste water through the city to the common sewage treatment plants or to common water courses and lakes.

Financing

The climate adaptive initiatives in Copenhagen are financed by a combination of public and private investments. The city Administration and the utility company (Kobenhavns Energi) via taxes and revenues from charges, and investments from private land- and homeowners. The total costs of the programme is estimated at DKK 1.5 billion. The city can save money if it coordinates the implementation of the cloudburst and stormwater management with other construction projects. The combined solutions also require private individuals to invest in anti-flood backflow valves and local stormwater drainage. The assessment found that while both the traditional sewer solution and the alternative solution meet the municipalities objectives concerning stormwater and cloudbursts, the alternative solution results in higher net benefits. The traditional sewer solution has been estimated to cost DKK 20 billion compared to the DKK 13 billion of the alternative solution. Both solutions would reduce the costs of damage by DKK 16 billion; thus, the net gain of the alternative solution is DKK 3 billion compared to the net loss of the traditional solution of DKK 4 billion.

Greening gardens and de-soiling

Copenhagen.

Copenhagen. Source: Foreground

Overview Cloudburst Management Plan, Copenhagen

Urgency	○ ○ ●
Budget	○ ○ ○ ●
Funding	Municipal budget & private funding
Complexity	○ ● ○

Greening gardens and de-soiling

Operatie Steenbreek

Overview Operatie Steenbreek, the Netherlands

Urgency	● ○ ○
Budget	● ○ ○ ○
Funding	Municipal budget
Complexity	○ ○ ●

Operatie Steenbreek, the Netherlands

The project 'Operatie Steenbreek' is a national partnership between 'green' knowledge institutes, businesses, governments and citizens and can be considered both as practical intervention(-s) as well as strategic action. The aim is to counteract the current trend of paving residential gardens and thereby improving the urban living environment, in particular trying to make citizens enthusiastic for greening their garden. The attention is mainly on the negative effects of paving, such as less biodiversity and the pressure on the sewage system during cloudbursts. Several cities throughout the Netherlands are programme member which gives them access to communication materials, information and a methodology for local interventions to stimulate households to green their gardens. First is the so-called 'garden ambassadors', people who can offer information about how to make your garden more natural and animal friendly. Secondly, they offer a course on garden reservations, in which members learn about nature friendly gardening. The last is the BIMBY method, which stands for Biodiversity In My Backyard, in which citizens are guided by collecting information about making their gardens more natural and animal friendly. The different cities all have their own strategy to promote Operatie Steenbreek among their citizens and to make them aware of their goal.

The project was initiated by Alterra (Wageningen Environmental Research/ WUR), and the University of Groningen. Operatie Steenbreek has become an independent foundation. Municipalities who become member usually collaborate with local actors such as water authorities, foundations, companies like garden centres, citizens, ecologists, city planners and local residents. The online platform allows municipalities to share knowledge and experiences.

Financing

The project is financed by the municipalities through a membership fee.

Gewildgroei, the Netherlands

Several municipalities in the Netherlands have invested in permeable pavement. This ‘Living Pavement’ is an open tile system that allows vegetation to grow. It can be used for water drainage, temperature regulation, air pollution and for aesthetic purposes. Local residents can adopt a green strip and volunteer to maintain it.

Financing

The tiles are bought and integrated by the municipality.

Permeable pavement

Gewildgroei and living pavement

Overview Gewildgroei, the Netherlands

Urgency	● ○ ○
Budget	● ○ ○ ○
Funding	Municipal budget
Complexity	● ○ ○

Strategic action

Vienna. Source: Wien info

Overview Green Urban Climate project, Austria

Urgency	○ ● ○
Budget	○ ● ○ ○
Funding	Private sector funding?
Complexity	○ ○ ●

GreenUrbanClimate project, Austria

The GreenUrbanClimate project (GrunStadtKlima) in Austria is a research project investigating the efficiency of various types of urban pavement with respect to their microclimatic effects, drainage behaviour and elimination of pollutants. The project is a collaboration between 30 partners from industry and research (Landscape Construction, Spatial Planning, Meteorology and Economy) who joined forces to investigate existing green roofs and walls, and permeable surfaces on different locations in Vienna. The aim of the project is to improve these existing NBSs and develop new methods for green roofs and walls, as well as permeable surfaces. This research is strategically important because it delivers convincing evidence-based proof that NBSs are viable solutions to climate adaptation. This will stimulate the further uptake of these green interventions as part of climate adaptation strategy in urban areas.

Financing

The project was funded by the Austrian Research Promotion Agency (FFG), the national funding agency for industrial research and development in Austria.

Amsterdam Rainproof

The city of Amsterdam and the local water authority invested in a platform approach, Amsterdam Rainproof. Amsterdam Rainproof initiative has been developed in order to build a city-wide network of actors that help to increase the ability of the city to absorb and re-use rain water, e.g. green roofs, green walls, rain barrels, green gardens and water-permeable pavements. As a platform it seeks to connect a broad network of actors and initiatives that work on this subject. Amsterdam Rainproof seeks to align existing (citizens) initiatives, municipal policies and entrepreneurial initiatives. The rationale behind this approach is that the city can only become resilient to rainwater if all stakeholders work together and take up their shared responsibility.

Currently, 76 partners are involved, including governmental organisations, private companies, citizen initiatives, network organisations and knowledge institutions. Ideas, information and a toolbox are available on the website.

Financing

The project is financed by the municipality and the water authority. Side-projects are financed by the participating actors.

Strategic action

Amsterdam. Source: Amsterdam Rainproof

Overview Amsterdam Rainproof

Urgency	○ ○ ●
Budget	○ ○ ○ ●
Funding	Municipal budget & private funding
Complexity	○ ○ ●

Strategic action

Malmö

Malmö. Source: Aline Lessner, Image Bank Sweden

Overview Western Harbour, Malmö, Sweden

Urgency	○ ○ ●
Budget	○ ○ ○ ●
Funding	National funding & private funding
Complexity	○ ● ○

Western Harbour, Malmö, Sweden

The city of Malmo has been experiencing negative impacts of climate change, in particular excessive rainfall causing flood-related problems. The most problematic issue has been the frequent overflow of sewage systems. To tackle these challenges the municipality has adopted a code for the design phase of urban development projects. This strategy requires that in each new development area in the city, in which the government collaborates with private developers, a co-creation process needs to take place at the beginning of a project to develop a sustainable project plan. In dialogue sessions, the municipality negotiates with the private developer responsible for the implementation, the particular sustainable and climate resilient project goals. This ensures that each new project is in line with the sustainable goals, but at the same time allows for a tailored approach in which there is room to incorporate project specific circumstances. The Western Harbour is an example of this approach. This former brownfield was redeveloped into a sustainable eco-city. The development includes both climate adaptation and mitigation measures (i.e. green roofs, green areas and stormwater management measures).

Financing

By integrating sustainable standards at an early stage of project development, and effective mix of public and private funding is created. The initial share of costs is part of the private development costs. Private developers are responsible for all the costs relating to the development of the plots. Even the roads, parks and streets on the site, which are developed by the city, are included in the price of the building plots and are therefore indirectly paid by developers. The costs of the development of the building plot itself are completely covered by the developers. The municipality adopts a co-funding construction to the sustainable quality standards. A small amount of budget is needed to cover the project management time spend by policy officers and conduct research (for which the costs are shared with the project developer).

Additional funding was requested from the national government and the European Commission to improve energy efficiency, realise green roofs and organise awareness raising events. A total of SEK 250.000.000 (approximately 26.300.000 euro) in national funding (Local Investment Fund) was awarded to the city. The applications were coordinated by the municipality but the project developer and the energy company contributed to some of these applications.

2.4.3. Private sphere initiative

There are a number of initiatives in which the government plays only a minor role. In these cases, either private sector actors such as companies and private households decide to invest in NBS measures on their privately owned ground (business or household). In some cases, this concerns a privately owned terrain which is publicly accessible. Besides the environmental benefits, greening (privately owned) blocks of buildings can be financially beneficial to increase estates value, but can have a gentrifying effect.

The Avenue, Washington, United States

The Avenue is a busy area downtown Washington, frequented by office workers, residents, and students. The project, which entails offices and residential buildings, was developed on a plot that was previously owned by the George Washington University Hospital. The buildings were designed with the use of various sustainable and NBS elements. A below-grade loading dock was used to create an interior courtyard of 8.000-square-foot. A green roof that is spread equally across the office and residential buildings. Green and light-coloured roofs were user since they absorb less heat than conventional black roofs, thereby decreasing peak roof surface temperature by approximately 4 degrees Celsius. The Avenue also uses a high-efficiency irrigation system and native and drought-tolerant plants, which reduce the amount of water needed by an estimated 62 percent. It furthermore functions as a stormwater retention system that enables to manage 76.000 gallons of stormwater and re-circulate is through a cistern and treatment system to supply the building with (filtrated) water.

The project is the result of a partnership between the Community Research institute from George Washington University and Boston Properties Inc. who partnered with the local government.

Financing

The buildings are under a 60-year lease contract which contributed to an estimated 11.5 million dollars in annual city tax revenues, and has since provided funding for the construction of the universities' Science and Engineering Hall. The ground lease terms were based on the amount of developable space rather than the possible floor/area ratio (FAR), which led the development team to create a courtyard concept slightly below FAR opportunities.

Raingardens and green roofs

Washington

Washington. Source: Eric Taylor and Craig Kuhner, Sasaki

Overview The Avenue, Washington, US

Urgency	○ ● ○
Budget	○ ○ ○ ●
Funding	Private sector funding
Complexity	○ ● ○

Raingardens and green roofs

Zurich. Source: A&K

Overview Zurich, Switzerland

Urgency	● ○ ○
Budget	○ ○ ● ○
Funding	Private sector funding
Complexity	● ○ ○

Zurich, Switzerland

In Zurich the Turbinenplatz is a public city square on a private estate. The original owner of the site (Sulzer Immobilen AG) renovated the square in 2004 and then donated it to the city of Zurich. Now it is the largest city square and covers approximately 14.000 m2. Due to the gradual withdrawal of the industry, the area became the largest urban development zone in the west part of Zurich. The flooring of the square is mainly made of concrete to remember the industrial site but it also contains some gravel surfaces with several birches and seating elements. Planted basins and plantation is integrated in the design to drain excess rainwater. Through the renovation, Turbinenplatz has become one of Switzerland's first large stormwater projects.

Financing

The project budget is a private sector investment estimated around 1 to 5 million euro.

Amsterdam, the Netherlands

Vrijburcht is a multipurpose living-and-working complex in Amsterdam created by residents as response to the expected impacts of climate change. The courtyard garden, composed of trees, lawns, flowers, benches and a greenhouse, provides solutions to prevent or reduce flooding from extreme rainfall, drought during dry periods and heat stress during hot summer days. In particular: Rain water (from the roof tops) is collected in two tanks that are buried in the garden and it is used for irrigation of garden and plants on the surrounding terraces/balconies. The parking garage is created under buildings and garden is paved minimally to create maximum permeability for rain water. The many trees in the garden provide shade and thus contribute to an agreeable microclimate on hot summer days.

Vrijburcht was initiated in 2000 by a group of people as a collective private commissioning (CPC) project. The municipality of Amsterdam designated a plot that was acquired by the foundation (Vrijburcht Foundation) in which the resident organised themselves, acting as a commissioner to design and plan the housing project. Once the project was realized, the residents formed a Homeowner Association, a legal entity taking care of buildings maintenance and other shared spaces (i.e. the common garden). The association has an executive committee, a general assembly, a chair and a financial committee.

Financing

Total costs of building complex were about 16 million euro. Garden costs (about 55.000 euro excluding rainwater storage facilities and greenhouse costs, respectively 17.500 euro and 30.000 euro) were financed collectively, whereas the housing units were purchased individually through personal loans. The foundations negotiated a special mortgage construction against a favourable interest rate and the local housing corporation provided a financial warranty.

On annual basis, maintenance costs for the garden amount to 3.000 euro (including the work of a gardener that assists volunteering residents). Also costs of the maintenance are carried by the inhabitants and the housing corporation as part of regular service fees of the building, and is managed by the Homeowner Association.

Raingardens and green roofs

Vrijburcht

Vrijburcht. Source: Voogd Makelaardij

Overview Vrijburcht, Amsterdam, the Netherlands

Urgency	● ○ ○
Budget	○ ○ ○ ●
Funding	Community funding
Complexity	○ ● ○

3 Parks and green residential areas in neighborhoods

3.1. Urban Challenges

Cities are usually densely populated areas in which buildings and grey infrastructure such as roads, squares and paved areas are predominant. Concrete and tiles absorb heat which can lead to a heat island effect, threatening the health of its residents. Summer nights in urban areas can be 5 – 10 degrees warmer compared to rural areas. Local higher temperatures affect the health of especially vulnerable and elderly people with limited mobility, who have limited means to seek cooling (Stuiver, M., 2018). Soil sealing prevents water absorption and water runoff, causing flooding events. The increased grey elements furthermore limit the habitat of flora and fauna, thereby decreasing the biodiversity.

3.2. Nature Based Solutions

Research and case studies have demonstrated that green elements can be used for water management purposes (prevention of flooding and drought), they positively impact urban biodiversity and deliver ecosystem services (reduce air pollution). Urban nature, such as trees, bushes, and green spaces at neighbourhood scale also have a positive effect on the urban ecology and the health and well-being of residents, for example a stress-reducing impact on people. Moreover, high quality green spaces are generally more attractive for outdoor recreational and outdoor activities (Lemee, C., 2019; Stuiver, M., 2018). Creating opportunities for residents to design and maintain (small pockets) green spaces in their neighbourhood has a positive impact on the social cohesion. Renaturing areas in and around the cities contributes to creating a habitat for a broad variety of animal species that helps to protect the biodiversity and ecosystem services. These green areas furthermore reduce the temperature (MacKinnon K., 2019; Kluck, J., 2020). Examples are large urban parks, heritage and botanical gardens, flower fields, urban woods and green cemeteries.

In the following section we present a selection of NBSs parks and green residential areas. The **NBS Explorer** at the Nature4Cities platform allows to browse other case examples.

3.3 Governance

Public areas in and around cities are publicly owned and fall under government responsibilities, in which local and/or regional authorities carry the final responsibility for deciding how these spaces can and cannot be used, how they are designed and maintained. These authorities can opt for allowing other actors and stakeholders to share that responsibility, either through a contract (e.g. project-based subcontracting) or an agreement to collaborate (e.g. through designating co-creative spaces). Privately owned parks, gardens and terrains fall under the responsibility of the owner (e.g. a business, home-owner, charity or foundation) but the government can exert influence through regulations, laws, agreements or subsidies and nudges.

3.4. Three different governance approaches to parks and green residential areas in neighborhoods

3.4.1. Government-led

Public parks and public space owned by the municipality can be repurposed and re-natured. This can gobble up a large amount of the infrastructural public budget. Some cities have taken the opportunity to find co-funding through European projects, whilst others reserved municipal budgets. In some cases, depending of course on the context and the particular urban challenges that are faced, grey solutions can be expensive and less cost effective than NBS and GI. Often citizens are not involved in these types of projects, given the size and scope they entail.

Eco-district Rouen, France

Ecodistrict Rouen is re-designing and re-development project of a former industrial area transformed into a sustainable neighbourhood with a mixture of residential housing, offices and commercial buildings. One of the key aspects of the project are the three hectares of green public space that has been created around water courses, corresponding to about 30% of the total ecodistrict area (9 hectares) creating a green recreational area (park) for its residents. The water courses, that previously were channelled under the ground, have been uncovered to improve connection with green areas and biodiversity of their banks. Together with the green corridors this decreases the urban heat island effect, as they can prevent part of the radiation from reaching the streets, thereby creating a comfortable microclimate. A future plan is to implement green rooftops to further reduce the urban heat island effect and improve rainwater drainage.

The project aimed to achieve an official French Ecodistrict qualification and to become a Ville de Demain Ecocit.

The project was initiated by the Metropole Rouen Normandie and the City of Rouen. The project is coordinated by the project development agency Rouen Normandie Amanagement.

Financing

The project costs were estimated at 5 million euro. Funded by the Metropole Rouen Normandie, the City of Rouen and The Haute Normandie region. Additional funding was received from the European Future Cities project, which is part of the INTERREG IBV program which receives funding from the Fonds European de Developement Economique et Regional (FEDER). Substantial funding has also been provided by the European Investment Bank.

Green residential area

Rouen

Rouen. Source: L. Perreau, Devilliers et associés

Overview Eco-district Rouen, France

Urgency	● ○ ○
Budget	○ ○ ○ ●
Funding	Municipal and regional budget & project funding
Complexity	● ○ ○

Gomeznarro Park

Gomeznarro Park. Source: Suds-atlantis, Dreneja sostenibile

Overview Gomeznarro Park, Madrid, Spain

Urgency	○ ○ ●
Budget	○ ● ○ ○
Funding	Municipal budget
Complexity	● ○ ○

Gomeznarro Park, Madrid, Spain

The Gomeznarro Park (10.000sqm) in Madrid has been affected by erosion during heavy rainfall events, and the surrounding residential areas suffered from flash flooding as a result of its topography and impermeable ground surface. In response to these problems, a natural drainage and rain water retention system was constructed in the park. Impervious pavement was replaced by permeable surfaces, restoration of compacted soils, re-vegetation of the areas at risk of erosion and installation of underground rainwater collection system and storage tanks. These measures eliminated the problem of erosion and flash flooding in the area, reduced pressure on wastewater management system and established a more natural water cycle in the area. An additional benefit came from the increased moisture in the soil that also helps to ameliorate the Urban Heat Island effect in and around the park. In 2004, the project received a good practice qualification as part of the best practice award scheme by the UN Habitat. The water infiltration and collection technology has been subsequently replicated in a number of projects in Madrid (e.g. green areas in Valdebebas development, Madrid Rio, M30 motorway, the sports areas Daoiz y Velarde and Marques de Samaranch and at the Alzheimer Centre Fundacion Reina Sofia) and elsewhere in Spain (e.g. the shopping centre carpark in Autonomous Community of Galicia and a park in Urbanizacion Torr Bar in Barcelona).

The project was initiated by the municipality of Madrid. The technology and consultancy for the intervention was provided by a private consultancy company. The park is surrounded by social housing built in the 1960s. Tenants complaints about the dampness in their houses caused by flash flooding provided an impulse for the housing association to refurbish the residential buildings. This process was integrated with the municipalities plan and the revitalisation of the Gomeznarro Park.

Financing

The municipality of Madrid financed the project. The construction cost is estimated at 343.600 euro. Whilst the benefits have not been assessed in monetary terms, there are no additional maintenance costs in comparison to traditional landscaping solutions used in parks. The project resulted in reduced erosion, risk of flooding and pressure on the drainage systems. The park receives yearly about 5 million litres of rain water, which now does not enter the drainage system but instead recharges the groundwater levels and results in a lower need for additional watering by park maintenance. Further benefits include improved air quality and reduced air temperatures in and around the park.

3.4.2. Co-creation and co-production

There is a wide diversity of co-creative projects in which public and private parties collaborate. In smaller scale parks it is often easier to involve local citizens, especially residents from surrounding neighbourhoods. But larger scale projects can fall under the authority of private foundations, or private sector parties.

GrünOase, Salzburg, Austria

Continuing urban growth leads to a decrease in public and private green spaces, as is also the case in Salzburg. The GrünOase project is a method that enables the smart sustainable design of green spaces, which was used to develop two parks in Salzburg. The project seeks to contribute to the creation of high-quality green spaces that enhance the urban climate and ecology in the city which have a positive effect on the quality of life of its residents and the micro-climate. The method involves a remote sensing tool for image classifications and requires additional surveying amongst user groups.

The project was initiated by the municipality in collaboration with the regional and national government. The concept was developed by allee42 landschaftsarchitekten. Local residents and other stakeholders were involved in the development the project.

Financing

The estimated costs were around 15.000 euro funded with public finances from the Austrian Climate and Energy Fund's initiative on Smart Cities.

Parks

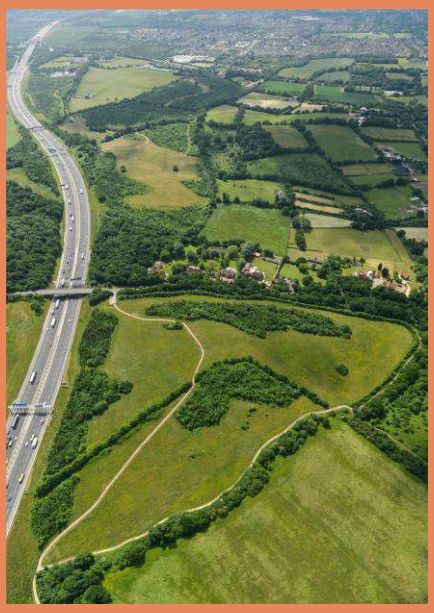
GrünOase

GrünOase. Source: ZGis

Overview Grünoase, Salzburg, Austria

Urgency	● ○ ○
Budget	● ○ ○ ○
Funding	Project funding
Complexity	○ ● ○

Green residential area



Thames Chase plan

Thames Chase plan. Source: Thames Chase

Overview Thames Chase plan, London/Essex, UK

Urgency	○ ● ○
Budget	● ○ ○ ○
Funding	Municipal budget & private funding
Complexity	○ ● ○

Thames Chase plan, London/Essex, UK

The Thames Chase plan is a large urban forest overlooking 40 square miles of countryside surrounding the London/Essex border. In the past the forest has suffered greatly, being damaged by urban sprawls, unplanned industrialisation, pollution and various visual intrusions that arise as a consequence of neighbouring such a large conurbation. These impairments coupled with landfilling, gravel/sand extractions and the rapid loss of woodland and farming area have injured the forest proving a need for restoration. The aim is to transform 30% of all open space with woodland and connect all historical sites in the area so that people can travel from one historical location to another without encountering a single busy road. The restoration and revitalisation contribute to ensuring an essential green lung for the local community.

The Thames Chase Community Forest is a partnership of national statutory agencies, local government, voluntary bodies and the private sector. The Thames Chase Trust, a charity, carries management responsibility for the Community Forest. The renovation plan was produced in consultation with the local government, private and public sector, funders and a team of volunteers.

Besides a number of local and regional authorities, other organisations are involved (e.g. the Woodland Trust, Essex Wildlife Trust and London Wildlife Trust, Royal Society for the Protection of Birds), and interest groups (e.g. community heritage groups and sites, horse riding groups, cycling groups, walking groups, health groups, carer and supported living organisations, other small charities) and local businesses.

Financing

Since Central Government funding for Community Forests ceased and the Thames Chase Trust was established, continued funding from Essex, Havering and Thurrock has been crucial and without the strong support of these three authorities there would be no Community Forest partnership.

3.4.3. Private sphere initiative

Large estates and gardens are often privately owned. In some cases, these are open to the public or to specific user groups, such as is the case at care facilities but it can also be private sector companies or community owned pieces of land.

Nacadia Therapy Garden, Denmark

The Nacadia Therapy Garden is constructed on a one-hectare parcel in the Horsholm Arboretum, which is located north of Copenhagen in Denmark. The Horsholm Arboretum contains the largest collection of plants and shrubs in Scandinavia, with over 2,000 different species. It is characterized as a healing forest garden because it is designed as a behavioural setting, a place where the physical environment and human behaviour are indissolubly connected. The Nacadia project has four objectives: a) provide treatment for patients with stress-related illness; b) obtain evidence-based knowledge about the effect of healing garden design and Nature-Based Therapy (NBT) for this patient group; c) develop and offer education within the field of healing garden design and NBT in general; d) serve as a knowledge and demonstration centre for the public.

The design of Nacadia and the NBT concept was developed by an interdisciplinary group at the University of Copenhagen, led by landscape architect Ulrika Stigsdotter. The group includes landscape architects, medical doctors, psychologists, and therapists with expertise in the field of nature-based therapy and stress treatment.

The project was initiated by Forest and Landscape Denmark and the Faculty of Life Sciences at the University of Copenhagen.

Financing

The project was financially supported by Realdania, Det Obelske Familiefond, G.B. Hartmanns Familiefond and Faculty of Science from the University of Copenhagen.

Community gardens

Nacadia Therapy Garden

Nacadia Therapy Garden

Overview Nacadia Therapy Garden, Denmark

Urgency	● ○ ○
Budget	○ ● ○ ○
Funding	Private sector funding
Complexity	● ○ ○

Community gardens

7 seasons. Source: Natuurlijke stad

Overview 7 seasons, Rotterdam, the Netherlands

Urgency	● ○ ○
Budget	● ○ ○ ○
Funding	Municipal budget & private community funding
Complexity	● ○ ○

7 seasons, Rotterdam, the Netherlands

7 seasons is a project that focuses on increasing biodiversity in the city of Rotterdam). The project started as a private sector initiative. The ambition of this project is to increase the interaction between urban dwellers and nature. In a period of 7 years, local residents are invited to start green, low-budget, initiatives to green their neighbourhood. Local residents that initiate a project can apply for funding to cover minor costs. The work is done on voluntary basis and most of the projects are temporarily implemented in abandoned and neglected areas.

Financing

The project started as a citizen's initiative but gained a minor budget from the city council and some additional small funding from private funds. Most of the work is done by local residents volunteering in the project.

4 Ensuring the continuity of Urban Ecological Networks

4.1. Urban Challenges

Ensuring the continuity of ecological networks plays a key role in preserving biodiversity, ecosystem protection and the provision of ecosystem services and thereby are key to large scale NBS interventions. An ecological network usually consists of a set of diverse green spaces, a combination of smaller and larger green areas and patches (nodes) that are connected through corridors (edges) (De Montis, 2016). Ensuring the continuity of these corridors is important because they create interaction between otherwise isolated ecological spaces. This has a positive impact on biodiversity and the habitat of animal species. It furthermore enhances the urban microclimate. The extent to which these ecological networks can provide such benefits depends on the quality, quantity and especially the cohesion of these areas (De Montis, 2016).

4.2. Nature Based Solutions

Cities have gained an increasingly important role in the preservation of ecological networks, because rural areas at the outskirts of cities are absorbed due to urban sprawl. These urban ecological networks can also contribute to higher quality flora and the migration of animals, but also used for water management and other climate adaptation measures (e.g. heat reduction. See also **§2.1)** (Ministerium für Klimaschutz NRW, 2011). The NBS interventions presented in previous sections contribute to the overall presence of green spaces in urban areas, but these are not necessarily coordinated at larger scale. NBSs can contribute in various ways to ensuring the continuity of ecological networks, above all the implementation of regulations to ensure the continuity is a relatively easy and efficient strategy. Other physical interventions can range from creating green strips in urban areas, green roofs, re-vegetation of aquatic planting, reopening streams, vegetation engineering systems for riverbanks, to creating unsealed and planted car parks. A combination of various interventions can result in an even more profitable outcome if addressed to several ecosystem services.

In the following section we present a selection of NBSs that contribute to ensuring the continuity of ecological networks. The **NBS Explorer** at the Nature4Cities platform allows to browse other case examples.

4.3. Governance

Similar to parks and green residential areas, ecological networks can either be publicly or privately owned. As such, publicly owned spaces are the responsibility of local and/ or regional authorities. Sometimes these responsibilities are shared with or delegated to other actors and stakeholders. Privately owned spaces fall under the responsibility of the owner (e.g. a business, home-owner, charity or foundation), but the government can exert influence through regulations, laws, agreements or subsidies and nudges.

4.4. Three different governance approaches to ensure the continuity of urban ecological networks

4.4.1. Government-led

Ensuring the continuity of ecological networks can be as diverse as a large number of small-scale intervention as well as large scale infrastructural works. The size and scope of the intervention oftentimes determines who is responsible for taking the initiative. Government-led interventions tend to be large scale and require mixed budgets from different sources, such as European funding and a combined budget from different public funding bodies.

Smolyan, Bulgaria

The Ustovo neighbourhood in Smolyan suffered from flooding which caused damage to local residencies. In response to this flooding the city implemented a number of flood protection measures through a mixed method of green and grey measures. These measures lead to the expansion of the riverbed of the Cherna River to create higher water capacity, and the reconstruction and upgrading of the existing retaining walls and construction of new walls with reinforced concrete railings and parapets on the left and right bank of the river.

The project was initiated by the municipality.

Financing

The estimated costs were 480.000 euro, mainly funded by the European Regional Development Fund (ERDF). A small part of the budget, 5% of the total sum, was funded with the municipal budget.

Renaturing rivers

Smolyan

Overview Smolyan, Bulgaria

Urgency	○ ○ ●
Budget	○ ● ○ ○
Funding	Municipal budget & project funding
Complexity	● ○ ○

Renaturing rivers

Kallang River-Bishan Park. Source: World Landscape Architect

Overview Kallang River-Bishan Park, Singapore

Urgency	○ ● ○
Budget	○ ○ ○ ●
Funding	Municipal budget
Complexity	○ ● ○

Kallang River-Bishan Park, Singapore

The Kallang River-Bishan Park in Singapore has become a popular recreational park. With the rapid modernisation and urbanisation of Singapore in the 1960s and 70s, concrete drains and canals were built to alleviate widespread flooding. Likewise, the Kallang River was set within a concrete channel in several key places so that water from heavy monsoons would drain quickly into the drink water system that provided water to the city. The concrete channel was renovated and transferred into a naturalized waterway, with a design based on a floodplain concept that at the same time created a recreational space for local residents alongside the riverbanks, such as a water playground with naturally cleansed river water. Depending on the water level, different types of activities are available (e.g. stepping stones by low tide). The renatured river has attracted a wide range of animal species which increased the biodiversity significantly (around 30% increase), creating a rich variety of micro-habitats, which on the long-term will continue to increase in number.

The project was a joint initiative between Singapores Public Utilities Board (PUB) and the National Parks Board (NParks) for the ABC Waters Program, in collaboration with international technical experts from the Ramboll Studio Drestil Design (Germany), CH2M Hill Engineers (US) and Peter Geitz & Partner Biological Engineering (Germany). From the start of the project, local residents were actively involved in looking out for cleanliness of the park and the safety of its visitors. The park created an important meeting space for the two previously, through the channel, disconnected neighbourhoods, contributing to an increase of social cohesion.

Financing

The project was financed by the PUB and NParks, costing more than 45 million euro.

Connswater Community Greenway, Belfast, Ireland

The Connswater community Greenway (CCG) is a 9km linear park running through east Belfast, following the course of the Connswater, Knock and Loop Rivers, connecting the open and green spaces. The Greenway has created vibrant, attractive, safe and accessible parkland for leisure, recreation, community events and activities. The project improves the quality of life for the people of east Belfast. The CCG aims to encourage healthier and more active people, engaging with community members and community groups in specific activities, with schools and colleges in specific activities and with key stakeholder groups. Furthermore, the Connswater Community Greenway aims to contribute to the economic regeneration of east Belfast through investment, employment and tourism, encouraging ownership through volunteer activities, promoting the Greenway in the media, developing tourism and heritage trails and Protecting properties from flooding.

The project has been developed by the EastSide Partnership and is being delivered by Belfast City Council. EastSide Partnership is a social partnership with community, statutory, political and business members who are dedicated to the regeneration of East Belfast.

Financing

The Connswater Community Greenway is a 40-million-euro investment funded by the Big Lottery Fund, the Belfast City Council (Department for Communities and Department for Infrastructure). An additional 11-million-euro flood alleviation scheme has been integrated in the project to reduce flooding occurrences at 1700 adjacent properties.

Green waterfront city

Connswater Community Greenway

Connswater Community Greenway.
Source: Arup

Overview Connswater Community Greenway, Belfast, Ireland

Urgency	● ○ ○
Budget	○ ○ ○ ●
Funding	Municipal budget & private funding
Complexity	○ ● ○

4.4.2. Co-creation and co-production

Private sector and civil society actors can play various roles in ecological restoration projects. This can be small scale adhering to Corporate Social Responsibility making private financial resources available for public infrastructure interventions, but often project developers are involved in large scale housing and redeveloping projects. These types of collaborations can be steered in to the direction towards more sustainable approaches.

Green strips and street trees

Bologna. Source: Municipality of Bologna

Overview GAIA, Bologna, Italy

Urgency	● ○ ○
Budget	○ ○ ○ ●
Funding	Companies funding/compensation
Complexity	○ ● ○

GAIA, Bologna, Italy

GAIA is the Green Areas Inner-city Agreement, a project developed in Bologna. The project is a public-private partnership in which the municipality and local companies collaborate to plant trees throughout the municipal area aiming to renature the city and create an ecological network. In total 23 areas are identified in Bologna that together have a potential of planting 3,000 trees. These areas include urban parks, industrial districts, hillside parks and local recreational areas. Combined, these areas create a green structure that connects the country side with green structures in the city.

Trees extract groundwater through their roots and release it into the atmosphere, contributing to the availability of atmospheric moisture vapour, and provide necessary cooling during heat waves. This is important because as many Southern European cities, Bologna is suffering under extreme temperatures causing a heat island effect, drought and (drink-)water scarcity. The trees also have the capacity to increase soil cohesion which inhibits the occurrence of landslides and erosion.

The GAIA project came into existence as part of the local Adaptation Plan to Climate Change which was developed in the context of the LIFE and project BLUE AP (Bologna Local Urban Environment Adaptation Plan for a Resilient City) project. The Municipality collaborated with four Partners: the Institute of Biometeorology of the National Research Council (IBIMET) developed scientific guidelines; Impronta Etica developed the Corporate Social Responsibility (CSR) structure on which the public-private partnership model is based; Unindustria Bologna, an association of entrepreneurs in Bologna, focuses on the involvement of enterprises; and finally, Cittalia, the National association of Italian cities and municipalities provided support in the communication and dissemination. Local businesses participate on a voluntary basis and receive a half-yearly monitoring report.

Financing

The GAIA mechanism is a based on the principle that local companies pay a financial compensation for their carbon footprint. This compensation is then used to purchase plants and trees, and maintain them. The estimated costs are around 1M- 5M. Bologna is currently implementing a GAIA spin-off project for citizens called RADICI. This project is financed through crowdfunding.

Zorrotzaurre District, Bilbao, Spain

Zorrotzaurre district project is implemented in Bilbao. The Zorrotzaurre district was a degraded, flood-prone industrial peninsula. Considering the increasing extreme precipitation predicted across the Basque country in the future due to climate change and the high demand of new housing and related infrastructure from Bilbao citizens, the municipality initiated a major urban regeneration project to redevelop Zorrotzaurre district into a new flood-proof residential quarter for social housing and environmentally-friendly industry.

To protect Zorrotzaurre from flooding, the Deusto canal was reopened reducing the flood potential by increasing the water capacity. The ground level was elevated so that new buildings are protected from rainfall events. A flood protection wall was created and green open spaces along the 7.5 km long river bank, creating a green public space for pedestrians and cyclists. The gardens of Botica Vieja on the opposite side are extended and connected by new bridges to the open spaces on the Zorrotzaurre island. The network is complemented with green fingers of more than 5.000sqm extending across the island from the canal to the pathway located on the riverbank. Lastly, two storm water tanks are provisioned to store excess water.

Two thirds of the space at Zorrotzaurre is reserved for public uses, including open green areas to be enjoyed by the local community and visitors alike and public facilities for educational, health, sport and cultural uses. The formation of this "mix" of residential (housing), public and economic activities aims to reduce mobility needs of the quarters inhabitants and stimulate space for artistic and creative innovation.

The project was initiated by the land owners of Zorrotzaurre, the Comisin Gestora de Zorrotzaurre (the Management Commission of Zorrotzaurre) which consist of a mixture of public and private sectors owners: the Regional Basque Government (through the Department of Employment and Social Affairs and the publicly-owned company Visesa), Bilbao City Council, the Port Authority of Bilbao, and private entities Sociedad Promotora Inmobiliaria Margen Derecha S.A. and Vicinay Cadenas S.A.. The Comision Gestora de Zorrotzaurre supervises the redevelopment plan of Zorrotzaurre (the Master Plan Zorrotzaurre). Local residents are involved through a neighbourhood association, allowing them to give their input on the design and planning of the project.

Financing

The members, who are the land owners, pay for all the expenses of the project and contribute financially relative to the share of land they own (51% public, 49% private). The residents of Zorrotzaurre do not contribute financially since they aren't land owners.

The costs for reopening the Deusto canal are budgeted at 20.9 million euro and will be taken up by the City Council while the Basque government will finance the costs of one of the new bridges. The municipality will also pay for the flood protection barrier (5.1 million euro, including the structural rehabilitation of the river bank) and the storm water tanks (costs estimated at 4.74 million euro). The costs for the ground level elevation and public, green spaces (as well as the other redevelopment costs) are paid by the Comision Gestora de Zorrotzaurre.

Overall estimated costs are more than 5 million euro.

Vegetation engineering systems for river banks and reopened streams

Zorrotzaurre District

Zorrotzaurre district masterplan. Source: Zaha Hadid Architects

Overview Zorrotzaurre district, Bilbao, Spain

Urgency	○ ● ○
Budget	○ ○ ○ ●
Funding	Municipal and regional budget & private funding
Complexity	○ ○ ●

4.4.3. Private sphere initiative

It is more difficult to find examples in which private actors play solely involved in the restoration of ecological networks. Here we present one case examples collected for Nature4Cities.

Green canals, Utrecht, The Netherlands

Greening Canals is an interesting citizens-initiated project in the public domain. Through a citizen initiative, a group of local residents, requested permission to take responsibility for greening the canals and river banks in the city of Utrecht. The aim was to improve the ecological quality and the attractiveness of the river banks for local residents. Part of the project are floating islands of plants and nature friendly river banks. Greening the river banks makes the area more resilient to the effects of climate change (drought, flooding, and heat waves). The renatured river banks have increased the urban biodiversity and created recreational spaces for local residents.

The citizens have organized themselves as the 'Citizen Initiative Greening Canals'. The group carries the responsibility for the implementation of the project and the continued maintenance of the area which is part of the public domain and should normally fall under the responsibility of the municipality. The group was granted autonomy to implement their plans as long as they abided by the existing regulations. Local residents, who are not member of the citizens' initiative, can support the project as volunteer helping to maintain the riverbanks.

Financing

The project received financial support from the municipality, the local water authority and is supported by local residents through volunteering.

Re-profiling river banks

Utrecht

Utrecht. Source: Harmke van Dam, Naturvation

Overview Green canals, Utrecht, the Netherlands

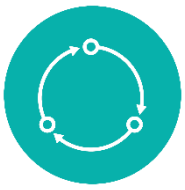
Urgency	● ○ ○
Budget	● ○ ○ ○
Funding	Municipal budget
Complexity	● ○ ○

5 Nature4Cities tools to support NBS project implementation

The **Nature4Cities platform** is a Nature Based Solutions knowledge diffusion and assessment platform for re-naturing cities and is a collection of technical solutions, methods and tools to support and empower urban decision making for NBS. This handbook focuses on implementation models suitable for the NBS, and is developed based on tools and methods developed for the Nature4Cities platform. The case examples in the first section offer inspiration and ideas of what type of NBS might be suitable for your own context, but there are a number of steps that need to be taken to work from ideation to planning.

There are five Nature4Cities tools presented in this section: The Step-by-Step (SBS) Guide for co-creation and co-production, the CitizenSay Platform, the Social Acceptance tool, the Implementation Model Database and the Implementation Models Pre-Selection Tool. These tools offer assistance and support to make that step. It is important to note that there are different entry points based on knowledge and competences, experience, resources, questions and needs. Therefore, the tools presented in this section can be read in the following order but there is also the option to pick and choose to read certain sections based on the information needs one has.

5.1 Step-by-Step Guide for co-creation and co-production



The **Step-by-step Guide for co-creation and co-production of NBS** is developed from the perspective that interventions and their outcomes (e.g. NBS) are the result of interactions between contextual conditions (infrastructural, physical, organizational and socio-economic and socio-cultural) and the project planners and stakeholders (including end users and citizens) involved in the planning and implementation of NBS. The settings and the local circumstances in which this collaboration takes place are highly contingent, a suitable governance approach should therefore be tailored to the context, instead of being prescribed upfront. The Step-by-Step Guide is developed to reflect on the relevant circumstances and conditions and to make decisions on what would work best.

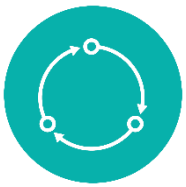
Practitioners, can use the SBS Guide from scratch, not having any idea of what type of interventions is suitable in their situation, but they can also opt to explore the potential to implement one of the cases from section 1 in their own context. The SBS Guide enables them to reflect on process requirements and suitable governance approaches. As such, the SBS Guide can be characterized as a process support tool (PST).

Figure 6: the different steps of the SBS Guide

The success of NBS as an innovative type of intervention depends largely on how well it becomes embedded in a particular local geographical and social context. To achieve this, not only local stakeholders and the host communities should learn and adapt some of their expectations and views as part of the process. The project organisation in many cases will also need to adapt some of its initial expectations in response to learning about the particular local contextual conditions and needs. Articulating views about how the intervention 'fits' in the local context offers a starting point to discuss or negotiate the conditions under which the NBS intervention is/ becomes acceptable. Such negotiations include discussions about costs, benefits and their distribution. Different visions and expectations can be articulated and confronted. The steps proposed intend to help creating a framework for dialogue, negotiation and learning in which diverse perspectives and types of knowledge are acknowledged and recognised, where there is room to discuss the distribution of

costs (including risks) and (co)benefits, and whereby an effort is done to enable and support all participants in the process to express their views. All the steps depicted in Figure 6 are discussed according to their relevance, what it entails and on how the project lead/ project organisation can address the implementation process. Examples are offered about potential methods and tools that can be used along each step, although the list is not exhaustive.

5.2 CitizenSay Platform



CitizenSay is an integrated platform for Citizen engagement and involvement throughout decision making and development processes. The CitizenSay platform is a Process Support Tool (PST) for project coordinators, facilitating communication and data collection. The N4C Step-By-Step Guide will be available to use with CitizenSay on the N4C Platform as an integrated module. The system facilitates structured multi-stage real-time live interactions between different stakeholders and documents and analyses processes and outcomes for later use using workflows that combine multiple interaction modules into a process-supporting timeline.

Figure 7: CitizenSay Landing Page

CitizenSay modules let users implement processes that e.g. require surveys to be completed by participants. CitizenSay has modules that allow users to add and combine various types of functionalities such as live voting, collaborative mapping and document editing both standalone and as part of live online meetings and discussions hosted on the CitizenSay platform. In addition to scheduling and carrying out these types of activities, the system generates a single document containing the outcomes of all the processes included in a workflow. Such a workflow could for instance include an initial online meeting, followed by a survey to elicit initial preferences, followed by an online video-moderated co-creation session in which participants edit a mission statement document and create a draft illustration of change on a topographical map together in real-time, followed up with regular emails to communicate progress, all of which is ultimately used as input for

a single document that is auto-generated by the system. Created workflows can also be saved as templates so that they can be re-used and adapted by other users.

Figure 8: CitizenSay collaborative map editing tool in the editor view

CitizenSay also automatically generates summaries in which all activities in a workflow are documented in office documents. This is is especially important for long term and complex projects in which responsibilities are shared and or may shift over time. An innovative feature of the platform is that it automatically analyses discussion content and tries to identify the sentiment and attitudes of participants overall and towards the different topics of discussions for both voice and text discussions (experimental support for languages other than English).

CitizenSay modules have been developed so that they support NBS workflows and functionalities, including parts of the step-by-step guide for which CitizenSay functionalities are relevant.

5.3 Social Acceptance Tool

The social acceptance of project and policy implementations are progressively becoming more important for policy and decision makers worldwide aiming to design policies that reach attempted targets smoothly with community support. Sustainability assessment has recently become an important issue for policy and decision makers due to a recognized requirement of balance between environmental, economic and social policies. The social acceptance tool that has been developed for Nature4Cities could be considered to conduct such social assessments. It could be considered as a Decision Support Tool because ideally, the

input from local citizens and stakeholders at an early stage should be used as an important building block for local climate adaptation and mitigation policies.

The NBS implementations and social acceptance can be linked through three dimensions of social acceptance, namely *socio-political acceptance*, *market acceptance*, and *community acceptance* as defined in Wüstenhagen, Wolsink and Bürer (2007). Socio-political acceptance includes the acceptance the public, key stakeholders and policy makers, market acceptance is concerned with consumers, investors, intra-firm relations, and their interdependent paths, and community acceptance stands for local stakeholders' acceptance of technologies or projects. The concept blankets the ideas of procedural justice (just decision making with participation of all stakeholders), distributional justice (fair distribution of burdens and benefits); and trust related to provided information, to the intentions of investors and of actors from the outside. The threefold understanding of social acceptance is also applicable to the preparation, planning and implementation of NBS. The success of social acceptance as a Decision Support Tool depends on comparability and flexibility of the method for different types of the NBS. Empirically, the following steps can provide a comparable and flexible method for NBS decisionmakers:

5.4 Nature4Cities IM Database

The **Implementation Model Database** has been developed as a browsing tool and is an integrated module in the Nature4Cities platform. It offers information on pioneering experiences of different NBS typologies and their business, financial and governance models. The case examples in the present handbook have been retrieved from this database. The database offers an even richer variety of NBS

providing an insight and understanding of how the NBS can be applied in different urban contexts. Providing technical information on the implementation aspects of the particular NBS. The database plays an important role in knowledge sharing and offer input for replication of NBSs in different contexts.

The browsing options offer searches based on keywords, NBS typology, Urban Challenge and type of business model (technological, social or economic) giving access to 56 documented Implementation Model cards (IM-cards). Each of these “IM cards” illustrating an NBS case, a description of the NBS typology and the governance, financial and business characteristics related to each IM identified.

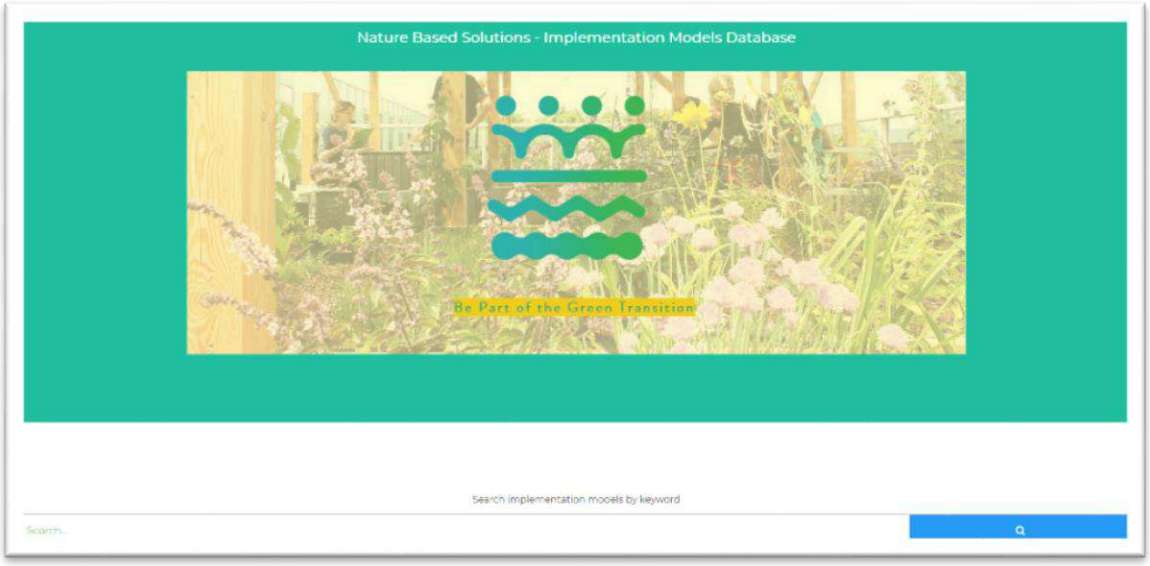


Figure 9: Landing page **Implementation Model Database** at the Nature4Cities platform

5.5 Implementation Models Pre-Selection Tool

In addition to the IM Database, the Implementation Models pre-selection tool has been developed. The pre-selection tool is an integrated module on the Nature4Cities platform and easily accessible. Both the database and the pre-selection tool are Decision Support Tools for practitioners that seek information on NBS that is accessible, technical in nature and concise. This digital tool allows to build a preliminary implementation proposal (model) for a future NBS project based on suitable governance and financial models and offers a selection of strategies linked to different elements of a potential business model.

The tool is based on a WHAT-WHO-HOW framework connecting the conditions (HOW) under which the project developer (initiating actor - WHO) starts an NBS project (WHAT). The conditions are the local cultural, social, economic and regulatory aspects that are of influence in the given context. This logic has been integrated as an IM preselection tool in the N4C platform.

The operation of the tool is very simple. The practitioners need to define the WHAT-WHO-HOW factors for the project and the tool provides recommendations regarding the most suitable business, financial and governance scheme for that project. In order to make the process manageable and easy to understand, the tool is divided in 5 different sections. The first section contains the introduction and the instructions to guide practitioners in the definition of an NBS project. The tool provides descriptions of every indicator to help selecting the WHAT-WHO-HOW factor for the project.

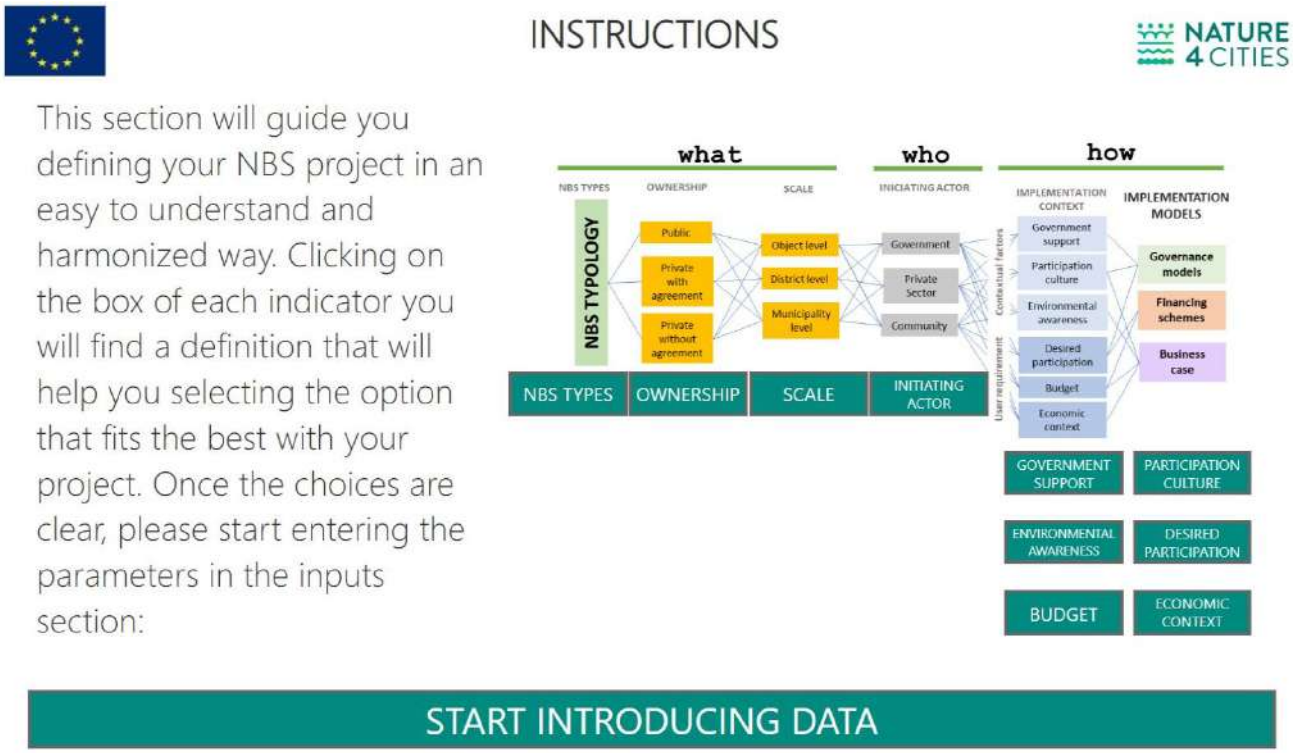


Figure 10: First section of the tool with the instructions to define the NBS project's WHAT-WHO-HOW factors

After defining the parameters, these are introduced in the second section of the tool to then visualize the eligible governance and financing models for the project together with a little description to make the selection process easier in the third section.

Once the most suitable governance and financing models have been selected for the project, the fourth section shows examples of real projects from the IM database where the selected implementation model (combination of governance and financing model) has been applied as guidance. The fifth and last section, contains the NBS business model canvas with the information of governance and financing models previously selected, as depicted in figure 11.

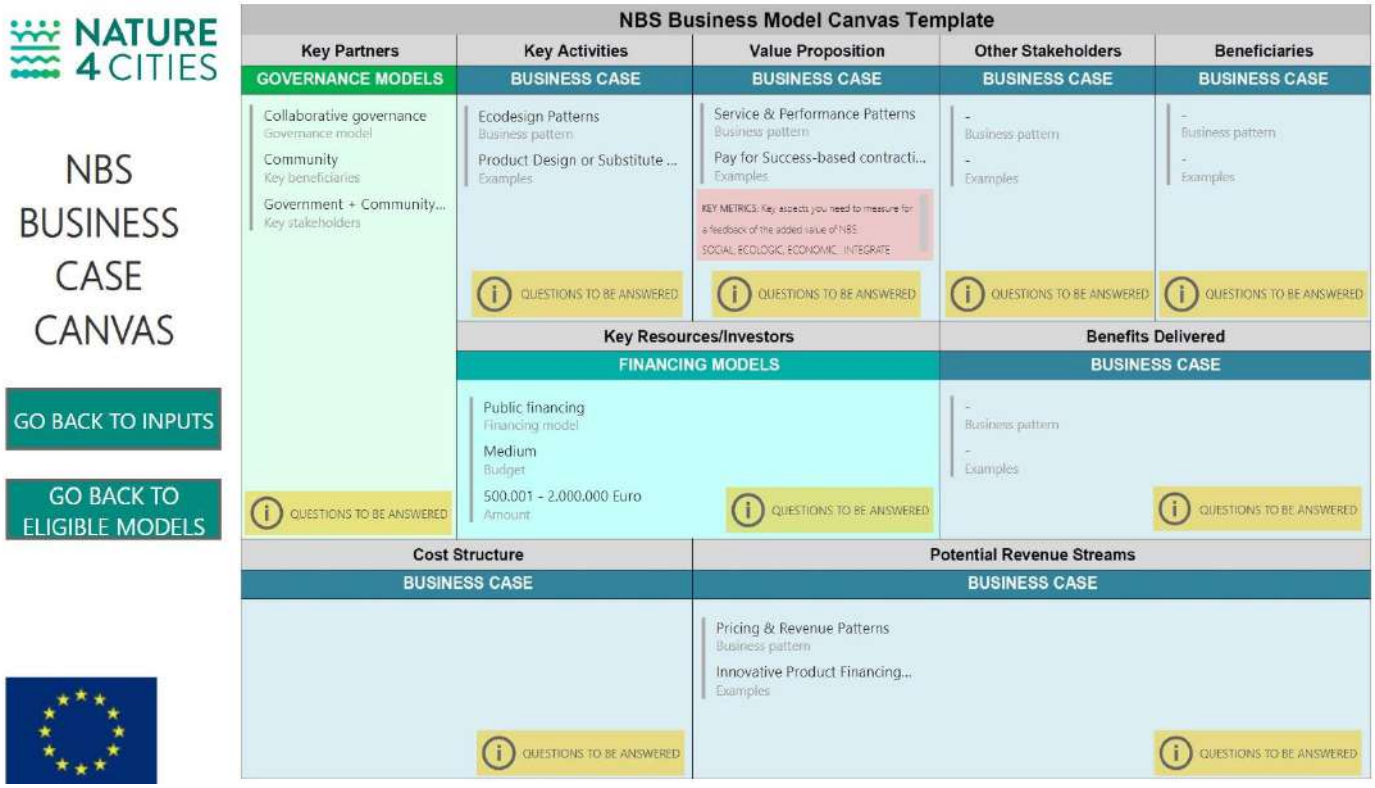


Figure 11: Fifth section of the tool that shows the NBS business model canvas to be completed

The NBS Business Model Canvas Template presents different business patterns that can help in the definition of the business model and some questions to be answered in order to complete the design of the business model for the defined NBS project. This part of the tool is based on the business model canvas developed by the **Connecting Nature** consortium.

6 Cities in transition: the next steps

The Process Support Tools and Decision Support Tools presented in this handbook and on the Nature4Cities platform are designed to support and empower urban decision making for NBS. The tools are an important step in changing the course of action in climate change policies. However, as mentioned in the introduction, cities are currently in a decisive moment in which they need to start re-organising to develop sustainable policies to become more resilient to the effects of climate change on the mid- and long-term. Cities need to build capacity in public administration for sustainable policies, not just for one NBS project, but a broad mix of tactics, strategies, experimentation, learning and collaboration is necessary to implement sustainable policies. Stamina is needed because the persistence of the urban challenges is not solved by a single or predictable solution but must be explored in a learning process in which the unsustainable practices of 'business as usual' are replaced with sustainable policy interventions (Loorbach, 2017). There are two aspects of this learning process that raise attention: how to deal with trade-offs that are the (inevitable) result of decision-making, and how to build local capacity for NBS interventions? We briefly discuss these two points in the following section.

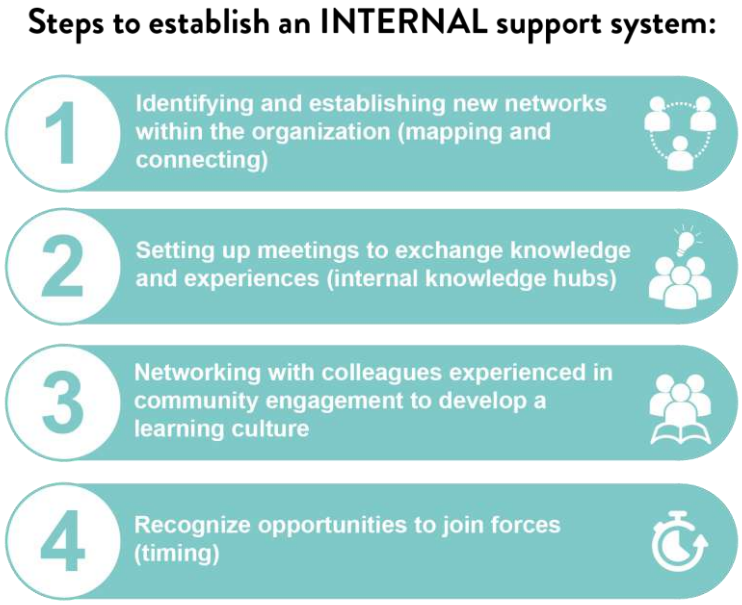
6.1 Towards a systemic trade-offs and synergies analysis

The case examples in this Handbook demonstrate that most NBS cases are often site-specific and dependent on local characteristics of the cultural, social, institutional, environmental and economic urban context. Therefore, in view of adopting a specific NBS model, it might be challenging to compare the different Implementation Models and decide which Implementation Model is suitable for the specific context in which the implementation of an NBS is planned. There is no unique solution suggested here to overcome this gap because each context in which an NBS is adopted is characterised by its own unique ecological, socio-economic as well as its political conditions which determine the necessary requirements for a suitable NBS design. In addition, each NBS project will by definition imply a decision-making process in which trade-offs between the environmental, social and economic dimensions need to be negotiated. The Step-by-Step Guide, together with the other PSTs and DSTs, offer guidance to understand the operational context, the conditions to work with, and how to guide the negotiation process.

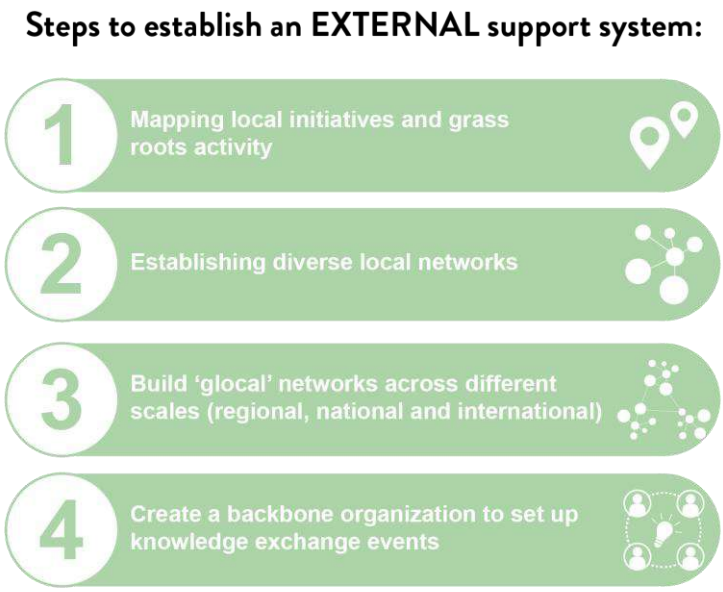
Nature4Cities furthermore proposes a **socio-economic impact assessment** methodology to investigate the impact associated with the three typologies of Implementation Model included in the pre-selection tool (i.e. governance models, financial models and business models). This methodology takes into account the choice of specific models and their relationships with different impact spheres for the urban communities (made by citizens, enterprises and public organizations), namely social, economic, cultural, institutional and environmental spheres (Rugani et. al, 2019).

6.2 Building Blocks for Capacity Building

To overcome the issue of short-term thinking as the predominant rationality of current climate adaptation policymaking, practitioners can influence the prevailing socio-technical regime by creating social acceptance as an important step to gain support for climate adaptation and mitigation policies. To put it more bluntly, if a project is not socially accepted the chances of failing are higher. Early and timely stakeholder involvement is therefore key to build capacity and support for NBS projects. Part of this process of creating acceptance for sustainable climate adaptation and mitigation policies and interventions, is to recognize the opportunities and social capital already existing that can be deployed to build capacity. This can be done by identifying potential alliances internally as well as externally to the organisation. In the local and regional governance organisation there might be other departments working on overlapping urban challenges, or who are more experienced with citizens participation. The following steps can be helpful to build internal organisational capacity:



The success of an NBS project is not only dependent on internal support and capacity. NBS projects are often complex and require the involvement of a diverse group of experts, stakeholders and citizens. Moreover, as explained in the previous section, creating social acceptance for NBS measures is prerequisite. Several steps can be taken to build external capacity for an NBS project, but also for longer term support for sustainable policies:



Both the Step-by-Step Guide and CitizenSay facilitate practitioners and project coordinators in building internal and external support.

Epilogue

We hope that this handbook is inspiring and useful for practitioners and policy makers responsible for the implementation of NBS projects. Embedding climate adaptation and mitigation strategies in the policy process is challenging because climate change concerns a complex network of urban challenges that are not always recognized in the same way or considered with the same shared sense of urgency to act. Evidence-based practices, tools and methods for (the planning and implementation of) NBSs are therefore crucial to support practitioners. The tools presented here are integrated part of the Nature4Cities platform which is online accessible. The Nature4Cities platform offers an even wider range of knowledge, information and support tools for NBSs suitable for broad audiences, including experts and professionals, decisionmakers, and citizens and stakeholders. We strongly recommend to browse the platform to learn more about the potential of NBSs.

Glossary

Climate change adaptation: anticipating to actual and expected impacts of climate change, aiming to prevent and minimize harm, or taking advantage of the beneficial opportunities that may arise (Moser & Ekstrom, 2010).

Climate change mitigation: preventative measures undertaken to reduce or break with emission of greenhouse gases. Mitigation can encompass measures such as transitioning to renewable energy and low to zero emission transport system, energy reduction and efficiency measures (UN Environment Programme).

Co-creation: is a governance approach in which a public sector entity opens up the decision-making process to actively involve stakeholders in creating public value. Stakeholders are invited to insert themselves into to the designing and delivery process of public services, and sometimes in sharing the costs. This co-creative process is aimed to create a win-win situation in which public sector costs are reduced whilst stakeholder satisfaction increases (Gouillart, F. and Hallett, T., 2015).

Co-production: is a governance approach in which citizens or service users collaborate in partnership by direct participation in the delivery of public services. Similar to co-creation, co-production can also imply participation in other stages of public service development, such as the design and planning. The concepts are therefore often used interchangeably, they have however different theoretical backgrounds (Cinquini L., 2017).

Ecosystem services: are the direct and indirect economic and human well-being benefits people receive or consume from ecosystems that support human survival and improve the quality of life (BISE; Maes, J. and Jacobs, S., 2017). The Common International Classification of Ecosystem Services exists in a nested hierarchical, disaggregating ecosystem services at three levels: “provisioning services,” “regulation and maintenance services” and “cultural services” (Haines-Young and Potschin, 2018).

Green infrastructure: (GI) are the green (natural and semi-natural) zones in and around urban areas which are often part of a strategically planned green infrastructural network aimed at delivering ecosystem services (EC, 2013, Maes, J. and Jacobs, S., 2017).

Grey infrastructure: are engineered infrastructural assets often composed of concrete and steel offering multiple societal services (IISD).

Heat island effect: a rise in temperature concentrated in urban areas which has an impact on its residents as well as on the ecosystem. (Urban Heat Islands, 2019)

Nature4Cities: project name for the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730468.

Nature Based Solutions: (NBSs) are actions inspired or supported by nature to address urban challenges regarding climate change, availability of resources, environmental quality, and socio-economic simultaneously at different and interconnected scales.

Urban resilience: the ability to respond of an urban system to respond to direct threats or disturbances of climate change by reducing or averting the risks (Gill, S.E., 2007; Meerow, S., 2017).

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