NBS Value Model

D6.4 Deliverable

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No & name	**D6.4 NBS Value Model**				
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Description of the related task and the deliverable. Extract from DoA	**T6.3.2 Development of a NBS Value Model referring to national and international policies to leverage financing (FHG)** M1-60 FHG will develop a holistic value model for NBS to provide cities with an instrument to leverage capital for NBS co-development and co-implementation where business models are not applicable due to an indefinable value chain and unclear assignment of benefits to specific beneficiaries. Holistic evaluation will be used to identify the beneficiaries of NBS and assign values to benefits in order to inform the design of mechanisms to leverage investments and encourage beneficiaries to pay for the benefits received via NBS implementation. FHG will work in close collaboration with WP3 to determine the value of NBS implemented in front-runner cities, analysing values assigned to changes in ecosystem services as a result of NBS implementation, focusing on benefits, costs and beneficiaries. Financial Instruments for NBS (implementation and operation) will be identified in the context of national and international policies. FHG will refer to national and international policies that support NBS financing in the respective country and make reference to larger UN-based programs (e.g. TEEB, climate finance etc.) as well as to national and supra-national sustainability policies that support biodiversity and ecosystem services (e.g. UNEP, biodiversity convention, national funding programs) and policy-based market mechanisms. This task outputs a section to D6.6 and contributes to D6.8.				
Participants	FHG in collaboration with STU (replication framework)				
Comments	This deliverable has not yet been approved by the funding agency				

V	Date	Authors	Description
1	01.12.2018	Sophie Mok	Draft outlining structure and approach
2	20.02.2019	Sophie Mok	Final Draft
3	25.02.2019	Hans-Georg Schwarz-v. Raumer	Cross Check
4	27.02.2019	Sophie Mok	Final

About UNaLab

UNaLab will develop, via co-creation with stakeholders and implementation of 'living lab' demonstration areas, a robust evidence base and European framework of innovative, replicable, and locally-attuned nature-based solutions to enhance the climate and water resilience of cities. UNaLab focuses on urban ecological water management, accompanied with greening measures and innovative and inclusive urban design. The UNaLab partners aim to develop smarter, more inclusive, more resilient and more sustainable local societies through nature based innovation jointly created with and for stakeholders and citizens. UNaLab's 3 front runner cities: Tampere, Eindhoven and Genova, have a track record in smart and citizen driven solutions for sustainable development. They support 7 Follower Cities: Stavanger, Prague, Castellon, Cannes, Başakşehir, Hong Kong and Buenos Aires plus share experiences with observers as City of Guangzhou and the Brazilian network of Smart Cities. Therefore UNaLab results will impact on different urban socio-economic realities, with diversity in size, challenges and climate conditions. In order to create an EU reference demonstration and go-to-market environment for NBS, UNaLab will use and further develop the ENoLL Urban Living Lab model, and the European Awareness Scenario Workshop method for the co-creation of solutions, and the roadmap approach, in this way achieving an innovative NBS toolbox.

Partners

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Acronym list

BID - Business Improvement District
NBS - Nature-Based Solutions
PPP - Public-Private-Partnership
UNaLab - Urban Nature Labs

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1. EXECUTIVE SUMMARY

The UNaLab Value Model explores the often intangible values of NBS. It thereby aims to establish a link between the identified NBS (NBS Technical Handbook, D5.1), associated beneficiaries and their individual benefits, as well as available financing options (D6.3 Business Models & Financing Strategies). This should allow to involve the right stakeholders and mobilise financial sources for NBS implementation and maintenance. The deliverable describes the underlying concept and data which, after a joint testing phase with the cities, will be used to program an interactive tool that will be part of the UNaLab replication framework.

2. INTRODUCTION

2.1 The value of nature-based solutions

Nature-based solutions have a great potential to combat pressing challenges of climate change and ongoing urbanisation (European Commission 2015). They thereby provide various functions and create benefits for different urban stakeholders. A popular way of classifying and understanding the benefits, which people obtain from nature, is through the concept of ecosystem services. These include four main domains: a) provisioning services which refer to products that can be obtained from ecosystems such as food, fibre, and fuel; b) regulating services, which derive from natural ecosystem processes, such as climate, water, and disease regulation; c) cultural services which are non-material and include the spiritual, recreational, aesthetic, and inspirational values; and d) supporting services which are necessary to sustain all the services mentioned above, for example soil formation, nutrient cycling and primary production (Millennium Ecosystem Assessment 2003). In addition to these aspects, more economic and social benefits can be associated with NBS, as these hold the potential of transforming public space and thereby providing new opportunities for social interaction and economic activities. Figure 1 outlines the links between ecosystem services and human wellbeing as described in the ecosystem services framework.

Yet, the type of value and benefit created varies greatly depending on the type of NBS in question, as well as the context in which it has been established. Along with the benefits, the associated beneficiary structure and the individual potential and willingness to invest in such an NBS differs greatly. For example, an intensive green roof with public access in a cold northern European city is going to create very different benefits for different beneficiaries than it would on a private building in a warm southern European city. This is because the various functions of NBS translate differently into benefits depending in the demands and preconditions of the surrounding context. Additionally, the different services NBS provide can be more public or private in nature, or usually a combination of both. For instance, the main beneficiary of a green roof might be a private building owner due to increased energy efficiency gains, but there may also be public co-benefits created, such as improved water management, biodiversity, and city cooling. This strong context specificity, the diffuse nature of many ecosystem services, as well as the multifunctionality of NBS make it difficult to establish clear business cases and find new sources of finance for such interventions. This is an important reason why building business models and finding alternative financing options from public and private sources has been identified as one of the major challenges of NBS (Kabisch et al. 2016; Keivani 2010; Toxopeus and Polzin 2017).

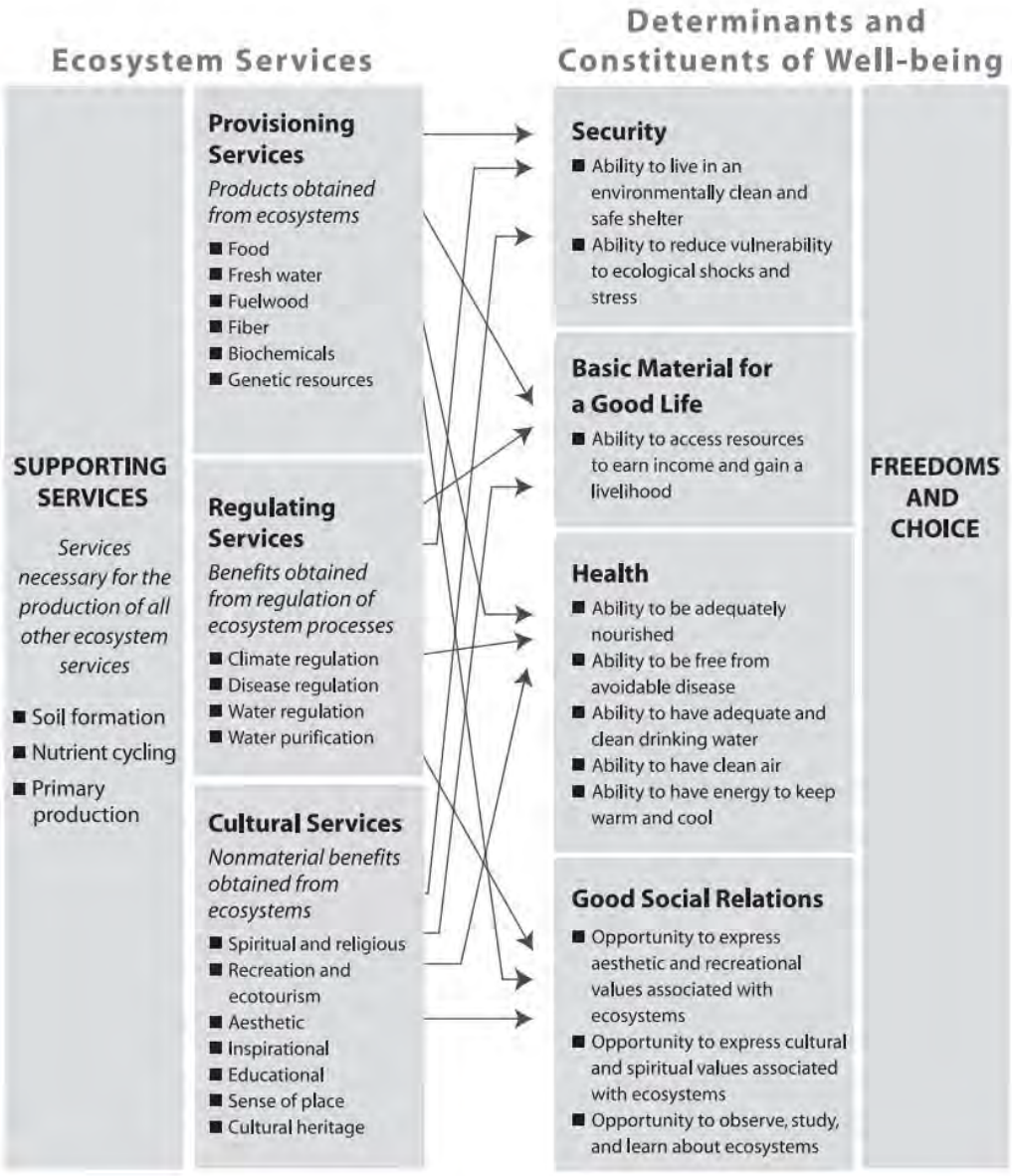


Figure 1: The link between ecosystem services and human well-being (taken from the Millenium Ecosystem Assessment 2003).

Whether a good or service is of private of public nature has direct implications on how NBS are governed, financed, and managed (Ostrom 2010). For instance, private sector finance is more likely to support an NBS that provides marketable products with private good characteristics (e.g. agricultural produce or rising property prices) whereas NBS which generate mostly public services (e.g. enhanced water retention due to public green infrastructure) mostly rely on public investments (Toxopeus and Polzin 2017). From a private perspective, investing in NBS with predominantly public benefits is often not very attractive, as the resulting benefits are not directly associated with the investor, rather diffuse in space and time, and therefore have a long payback period at a high risk (Tompkins and Eakin 2012; Faber and Frenken 2009; Polzin 2017).

Against this background, many initiatives and approaches seek to better describe and capture the values of NBS and green infrastructure components. It is assumed that through a better understanding and being able to effectively quantify the benefits, the evidence base will pave the way for the development of new financing and business models to facilitate the uptake of NBS in cities. Still, it is a challenge to establish effective impact assessments, which are also able to measure the diffuse benefits and to take context

specific preconditions into account. This uncertainty factor significantly increases when trying to anticipate the impacts of a planned future intervention (ex-ante).

Several quantification tools have been developed to assess and calculate the (economic) value of NBS (see evaluation tools described in chapter 4). However, most of these are based on highly sophisticated and NBS-specific algorithms and require detailed data on the specific context in order to provide reliable and realistic outcomes. Additionally, valuation has been approached by assessing market behavior and theory (e.g. via hedonic housing prices) (Bockarjova et al. 2017). Also here it becomes evident that a more nuanced view on the type, condition, and context of the respective NBS has to be taken into account in order to fully understand the underlying values and benefits.

To enable a targeted and easy navigation through this complex issue of NBS valuation, the UNaLab Value Model systematises and organises expected benefits and beneficiaries of a broad range of NBS explored in the UNaLab project. It aims at assessing NBS benefits across the different ecosystem services and identifying potential beneficiaries in the urban context. Based on the beneficiary structure and the rather public or private nature of the solution at hand, it explores the "value capture potential" of the intervention and suggests potential financing options. It thus takes a more informative and stakeholder driven approach to NBS financing and is foreseen as a tool for initial scoping and inspiration in project planning.

2.2 Purpose and target group

The UNaLab Value Model is primarily supposed to be used by project managers and decision makers in the field of NBS. It is an information repository and logic which

a) systematises information around NBS benefits, beneficiaries and potential financing options

b) provides a customised filtering and selection process for the user and thereby helps to identify the beneficiaries and financing options which are relevant in their specific context

c) inspires and educates on the above mentioned issues in a journey kind of experience

The model will be used in the UNaLab roadmapping workshops from August 2019 to January 2020 to inform and enrich the NBS project planning in the follower cities. It will be further tested and ultimately embedded and used as an entry point within the UNaLab replication framework.

2.3 Approach to the development of the value model

2.3.1 Method and underlying principles

The development of the value model involved two main activities. Firstly, the collection and organization of relevant knowledge and data in this area, and secondly the design of a logic which links the different components and enables a more context specific outcome. For this purpose, a broad literature review was performed to assess available quantification and evaluation approaches and tools which assess the different benefits and values of NBS and green infrastructure elements. Thereby a database with different literature sources, tools, and case studies was compiled. Furthermore, available UNaLab outcomes, specifically the NBS Technical Handbook (D5.1) and the NBS Business Models & Financing Strategies (D6.3) were used to better define the scope of work (see chapters 2.3.3 and 2.3.5). Several internal expert workshops and review loops were conducted between August 2018 and January 2019 to compile, cluster, evaluate, and enrich the gathered data and information.

The UNaLab Value Model covers a broad range of 15 NBS clusters and tries to include all types of benefits and beneficiaries. To ensure that some context specificity and an effective filtering of relevant information can be achieved within this wide scope, the model relies on the user to bring in his or her own context and perspective. This is mainly realised through inbuilt pick-and-choose mechanisms. The model will confront the user with predefined sets of information (e.g. challenges, NBS, beneficiaries,

benefits, etc.) based on UNaLab project outcomes and literature, of which the user will have to select or unselect those which are relevant for his or her specific context and purpose. Based on these choices, model outputs will be adjusted and prioritised. The foreseen process of the value model tool is described in chapter 3.

2.3.2 Components and linkages

Given the complexity and difficulty to assess, capture and quantify the manifold values of a nature-based solution, the UNaLab Value Model takes a closer look at the expected beneficiaries of certain nature-based solutions and explores how these stand in relation to potential financing options. Figure 2 summarises the main components for which information was collected, as well as the underlying assumptions and linkages.

The starting points for the value model are the urban challenges, which a city might want to solve through NBS. Based on these challenges and the availability of solutions, specific interventions (in this case NBS) are suggested whose functions (e.g. ecosystem services) are supposed to address the challenges at hand. At the same time, these functions provide individual benefits to a range of different urban stakeholders (beneficiaries). Individual benefits can thereby come in various shape and forms (e.g. be of monetary or non-monetary nature). Depending on this benefit type the value of the intervention will be harder or easier to capture and accordingly the beneficiary will have a higher or lower incentive to support and / or (co-)finance it (see chapter 2.3.4). Next to this individual willingness to pay or invest, the type of NBS will also determine which financing options are feasible or not (e.g. taking into account if there are international funds and/or policies in place to support the intervention at hand). This link is further described in chapter 2.3.6.

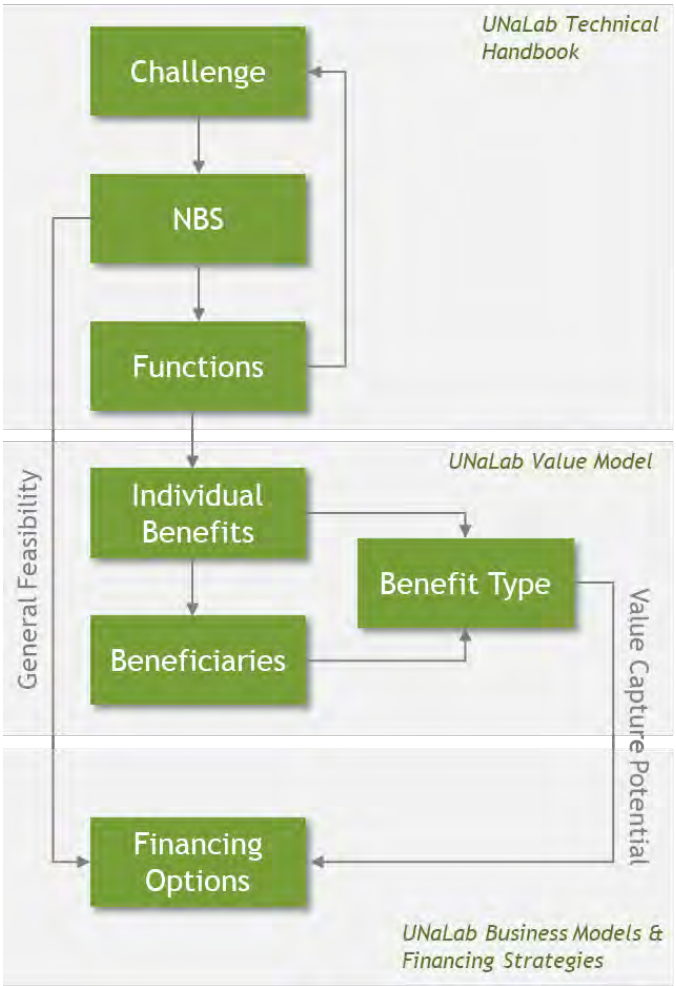


Figure 2: General components and logic of the UNaLab Value Model

2.3.3 Definition of NBS clusters and scenarios

The initial list of NBS interventions was taken from the UNaLab Technical Handbook. This deliverable has a strong understanding of the underlying ecology and performance of NBS. However, for the value model a more economic and social perspective had to be added to the ecological basis. Furthermore, solutions with a similar beneficiary and value structure had to be clustered in order to come up with a manageable number. Based on this premise, NBS clustering workshops were conducted which were informed by the Technical Handbook, extensive literature research, as well as different case studies. A total of 15 NBS clusters were chosen for the value model which are further described in chapter 4. For each NBS cluster, different scenarios were elaborated to better visualise and communicate the respective scope of the cluster. Technical content and information was taken and summarised from the Technical Handbook. Furthermore, existing quantification and evaluation tools were added as reference to allow users to assess certain NBS or ecosystem services more in detail.

2.3.4 "Usual suspect beneficiaries" and "value capture potential" of NBS

For each NBS cluster, "usual suspect beneficiaries" were collected (from public, private and civil society sectors) which are most likely to benefit from the interventions at hand. The collection was complemented by short explanations on what the expected individual benefits of the named stakeholders are. The goal of collecting and displaying these "usual suspect beneficiaries" is to get project managers to think more closely about the question of who potential beneficiaries of their planned interventions are (or could be) and who should therefore be further involved in the planning and financing of the intervention.

The underlying assumption behind the "value capture potential" is that beneficiaries are more willing to contribute to and (co-)invest in an intervention a) the more tangible the benefit is (e.g. direct money flows versus diffuse health benefits), b) the better it can be linked to the individual beneficiary (e.g. exclusivity), and c) the better it can be linked to the given NBS (evident cause – effect relationship). In general private goods are more likely to show a higher value capture potential and thus a higher chance of private capital leverage, whereas the value capture potential of public goods tends to be lower (even though the value creation might be higher overall) emphasizing the higher necessity of public sector financing (see for example Toxopeus and Polzin 2017). To better depict and systematise these assumptions, the individual benefits from NBS were categorised in six different benefit types which are summarised in Table 1: Benefit types and characterization. A table with all identified benefits per benefit type can be found in the Annex (Table 5).

Table 1: Benefit types and characterization[1].

Benefit Type	Description	Example	Value
Revenue & Income	The beneficiary directly increases his/her income through the intervention	Increased property values, improved sales through increased foot traffic in business areas	Monetary
Cost Savings	The beneficiary saves money due to the intervention	Better insulation and reduced energy costs, flood damage mitigation	
Compliance	The intervention helps the beneficiary to fulfill a mandate or comply with regulations	Fulfilling environmental standards, achieving city goals	Non-monetary
Active Use	The beneficiary can make direct use of the intervention	Opportunities for recreation and sports	
Local Identity & Image	The beneficiary gains recognition and visibility or identifies better with the place	Improved city marketing, CSR, sense of place	
General Wellbeing	The beneficiary's quality of life/health/wellbeing is improved through the intervention	Better air quality, increased contact with blue green spaces	

Higher ↑ Value Capture Potential ↓ Lower

2.3.5 Identification of NBS financing and governance options

The objective of the financing and governance options was to provide inspiration to city partners developing NBS through the UNaLab Replication Framework to consider other potential financing options based on the individual stakeholder constellation. Through providing impulses based on good practices in other European cities, the aim is for users to expand their understanding about how such interventions can be built and managed. The development of the financing options attempts to move from case studies whose governance constellation are much tied to the site-specific context where it emerged toward more generic options that can be used to inform the development of new constellations.

1 Icons designed by Freepik from www.flaticon.com

Identifying potential NBS financing and governance options:

The UNaLab project deliverable D6.3 Business Models and Financing Strategies was used a basis for identifying the potential financing options of NBS. However, a broader literature review that included the relevant academic and grey literature focusing on the financing options for NBS was performed too.

Integrating financing, business and governance models:

Since looking only at financing options limits the potential for innovation in this area by focusing on actors with capital, the research was expanded. The information gathered on the financing options and business models for NBS was complemented by literature focusing on the potential NBS governance models. The work builds particularly on the ground covered in the report on Innovative Governance for Urban Green Infrastructure Planning and Implementation (Ambrose-Oji et al. 2017) as part of the "Green Surge" project.

Based on the research, it became clear that there has been important knowledge generated to better understand the emergence of new governance constellations around (nature-based) urban interventions (such as grass roots initiatives or community-managed public space). Although these would not typically be understood as "financing models", they can reduce the financial burden on the city through contributing labour or other maintenance or even support during construction. In addition, partnerships between private actors and the city for building and maintaining NBS often need to be complemented with a governance model to ensure that the benefits of the for the public good are realised and that long term contractual arrangements are upheld. For these reasons, the models attempt to integrate both financing, business and governance models to facilitate a broader understanding of these aspects. The literature review findings have been further investigated and validated through a series of expert workshops.

Organisation of the options:

The organisation of the identified NBS governance and financing models is based on government-market-community trichotomy. In its traditional form, this trichotomy implies that any productive activity or resource is owned/executed by government, market or community. *Table 2.* Main features of the traditional trichotomy model provides insight into the main features of each of these organisational forms (adapted from Kolbjørnsrud 2018):

Table 2. Main features of the traditional trichotomy model (Kolbjørnsrud 2018)

	Market	Government	Community
Locus of design	Market institutions, contracts	Authority structure	Values, rules and protocols
Goals	Actor-specific goals	Efforts to achieve goal alignment among organisational members	Shared goals and values
Resource ownership	Actors own resources, private-property regime	Organisation owns resources	Shared resources, common-property regime
Affiliation	Market contract	Employment	Membership

The integrated NBS financing and governance options were organised following the traditional trichotomy methodology. However, the traditional model has been expanded to account for the hybrid solutions that can occur in between the three extremes of the model. The final selection of the integrated financing and governance models including the hybrid solutions can be observed in *Figure 3.* Identified NBS financing and governance options

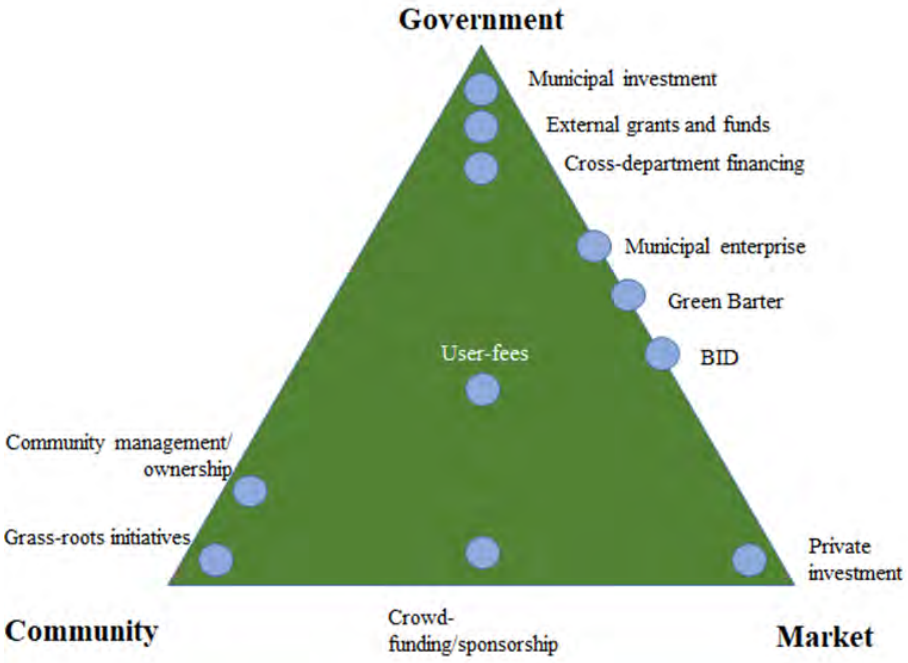


Figure 3. Identified NBS financing and governance options.

Expanded research on EU and other funds, financing facilities and platforms

In addition to the identification, integration and organisation of the potential financing and governance models for NBS, a comprehensive research on the potential external NBS financing schemes and sources was performed. The EU, as well as other international organisations and financial institutions, can, in some cases, be a major contributor to NBS implementation financing and governance aspects. Subsequently, an overview of the funds, financing facilities and platforms has been compiled to draw the cities' attention to such financing possibilities, as well as their major eligibility criteria that often call for national and/or local political and financial support.

2.3.6 Linking NBS clusters and financing and governance options

The identified NBS financing and governance options were linked with the NBS clusters based on the identified NBS scenarios, as well as the main features of the financing and governance options. For each cluster of NBS both, the initial investment as well as operation and maintenance costs were considered. A screening of NBS financing and governance case studies helped to verify the respective allocation. Table 3 Table 4 summarise the respective outcomes.

*Table 3: Linking of NBS clusters and financing options: investment costs (*applies under certain circumstances, e.g. if the intervention is built on private or public land, or only at a certain scale).*

0	SCENARIO	Investments costs										
		Municipal Investment	Cross-departmental funding	External funding	User Fees	Municipal Enterprises	Green Barter	BID	Private Sector	Grass Roots	Crowd-funding/ sponsor-ship	Communi-ty Mana-gement / Adoption
A Detention / Retention Pond & Infiltration	A1 Natural space		x	x		x	x*					
	A2 Mixed-use public space	x	x	x		x	x*					
B Under-ground Water Storage	B1 Small-scale	x		x		x			x*			
	B2 Large-scale	x		x		x	x					
C Biolfilters	C	x		x		x			x			
D Green Roof	D1 Intensive	x		x			x		x			x
	D2 Extensive	x		x			x		x			
E River Restoration (Renaturing/ Daylighting)	E1 Built-up area		x	x		x	x	x	x			
	E2 Non built-up area	x	x	x		x						
F Mobile vertical greening	F1 Green street furniture	x							x		x	
	F2 Moss walls	x							x			
G Public Green Spaces	G	x	x	x	x	x	x	x	x	x	x	x
H Permeable Pavements	H	x	x	x					x			
I Urban Trees	I1 Single line trees	x	x	x*				x	x			
	I2 Group of trees	x	x					x	x			
	I3 Urban Forest	x	x	x			x				x	
J Constructed Wetlands	J	x	x	x		x			x			
K Raingarden /Bioswale	K1 Raingarden	x							x	x	x	x
	K2 Bioswales	x	x			x						
L Urban Agriculture	L1 Community garden	x								x	x	x
	L2 Urban farming	x							x	x	x	x
M Vertical Greening	M1 Green facades	x							x			
	M2 Green walls	x	x						x			
O Landscape Engineering (on rivers / slopes)	O	x		x					x			

*Table 4: Linking of NBS clusters and financing options: operation costs (*applies under certain circumstances, e.g. if the intervention is built on private or public land, or only at a certain scale).*

NBS	SCENARIO	Operation costs										
		Municipal Investment	Cross-departmental funding	External funding	User Fees	Municipal Enterprises	Green Barter	BID	Private Sector	Grass Roots	Crowd-funding/ sponsor-ship	Communi-ty Mana-gement/ Adoption
A Detention / Retention Pond & Infiltration Basin	A1 Natural space				x*							x*
	A2 Mixed-use public space											x
B Under-ground Water storage	B1 Small-scale	x			x	x						
	B2 Large-scale	x				x						
C Biolfilters	C											
D Green Roof	D1 Intensive	x							x			x
	D2 Extensive	x							x			x
E River Restoration (Renaturing/ Daylighting)	E1 Built-up area	x	x			x						
	E2 Non built-up area	x	x			x						
F Mobile vertical greening	F1 Green street furniture											
	F2 Moss walls	x							x			
G Public Green Spaces	G	x			x		x	x	x	x		x
H Permeable Pavements	H	x							x			
I Urban Trees	I1 Single line trees											x
	I2 Group of trees											
	I3 Urban Forest											
J Constructed Wetlands	J	x	x			x			x			
K Raingarden /Bioswale	K1 Raingarden	x							x	x	x	x
	K2 Bioswales	x	x			x						
L Urban Agriculture	L1 Community garden	x			x							x
	L2 Urban farming				x				x			x
M Vertical Greening	M1 Green facades	x						x	x			
	M2 Green walls	x	x					x	x			
O Landscape Engineering (on rivers / slopes)	O	x							x			

3. USING THE VALUE MODEL – A STEP BY STEP GUIDE

Figure 4 toFigure 7 show a draft pilot of the UNaLab Value Model tool as it could be depicted in the final UNaLab Replication Framework. The numbers and content were chosen arbitrary and will be updated once the tested and final data is agreed upon. The user will be able to access the tool from various entry points and choose if they would like to start with a) specific urban challenges to be addressed, or b) with a concrete NBS solution already in mind. In each of the following steps, the selection and un-selection will help to organise, prioritise and filter relevant information which will be displayed in the final output sheet.

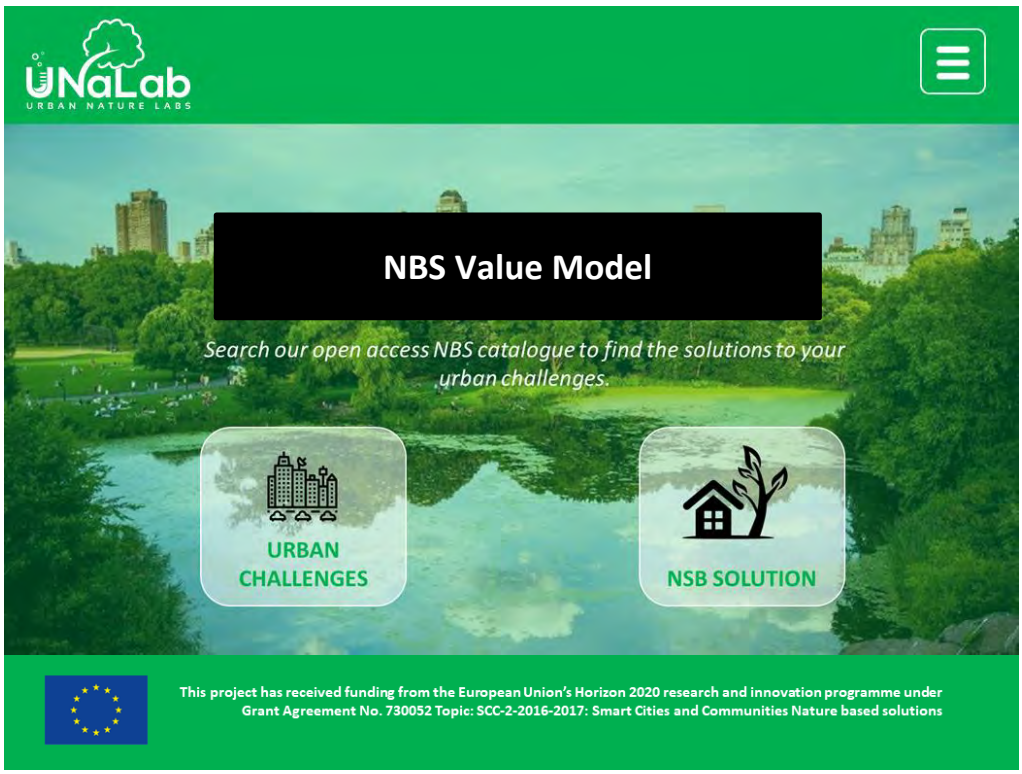


Figure 4: UNaLab Value Model Tool: Starting page (draft)

In case the user decides to start with urban challenges, they will be able to select from a list of urban challenges the ones which are relevant to their specific context. Based on the selection of challenges, specific NBS will be suggested that are most suitable. Exemplary choices of the user are depicted in green. In a next step, the users will be provided with a little bit more background information on the selected NBS, and the different scenarios and variations which it might come in (see data in chapter 4). They will be asked to give a little bit more context on the project at hand, most importantly on the scale and whether the intervention is planned on public or private land.

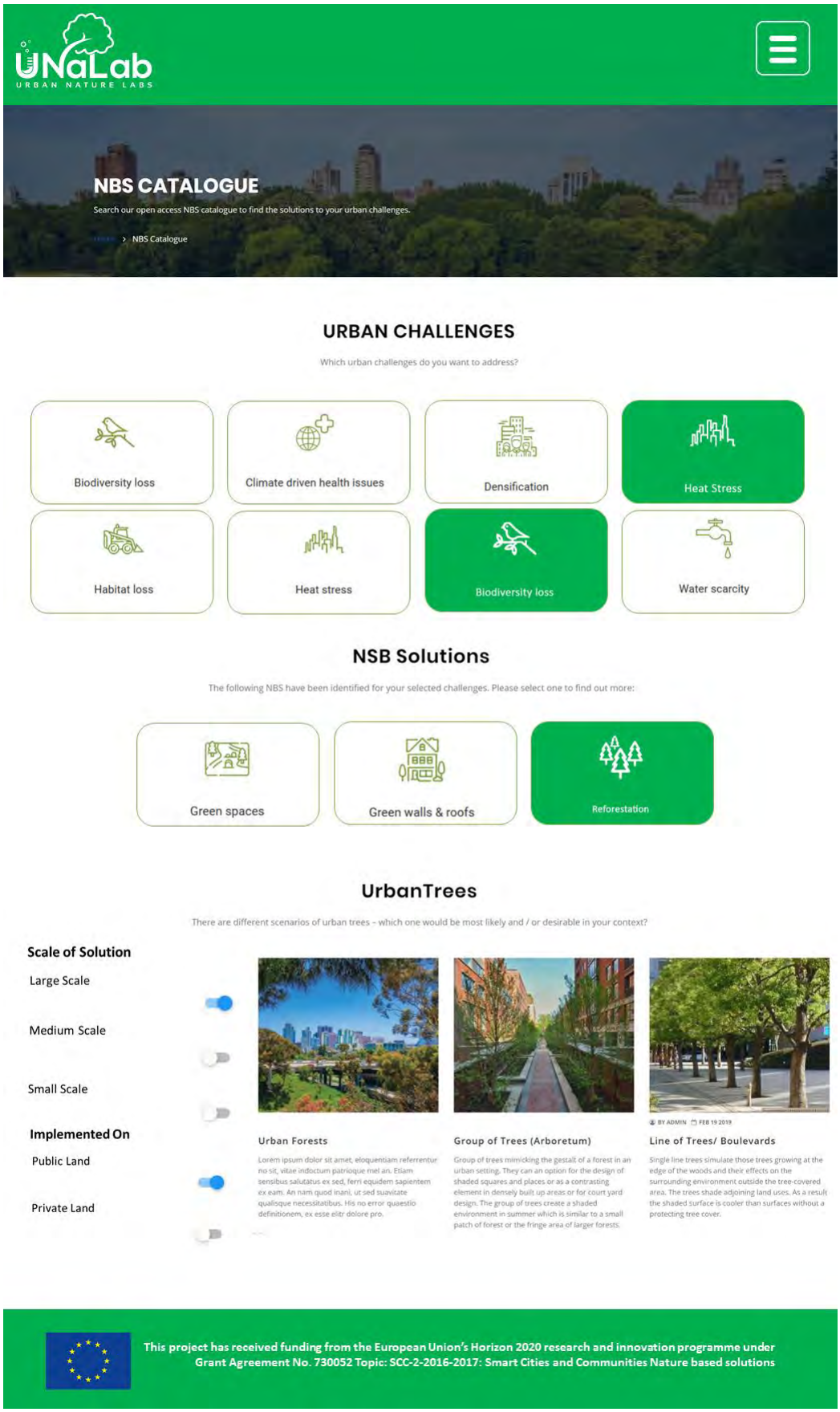


Figure 5: UNaLab Value Model Tool: Challenge and solution selection (draft)

Based on the user inputs, the tool proposes "usual suspect beneficiaries" (urban stakeholders who could potentially benefit from a proposed intervention based on similar existing interventions). An inbuilt function will enable the user to scroll over the different beneficiaries and learn what their main expected benefits are (based on similar existing interventions). The user is then able to select the foreseen beneficiaries based on their understanding of the local context. Furthermore, there will be the option of inserting any further beneficiaries that have not been named.

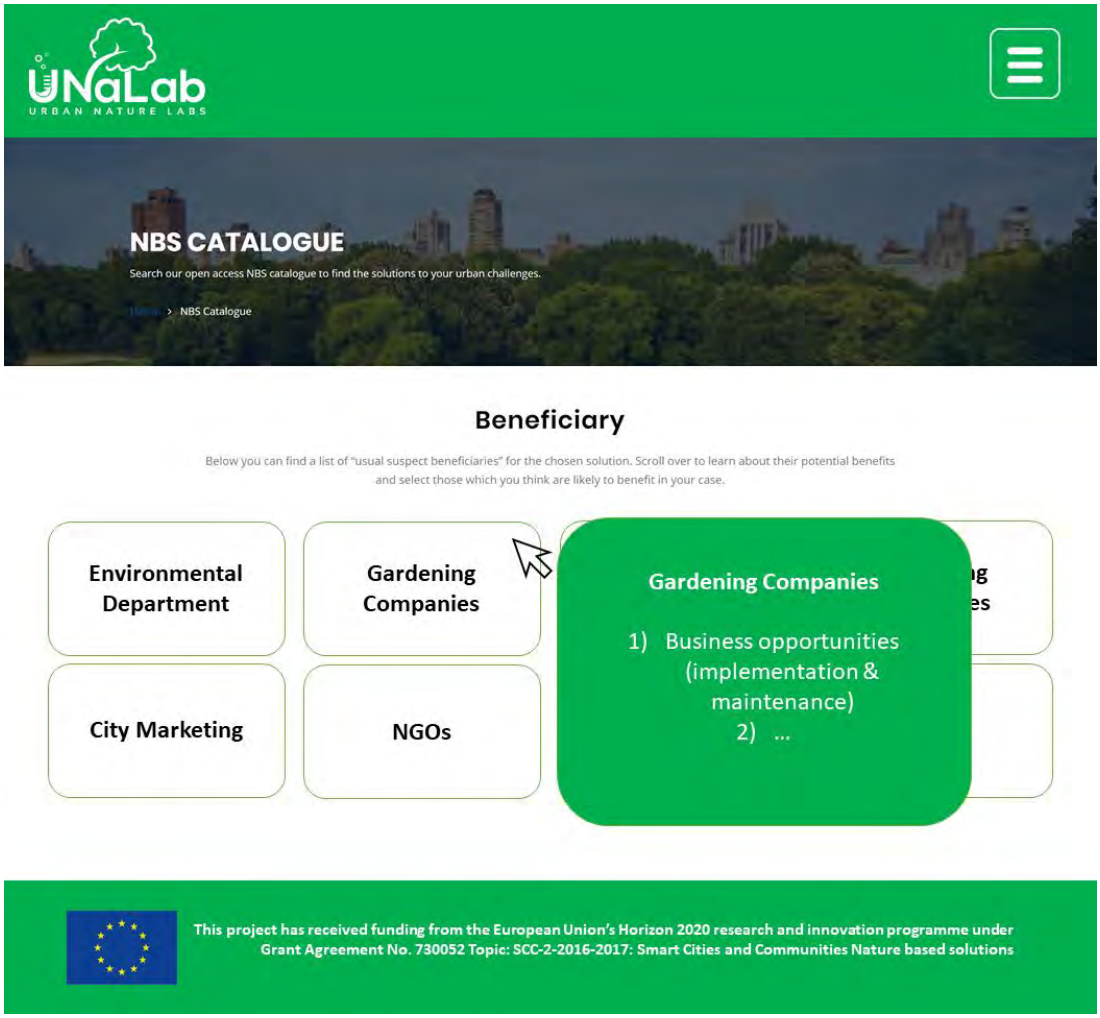


Figure 6: UNaLab Value Model Tool: Usual suspect beneficiaries list (draft)

The output sheet of the tool will summarise all user inputs and give a short overview on NBS functions, expected beneficiary structures, dominant benefit types and the resulting value capture potential. Furthermore, suitable financing options for implementation and maintenance will be displayed along with relevant case studies. Lastly, indications will be given on what further literature might be interesting for the project at hand and what kind of quantification tools exist to further explore specific aspects and services of the chosen NBS. The suggested financing strategies will be linked to the respective chapters in the replication framework where more detailed information will be displayed for each alternative (see data in chapter 5).

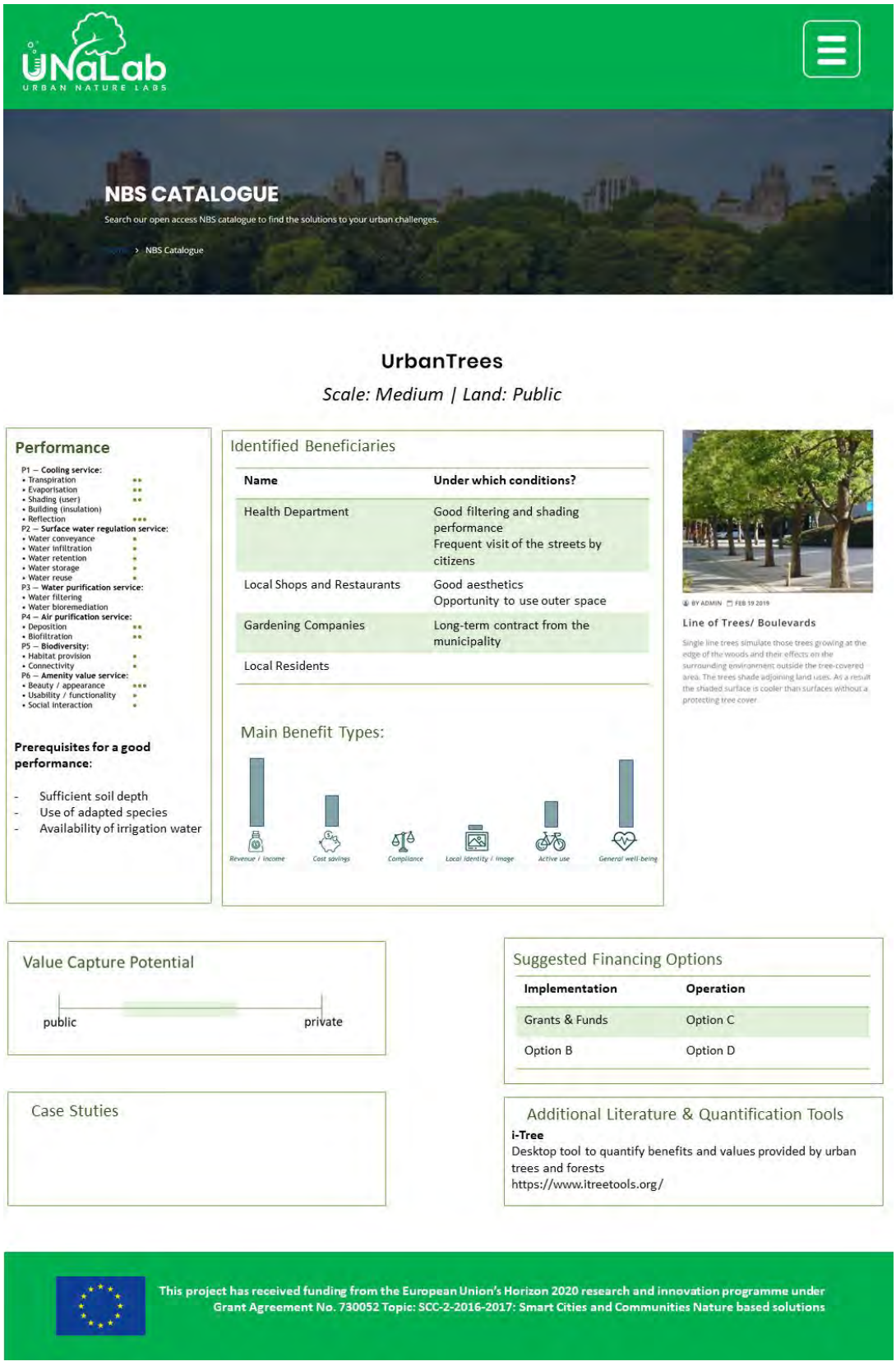


Figure 7: UNaLab Value Model Tool: Output information sheet based on the user inputs (draft)

4. NBS CLUSTERS AND SCENARIOS

4.1 Urban trees

4.1.1 Description

Urban trees have multiple effects on the local micro-climate conditions, absorb particular matter and provide shade for people as well as for buildings. One of the main positive effects for the human well-being in periods with high temperatures is the air cooling effect. The mentioned effect of urban trees in general depends on different factors such as tree size, canopy coverage, planting density, tree species, tree health, location, availability of root water or leaf area index. Urban trees can be planted in several ways and fashions. Out of these, three main scenarios were identified:

(a) *Single trees lining a street and cycle path in Herzogenaurach*[2]

(b) *Groups of trees leading to the baroque castle of Ludwigsburg*[3]

(c) *Urban forest - A group of adult trees creates a microclimatic environment that mitigates heat stress on hot summer days*[4]

Single line trees (a) simulate those trees growing at the edge of the woods and their effects on the surrounding environment outside the tree-covered area. The trees shade adjoining land uses. As a result the shaded surface is cooler than surfaces without a protecting tree cover.

A group of trees (b) represent a possibility to establish several trees in cities amongst others to mitigate urban heat stress. An example of these groups can be boulevards. Within these boulevards, trees are commonly arranged along streets, bicycle paths and sidewalks and - if circumstances allow - established on both sides of the route. The treetops of opposite trees often form a (nearly) closed canopy. As a result, the street in die middle of two tree lines is protected, shaded and the air temperature is lowered. Boulevards simulate those trees growing at the edge of the woods (fringe area) and their effects on the surrounding environment outside the tree-covered area. The trees shade adjoining land uses - in natural forest commonly vegetated areas like fields, meadow or water surfaces. As a result, the shaded surface is cooler than surfaces without protection/tree cover). The shading effect is determined by the characteristics of the trees (tree density, canopy density and season). Other effects are a reduced wind velocity; transpiration/air cooling, air purification.

An urban forest (c) mimicking a forest in an urban setting. They can an option for the design of shaded squares and places or as a contrasting element in densely built up areas or for court yard design. The group of trees create a shaded environment in summer which is similar to a small patch of forest or the

[2] source: © Berny Meyer, Nordbayern.de

[3] source: © BUND Ludwigsburg

[4] source: barkinganddagenhampost.com

fringe area of larger forests. It may thus have different beneficiaries as compared to a single line or group of trees.

Potential disservices of trees may be the allergenic potential of pollen and BVOC emissions, resulting in high O_3 concentrations in summer. These have to be taken into account to manage trade-offs.

4.1.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Water department	Flood risk aversion, improved water quality	Compliance
Urban planning department	Creating attractive urban spaces	Complicance
Green space department	Creating attractive urban spaces, improved biodiversity	Compliance
Environmental department	Improved air quality, decreased noise pollution, improved water quality, carbon sequestration, improved biodiversity, decreased urban heat island	Complicance
City marketing	Visibility of green solutions	Local Identity & Image
Health department	Improved mental and physical health, lower health expenditures	Compliance, Cost Savings
Social development department	Improved social cohesion	Compliance
Private Sector		
Gardening companies	Business opportunities	Revenue & Income
Local shops and restaurants	More foot traffic, employees using the space, space for commercial activities	Revenue & Income, Active Use
Private Developers	Increased property values	Revenue & Income
Civil Society Sector		
NGOs	Increase in biodiversity	Compliance
Local building owners	Increased property values	Revenue & Income
Nature lovers, pet owners, sportspersons, cyclists, bird watchers	Recreation opportunities, better commuting facilities, better air quality, city cooling	Active use, General Wellbeing

Local residents	Increased contact with green space, improved air quality, recreation opportunities, improved social cohesion	Active Use, General Wellbeing

4.1.3 Associated evaluation tools

- **National Tree Benefit Calculator:** This calculator enables the user to insert a specific location, species and tree size to get a basic understanding of environmental and economic benefits, which it will provide (in a monetary value). Mainly assessed are the impacts in the areas of storm water management, property value, energy, air quality, and CO_2. The calculator is based on i-Tree's street assessement tool and can be applied for different locations in Northern America: http://www.treebenefits.com/calculator/

- **i-Tree**: i-Tree offers a range of different tools to assess and manage forests and community trees by quantifying tree structures, threats, and benefits. Different applications enable the assessment of whole forests, individual trees, the impacts of canopies on water quality and quantity, species recommendations, carbon storage potential, etc. The tools are built findings from peer-reviewed science: https://www.itreetools.org/

- **Green Values Stormwater Management Calculator:** This calculator allows a comparison of the performance, cost, and benefits of green infrastructure and conventional stormwater practices (in a monetary unit). It thereby focusses on the stormwater runoff reduction goal (volume-wise). It requires detailed input data for the existing site (e.g land use) and enables the assessment of a combination of green infrastructure components: http://greenvalues.cnt.org/national/calculator.php

- **Green infrastructure valuation toolkit (GI-Val):** This toolkit provides a set of calculator tools which help to evaluate existing green assets or proposed green investments. Thereby 11 key benefits are assessed, including climate change adaptation & mitigation, flood management, quality of place, health & wellbeing, land & biodiversity, productivity, land & property values, economic growth & investment, tourism, products from the land, and recreation & leisure. Depending on the project, it provides outputs in monetary, quantitative, or qualitative terms: https://www.merseyforest.org.uk/services/gi-val/

- **BE£T (Benefits Estimation Tool):** The BE£T tool is used for valuing the benefits of blue-breen infrastructure, especially SUDS and natural flood management measures. It bases its assessment on the Ecosystem Services and the Triple Bottom Line criteria and will in future also provide Natural Capital Accounting. Many of the respected benefit categories have been monetised. Download requires login or registration at the CIRIA website: https://www.susdrain.org/resources/best.html

- **InVEST (Integrated Valuation of Ecosystem Services and Trade-offs):** InVEST includes a range of open-source software models for mapping and valuing ecosystem services provided by land- and seascapes. It uses environmental data to explore how changes in ecosystems may affect the flow of benefits to people. It is designed to inform decision-making on natural resource management. It uses input data (maps, GIS data and information tables) and helps preparing, processing and visualizing the data. Results are either displayed in biophysical or economic terms: http://www.naturalcapitalproject.org/invest/

4.2 Green roofs

4.2.1 Description

Green roofs are vegetative layers implemented on rooftops - especially in urban areas - with the aim to provide green space for different purposes and mitigate against urban heat islands. Several types of green roofs with varying coverings, complexity and scopes can be implemented on rooftops. Main positive effects associated with green roofs are for instance cooling and evapotranspiration, which lead to a reduction of the roofs temperature itself as well as of the surrounding air. As a result, green roofs contribute to mitigating negative effects in urban areas, in particular caused by urban sealing, buildings and heat emissions. Further functions are temporary storing and buffering rain, as well as sunlight absorption. In accordance with the Technical Handbook the value model focusses on two different scenarios - intensive and extensive green roofs, but intermediate systems also exist:

(a) Intensive green roof[5]

(b) *Extensive green roof Oversum*-Winterberg[6]

Intensive green roofs (a) are often associated with residential buildings, hotels or underground parking. The more complex and heavier greening systems are characterised by a higher installation, maintenance, management effort (regular irrigation and fertilization) which leads to higher costs for the mentioned system type compared to extensive green roofs. Intensive green vegetation is often established on roofs that are accessible for public or recreation purposes and also for regular maintenance measures. The intensive green roof type is regularly frequented by humans: Different activities including gardening, relaxing and socializing are designated for intensive green roofs. To enable human activities on green roofs and the integration of larger plants, trees and architectural elements, suitable rooftops need to be relatively flat. The choice of suitable plants has to be greater (than on extensive green roofs) because of the different requirements and applications e.g. aesthetic and ecological requirements. Appropriate plants for intensive green roofs are mainly trees, shrubs and perennials. The growth media is relatively thick and notably deeper than for extensive systems with integrated low-growing plants. The growth media of intensive green roofs needs to be relatively deep and nutrient rich to support the growth of plants or bigger trees. Beside a variety of plants, different kinds of architectural elements (buildings, solar panels) can be established on intensive green roofs.

Extensive green roofs (b) are basic, light weight systems, characterised by minimum maintenance and management (artificial irrigation, fertilization) after establishment of the system. The installation and maintenance of extensive green roofs is less expensive than that of intensive systems. Extensive green vegetation is often established on roofs that are not accessible or with limited access for public or recreation purposes (but annual maintenance) and partially characterised by steep slopes. Appropriate plants for extensive green roofs are low growing, rapidly spreading and shallow-rooting plants/hardy perennials (succulents such as sedums, herbs, wildflowers, grasses, mosses) that are able to survive with

[5] source: Odugreenroof: www.odu- green-roof.com

[6] source: © Optigrün

minimum nutrient uptakes and without additional nutrient supply. The number of different plant species is limited on extensive roofs, yet the biodiversity on extensive green roofs is generally greater than on intensive green roof types. Through the establishment of (extensive) green roofs on rooftops, different services of natural vegetation layers are replicated. As the growth medium is usually relatively thin compared to intensive green roofs, the services of water buffering, temporary storage, retention and filtration often lower than for intensive green roofs. Benefit and beneficiary structures thus differ from the previous scenario.

Potential limitations include a limited effect on biodiversity due to human activities and regular maintenance and management, as well as limited space for rooting.

4.2.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Water department	Flood risk aversion, avoiding grey infrastructure upgrades	Compliance, Cost Savings
Environmental department	Increase in biodiversity, visibility of green solutions, awareness raising, improved air quality, decreasing urban heat islands	Compliance, Active Use
City marketing	Visibility of green solutions, publicity	Local Identity & Image
Private Sector		
Gardening companies	Business opportunities (implementation & maintenance)	Revenue & Income
Civil Society Sector		
Local building owners	Increased property value, reduced energy consumption (insulation)	Revenue & Income, Cost Savings
Building residents	Reduced energy consumption (insulation), contact with green space	Cost Savings, General Wellbeing

4.2.3 Associated evaluation tools

- **EPA Green Infrastructure Modeling Toolkit:** A collection of different tools and models to assess and manage water runoff in urban environments. The toolkit includes different green and grey infrastructure components. Examples are a storm water management model and a tool to model hydraulics and water quality issues: https://www.epa.gov/water-research/green-infrastructure-modeling-toolkit

- **Green Values Stormwater Management Calculator:** This calculator allows a comparison of the performance, cost, and benefits of green infrastructure and conventional stormwater practices (in a monetary unit). It thereby focusses on the stormwater runoff reduction goal (volume-wise). It requires detailed input data for the existing site (e.g land use) and enables the assessment of a combination of green infrastructure components: http://greenvalues.cnt.org/national/calculator.php

- **Water Research Foundation Life Cost Models:** A set of spreadsheet tools which help users to understand and calculate the life cycle costs (capital & long-term maintenance) of different green infrastructure components. A registration is required to get access to the tools: http://www.werf.org/i/a/Ka/Search/ResearchProfile.aspx?ReportId=SW2R08

- **Green infrastructure valuation toolkit (GI-Val):** This toolkit provides a set of calculator tools which help to evaluate existing green assets or proposed green investments. Thereby 11 key benefits are assessed, including climate change adaptation & mitigation, flood management, quality of place, health & wellbeing, land & biodiversity, productivity, land & property values, economic growth & investment, tourism, products from the land, and recreation & leisure. Depending on the project, it provides outputs in monetary, quantitative, or qualitative terms: https://www.merseyforest.org.uk/services/gi-val/

- **Living Architecture Performance Tool (LAPT):** Developed by the green infrastructure foundation, LAPT is a rating system to certify that green roofs and walls are designed to achieve certain measurable and replicable performance benefits. It consists of a 110-point system, encompassing 30 credits in the areas of water, habitat & biodiversity, innovation, management & operations, health & well-being, post-construction, energy and process. The tool is currently in piloting phase in North America: https://greeninfrastructurefoundation.org/lapt

- **BE£T (Benefits Estimation Tool):** The BE£T tool is used for valuing the benefits of blue-breen infrastructure, especially SUDS and natural flood management measures. It bases its assessment on the Ecosystem Services and the Triple Bottom Line criteria and will in future also provide Natural Capital Accounting. Many of the respected benefit categories have been monetised. Download requires login or registration at the CIRIA website: https://www.susdrain.org/resources/best.html

4.3 River restoration (renaturation & daylighting)

4.3.1 Description

According to the International Union for Conservation of Nature (IUCN), river restoration is defined as *"the re- establishment of natural physical processes (e.g. variation of flow and sediment movement), features (e.g. sediment sizes and river shape) and physical habitats of a river system (including submerged, bank and floodplain areas)." (IUCN in The River Restoration Centre, n.d. p.1).* The main aim of restoration is to design rivers towards more near-natural state with the effect, that the reinstated channels fulfil (again) important functions for the environment and for public protection. After restoration, the rivers are characterised by dynamic water courses and sediment movements. Some of the mentioned functions are storm water regulation and flood risk reduction, habitat provision, and the provision of public space for recreation. The measures of restoration are diverse and modify different parts of the river e.g. the riverbed, the riverbank or floodplains and include small-scale as well as larger scale interventions.

One of the most prominent tools in river restoration is Daylighting. In this intervention, covered or buried watercourses (such as rivers or drainage systems) are reopened by removing concrete layers or other restricting layers. This leads to more space for water and increases the storage capacity of the channel. Daylighting also develops close-to nature riverbeds and riparian zones. After successful daylighting, benefits in storm water managements, environmental and other co-benefits can be seen. Other positive effects are flood risk reduction, amenity value and recreation value, as well as improvements of habitat quality. The overall idea of this concept is that Daylighting allows the natural

development of a water channel that fulfils services of a natural water channel or river e.g. habitat for wildlife and aquatic life and plants; regulation and uptake of storm water runoff.

In terms of the value model, a distinction was made between restoring rivers in **built-up areas** or in **non-built up areas**, as the stakeholder and beneficiary constellation is expected to vary based on this difference:

(a)Saw Mill River after daylighting in a built-up area, Yonkers, NY[7]

(b)Daylighting of a small stream in a non-built up area.[8]

4.3.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Water department	Flood risk aversion, avoiding grey infrastructure upgrades costs, decreased pressure on water treatment system, publicity and public support	Complicance, Cost Savings, Local Identity & Image
Environmental department	Decrease heat stress, increase in biodiversity, improved air quality, increased visibility of green solutions	Compliance, Local Identity & Image
Health department	Improved mental and physical health, lower health expenditures	Compliance, Cost Savings
Mayor	Publicity, public support	Local Identity & Image
Private Sector		
Private Developers	Increased property value, marketing potential, business opportunities (PPP)	Revenue & Income, Local Identity & Image

[7] source: Groundwork Hudson Valley

[8] source: Boffa Miskell; www.boffamiskell.co.nz/

Local Shops and restaurants	More foot traffic, business opportunities, space for commercial activities	Revenue & Income, Active Use
Tourism	Recreation opportunities, marketing potential	Active Use, Local Identity & Image
Civil Society Sector		
Environmental NGOs	Increase in biodiversity, awareness raising, research opportunities	Compliance, Active Use
Local residents, sportspersons, dog walkers, nature lovers	Contact with green space, city cooling, sports and recreation opportunities, better air quality	General Wellbeing, Active Use

4.3.3 Associated evaluation tools

- **eWater Toolbox:** The eWater Toolbox includes several tools to analyse the hydraulics of river channels and determine discharge values. Furthermore, rock chutes can be assessed which are employed in river restoration and erosion control projects: https://ewater.org.au/products/ewater-toolkit/rivers-tools/

- **BE£T (Benefits Estimation Tool):** The BE£T tool is used for valuing the benefits of blue-breen infrastructure, especially SUDS and natural flood management measures. It bases its assessment on the Ecosystem Services and the Triple Bottom Line criteria and will in future also provide Natural Capital Accounting. Many of the respected benefit categories have been monetised. Download requires login or registration at the CIRIA website: https://www.susdrain.org/resources/best.html

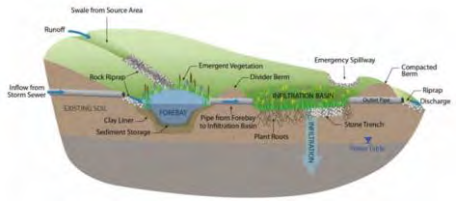
- **InVEST (Integrated Valuation of Ecosystem Services and Trade-offs):** InVEST includes a range of open-source software models for mapping and valuing ecosystem services provided by land- and seascapes. It uses environmental data to explore how changes in ecosystems may affect the flow of benefits to people. It is designed to inform decision-making on natural resource management. It uses input data (maps, GIS data and information tables) and helps preparing, processing and visualizing the data. Results are either displayed in biophysical or economic terms: http://www.naturalcapitalproject.org/invest/

- **Natural Capital Planning Tool (NCPT):** The excel-based tool allows users to assess the impact of new or proposed developments on the value of Natural Capital and ecosystem services. To do so, it calculates a project impact score (tool specific unit), which indicates the direction and magnitude of impact for 10 different ecosystem services, as well as for all services combined over a 25 year timescale: http://ncptool.com/

- **tessa - Toolkit for Ecosystem Service Site-Based Assessment:** The tessa toolkit is an interactive pdf document that provides practival guidance on how to identify ecosystem services which are significatnt at a given site of interest, what data is needed to measure tham, and which methonds and sources can be used and are most suitable to obtain the data. It furthermore gives recommentations on how to best communicate the results: http://tessa.tools/

4.4 Infiltration basin (retention & detention ponds)

4.4.1 Description



(a)Infiltration basin[9]

(b)Detention Pond[10]

(c)Retention Pond [11]

Infiltration basins (a) are flat areas planted with grass and normally dry. After a heavy rain the water fills up the basin and soaks into the ground. Detention ponds (b) are surface storage basins that retain storm water. During periods of heavy rain, the area gets flooded and could lead to filling up of the detention pond in cases of longer duration of rainfall. After the rain ends, the water flows in the sewer system. If there is no event of heavy rainfall the detention ponds are dry and could be used as a green area. Retention ponds (c) retain storm water continuously. In dry periods they also hold water. The detention ponds can improve the water quality (for example with downstream infiltration).

In terms of scenarios, the value model proposes a distinction between these more **natural infiltration options** and retention spaces which are more inbuilt in the urban fabric (e.g. **mixed-use spaces** which can be flooded and retain water during heavy rain events).

4.4.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Water department	Flood risk aversion, avoiding grey infrastructure upgrades costs	Revenue & Income, Cost Savings
Urban planning department	Creating attractive urban spaces, creating liveable spaces, increasing blue green space accessibility	Compliance
Green space department	Increasing blue green space accessibility, increase in biodiversity	Compliance
Environmental department	Decreasing urban heat islands	Compliance
Mayor	Publicity, public support	Local Identity & Image

[9] source: provided in: Massachusetts Department of Environmental Protection; geosyntec.com/

[10] source: www.sudswales.com

[11] source: Prorooter; www. prorooter.com

Private Sector		
Gardening companies	Business opportunities (implementation & maintenance)	Revenue & Income
Local shops and restaurants	Using space for commercial activities, employees using the space	Active Use
Event organisers	Business opportunities, potential venue for events	Revenue & Income, Active Use
Civil Society Sector		
Environmental NGOs	Increase in biodiversity, awareness raising	Compliance
Local building owners	Reduced insurance cost, reduced risk of flood damage	Cost Savings
Families & pet owners	Sports and recreation opportunities, contact with green space, sense of place, better air quality	Active Use, General Wellbeing

4.4.3 Associated evaluation tools

- **EPA Green Infrastructure Modeling Toolkit:** A collection of different tools and models to assess and manage water runoff in urban environments. The toolkit includes different green and grey infrastructure components. Examples are a storm water management model and a tool to model hydraulics and water quality issues: https://www.epa.gov/water-research/green-infrastructure-modeling-toolkit

- **Green Values Stormwater Management Calculator:** This calculator allows a comparison of the performance, cost, and benefits of green infrastructure and conventional stormwater practices (in a monetary unit). It thereby focusses on the stormwater runoff reduction goal (volume-wise). It requires detailed input data for the existing site (e.g land use) and enables the assessment of a combination of green infrastructure components: http://greenvalues.cnt.org/national/calculator.php

- **Water Research Foundation Life Cost Models:** A set of spreadsheet tools which help users to understand and calculate the life cycle costs (capital & long-term maintenance) of different green infrastructure components. A registration is required to get access to the tools: http://www.werf.org/i/a/Ka/Search/ResearchProfile.aspx?ReportId=SW2R08

- **Recarga Model:** This model by the Winsconsin Department of Natural Resources enables the evaluation of different bioretention solutions and their performance. It simulates the movement of water throughout the facility. It can be used to define the scaling of a solution or to analyze the potential impacts of different design parameters. It is intended for use by highly technical professionals: https://dnr.wi.gov/topic/stormwater/standards/recarga.html

- **P8 Urban Catchment Model:** This model is used to predict the generation and transport of runoff pollutants in individually defined urban watersheds. It considers different elements of watersheds, solutions, particle classes and water quality components. It is intended for use by urban planners and engineers that are familiar with hydrologic evaluations: http://www.wwwalker.net/p8/

- **Music by eWater:** The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) is a software that helps developers and planners to devise water sensitive urban designs (WSUD) and integrated water-cycle management in urban areas. It enables stormwater flow simulation, estimation of harvesting and reuse potentials, pollutant modelling, water balance modelling, comparison of different treatment scenarios and the planning of entire stormwater systems: https://ewater.org.au/products/music/

- **WinSLAMM:** WinSLAMM is a hydrologic tool which is used to predict stormwater flows and pollutant characteristics for a broad range of rains. It is based on actual field observations and includes a wide variety of control practices, including NBS: http://winslamm.com/winslamm_overview.html

- **BE£T (Benefits Estimation Tool):** The BE£T tool is used for valuing the benefits of blue-breen infrastructure, especially SUDS and natural flood management measures. It bases its assessment on the Ecosystem Services and the Triple Bottom Line criteria and will in future also provide Natural Capital Accounting. Many of the respected benefit categories have been monetised. Download requires login or registration at the CIRIA website: https://www.susdrain.org/resources/best.html

4.5 Underground water storage

4.5.1 Description

Underground water storage[12]

Underground systems below public open spaces are composed of modular elements to retain flash floods and to store water for irrigation purposes nearby. These depend on the underlying geology and often cover a large area. In addition, small-scale solutions exist which allow individuals to retain and collect water from building runoff and use it e.g. for toilet flushing or irrigation purposes. The value model thus considers two scenarios, namely **large-scale** and **small-scale** water storage solutions.

[12] UNaLab Technical Handbook

4.5.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Water department	Flood risk aversion, improving water supply	Compliance
Private Sector		
Solution providers (start-ups)	Business opportunities (implementation & maintenance)	Revenue & Income
Civil Society Sector		
Building residents	Reduction of water costs, local water source	Cost Savings, Active Use
Water consumers (farmers, gardeners, etc.)	Reduction of water costs, local water source	Cost Savings, Active Use

4.6 Biofilters

4.6.1 Description

Biofilter [13]

Biofilters are developed to collect and purify storm- and wastewater and represent a promising system for storm water treatment. Bacteria and microorganisms are located on a filter medium (biofilm), which often consists of sand or granular activated carbon. The biofilm degrades nutrients and contaminations in the wastewater that is piped through the filter material. The term "filter" is thereby misleading, as biofilters separate and remove nutrients and organic carbons through biodegradation. As a result biofiltration improves the quality of wastewater (reduction of nutrients, metals, sediments) and stormwater and at the same time harvests storm water and stores it for a certain period. In this case, only one scenario has been identified.

[13] source: Monash University; https://www.monash.edu

4.6.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Water department	Improving water quality, decreased pressure on water treatment system	Compliance
Environmental department	Improved water quality, increased visibility of green solutions	Compliance, Local Identity & Image
Private Sector		
Local industries	Meeting water regulations, mitigated water treatment cost, potential for water reuse	Compliance, Cost Savings, Active Use
Civil Society Sector		
Water Associations (e.g. NGOs)	Improved water quality, improved water supply, research opportunities, awareness raising	Compliance, Active Use
Water consumers (farmers, gardeners, etc.)	Local water source, better water quality	Active Use, General Wellbeing

4.7 Green street furniture

4.7.1 Description

As an example of green street furniture, the mobile Green Living Room consists of living wall modules (wire frame cubes) that are fixed to a hook lift container platform. The vegetation cover is very diverse in order to illustrate the high potential of living walls to increase amenity value and stimulate biodiversity. A light open roof structure, partly covered with vegetation, provides shade. It provides instantly services for clean air provision, cooling and shading, a habitat for urban biodiversity. Green street furniture can be used as mobile demonstration for green infrastructure, as a test feature, a temporary green installation or as an open green office for information and communication purposes.

Mobile Green Living Room[14]

4.7.2 Usual suspect beneficiaries

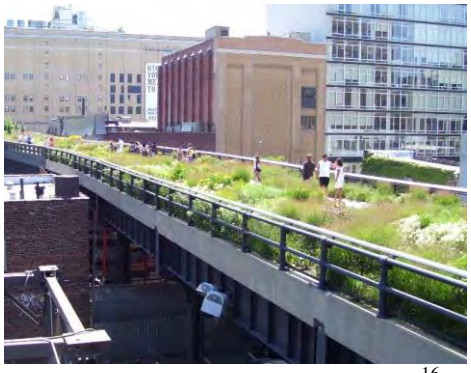
Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Green space department	Creating attractive urban spaces, improved biodiversity	Compliance
Environmental department	Improved air quality	Compliance
City marketing	Visibility of green solutions	Local Identity & Image
Health department	Improved mental and physical health	Compliance
Private Sector		
Local shops and restaurants	More foot traffic, employees using the space	Revenue & Income, Active Use
Solution providers (e.g. start-ups)	Business opportunities (implementation & maintenance)	Revenue & Income
Civil Society Sector		
Schools & educational institutions	Awareness raising, contact with green space	Active Use
Locals, pet owners, sportspersons, people shopping, commuters	Contact with green space, resting opportunities, increased comfort, better commuting facilities	Active Use, General Wellbeing

[14] source: © Eisenberg

4.8 Public green spaces

4.8.1 Description

(a) Innocentia Park, Hamburg[15]



(b) High line park in Manhattan, New York[16]

Public green spaces are categorised according to size, catchment area, services provided and urban design aspects. In an integrated system, often connected through tree lined streets, they serve as the back bone of *urban* green infrastructure and provide many beneficial services for the city. Residential Parks (a) are part of the green infrastructure of cities and serve the residential areas as the nearest main entry point for nature based recreation. Larger spatial elements of green infrastructure are district parks that often deliver more functions and combine various uses (e.g. sport fields). Smaller green spaces are often playgrounds or connecting green strips of land. Areas of derelict infrastructure, also called green corridors (b), e.g. railway lines, that are transformed into linear parks play an important role in urban green infrastructure networks and help to re-nature cities. Also regeneration along waterways and rivers often results in linear interconnecting parks. It was assumed that the general beneficiary structure of public green spaces will be rather similar, therefore no separate scenarios were developed.

4.8.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Urban planning department	Creating attractive and liveable spaces, increasing blue green space accessibility	Compliance
Green space department	Creating attractive urban spaces, improved biodiversity	Compliance
Environmental department	Decrease heat stress, increase in biodiversity, improved air quality, increased visibility of green solutions	Compliance, Local Identity & Image
City marketing	Visibility of green solutions, higher visibility, publicity	Local Identity & Image, Compliance
Health department	Improved mental and physical health	Compliance

[15] source: © BSU, Hamburg.de

[16] source: wikipedia.de

Social development department	Improved social cohesion	Compliance
Mayor	Publicity, public support	Local Identity & Image
Private Sector		
Gardening companies	Business opportunities (implementation & maintenance), marketing potential	Revenue & Income, Local Identity & Image
Local shops and restaurants	More foot traffic, employees using the space, space for commercial activities	Revenue & Income, Active Use
Event organisers	Business opportunities, potential venue for events	Revenue & Income, Active Use
Tourism	Marketing potential	Local Identity & Image
Solution providers (e.g. start-ups)	Business opportunities (implementation & maintenance)	Revenue & Income
Civil Society Sector		
Schools & educational institutions	Research opportunities, awareness raising, contact with green space	Active Use
Environmental NGOs	Increase in biodiversity, awareness raising, research opportunities	Compliance
Social NGOs	opportunity for social and integration programmes, improved social cohesion, awareness raising	Active Use, Compliance
Local building owners	Increased property value	Revenue & Income
Building resident	Sense of place, contact with green space, improved air quality, improved social cohesion	Local Identity & Image, General Wellbeing
Locals, families, pet owners, nature lovers, sportspersons, cyclists	Sports and recreation opportunities, contact with green space, sense of place, city cooling, better air quality, improved commuting facilities	Active Use, General Wellbeing
Low income households	Contact with green space, sports and recreation opportunities	General Wellbeing, Active Use

4.8.3 Associated evaluation tools

- **Green infrastructure valuation toolkit (GI-Val):** This toolkit provides a set of calculator tools which help to evaluate existing green assets or proposed green investments. Thereby 11 key benefits are assessed, including climate change adaptation & mitigation, flood management, quality of place, health & wellbeing, land & biodiversity, productivity, land & property values, economic growth & investment, tourism, products from the land, and recreation & leisure. Depending on the project, it provides outputs in monetary, quantitative, or qualitative terms: https://www.merseyforest.org.uk/services/gi-val/

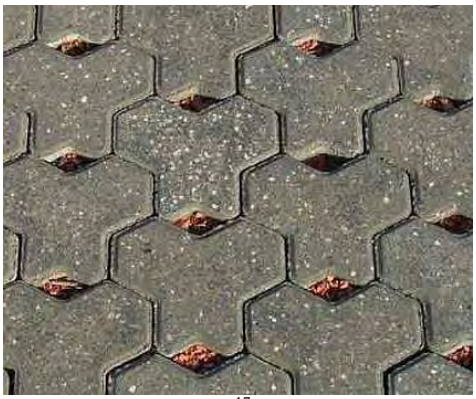
- **InVEST (Integrated Valuation of Ecosystem Services and Trade-offs):** InVEST includes a range of open-source software models for mapping and valuing ecosystem services provided by land- and seascapes. It uses environmental data to explore how changes in ecosystems may affect the flow of benefits to people. It is designed to inform decision-making on natural resource management. It uses input data (maps, GIS data and information tables) and helps preparing, processing and visualizing the data. Results are either displayed in biophysical or economic terms: http://www.naturalcapitalproject.org/invest/

- **Natural Capital Planning Tool (NCPT):** The excel-based tool allows users to assess the impact of new or proposed developments on the value of Natural Capital and ecosystem services. To do so, it calculates a project impact score (tool specific unit), which indicates the direction and magnitude of impact for 10 different ecosystem services, as well as for all services combined over a 25 year timescale: http://ncptool.com/

- **tessa - Toolkit for Ecosystem Service Site-Based Assessment:** The tessa toolkit is an interactive pdf document that provides practical guidance on how to identify ecosystem services which are significant at a given site of interest, what data is needed to measure them, and which methods and sources can be used and are most suitable to obtain the data. It furthermore gives recommendations on how to best communicate the results: http://tessa.tools/

4.9 Permeable pavements

4.9.1 Description



*(a)Permeable pave*ment[17]

(b)Permeable pavement with grass between bricks[18]

[17] source: Texas home and garden; www.texashomeandgarden.com
[18] source: Texas home and garden; www.texashomeandgarden.com

Permeable paving systems are known as surfaces that are able to absorb storm water and thus, minimise the surface water runoff. Different systems of permeable pavement surfaces exist. They are commonly installed on car parks, residential streets or sidewalks. Permeable pavers consist of concrete bricks with gaps or funnels between the single bricks or gaps and funnels between bricks are commonly filled with stone and sand or grass (vegetated grid pavers). After a storm water event, water trickles and/or infiltrates through the gaps and funnels between bricks. Then, water is temporary stored in underlying stone layers and infiltrates into the soil or to an additional drainage layer conveys water into sewage system (subsurface drain). Water can also be taken up by plants, if plants established in funnels between concrete bricks. As functions and beneficiary structures are rather similar for the different types of pavements, no distinction in different scenarios was necessary.

4.9.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Water department	Flood risk aversion, avoiding grey infrastructure upgrade cost (underground pipes)	Compliance, Cost Savings
Transport department	Enhanced road safety and comfort, reduced risk of flood damage	Compliance, Cost Savings
Private Sector		
Local shops and restaurants	Reduced risk of flood damage, reduced insurance cost	Cost Savings
Civil Society Sector		
Local building owner	Reduced risk of flood damage, reduced insurance cost	Cost Savings
Road users	Increased comfort (street use), safer roads	General Wellbeing

4.9.3 Associated evaluation tools

- **EPA Green Infrastructure Modeling Toolkit:** A collection of different tools and models to assess and manage water runoff in urban environments. The toolkit includes different green and grey infrastructure components. Examples are a storm water management model and a tool to model hydraulics and water quality issues: https://www.epa.gov/water-research/green-infrastructure-modeling-toolkit

- **Water Research Foundation Life Cost Models:** A set of spreadsheet tools which help users to understand and calculate the life cycle costs (capital & long-term maintenance) of different green infrastructure components. A registration is required to get access to the tools: http://www.werf.org/i/a/Ka/Search/ResearchProfile.aspx?ReportId=SW2R08

- **WinSLAMM:** WinSLAMM is a hydrologic tool which is used to predict stormwater flows and pollutant characteristics for a broad range of rains. It is based on actual field observations and includes a wide variety of control practices, including NBS: http://winslamm.com/winslamm_overview.html

- **BE£T (Benefits Estimation Tool):** The BE£T tool is used for valuing the benefits of blue-breen infrastructure, especially SUDS and natural flood management measures. It bases its assessment on the Ecosystem Services and the Triple Bottom Line criteria and will in future also provide Natural Capital Accounting. Many of the respected benefit categories have been monetised. Download requires login or registration at the CIRIA website: https://www.susdrain.org/resources/best.html

4.10 Constructed wetlands

4.10.1 Description

(a)Constructed wetlands[19]

(b)Urban wetland, Tanner Springs Park in Portland, Oregon[20]

Constructed wetlands represent artificial wetlands with the main objective to harvest, treat and store storm- and/or grey water runoff in urban areas. The processes and services of natural wetlands are adapted to constructed wetlands focusing on water purification and storage. Hydrological processes of natural wetlands are simulated in constructed wetlands. Wetlands are complex systems: The established vegetation, the soil and microbiological activity play an important role for the filter performance of constructed wetlands. Constructed wetlands are mostly shallow basins that are filled with substrate. The substrate type is variable but usually consist of sand or gravel. The substrate layer is planted with vegetation, e.g. aquatic plants. Constructed wetlands have an inlet for storm water runoff. The water flows horizontally through the wetland while it is naturally filtered and cleaned. The main processes in a constructed wet roof are: settling of particles, filtration, chemical transformation, adsorption, ion exchange e.g. on plants and substrates, as well as the uptake, breakdown, and transformation of pollutants and nutrients by microorganisms and plants. The storm water runoff can flow over or through the substrate layer. The constructed wetland is equipped with an outlet for controlled water discharge. The purified water then flows into another pond where it is stored and can be used for different purposes (e.g. for irrigation within the city in green areas). For the value model, no distinction between the different types was made.

[19] source: City of Melbourne 2015

[20] source: ennclosure and Cynthia Goodson; https://enclosuretakerefuge.com/

4.10.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Water department	Flood risk aversion, improved water quality	Compliance
Environmental department	Increase in biodiversity	Compliance
Private Sector		
Local industries	Improved water quality, employees using the space	Compliance, Active Use
Civil Society Sector		
Schools & educational institutions	Awareness raising , research opportunities	Active Use
NGOs	Increase in biodiversity	Compliance

4.10.3 Associated evaluation tools

- **Music by eWater:** The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) is a software that helps developers and planners to devise water sensitive urban designs (WSUD) and integrated water-cycle management in urban areas. It enables stormwater flow simulation, estimation of harvesting and reuse potentials, pollutant modelling, water balance modelling, comparison of different treatment scenarios and the planning of entire stormwater systems: https://ewater.org.au/products/music/

- **BE£T (Benefits Estimation Tool):** The BE£T tool is used for valuing the benefits of blue-breen infrastructure, especially SUDS and natural flood management measures. It bases its assessment on the Ecosystem Services and the Triple Bottom Line criteria and will in future also provide Natural Capital Accounting. Many of the respected benefit categories have been monetised. Download requires login or registration at the CIRIA website: https://www.susdrain.org/resources/best.html

4.11 Raingardens & bioswales

4.11.1 Description

Bioswales and raingardens are both rather small-scale interventions in the urban fabric with the primary function of collecting and storing surface runoff. It was estimated that the “use” by citizens and the resulting beneficiary structure will be rather similar. Thus, they were summarised into one NBS cluster, but represent two different scenarios:

(a)Bioswale[21]

(b)Small scale Raingarden[22]

A **bioswale** (a) is a vegetated, linear and low sloped pit often established in urban areas near or between roads with the objective to reduce flood risk during or after heavy rain events. The intention of bioswales is comparable to rain gardens. Bioswales absorb, store and convey surface water runoff (mainly draining from roadways) and also remove pollutants and sediments, when the water trickles through the vegetation and soil layer. The choice of vegetation for bioswales is variable but deep-rooted native plants are common and preferred. To support infiltration of water runoff, some swales are equipped with dams or similar constructions. Bioswales are not limited to a certain region or country. If properly planned and planted with native plants, a bioswale is a reasonable contribution to local storm water management and control.

A **raingarden** (b) is a kind of garden that primarily serves as area for water control (storage and infiltration) on a small-scale, especially in urban areas. Raingardens are established in artificial surroundings and catch water runoff from roofs, roads and other (sealed) surfaces. Stormwater runoff is drained into raingardens, where it is stored for a certain period, and infiltrates either into the ground soil or flows into the sewage system. A certain amount of water is taken up and transpired by plants. Different designs and arrangements of rain gardens are established and a variety of elements are used, such as grass filter strips, water ponds, mulch areas, planting soil, plants or sand beds. All the mentioned elements have a particular function for example slow down, reduce, filter and store water runoff or increase evapotranspiration. Beside their function to store and infiltrate storm water, raingardens have aesthetical functions and improve the amenity value. Raingardens are not restricted to a certain climate condition and can be found in different European countries. But, the selected plants and components should be native and well adapted to local climate conditions.

4.11.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Water department	Decreased pressure on water treatment systems, flood risk aversion	Compliance
Environmental department	Increase in biodiversity, visibility of green solutions	Compliance, Local Identity & Image
Transport department	Enhanced road safety and comfort	Compliance

[21] source: Soil Science Society of America (SSSA); www.soils.org

[22] source: Andreas Kis provided in: European Commission n.d.a

Private Sector		
Gardening companies	Business opportunities, marketing potential	Revenue & Income
Civil Society Sector		
Schools	Research opportunities, awareness raising, contact with green space	Active Use, General Wellbeing
Environmental NGOs	Research opportunities, awareness raising	Compliance
Local building owners	Marketing potential, reduction of water fees/costs, increased green space accessibility	Local Identity & Image, Cost Savings, Compliance
Building residents	Sense of place, contact with green space	General Wellbeing

4.11.3 Associated evaluation tools

- **EPA Green Infrastructure Modeling Toolkit:** A collection of different tools and models to assess and manage water runoff in urban environments. The toolkit includes different green and grey infrastructure components. Examples are a storm water management model and a tool to model hydraulics and water quality issues: https://www.epa.gov/water-research/green-infrastructure-modeling-toolkit

- **Green Values Stormwater Management Calculator:** This calculator allows a comparison of the performance, cost, and benefits of green infrastructure and conventional stormwater practices (in a monetary unit). It thereby focusses on the stormwater runoff reduction goal (volume-wise). It requires detailed input data for the existing site (e.g land use) and enables the assessment of a combination of green infrastructure components: http://greenvalues.cnt.org/national/calculator.php

- **Water Research Foundation Life Cost Models:** A set of spreadsheet tools which help users to understand and calculate the life cycle costs (capital & long-term maintenance) of different green infrastructure components. A registration is required to get access to the tools: http://www.werf.org/i/a/Ka/Search/ResearchProfile.aspx?ReportId=SW2R08

- **Recarga Model:** This model by the Winsconsin Department of Natural Resources enables the evaluation of different bioretention solutions and their performance. It simulates the movement of water throughout the facility. It can be used to define the scaling of a solution or to analyze the potential impacts of different design parameters. It is intended for use by highly technical professionals: https://dnr.wi.gov/topic/stormwater/standards/recarga.html

- **P8 Urban Catchment Model:** This model is used to predict the generation and transport of runoff pollutants in individually defined urban watersheds. It considers different elements of watersheds, solutions, particle classes and water quality components. It is intended for use by urban planners and engineers that are familiar with hydrologic evaluations: http://www.wwwalker.net/p8/

- **Music by eWater:** The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) is a software that helps developers and planners to devise water sensitive urban designs (WSUD) and integrated water-cycle management in urban areas. It enables stormwater flow simulation, estimation of harvesting and reuse potentials, pollutant modelling, water balance modelling, comparison of different treatment scenarios and the planning of entire stormwater systems: https://ewater.org.au/products/music/

- **WinSLAMM:** WinSLAMM is a hydrologic tool which is used to predict stormwater flows and pollutant characteristics for a broad range of rains. It is based on actual field observations and includes a wide variety of control practices, including NBS: http://winslamm.com/winslamm_overview.html

- **BE£T (Benefits Estimation Tool):** The BE£T tool is used for valuing the benefits of blue-breen infrastructure, especially SUDS and natural flood management measures. It bases its assessment on the Ecosystem Services and the Triple Bottom Line criteria and will in future also provide Natural Capital Accounting. Many of the respected benefit categories have been monetised. Download requires login or registration at the CIRIA website: https://www.susdrain.org/resources/best.html

4.12 Urban agriculture (community gardens & urban farming)

4.12.1 Description

(a) Urban Community garden, City of Powell US[23]

(b) Urban Farm, Sydney Australia[24]

Community gardens and **urban farming** are a ways to produce food in an urban context with the benefit of higher accessibility, less transportation costs and therefore less CO_2 emissions. Plants and/or animals are cultivated in and near urban areas and produce a variety of products (e.g. vegetables, fruits or dairy products), depending on climatic conditions, site conditions, available technologies and cultural preferences (Artmann and Sartison 2018). Urban farms most often produce food and sell these products directly on-site or on local farmers markets, distribute or collaborate with local restaurants or retail structures. The value model thereby distinguishes between two different scenarios, (a) community gardening with the main goal of enhancing social cohesion and enabling citizens to grow their own food, and (b) more production-oriented and large-scale farms which are centrally run and mostly for profit. Benefits and beneficiaries are expected to vary depending on the chosen scenario.

[23] Source: cityofpowell.us/residents/parks-recreation/community-garden/

[24] Source: https://sydney.edu.au/news-opinion/sydney-ideas/2018/urban-farming-feeding-the-future.html

4.12.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Environmental department	Raising awareness, strengthening local food production and sustainable farming practices, preserving local knowledge and culture	Compliance, Local Identity & Image
Social development department	Improved social cohesion, ensuring food security, opportunity for social and integration programmes	Compliance, Active Use
Mayor	Preserving local knowledge and culture	Local Identity & Image
Private Sector		
Farm operators	Business opportunities (selling of produce)	Revenue & Income
Local restaurants using the output	Source of local and fresh food production	Local Identity & Image
Civil Society Sector		
Schools	Awareness raising, research opportunities, contact with green space	Active Use, General Wellbeing
Environmental NGOs	Awareness raising, preserving local knowledge, species and culture	Compliance, Local Identity & Image
Social NGOs	Opportunities for social and integration programmes, improved social cohesion, awareness raising	Compliance, Active Use
Low income households	Free / cheap source of high quality food, contact with green space, recreation opportunities	Cost Savings, Active Use, General Wellbeing
Local residents	Free / cheap source of high quality food, contact with green space, recreation opportunities	Cost Savings, Active Use, General Wellbeing

4.12.3 Associated evaluation tools

- **InVEST (Integrated Valuation of Ecosystem Services and Trade-offs):** InVEST includes a range of open-source software models for mapping and valuing ecosystem services provided by land- and seascapes. It uses environmental data to explore how changes in ecosystems may affect the flow of benefits to people. It is designed to inform decision-making on natural resource management. It uses input data (maps, GIS data and information tables) and helps preparing, processing and visualizing the data. Results are either displayed in biophysical or economic terms: http://www.naturalcapitalproject.org/invest/

- **Natural Capital Planning Tool (NCPT):** The excel-based tool allows users to assess the impact of new or proposed developments on the value of Natural Capital and ecosystem services. To do so, it calculates a project impact score (tool specific unit), which indicates the direction and magnitude of impact for 10 different ecosystem services, as well as for all services combined over a 25 year timescale: http://ncptool.com/

- **tessa - Toolkit for Ecosystem Service Site-Based Assessment:** The tessa toolkit is an interactive pdf document that provides practical guidance on how to identify ecosystem services which are significant at a given site of interest, what data is needed to measure them, and which methods and sources can be used and are most suitable to obtain the data. It furthermore gives recommendations on how to best communicate the results: http://tessa.tools/

4.13 Vertical greening

4.13.1 Description

Musée du Quai Branly, Paris [25]

University building, Berlin-Adlershof[26]

Vertical greening is used as the general term for any vegetation cover on vertical surfaces, no matter where the roots are located. Similar to green roofs vertical greening can be differentiated according to the level of technical support that is needed to sustain vegetation. However since vertical soil itself has no model in natural settings, almost all types of vertical greening are "intensive" and therefore different characteristics are used to describe vertical greening. Furthermore, vertical greening can be build indoor or outdoor. The value model mainly distinguishes between two different scenarios, **façade greening** which is attached to a building, and **free-standing green walls**.

Both scenarios can technically be divided into two types, wall-bound greening which is a part of the facade or uses the facade for fixing panels and containers to it, and ground-based greening which employ climbing plants. Facade-bound greening is in most cases very intensively using technology for irrigation, and special substrates for reducing the weight of the green facade. Pre-cultivated panels or special plant pot systems are most often used. For light weight structures special tissues are used. Because of the thinness of the soil or substrate layers, temperatures below 0° C may be a problem. Some greening systems allow to remove the panels during winter.

[25] source: Greenroofs.com

[26] source: © Köhler; source: neuelandschaft.de

4.13.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Environmental department	Increase in biodiversity, decrease heat stress	Compliance
City marketing	Higher visibility	Compliance
Mayor	Publicity, public support	Local Identity & Image
Private Sector		
Gardening companies	Business opportunities, marketing potential	Revenue & Income
Local shops and restaurants	More foot traffic, marketing potential	Revenue & Income
Civil Society Sector		
Environmental NGOs	Increase in biodiversity, research opportunities, visibility of green solutions	Compliance, Local Identity & Image
Local building owners	Reduced energy consumption, marketing potential	Cost Savings, Local Image & Identity
Building residents	Visibility of green solutions, reduced energy consumption, less noise pollution	Local Image & Identity, Cost Savings, General Wellbeing

4.13.3 Associated evaluation tools

- **Living Architecture Performance Tool (LAPT):** Developed by the green infrastructure foundation, LAPT is a rating system to certify that green roofs and walls are designed to achieve certain measurable and replicable performance benefits. It consists of a 110-point system, encompassing 30 credits in the areas of water, habitat & biodiversity, innovation, management & operations, health & well-being, post-construction, energy and process. The tool is currently in piloting phase in North America: https://greeninfrastructurefoundation.org/lapt

- **BE£T (Benefits Estimation Tool):** The BE£T tool is used for valuing the benefits of blue-breen infrastructure, especially SUDS and natural flood management measures. It bases its assessment on the Ecosystem Services and the Triple Bottom Line criteria and will in future also provide Natural Capital Accounting. Many of the respected benefit categories have been monetised. Download requires login or registration at the CIRIA website: https://www.susdrain.org/resources/best.html

4.14 Landscape engineering

4.14.1 Description

(a)Living Fascine[27]

(b)Revetment under construction[28]

(c)Planted embankment mat[29]

This NBS cluster includes three main NBS: living fascines (a) which are bundled branches of dead of living wood that are covered with bushes to support slope stability; revetment with cuttings (b) where cuttings from willows or brushwood are used to protect the area from wind and water erosion; and planted embankment mats (c), which are used in combination to local vegetation to cover the area, slow down water velocity and promote sedimentation. In terms of scenarios, a distinction was made between the focus on the protection and stabilization of **water banks** and erosion control on **hillsides**.

4.14.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Water department	Erosion control, improved water quality	Compliance
Green space department	Erosion control, increasing blue green space accessibility	Compliance
Environmental department	Increased visibility of green solutions, Increased biodiversity	Compliance, Local Identity & Image
Private Sector		
Gardening companies	Business opportunities (implementation & maintenance)	Revenue & Income
Civil Society Sector		
Environmental NGOs	Increased visibility of green solutions, Increase in biodiversity	Local Identity / Image, Compliance
Water Associations (e.g. NGOs)	Erosion control on riverbanks, improved water quality	Compliance

[27] source: freitag-weidenart.com

[28] source: Jany, Angeika and Peter Geitz 2013

[29] source: Jany, Angeika and Peter Geitz 2013

4.15 Moss walls

4.15.1 Description

MoosTex: Test site for pollution absorbing noise protection wall[30]

City tree [31]

Mosses have compared to other plants a large bio-active surface, they transpire more and also actively reduce some pollutants. There is a range of test sites with open air experiments in order to test the effectiveness for fine dust and reduction and air quality improvement. Due to its large surface (in comparison to many other plants), mosses store a relatively large amount of water and at the same time provide a relatively large surface area for water transpiration. As a consequence the transpiration of water leads to a reduction of air temperature on a local scale. Due to these functions, moss has also been used in high tech product development. As example, the City Tree is a bio-tech-filter with the aim to improve the air quality in cities. It is a compact and mobile construction, vertically planted with different species of mosses on its front and back side. The moss surface contribute to improve the air quality through the binding of air pollutants like particulate matter and nitrogen oxide.

4.15.2 Usual suspect beneficiaries

Beneficiaries	Associated Benefits	Benefit Types
Public Sector		
Environmental department	Improved air quality	Compliance
Health department	Improved air quality, lower health expenditures	Compliance, Cost Savings
Private Sector		
Gardening companies	Business opportunities (implementation & maintenance)	Revenue & Income
Solution providers (start-ups)	Business opportunities (implementation & maintenance)	Revenue & Income

[30] source: Helix-Pflanzen

[31] source: greencitysolutions.de

Civil Society Sector		
Schools & educational institutions	Awareness raising	Active Use
Local residents, sportspersons, pet owners	Better air quality	General Wellbeing

5. FINANCING AND POLICY INSTRUMENTS

5.1 Overview

Based on an extensive literature review and the subsequent expert workshops, eleven integrated financing and governance models have been identified, which are listed below. The gathered content will be made available to the users of the Value Model, as one of the outputs of the simulation. In addition, this information will be presented to the UNaLab follower cities as inspiration cards to facilitate the Roadmapping process. The sample of such inspiration cards could be observed in *Figure 8. Drafted version of the Financing Inspiration Cards*

The identified financing and governance models include:

1. Municipal investment
2. Cross-departmental financing
3. Securing external financing from the EU and other funds, financing facilities and platforms
4. User fees
5. Mobilising investment from municipal enterprises/utilities
6. Green Barter (Public and Private Partnership)
7. Business Improvement District (Public and Private Partnership)
8. Private sector financing
9. Supporting grassroots initiatives
10. Crowd-funding / sponsorship
11. Community management/ownership of NBS

Figure 8. Drafted version of the Financing Inspiration Cards.

5.2 Municipal investment

This is a traditional top-down approach where municipality takes the lead in NBS financing by earmarking a share of public budget for the NBS implementation and maintenance. The municipal financing programmes might be a part of more overarching municipal, regional or national polices promoting sustainable urban development. Also, municipal investments in NSB could be supported by practicing innovative green public procurement practices.

5.2.1 Benefits

Municipal investments in NBS follow well-established and relatively simple processes for municipality.

5.2.2 Preconditions

Efficient municipal investments in NBS might call for:

- Central coordination
- Clear objectives
- Sufficient resources
- Dedicated budget for the projects
- Following innovative, green procurement guidelines instead of "lowest cost" practice
- Political support for NBS

5.2.3 Example

Alna Environmental Park in Oslo is a part of a large scale river day-lighting project led by the Oslo municipality. The Environmental Park is foreseen to run along the river Alna and transform grey infrastructure to accessible parks and recreation areas. The project is funded by the Oslo municipality in combination with national government transfers (source: (Naturvation n.d.).

5.3 Cross-departmental financing

NBS financing could be enhanced by promoting the communication, cooperation and cost sharing cost sharing across the budgets of different municipal departments. This could also mean establishing cross-departmental budgets for the multidisciplinary interventions, for example, setting up a dedicated sustainability budget. The usual suspects of the cooperating municipal departments could be:

- Green and blue infrastructure departments
- Health department
- Mobility department

5.3.1 Benefits

- More available funds for NBS financing
- Enhanced cooperation between departments

5.3.2 Preconditions

- Establishing the practice of communication and coordination among municipal departments
- Demonstrating and/or communicating the benefits of sharing the budget of NBS implementation

5.3.3 Example

Herron Park in Philadelphia has been reconstructed from a largely concrete covered area to an urban park with recreational amenities and stormwater management elements. The Philadelphia Recreation Department and the Philadelphia Water Department have funded this project in relation to the municipal strategy adopted by the city for implmeneting the imporvements in stormwater management and water quality in local streams and rivers. This approach focused on using green infrastructure to change the city's drainage and provide other benefits to the local community (source: (EPA 2017)

5.4 Securing external financing from the EU and other funds, financing facilities and platforms

External financing sources obtained through the EU and/or other funds and financing facilities can be an important source of NBS financing. Such financial instruments might facilitate the promotion of the desired policy shifts on a national, regional or global scale towards the desired NBS interventions and technologies. The funding programmes and tools listed below are examples of some of the most relevant contemporary financing possibilities made available to the cities across the world. These programmes are often associated with the EU, UN and other relevant research programmes and policies on climate change adaptation, biodiversity, ecosystem preservation, as well as sustainable development.

1. **European Regional Development Fund (ERDF).** Among other objectives, this fund focuses on ecosystems, bio-economy, SMEs, innovation, and climate change mitigation and adaptation. ERDF can provide funding through loans, microcredit, guarantees and equity, which can be combined with additional grants from ERDF (EIB 2015) . Often its funds can be accessed through local funds:

    a. **Green Infrastructure Community Engagement Fund** combines 0.5 million GBP of ERDF funding. Together with 0.7 million GBP of match funding, this fund will deliver 1.2 GBP million worth of support for community engagement projects in cities and larger towns in Scotland to make better use of the green space, or to develop community-led proposals on how it could be improved.

    Funding conditions:

    i. Projects must be located in population areas of 10 000 or more, and in the 20% most deprived areas according to the Scottish Index of Multiple Deprivation
    ii. Total project cost between 50 000 – 120 000 GBP

iii. The provided grant must cover 10-60 % of the total project cost
iv. The proposed project must be "additional"
v. Projects must encourage community engagement and raise awareness about green infrastructure
vi. Source & more information on Green Infrastructure Community Engagement Fund: https://www.greeninfrastructurescotland.scot/green-infrastructure-community-engagement-fund

b. **Urban Innovative Actions**: provides urban areas throughout Europe with resources to test new and unproven solutions to address urban challenges. UIA 5th Call for Proposals should open in September 2019.

Funding conditions:

i. Funding provided to urban authorities of more than 50 000 inhabitants, or a grouping of urban authorities with a total population of a least 50 000 inhabitants, located in EU-28
ii. Grants up to 80% of the total project value
iii. Provides up to 5 million EUR funding
iv. Source & more information on Urban Innovative Actions: https://www.uia-initiative.eu/en

2. **European Investment Bank (EIB) climate finance – Infrastructure & Environment** fund provides equity investment in equity, hybrid or debt funds supporting projects aligned with the strategic EU policy objectives, such as infrastructure, climate and environment. Source & more information on EIB Infrastructure & Environment fund**:** http://www.eib.org/en/products/sheets/infrastructure-environment-fund-investments-features.htm

3. **LIFE Environment and Climate action sub-programmes** provide funding for environmental and climate action including urban adaptation to the climate change.

Funding conditions:

i. Projects must be located in the EU
ii. Funding for best practice, pilot and demonstration projects
iii. Technologies and solutions must be ready to be implemented in close-to-market conditions, at industrial or commercial scale, during the project duration
iv. Grants cover up to 55% of the project funding
v. Source & more information on LIFE: https://ec.europa.eu/easme/en/section/life/life-environment-sub-programme

4. **The Natural Capital Financing Facility (NCFF)** supports projects oriented at biodiversity, ecosystem restoration and management, and nature-based adaptation to climate change. NFCC comprised of financing and technical facility components.
Funding conditions:

i. Projects exclusively located in EU-28
ii. Project size 2-15 Million EUR to be supported by the financing facility
iii. Financing up to75% of total project costs for direct debt financing and up to 33% of the total project cost when providing equity
iv. Funding lifespan of 10 years plus possible extensions
v. Projects need to generate revenues or demonstrate cost savings

vi. The eligible recipients of support could be public, private commercial and private non-commercial entities
vii. Grants up to 1 million EUR per project are available for the technical support
viii. Source & more information on NCFF: http://www.eib.org/en/products/blending/ncff/in-a-nutshell/index.htm

5. **Cohesion Fund** is aimed at EU Member States whose Gross National Income (GNI) per inhabitant is less than 90 % of the EU average. Environment and promoting climate change adaptation and risk prevention is one of its key strategic areas. The Cohesion Fund allocates a total of € 63.4 billion to activities**.** Main source & more information on Cohesion Fund: https://ec.europa.eu/regional_policy/en/funding/cohesion-fund/

6. **European Fund for Strategic Investments (EFSI)** supports economically viable, higher-risk projects focused on: strategic infrastructure; education, research, development and innovation; renewable energy and resource efficiency; and projects put forward by SMEs and small businesses.

Funding conditions:

i. Funding can be provided to private sector entities, public sector entities, banks and financial institutions, investment platforms and funds
ii. Debt financing
iii. The projects need to be economically feasible and bankable
iv. Source & more information on EFSI: http://www.eib.org/en/efsi/how-does-a-project-get-efsi-financing/index.htm

7. **European Investment Project Portal** is an online platform that enables business to advertise their innovative solutions and secure additional investments. The portal ensures high visibility for EU investment project promoters to showcase their European projects to potential investors worldwide. Source & more information: https://ec.europa.eu/eipp/desktop/en/index.html

8. **European Bank for Reconstruction and Development (EBRD)** offers a range of financial instruments to support the municipal and environmental infrastructure investments under its Green Cities programme. The bank can offer loans, guarantees and equity investments to cities.

Funding conditions:

i. Projects in South-eastern Europe, Central Europe, Baltic States, Eastern Europe and the Caucasus, and Central Asia
ii. Supports up to 35% of the total project cost for a greenfield project or 35% of the long-term capitalisation of an established company
iii. Project needs to be funded by additional sponsors or co-financiers
iv. Projects need to have the potential of generating revenue
v. Projects need to comply to the EBRD's environmental standards and those of the host country
vi. Projects need to benefit the local economy
vii. Source & more information on EBRD: https://www.ebrd.com/work-with-us/project-finance.html

a. **Green Cities Facility** provides funding for climate change adaptation and mitigation efforts that promote sustainable urban development. The facility is financed by EBRD with support from Green Climate Fund (GCF).

Funding conditions:

i. Funding is provided for cities in Albania, Macedonia, Serbia and Moldova, as well as in Armenia, Georgia, Jordan, Mongolia and Tunisia
ii. The facility will provide concessional loans, investment grants and support for technical assistance (Pyrkalo 2018).

2. **Horizon 2020** provides funding for innovative research and demonstration projects in the EU**.**

3. **Swiss Agency for Development and Cooperation** provides funding for projects on sustainable water management for ensuring water security by applying nature-based solutions for water.

Funding conditions:

i. Projects from Latin America, Africa and the Balkans. Project must include the cooperation in all three regions
ii. Funding provided to public and private entities, as well as non-profits
iii. Project size of 2.5-3.5 Million CHF
iv. Project duration of 3 years
v. Grant funding
vi. Source & more information https://www.shareweb.ch/site/Water/news-networking-tools/Lists/News/DispForm.aspx?ID=195&ContentTypeId=0x010400B54A060B26E5FC478F395091F5B606BA

4. **Sustainable Cities Impact Program by Global Environmental Facility** (GEF) provides support for cities to pursue sustainable urban planning and implement spatially integrated solutions towards achieving better and utilization of green space and infrastructure among other climate-oriented initiatives. This program is a national level funding program and it was kicked off in Brazil, China, Cote d'Ivoire, India, Malaysia, Mexico, Paraguay, Peru, Senegal, South Africa, and Viet Nam (GEF n.d.). It provides grant funding, which needs to be matched with national government funds. Main source & more information: https://www.thegef.org/sites/default/files/council-meeting-documents/GEF-7%20Programming%20Directions%20-%20GEF_R.7_19.pdf .

5.4.1 Benefits

Additional capital is made available to the municipality to implement NBS

5.4.2 Preconditions

- Satisfying the relevant eligibility criteria
- HR for reporting and other project-related paperwork
- Political support

5.4.3 Example

The city of Craiova in Romania has received a 15 million EUR long-term loan from EBRD to finance key urban projects in the city, which include the implementation of the green infrastructure. Under this programme, the EBRD will support the city of Craiova with developing a Green City Action plan which will look at ways to improve the urban environment, as well as invest in greener transport, water and waste management (source: (Rosca 2018).

5.5 User fees

User fees constitute an important share of the internal municipal revenue source. They are charges incurred by the citizens or companies in return for the delivery of specific services, benefits and utilities (Kamiya and Zhang 2016). User fees could also include contractual fees, such as fees incurred for using a public park as a venue for an event. Charging fees for usage of programmatic aspects of park and recreation services is one of the most common strategies for raising non-tax revenue from parks and green spaces (Minneapolis Park and Recreation Board 2015).

5.5.1 Benefits

- Additional revenue source for the local government, which enhance the financial resources of the local government and thus its ability to finance NBS
- Well-suited for charging the public goods and services

5.5.2 Preconditions

- Strong "users-pay" culture
- Users can afford to pay
- Clear value-added for the services

5.5.3 Example

New York City requires its residents and visitors to apply for a Parks Special Event Permit when organising events in the city parks that host more than 20 participants. The special permits are issued for a fee of 25 USD/permit. The Department of Parks and Recreation has estimated that in the fiscal year of 2018, event fees would constitute a little over 6% of their total revenue estimates (sources: (NYC Parks n.d.); (Mark-Viverito and Levine 2017)) .

5.6 Mobilising investment from municipal enterprises/utilities

Municipal enterprises are businesses owned by local governments that provide services and generate revenue for local communities (e.g. utility companies) (Community Wealth n.d.). Municipalities and municipal companies might want to co-invest in interventions that support achieving their strategic and political goals.

5.6.1 Benefits

- Additional source of capital
- Risk sharing
- Improved coordination between utilities and municipalities

5.6.2 Preconditions

- Existing municipal enterprises/utility companies
- Central coordination
- Clear and well-aligned objectives
- Sufficient resources
- Well-defined business case of investment

5.6.3 Example

Clean Rivers project is 2.6 billion USD project led by the DC Water utilities company in the District of Columbia (DC), USA (Adaptation Clearinghouse 2015). The project focuses on implementing large scale green and grey infrastructure upgrades including permeable pavements, green roofs, rain gardens, and rain barrels and downspout disconnections (DC Water 2015). The project is also aimed at supporting

local economy and creating green jobs. DC Water has raised a part of the capital needed for financing this project by issuing green bonds. This was a landmark transaction, as it was utility's first green bond and also the first century bond issued by a water/wastewater utility in the U.S. The issuance achieved its "green bond" certification based on the project's environmental benefits, which include improving water quality by promoting climate resilience and improving quality of life through promotion of biodiversity and waterfront restoration (DC Water n.d.).

5.7 Green barter (public-private partnership)

Businesses develop and/or maintain green space in exchange for a formalised right to use the values of those spaces for business purposes and profits. Green barters may involve small as well as medium sized sites and it could serve municipal as well as business objectives (Ambrose-Oji et al. 2017).

5.7.1 Main benefits

- Financial savings on investment and/or maintenance costs
- CSR enhancement and extra publicity for businesses
- Encourage private engagement in NBS development

5.7.2 Site-specific preconditions

- Vested interest from the private sector
- Good relationship between municipality and private sector
- Reliable and transparent contractual agreements

5.7.3 Example

Green Barter agreement between a private developer company and the municipality in Lodz, Poland. The developer of a newly established residential area suggested clearing and rehabilitating the adjacent public land that has been contaminated by construction waste. The private developer company was driven by the potential of improving the neighbourhood image and increasing the value of its property. This initiative was approved by the municipality of Lodz and the temporary public-private agreement was made. However, the ownership, as well as the subsequent maintenance of the said green space belong to the municipality of Lodz (source: (Ambrose-Oji et al. 2017)).

5.8 Business improvement district (public-private partnership)

Business Improvement District (BID) implies financing and managing improvements to commercial and industrial environments based on the consent by a majority of businesses (could include land owners and/or tenants) who accept an additional levy (Merk et al. 2012). This is a form of a partnership between public and private actors, as it is usually the municipality who carries out the desired implementation of the desired infrastructure improvements.

5.8.1 Main benefits

- Financial savings on investment and/or maintenance costs
- CSR for businesses
- Encourage private engagement in NBS development

5.8.2 Site-specific preconditions

- Vested interest from the private sector
- Good relationship between municipality and private sector
- Reliable and transparent contractual agreements

5.8.3 Example

The BID in Eindhoven is the largest BID in the Netherlands as it includes the entire city centre of Eindhoven. The income collected from the tax in the BID area is collected and managed by an independent association. It is spent on the local initiatives based on the proposals submitted by the local business community members. Even though the fund managing association is independent from the municipality of Eindhoven, the strategic city goals seem to be taken in consideration when allocating the funding. For example, projects aiming at improving the city image by introducing more greenery in the city have received financial support from the association. According to the municipal economic experts, the BID has proven to be a great instrument to mobilise the local business community members including local producers, retail chains and real estate owners and provide financial support for bottom-up urban greening initiatives (source: Hawxwell et al. 2018).

5.9 Private sector financing

Private companies integrate NBS into their processes and structures either voluntarily through marked based policy instruments, such as incentive systems or through coercion (binding regulation). Market-based mechanisms attribute a price to represent the costs of the environmental externalities caused by a private company and establish incentives (taxes, emission allowances, water charges, etc.) for economic actors to internalise these costs. The non-market based instruments, on the other hand, are aimed at use non-monetary incentives and imposition of restrictions and on private actors to induce a behavioural change (Cioffi et al. 2018).

5.9.1 Benefits

- Unlocking private sector investment in NBS
- Faster uptake of innovative technologies

5.9.2 Site-specific preconditions

- Regulations and incentive structures that encourage private investments
- Well-defined business case of investments in NBS

5.9.3 Example

Green roofs in Tampere. The private developers and building owners support the NBS implementation by setting up green roofs on their properties. Such private sector efforts are mostly guided by the municipal policies that require the construction companies to include a certain amount of green area in their new buildings. The municipality in Tampere has also introduced new planning tools like the Green Factor, which accounts for the green areas in land use and construction projects and thus facilitates the implementation of the NBS policy guidelines.

5.10 Supporting grassroots initiatives

Grassroots initiatives are relatively small scale initiatives, focused on a specific site, usually located on public or municipal land. Initiatives are normally started and maintained quite autonomously by local residents. They serve citizen and community objectives. By supporting grassroots initiatives municipality could save costs for greening.

5.10.1 Benefits

- Supporting sense of place
- Supporting ownership of public space
- Supporting social cohesion

5.10.2 Site-specific preconditions

- Grass roots organisations present
- Long term tenure and formal management agreements will support effective management

5.10.3 Example

DeRuigeHof grassroots association is managing around 13 ha of peri-urban green space in the southeast of Amsterdam. The local community formed the association in the 1980s to protect a green space that had begun to appear on abandoned construction sites, which are owned by the municipality of Amsterdam. The municipality granted the association the right to manage two sites of the municipal land for a symbolic €1 lease agreement. The activities of the association have involved conservation management on meadows, woodland and wetland, which has enhanced the quality of this unplanned green space in terms of wildlife, biodiversity and the connection of local people to the site (source: (Ambrose-Oji et al. 2017)).

5.11 Crowd-funding / sponsorship

Crowd-funding is a way of raising funds for a project, event or activity by asking a large number of people to each contribute a relatively small amount of money. Crowd-funding can be seen as a donation-based activity, where the donors do not expect a pre-defined return for the donation. Sponsorship, on the other hand, can involve contractual agreements between the sponsoring company and the recipient of the financial support. This can often imply granting advertising or promotion rights for the company.

5.11.1 Benefits

- Additional source of capital for the development of NBS
- Higher awareness of NBS
- Sense of ownership for investors

5.11.2 Preconditions

- Good publicity of the project
- more successful for obtaining physical assets than organizing work (e.g. maintenance)
- High utility for potential funders

5.11.3 Example

MyParkScotland offers an online platform created for raising funds for green spaces and parks in Scotland. The website combines elements of project funding for individuals and businesses in an attempt to contribute to the developing of the long-term sustainability and endowment funds. The company has developed a free Crowd-funding Resource Kit that provides guidance for groups willing to kick-off crow-funding projects. The project portfolio of the MyParkScotland includes crowd-funding initiatives aimed supporting and implementing green elements, educational events, as well as the built infrastructure (sports and children playgrounds) and monuments (source: (MyParkScotland n.d.)).

5.12 Community management/ownership of NBS

Management of NBS can be transferred to community groups. It can range from community adopting a green public element to a community asset transfer, which is a transfer of the ownership of the municipal asset to a community organisation. Community management/ownership transfer has potential to serve municipal as well as citizen and community objectives. Such initiatives are usually located on municipal land and may involve additional public assets (e.g. playgrounds, etc.).

5.12.1 Main benefits

- Fostering citizen engagement
- Financial savings on maintenance costs
- Supporting „Place making“ – local ownership over public space

5.12.2 Site-specific preconditions

- Engaged citizens
- Effective oversight by municipal authorities
- Good communication channels between citizen groups and municipalities
- Sufficient resources for tools & capacity building

5.12.3 Example

“Adopt a place” initiative in Barnet London. The residents of the Barnet borough in London are encouraged to apply for maintaining a local feature, green space or the entire street. The citizens can get involved with maintaining flower beds, watering green elements, planning and maintaining the projects, as well as raising funds for new park features. The “Adopt a place” initiative provides the residents with all necessary support, materials and tools. Groups that could benefit from this community management scheme include schools, local businesses, neighbourhood associations, sports clubs or groups, youth groups, ‘friends of parks’, or nature enthusiasts (source: (Barnet London Borough n.d.)).

6. NEXT STEPS

6.1 Testing and refining the value model

The collected data that has been described above will serve as initial basis to enable informed discussions on these issues within the UNaLab project. Three main feedback rounds are foreseen to better include the city perspective in the model.

Testing and refining the model – feedback from the UNaLab follower cities

Based on the data collected for the value model, Value Inspiration Cards (Figure 9**)** will be developed for use in the upcoming UNaLab roadmapping workshops in the follower cities. The cards contain the identified usual suspect beneficiaries with their respective benefits and will be used to a) identify beneficiaries for the respective follower cities projects at hand, and b) inspire and encourage discussions on how to involve them in the overall financing and governance scheme. The observation of the discussion along with the workshop outcomes will be documented and enable an evaluation and improvement of the value model.

Testing and refining the model – feedback from the UNaLab frontrunner cities

Secondly, the model will be refined based on experiences from the frontrunner cities once their interventions have been implemented and first monitoring results have been obtained. This will be done through short interviews with perceived local NBS beneficiaries on their respective costs and benefits using data from the value model and from WP3 results. These UNaLab stories on the value of NBS will be added to the case study pool of the value model. The outcomes and feedback of the UNaLab cities will be used to refine the value model database and tool.

Testing and refining the model – feedback from cities beyond UNaLab

To be able to test the value model beyond the scope of the UNaLab project, further NBS case studies will be identified and used as points of reference to validate and improve the underlying assumptions. Interviews will be conducted to test whether the benefits are perceived as such by the beneficiaries and whether they see added value and investment potential. This will test the assumptions in the model on value capture potential and places the value model in a wider discussion on new urban governance trends, focusing on leveraging private capital for NBS.

Figure 9: Drafted version of the Value Inspiration Cards.

6.2 Programming the value model tool

Once the value model has been tested in practise and refined and enriched based on UNaLab experiences, the updated data will be used to program an interactive tool which can be used as entry point within the UNaLab replication framework and is available to cities and interested parties beyond the UNalab project. The programming effort will be undertaken in close collaboration with WP7. A first draft of the tool and its potential design is depicted in chapter 3.

7. APPENDICES

Table 5: List of all identified benefits categorised according to benefit types.

Type of Benefit					
Revenue / Income	**Cost savings**	**Compliance**	**Active use**	**Local Identity / Image**	**General Wellbeing**
Benefits					
More foot traffic	Avoiding gray infrastructure upgrade costs	Flood risk aversion	Employees using the space	Sense of place	Contact with green space
Increased property value	Reduced energy consumption	Creating livable spaces	Using space for commercial activities	Increased visibility of green solutions	Better air quality
Business opportunities	Decreased pressure on water treatment system	Creating attractive urban spaces	Awareness raising	Publicity	City cooling
	Reduction of water fees/costs	Increasing blue/green space accessibility	Local water source	Marketing potential	Better water quality
	Mitigated water treatment costs	Increase in biodiversity	Potential for water reuse	Public support	Safer roads
	Reduced risk of flood manage	Improved air quality	Increased green space visibility	Source of local and fresh food production	Better social cohesion
	Reduced insurance cost	Strenghtening local food production and sustainable farming practices	Opportunities for social and integration programmes	Preserving local knowledge, species, and culture	Less noise pollution
	Free/cheap source of high quality food	Meeting water regulations	Sports and recreation opportunities		Improved mental and physical health
	Lower health expenditures	Improving water supply	Potential venue for events		Increased comfort
	Reduction in livestock losses	Improved water quality	Research opportunities		
		Decreasing urban heat island	Resting opportunities		
		Decreasing heat stress	Better commuting facilities		
		Decreased noise pollution			
		Enhanced road safety and comfort			
		Carbon sequestration			
		Higher visibility			
		Improved social cohesion			
		Improved mental and physical health			
		Ensuring food security			
		Erosion control			

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