URBAN NATURE ATLAS: A DATABASE OF NATURE-BASED SOLUTIONS ACROSS 100 EUROPEAN CITIES

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

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DISCLAIMERS:

Data collection was carried out between June-August 2017, the information presented in the report reflects the date of the data collection.

The results displayed in the online version of the Urban Nature Atlas may slightly differ from the results presented in this report, due to an additional round of data quality check performed between January-February 2018.

The use of this data for research and presentation purposes is possible upon the acknowledgement of the provided reference/ source.

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EXECUTIVE SUMMARY

Launched in 2016, the four-year NATURVATION project, funded through the EU Horizon 2020 Programme, seeks to map the nature-based solutions (NBS) landscape in European cities, understand what makes NBS work and use this knowledge to inform policy and practice. As one of the first tasks, the project set out to develop an Urban Nature Atlas with up to 1000 NBS interventions from 100 European cities. The Urban Nature Atlas is intended as the first systematic survey of NBS interventions in European cities, present the findings in an interactive online platform and provide a basis for the analysis of socio-economic and innovation patterns associated with urban NBS in Europe.

This report provides an overview of the Urban Nature Atlas and a first-order analysis of its content and thus offers a basic profile of urban NBS across Europe.

DEVELOPMENT PROCESS

The 100 cities covered in the Urban Nature Atlas include 94 cities from the Urban Audit[1] and NATURVATION's 6 partner cities (Barcelona, Győr, Leipzig, Newcastle, Malmö, and Utrecht). The 94 cities from the Urban Audit were systematically selected based on criteria and methods developed by Ecologic to ensure the representation of diverse urban and environmental conditions across Europe, while also taking geographical distribution into account.

The Urban Nature Atlas was developed between January and August 2017, and involved developing and piloting a questionnaire, technical design and testing of the web-based questionnaire, the development of data collection guidelines, the training of the data collectors, the population of the Urban Nature Atlas with the involvement of 20 interns from the Master's Programmes of CEU, Lund University and Utrecht University and the quality control of the submitted data. In total 997 questionnaires have been submitted and 976 processed for further analysis.

What are the key characteristics of NBS across Europe?

Data allows the characterisation of NBS based on their spatial scale and level of financing; the challenges they address and the type of organisation responsible for overseeing their implementation. Some of the patterns found include the following:

[1] http://ec.europa.eu/eurostat/web/cities/data/database

- **Urban setting:** Almost half of the NBS are parks or urban forests, 40% are associated with traditional grey infrastructures, while 30% involve blue areas.

- **Challenges addressed:** NBS are most likely to address challenges related to green space, habitats or biodiversity protection, but more than half of the initiatives are also related to land-use or urban development and health or well-being. One third of all projects also addressed water management and climate change.

- **Timescale:** 50% of the NBS were completed by June 2017, while 40% are in the process of implementation. There was a steep increase in the number of NBS after the mid-2000s.

- **Financing:** Almost half of the projects were medium size with a total cost between EUR 50K – 4 million and one third costed over EUR 4 million. Larger projects were more likely to involve green areas for water management, blue space and green buildings.

- **Governance arrangements:** 44% of the identified NBS were implemented jointly by governmental and non-governmental actors, while 30% and 26,5% were managed solely by governmental or non-governmental bodies. Public actors were more likely to be in charge of parks, while green buildings and community gardens were more frequently managed exclusively by non-governmental organisations. Co-governance was over 50% more common

WHAT DRIVES AND ENABLES THE IMPLEMENTATION OF NBS?

NBS are driven and enabled by several different governance, policy and financing arrangements. Main findings include:

- **Responding to challenges as a motivation to create NBS**: While in some cases NBS are focused on a single dominant objective, many address multiple objectives, recognising their multi-functionality potential and the fact that sustainability challenges are often systemically linked.

- **Initiating organisations and stakeholder involvement**: Over the period between 1990 and 2016 there was a strong decline in the number of NBS initiated by public bodies, while the number of NBS started by private and other groups increased. In terms of the forms of involvement 'information dissemination' stood out as more frequent, but there was also a sharp increase in 'co-planning', 'consultation' and 'joint implementation'.

- **Policy drivers as an engine for deploying NBS projects**: Local policies were found to most frequently drive NBS implementation, gaining further increased importance after 2011.

- **Financing NBS projects**: The majority of the NBS projects across almost all urban domains were financed through the budgets of local authorities.

WHAT ARE THE IMPACTS OF NBS?

Ecosystem services delivered by NBS impact a wide range of beneficiaries. Among others, the analysis found that 87% of all NBS claimed to deliver some type of cultural services; 69% and 65% regulating or habitat and supporting services; respectively; and 31% were reported to produce provisioning services. Wider environmental, social and economic impacts often included green space, habitats and biodiversity; urban development or regeneration and health and well-being benefits. The analysis also revealed that almost 90% of all NBS intended to deliver benefits to citizens at large or community groups, but also public bodies. While the impacts are overwhelmingly positive, in some cases negative impacts have also been recorded. Only about 10% of the projects had impact assessment tools, using a variety of approaches for the measurement of various environmental, economic and social impacts.

WHAT FUELS INNOVATION AND WHAT FORMS DOES IT TAKE IN RELATION TO NBS?

Almost 60% of the NBS involved some type of technological innovation, 45% social innovation, while almost 5% involved both, through initiatives such as ecodistricts, large-scale river and coastal regeneration or restoration projects, and the creation of multifunctional green-areas. The analysis also investigated whether innovation built on previous projects and whether it was transferred to new initiatives.

IS THERE A SYSTEM TO MONITOR AND COLLECT DATA AND IS THERE A SYSTEM TO ENABLE LEARNING?

Studied monitoring mechanisms included targets and indicators, monitoring reports, impact assessments and citizen involvement in assessments. However, less than 40% of projects had formal monitoring systems, used indicators in reporting, published monitoring or evaluation reports and/or involved citizens in monitoring efforts.

CONTENTS

1. INTRODUCTION

In the face of global change and growing environmental, economic and social pressures in an increasingly urban world, sustainable development and resilience are more important than ever for cities in Europe and beyond. Nature-based solutions (NBS) are seen to hold significant promise in enabling the urban transition to sustainability and meeting several sustainable development goals. They have potential to provide multiple benefits across a range of sustainability challenges facing cities – such as managing flooding, supporting improved health outcomes or creating places for social interaction and recreation.

The four-year NATURVATION project, funded under the EU Horizon 2020 Programme, seeks to assess the performance of NBS by examining the services they provide, their value and benefits, their scope in terms of the constituents (and potentially ecosystems) through which these are realised, as well as the dynamics and the politics of these interventions (including modes of governance, business/financing models and civic engagement) (Bulkeley, 2016). Launched in December 2016, it is led by Durham University and involves 14 partners including six Urban-Regional Innovation Partnerships (URIPs) across Europe.

The project website with further information is available at www.naturvation.eu.

1.1 INTRODUCTION TO THE URBAN NATURE ATLAS FOR MAPPING AND CHARACTERISING NBS IN EUROPEAN CITIES

One key aspect of the project is to develop knowledge beyond the analysis of individual NBS projects. As a first task, we set out to develop an Urban Nature Atlas with up to 1000 NBS interventions from 100 European cities. The aim was to create the first systematic survey of NBS interventions in urban environments in Europe and to be an interactive online platform which allows users to study how NBS are implemented in different European urban environments (Bulkeley, 2016). Subsequent tasks will include the analysis of NBS' socio-economic and innovation patterns, building on the data collected.

By choosing a representative sample of cities using the Eurostat Urban Audit , the project aimed to analyse which types of NBS are being implemented, where, how they are being delivered and the issues they are seeking to address, what is their

type, form, function and distribution. The Urban Nature Atlas presents the key characteristics of urban NBS[2]; the relation between urban NBS and economic development, social inclusion & health; and the types of innovation that support their uptake in different European contexts.

The results of the data collection are set to be used for the following purposes:

- Carry out the basic profiling of NBS interventions across Europe in order to understand their key characteristics.
- Create an interactive online platform, which allows experts and non-expert users to discover various NBS solutions and their basic profiles across Europe.
- Provide a basis for analysing the patterns between existing socio-economic contexts and the use of NBS in cities
- Provide insights into the characteristics, dynamics and barriers facing NBS innovation.
- Support case study selection to undertake an in-depth, internationally comparative analysis to identify the innovation potential of NBS.
- Inform capacity-building, communication, dissemination and impact activities of the project.

1.2 OUTLINE

This report provides a first analysis of the Urban Nature Atlas and basic profile of urban NBS interventions across Europe and is structured as follows:

- Section 2 provides a short overview of the methodology of the Urban Nature Atlas development, including the design of the concept; the city selection process as well as the approach to data collection, and discusses the limitations of the collected information.
- Section 3 includes a basic statistical analysis of NBS across Europe, including an assessment of the type of interventions; their spatial scale and level of financing; the challenges they address and the type of organisation responsible for overseeing their implementation.
- Section 4 discusses what has driven and enabled NBS, including governance arrangements; policies and financing.
- Section 5 delivers a short overview on the impacts of NBS, including the ecosystem services delivered beneficiaries affected by the different type of NBS.
- Section 6 presents the forms of innovations of NBS.
- Section 7 focuses on monitoring practices, including targets set and indicators applied, impact assessment mechanisms and citizen involvement in monitoring activities.
- Section 8 provides the conclusions and next steps.

[2] http://bit.ly/2pZNhiD

2.APPROACH AND METHODOLOGY

This section provides a short overview of the methodology of the Urban Nature Atlas development, including the design of the concept, the city selection, and the approach to data collection. The section also discusses potential limitations of the collected information.

2.1 DEFINITION OF NBS

According to the NATURVATION project, NBS are deliberate interventions that can be inspired by or support nature in addressing urban challenges, such as climate change mitigation, water management, land-use and urban development (Bulkeley et al, 2017). Within the project, existing green areas or structures are not considered de facto to be NBS. Instead, NBS are defined as being interventions that change or enhance the function of the area/structure to address current societal challenges.

Therefore, NATURVATION is interested in identifying solutions with such 'function-enhancing' features. For instance, an urban park itself is not necessarily an NBS. However, if it was transformed from unused railway tracks or includes permeable surfaces that can manage storm water, or if the management, ownership, organisation, financing of the park was purposefully changed to enhance its functions and value, it can be considered an NBS. In addition, the project considers that the use and the inspiration of nature to address an urban problem can be either a physical intervention or a discursive one. For instance, a park that has existed for 100 years can be considered as a NBS if it is repurposed as a solution to health problems, for example as a result of new efforts to create knowledge about how exercise improves mental and physical health and efforts to improve the accessibility of the park.

2.2 CITY SELECTION PROCESS

A systematic approach was applied to select the 94 cities included in the survey, in addition to the project's 6 partner cities (Barcelona, Győr, Leipzig, Newcastle, Malmö, and Utrecht). The aim was to select a city sample that ultimately represents

the varied urban and environmental conditions across Europe and which has a broad geographical distribution. While the process and indicators are described in more detail below, Figure 1 provides an overview of the 100 cities included in the Urban Nature Atlas.

ASSIGNMENT OF CITIES

NBS interventions are collected from 100 cities across Europe, as showned on the map.
The 6 URIP cities are highlighted.

Figure 1: Cities included in the Urban Nature Atlas

In the first step, a wide range of available indicators was assessed against a set of urban and environmental criteria. Relevant factors for selection include, for example, economic development, level of wealth, demographics, and city size (urban condition) as well as temperature, climate vulnerability, coastal/river location, proportion of green space (environmental condition). The sources of data for these indicators included the Urban Audit[3] (a database of European cities that is managed by Eurostat[4]), Copernicus/Urban Atlas data from DG Regio, and data from the FP7 RAMSES-research project[5]. Population size and unemployment were taken from the Urban Audit, as coverage[6] of the other indicators across European cities was quite low, and recent data from DG Regio on the share and access to green urban areas was considered. In order to reflect on the cities' climate vulnerabilities, data from the FP7 RAMSES project was also used[7], as they adopted a high-level climate risk analysis methodology for urban areas that provides a broad indication of climate risks facing cities across Europe (Tapia et al. 2016). The following table present the final indicators deployed for the selection process.

The application of these indicators resulted in an initial selection of 561 cities.

[3] http://ec.europa.eu/eurostat/web/cities/data/database

[4] Data collection is undertaken by the national statistical authorities, the Directorate-General for Regional and Urban Policy (DG REGIO) and Eurostat. The database provides statistics on a range of socioeconomic aspects relating to urban life in more than 900 cities, each with a population of at least 50,000 inhabitants in the urban centre, spread across the EU28.

[5] The NATURVATION WP2 team would like to acknowledge the contribution of the cities vulnerability indices by the RAMSES project, which strongly supported the selection process of the 100 NATURVATION cities.

[6] Refers to the number of cities for which data was available

[7] This data is not yet publicly available.

TABLE 1. INDICTATORS FOR THE CITY SELECTION

INDICATOR	DESCRIPTION	No. of cities covered	Source
Population size	Total no. of inhabitants in the city	829	Urban Audit (Eurostat), Indicator no. DE1001V
Unemployment	Total no. of unemployed persons (aged 15 to 74)	978[8]	Urban Audit (Eurostat), Indicator no. EC1010V
Green urban areas and forests	Share of green urban areas and forests (2012)	829	DG Regio[9] (based on Copernicus / Urban Atlas data)
Assessing access to green areas in Europe's cities	The share of population without green area within a 10-minute walk	829	DG Regio[10] (based on Copernicus / Urban Atlas data)
Climate risk vulnerability index	Average value of the following three indexes: relative heatwave vulnerability levels; drought vulnerability levels; relative pluvial flood vulnerability	571	RAMSES project[11], Tapia et al. 2016

In the second step, given that the project aimed to identify ca. ten NBS interventions in each city, all cities with a population of less than 250 000 inhabitants were removed from the list. This process reduced the number of eligible cities from 561 to 156.

In the third step, a scoring of the 156 cities was conducted based on an equal weighting of the remaining four indicators, i.e. Unemployment, Green urban areas and forests, Assessing access to green areas in Europe's cities and Climate risk vulnerability index. Each indicator was assigned a score and ranked from "worst" to "best" performance[12], resulting in four different sets of scores. Taking these outcomes into account for each criterion, a total score (represented as a cumulative number) was calculated for each city. The cumulative scores resulted in a total ranking of all 156 cities.

In a fourth step, in addition to the already confirmed six partner cities, three groups of cities representing different levels of performance were designated as a basis for selecting the remaining cities. Specifically, the cities with the highest, middle and lowest rankings in the sample were identified. To this end, the 94 cities in the sample include the 32 cities which were ranked highest, 30 cities ranked in the middle of the sample and the 32 cities ranked the lowest in terms of performance.

[8] For Romania, Cyprus, Slovenia and Poland average values and proxies have been used

[9] http://ec.europa.eu/regional_policy/en/information/publications/working-papers/2016/a-walk-to-the-park-assessing-access-to-green-urban-areas-in-europe-s-cities, see also: http://ec.europa.eu/regional_policy/sources/docgener/work/2016_03_green_urban_area.pdf (A walk to the park? Assessing access to green areas in Europe's cities. Last update in April 2017

[10] http://ec.europa.eu/regional_policy/en/information/publications/working-papers/2016/a-walk-to-the-park-assessing-access-to-green-urban-areas-in-europe-s-cities, see also: http://ec.europa.eu/regional_policy/sources/docgener/work/2016_03_green_urban_area.pdf (A walk to the park? Assessing access to green areas in Europe's cities., Last update in April 2017

[11] RAMSES: Reconciling Adaptation, Mitigation and Sustainable Development for citiES, http://www.ramses-cities.eu/

[12] E.g. the city with the highest employment rate was no.1 and the city with the lowest unemployment rate was no.156; the city with the lowest share of green urban areas was ranked no.1 and the city with the highest share of green urban areas was ranked no.156

Due to language limitations within the data collection team, six cities from the initial list of 94 cities were replaced in a final step with other cities which met the criteria above but where in addition there was sufficient language coverage.

A list of the 100 cities selected for inclusion in the Urban Nature Atlas can be found in the Annex of this report.

2.3 OVERVIEW OF THE DATA COLLECTION PROCESS

The Urban Nature Atlas was developed between January and August 2017. As a first task (January to March 2017), the structure and attributes were developed and organised in a questionnaire format by the Central European University (CEU) and Ecologic Institute teams, based on the review of existing databases and feedback from project partners. The questionnaire was then tested in the NATURVATION partner cities through the Urban-Regional Innovation Partnership (URIP) forum and the concept with the questionnaire was finalised in April 2017. The technical design and testing of the web-based questionnaire took place in May 2017. The Urban Nature Atlas was populated with data collected by 20 interns, using this online questionnaire, drawn from the Master's Programmes of CEU, Lund University and Utrecht University from June to Mid-August of 2017. Prior to the data collection, all interns took part in a one-day training organised by CEU based on the training manual developed by the CEU team. Data collection was supervised by the respective institutions for their own interns and had to pass a quality control by the project team at CEU. Data collection was completed by the end of August 2017. Data analysis and the development of the online public platform was launched in September 2017. The following figure presents an overview of the Urban Nature Atlas development process.

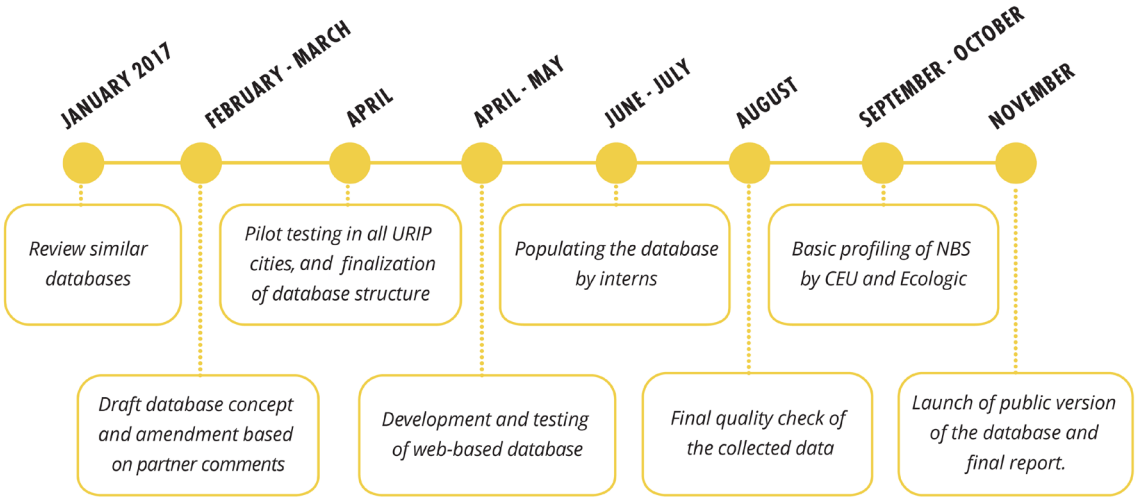


Figure 2: Overview of the Urban Nature Atlas development process

2.3.1 The structure of the Urban Nature Atlas

The questionnaire used for data collection contained seven sections and covers the key characteristics of urban NBS, governance arrangements that enable their implementation, direct beneficiaries and impacts, and the type of innovation of different NBS domains, among others. Details of the questionnaire are summarised in Table 2.

TABLE 2. OVERVIEW OF THE NBS QUESTIONNAIRE

Section 1. General Information	(i) **Location and description of the project** in which basic information about the intervention is requested such as the name of the project, country and city of origin, short description, (ii) **contact information** and (iii) **timeline**
Section 2. Objectives	Goals of the intervention, quantitative targets and underlying monitoring indicators, implementation activities and sustainability challenges addressed.
Section 3. Key characteristics	(i) **Ecological domain(s)** where the NBS was/is being implemented, (ii) **ecosystem services provided**, (iii) **spatial scale** and (iv) **primary beneficiaries**. The NBS ecological domains and scale were defined by the project, while the classification of ecosystem services used the TEEB classification system.
Section 4. Governance and financing	**Governance arrangements**, including (i) **key actors and stakeholders** involved in the planning and implementation of NBS, participatory methods used; (ii) **policy drivers** of the NBS intervention at EU, national and local levels; (iii) **enablers** of the project e.g., strategies, research projects, subsidies; (iv) **financing aspects**, such as the sources of funding, total cost and types of funding used.
Section 5. Innovation	**Innovation** potential with technological and/or social components, novelty level and replicability or transferability potential.
Section 6. Evaluating and Learning	(i) **Impacts** of the NBS intervention (environmental, social and economic) and which indicators were used to assess them; the (ii) **evidence for use of the assessment**; (iii) **presence of impact assessment mechanisms** and (iv) **if there was citizen involvement in the assessment/ evaluation and analysis**
Section 7. Sources	References and links to source materials used.

2.3.2 Data collection and quality control

The selected cities were distributed amongst 20 interns from the Master's Programmes of CEU, Lund University and Utrecht University, taking into account language capacities. The interns were requested to identify *up* to ten NBS interventions per city, while also aiming for a diversity of the selected interventions in terms of the ecological domains where they take place, the sustainability challenges they address or the governance arrangements they employ. Interventions were identified from city-level NBS/green or blue infrastructure strategies, climate change/biodiversity/green space/ smart city strategies; urban planning documents; online databases such as the Oppla.eu, Climate-Adapt, LIFE project database; from scientific literature or through targeted online search.

The analysis of the identified NBS interventions was based on secondary sources (e.g. project reports and other project documents, websites, news articles, research articles, studies and blog posts). Data was interrogated using discourse analysis. The intention was not simply to look for terms (e.g. nature-based solutions, green or blue infrastructure) but to search for patterns of discourse connected to those terms. Nevertheless, all answers reported in the Urban Nature Atlas are based, without exception, on factual information with a reference[13].

[13] A guidance manual (Nature-based Solutions Data Collection Guidance Manual), was prepared for the training of the interns who worked on collecting and reporting the data and contains further details on the data collection methodology.

As part of the data quality checking exercise performed in August 2017 by the supervisors and the CEU project team, all reported data was reviewed and any identified inconsistencies were corrected.

2.4 OUTCOMES OF THE DATA COLLECTION

While the data collection process aimed to identify up to ten interventions per city, this was not always possible due to the lack of information regarding such projects or because of a lack of NBS interventions more generally. In cases where it was not possible to find ten NBS interventions, local municipalities, researchers and individuals involved in GI/NBS projects were contacted in order to understand the situation and, if possible, gather additional information. Even after additional efforts, less than ten interventions per city were identified in some cities, such as Plovdiv (Bulgaria), Tallinn (Estonia), Sintra (Portugal), Craiova (Romania). In addition, during the data quality control process approximately 30 initiatives were found to be only marginally in line with the project's concept of NBS. These cases were decided to remain as "unpublished drafts" and were not processed for further analysis or inclusion in the online public platform. NBS interventions were considered marginal if they included primarily grey infrastructure elements; projects with controversial and potential negative impacts; or were largely policy tools (e.g. NBS-related strategies or plans) without information on actual implementation.

The majority of the questionnaire could be completed for most NBS initiatives. This was particularly the case for goals, activities, challenges addressed, ecological domain, ecosystem services provided, scale, beneficiaries and governance arrangements. The questions related to policy drivers, enablers and financing also had a relatively good coverage. However, questions on enablers and innovation aspects could not always be answered due to lack of available data. Information on evaluation and monitoring aspects were also often limited.

The questionnaires were made available in the internal area of the project website and the data was also transferred to a summary excel sheet to support further analysis. A first analysis of the results is presented as a basic profiling exercise in this report, and a clean version of the research database will be available for other projects. A public version of the research database is also being developed for wider, non-expert audiences.

2.5 LIMITATIONS AND FURTHER CONSIDERATIONS

As set out above, data availability was a problem in some cases, especially in smaller cities. Moreover, project documents can be confidential, limiting access. In some cities, the NBS interventions were limited to certain types (e.g. small-scale green infrastructure projects funded from city participatory budgets, allotment and community gardens) or had a generally weak innovation level.

Beyond limited data availability, some methodological issues also had to be tackled. The accuracy of the reported data was highly dependent on the discourse analysis approach and its application and the referenced information. In order to ensure consistency across the data collected, information collected through direct contact (e.g. phone calls, interviews) was not included in the Urban Nature Atlas unless a document containing the obtained data that could be referenced was available. On the other hand, contacting informants allowed a certain degree of autonomy for the interns to answer some questions (such as primary beneficiaries of the intervention or innovation type) and it was not possible for the quality control team to verify individual information sources, due to time limitations and language barriers.

Further limitations resulted from the time scale of the project. With approximately one week available for data collection per city, further research (e.g. contacting key informants) was not possible in some cases, if information on NBS was found lacking. In some instances, we did not have an intern who spoke the language of a given city; this obviously also affected the quality of data collection and the sources that could be used.

In some cases, the data analysis should also be interpreted with a degree of caution.

- First, due to the applied methodology of the data analysis, answers to certain questions, i.e. challenges addressed, ecosystem services provided, impact and beneficiaries affected, policy drivers and enablers were not necessarily exhaustive and based on objective assessment. This is due to the fact that these answers are the result of the analysis of secondary sources, project documentations; thus, reflect the discourse around the projects. When the answers are "perceived" by the available documentation, it is outlined throughout the report.
- Second, "unknown" answers to questions about governance, innovation and monitoring reflect the lack of available information online. For instance, while monitoring activities were not possible to identify for the majority of the studied projects, it is probable that such activities were carried out for a higher number of projects, but without disclosing information online.
- Third, analysis of projects distribution over the years, which forms the basis for some of the conclusions, should be studied with caution as the number of NBS interventions implemented over the years.

3. BASIC PROFILING AND KEY FINDINGS ABOUT THE NATURE OF NBS ACROSS EUROPEAN CITIES

This section includes a basic statistical analysis of the NBS interventions in the Urban Nature Atlas, including an assessment of the urban setting of the interventions; their spatial scale and level of financing; the challenges they address and the type of organisation responsible for overseeing their implementation.

The 100 cities covered by the survey included 94 cities selected from the Eurostat Urban Audit[14] to represent various urban conditions (in terms of e.g. economic development, proportion of green space, climate vulnerability) and the six URIP cities where further in-depth research during the NATURVATION project will be carried out. The cities included in the survey are shown on Figure 1.

As a result of the data collection carried out between June and August 2017, 997 questionnaires have been submitted. After a detailed quality check, 976 NBS questionnaires were processed for further analysis.

Regarding the phase of implementation, 489 of the 976 NBS were completed, 388 were being implemented, 51 were in the planning or piloting stage and 12 were envisioned. It was not possible to definitively conclude the stage of implementation for 36 projects, i.e. the project had multiple steps or the available project-related documents were inconclusive.

Regarding the start date of the implementation, a steep increase can be observed in NBS interventions after the mid-2000s: while in the year 2003 only 13 interventions were identified, this number has increased to 48 by 2010 and 101 in 2016 (see Figure 3). In the first half of 2017, the implementation of 71 other project has been already started. It is to be noted that the research also sought to identify those projects which fall under the umbrella of NBS but were not labelled in this way. This means it has captured a 'real effect' – the rise of nature-based solutions – rather than an increase in using this term.

The figure below provides an overview of the implementation starting date of those 827 interventions where information was available and implementation has already started.

[14] http://ec.europa.eu/eurostat/web/cities/data/database?p_p_id=NavTreeportletprod_WAR_NavTreeportletprod_INSTANCE_KhPDfq283AOB&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-2&p_p_col_count=1

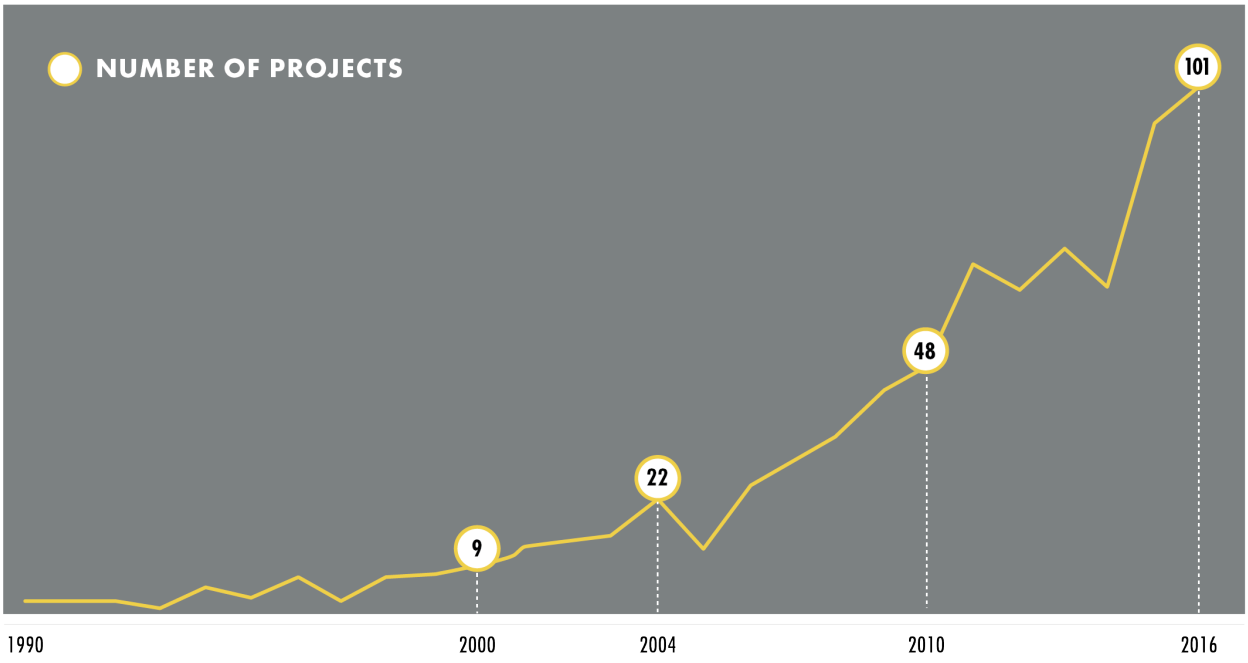


Figure 3: Implementation starting year of the studied projects[15]

3.1 URBAN SETTING OF THE NBS COLLECTED

In order to have a better understanding of where the NBS are physically located within the urban landscape, the NATURVATION project introduced the term "ecological domains" (Bulkeley, 2017). Since NBS can take various forms, the project – when establishing its framework in WP1 – distinguished the following categories adapted from different sources (Braquinho et al, 2015; Xing et al, 2017; Ecologic Institute, 2011, US EPA, Ndubisi et al., 1995):

- Building greens, such as green roofs and green walls;
- Urban green areas connected to grey infrastructure, e.g. alley and street trees, railroad bank, house gardens, green playground/ school grounds;
- Parks and (semi)natural urban green areas, including urban forests;
- Allotments and community gardens;
- Green indoor areas;
- Blue areas, such as rivers, lakes, seacoasts, wetlands;
- Green areas for water management, e.g. rain gardens or sustainable urban drainage systems;
- Derelict areas, abandoned spaces with patches of wilderness

As shown in Figure 4, the analysis of the data concluded that almost half of the studied projects were taking place in parks and urban forest areas and almost 40% of them in smaller green areas connected to a grey infrastructure. One third of the projects represented blue areas and one fourth of them were related to community gardens or allotments. The figure below provides and overview of the urban settings of the identified NBS projects per ecological domains where they took place.

[15] Projects with an implementation starting date before 1990 and after 2016 were excluded, in addition the information was not applicable or not available for an additional 124 interventions.

When reviewing the results, it is to be noted that one project could include more than one urban location/ ecological domain. Among the NBS projects in parks and natural urban green areas, 239 large urban parks, 195 pocket parks/neighbourhood green spaces and 121 green corridors were identified. Among NBS concerning smaller urban green spaces connected to grey infrastructure, 150 projects were carried out in alleys and streets, 96 in riverbanks and 94 are related to playgrounds and schools. As for projects in blue areas, 138 NBS were targeting rivers, 116 lakes and ponds and 83 wetlands, bogs and marshes.

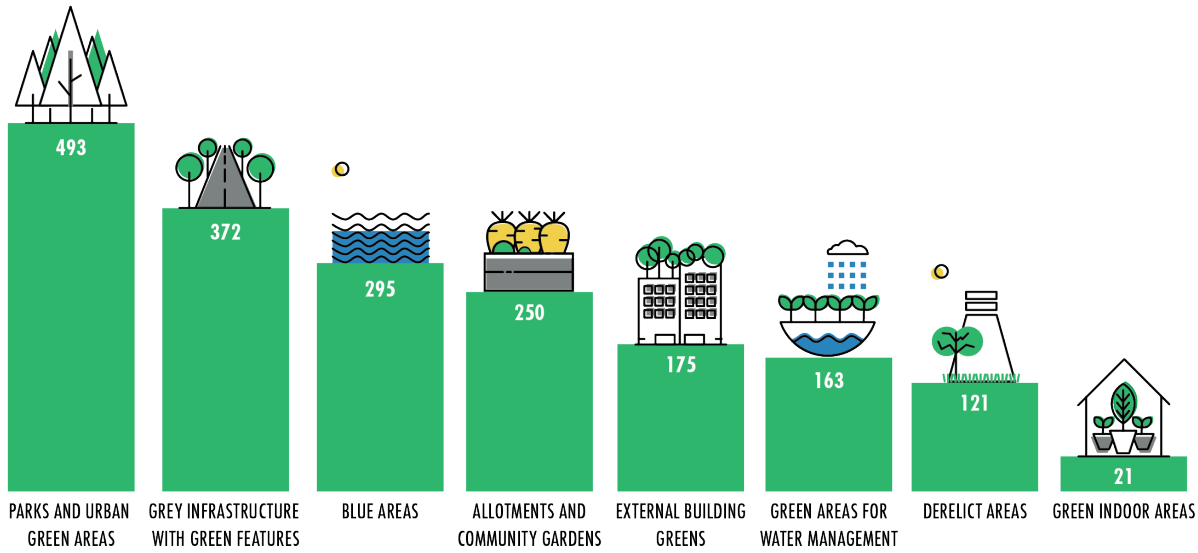


Figure 4: Urban setting of the studied projects per ecological domains[16]

While 422 projects (43%) took place at one type of location: i.e. they solely targeted a green roof development, a park renovation or the creation of a community garden, over half targeted more than one type of intervention. About 314 (32%) covered two, 146 (15%) three while 62 covered four domains (6%). Examples of NBS with multiple locations include:

- Park redevelopments along with the introduction of rainwater management solutions, such as the Liberty Square renovation in Bratislava, Slovakia or with community gardening opportunities; e.g. the Green Campus at the National Veterinary School of Toulouse, France.
- A combination of blue and green infrastructure solutions, like a planned restoration project at the Orteto river in Palermo, Italy which also included the creation of a natural park or the development of the Beach park in Bremen, Germany, which aimed both at the creation of a flood protection system and new recreational spaces.
- Green building solutions, which also offer green spaces for water management solutions and community gardening. For example, the Polder Roof Zuidas in Amsterdam, the Netherlands, offers an innovative green roof solution with a controllable water storage and drainage system on which crops are grown. The greening of the Opera building in Bialystok, Poland, included the creation of green roofs, green walls as well as small gardens and ponds.
- Larger-scale eco-district development projects, which encompassed various NBS solutions, including green buildings, urban green spaces and parks, water management solutions as well as blue infrastructures. Examples gathered in the database include the Eco City Augustenborg of Malmö and Hammarby Sjöstad of Stockholm, in Sweden; the Danube Eco-District project is Strasbourg, France and a Green and Sustainable Student Village in Bradford, UK.

[16] More than half of the studied interventions concerned more than one ecological domain, thus the overall number of identified domains is above the total number of identified interventions.

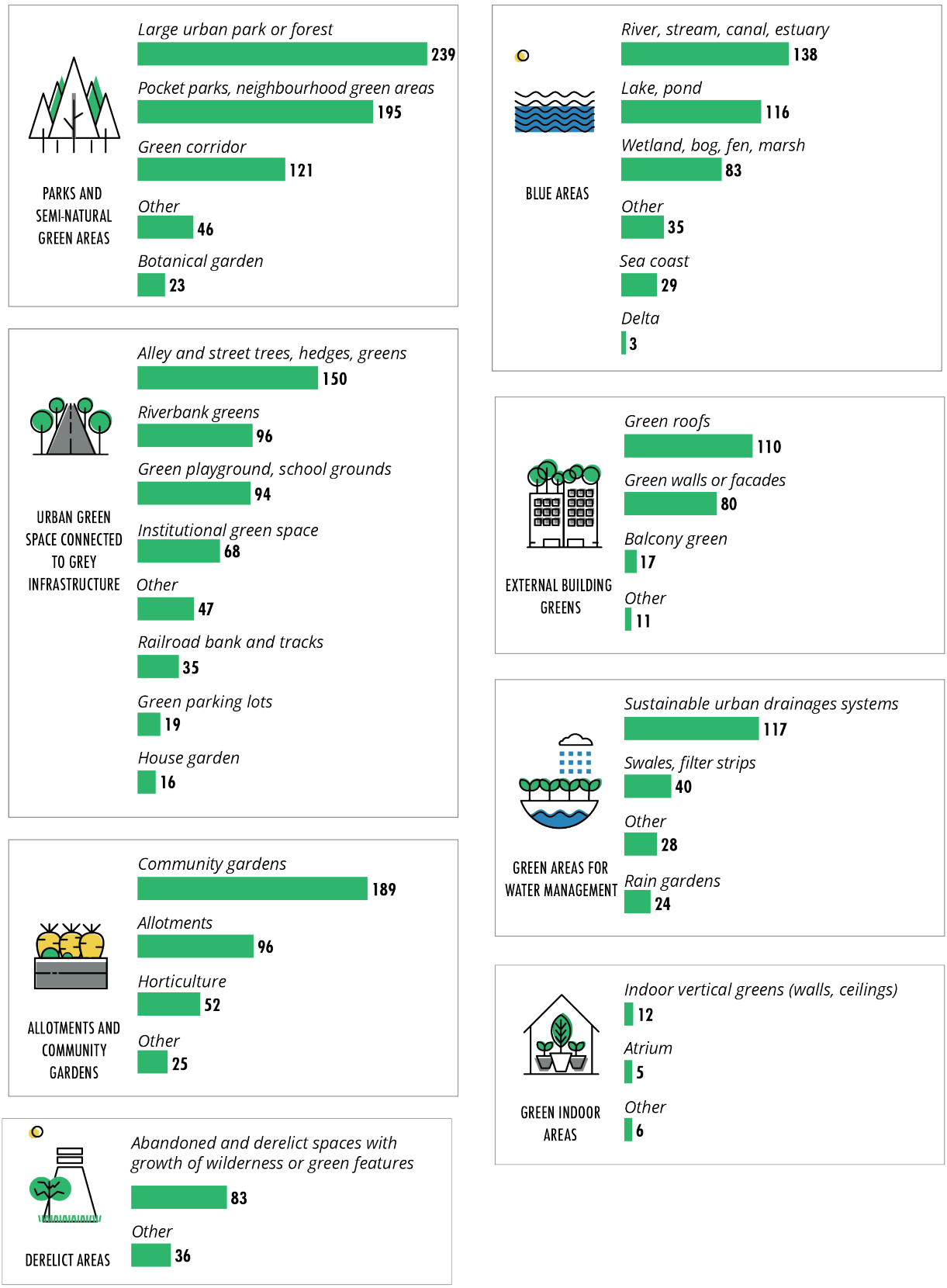


Figure 5: Urban setting of the NBS projects and their frequency among the NBS projects

Figure 5 provides an overview of the urban setting of NBS and their frequency among the projects for the most frequently selected ecological domains.

The analysis also suggests that NBS which took place at multiple urban settings or ecological domains were often more systemic in the development of NBS, trying to work across different flows and system in the cities and bringing more complex solutions to specific challenges.

3.2 SPATIAL AND FINANCIAL SCALE OF THE PROJECTS

Regarding spatial scale, almost half of the NBS (461) are at the neighbourhood or district-level, with almost 40% (380) on a street or building-scale, and just over 20% (221) operating on a larger, city- or regional-scale. About 8% of the projects were spread across more than one spatial scale. Examples include several unconnected buildings or streets in a city, such as the green facades initiative "Kletterfix" in Leipzig, Germany, which targeted individual buildings across the city. Other projects took place at the district level, but extended to more than one district across the city, such as the Aarhus River project in Aarhus, Denmark, that aimed at resurfacing the river, which was covered during the 1930s.

The analysis also suggested that NBS concerning blue areas were more likely to take place at the regional/urban level: 35% of all blue area NBS operated on a larger, city-level scale. At the same time, indoor or external green building initiatives appeared to take place as individual projects at the street-scale in more than 80% of all identified cases.

Concerning the level of financing for NBS, information was available for only 65% of the interventions. In the 632 cases in which the level of finance was possible to identify, the total costs of the interventions ranged as follows:

- Total cost below EUR 50 000: 16,3%, 103 NBS;
- Total cost between EUR 50 000 - 500 000: 22,3%, 141 NBS;
- Total cost between EUR 500 000 - 4 000 000: 25,6%, 162 NBS;
- Total cost above EUR 4 000 000: 33%, 209 NBS;
- No cost was incurred during implementation and/or it delivered cost savings: 2,7%, 17 NBS.

The figure below provides an overview of the level of financing in urban NBS.

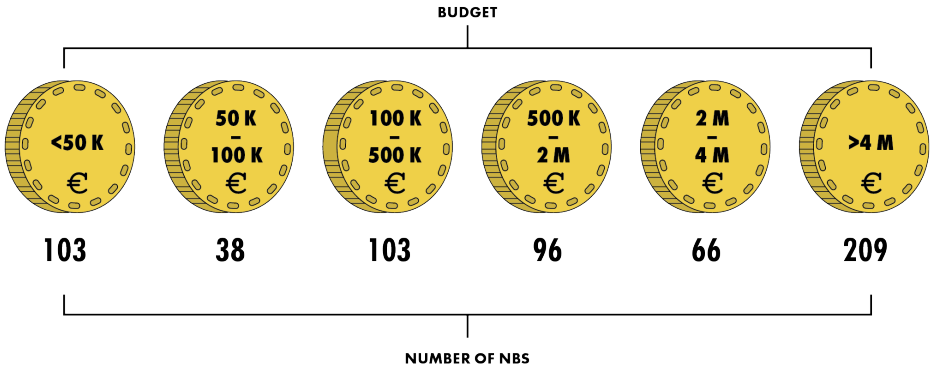


Figure 6: Overview of the level of financing of the identified nature-based solutions

Among the small-scale of NBS with a total cost below EUR 50 000, the data analysis identified more frequently allotments and community gardens - 29% of all projects - and less frequently water management solutions in green areas and blue infrastructure solutions – only 4% and 7% respectively. As for large-scale projects above EUR 4 000 000, the analysis concluded that projects taking place or involving green areas for water management and green building NBS were more likely to fall within this range. Almost half of all the NBS within these categories were large-scale investments. It of course raises the question whether these projects are in some sense "more valuable" as NBS or whether financing is more readily available at this scale for this kind of projects.

3.3 URBAN SUSTAINABILITY CHALLENGES ARE ADDRESSED BY NBS

Research shows that NBS can address a variety of challenges which are not only relevant for urban development, but also for wider global development challenges. Based on the review of state of-the-art literature and the UN Sustainable Development Goals (SDGs) (Raymond et al., 2017 and the UN General Assembly, 2015), the NATURVATION project defined twelve such urban sustainability challenges, which NBS can potentially tackle:

- Climate action for adaptation, resilience and mitigation (in line with the SDG 13)
- Water management (in line with SDG 6)
- Coastal resilience and marine protection (in line with SDG 14)
- Green space, habitats and biodiversity (in line with SDG 15)
- Environmental quality, including air quality and waste management (in line with SDG 11)
- Regeneration, land-use and urban development (in line with SDG 11)
- Inclusive and effective governance (in line with SDG 16)
- Social justice, cohesion and equity (in line with SDG 10)
- Health and well-being (in line with SDG 3)
- Economic development and decent employment (in line with SDG 8)
- Cultural heritage and cultural diversity (in line with SDG 11)
- Sustainable consumption and production (in line with the SDG 12)

The analysis of the collected data revealed that almost all NBS (843 projects, 86,37%) tackled challenges related to green space, habitats or biodiversity protection. Evidence was also found that 60% and 55% of the NBS addressed regeneration, land-use or urban development and health or well-being issues, respectively. Moreover, 351 NBS (36%) found to address water management issues and 319 (33%) targeted climate actions. On the other hand, only a smaller number of projects considered issues like governance, economic development or Sustainable Production and Consumption (SCP). The least addressed challenge, with 66 relevant NBS, was related to coastal and marine protection issues. This was however probably also due to the fact that only 30% of all studied cities in the Urban Nature Atlas are coastal cities. Challenges addressed by the studied NBS, with the applicable SDGs shown in brackets in Figure 7.

When looking at how different projects - taking place at various urban settings – were perceived to address various challenges, some variation could be observed. For example, while only 33% of all NBS stated that they have addressed climate challenges, green areas created for water management, such as rain gardens, swales/filter strips or sustainable

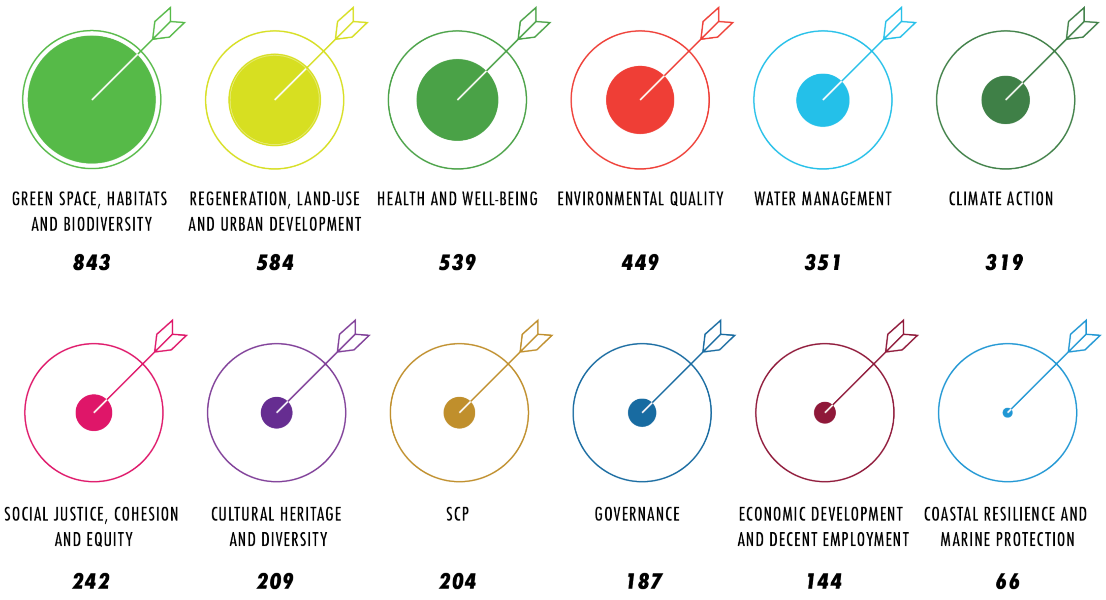


Figure 7: Frequency of sustainability challenges addressed by the studied nature-based solutions.

urban drainage systems were considered to tackle these issues at a much higher ratio, around 55%. At the same time, documentation about external green buildings identified climate issues at a smaller ratio than the average, at around 25%. On the other hand, environmental quality, including air quality, objectives were recognised much more prominently for green buildings and indoor areas: 64-67% of the intervention tackled this issue compared to a 46% average for all projects. It was also found that while governance, social justice and SCP matters were only addressed by approx. 20%- 25% of all NBS, community gardens and allotment projects seemed to consider these issues much more frequently (41%, 51%, 62% respectively). Considering the above, we can conclude that different kinds of NBS are more likely to tackle different problems and thus, it implies that if analysis focuses on NBS projects implemented exclusively in certain settings, it could alternate the overall picture of how they are addressing urban sustainability.

Figure 8 provides an overview of the extent to which NBS in different urban settings are recognised to address various sustainability challenges and Box 1 provides concrete examples of how various projects addressed different sustainability challenges.

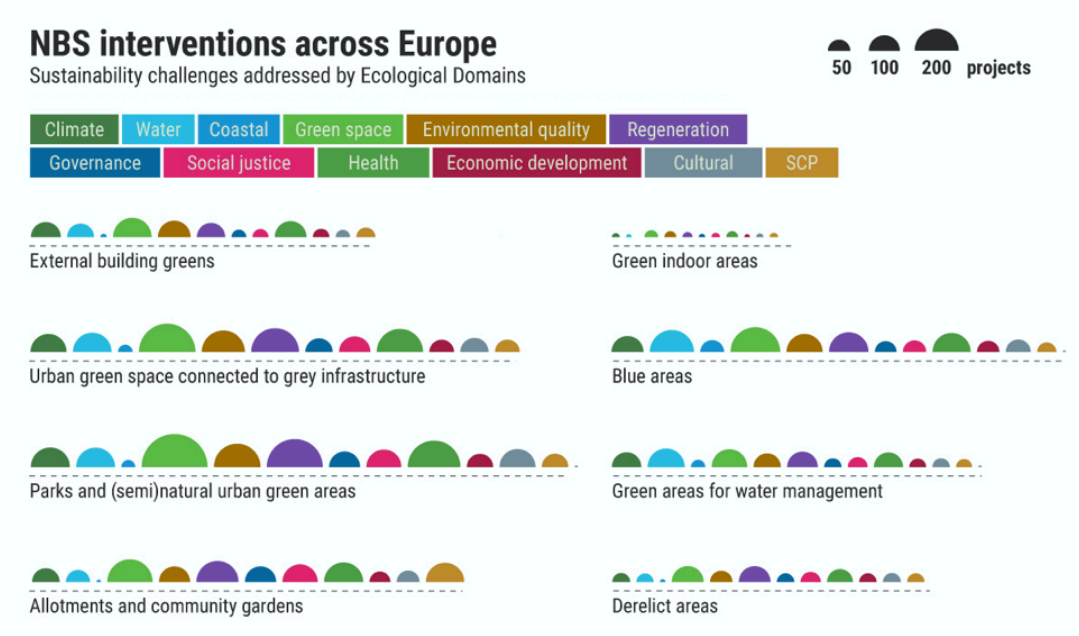


Figure 8: Sustainability challenges addressed by NBS in different urban settings

DRAINING BASIN OF THE VENICE LAGOON, ITALY

The Venice Lagoon is characterised by intensive agriculture and by a web of drainage channels discharging into the rivers. A project aimed at re-structuring the effluents of the mid-course of the Dese river (Rio S. Martino, Rio S. Ambrogio and Scolo Desolino). Such effluents are mostly draining channels, draining water from agricultural fields to the Dese river. The primary objective was the reduction of the amount of N and P reaching the Venice lagoon through phytodepuration, improving the water quality by retaining significant amount of nutrients that can be retained by such measures and the reduction of flooding issues affecting the area. As a result, the project was considered to address the following sustainability challenges:

- Water management (SDG 6)
- Coastal resilience and marine protection (SDG 14)
- Green space, habitat and biodiversity protection (SDG 15)

Source: NWRM (2017)

TELEKI SQUARE COMMUNITY PARK – BUDAPEST, HUNGARY

The square is located in the most stigmatised area of Budapest, the 8th District. The project was part of the third phase of the socially sensitive urban regeneration programme of the neighbourhood, the so-called Magdolna Quarter Programme III. The park was renovated with the involvement of local people. Local participants later established an association that provides them a legal frame for taking care of the park. The aim of the project was to strengthen social cohesion and to ensure the sustainability of the newly renovated park. As a result, the project was considered to address the following sustainability challenges:

- Regeneration, land-use and urban development (SDG 11)
- Inclusive and effective governance (SDG 16)
- Health and well-being (SDG 3)

Source: REV8, 2012

SCIENCE CENTRAL BLUE-GREEN INFRASTRUCTURE - NEWCASTLE, UK

Science Central is Newcastle's flagship project aiming to create a global centre for urban innovation. The 24-acre site has been at Newcastle's industrial heart for 200 years. The site is transforming into an exemplar of urban sustainability, a 'living laboratory' where it will trial innovative urban technologies. (Northumbrian Water, 2012 and Newcastle University, n.d.) Science Central has been studied as such in the GUST project. The different aspects of the green-blue infrastructure are being developed with different aims: • The carbon capture and storage garden – aims include: applying research knowledge to practice and carbon capture and storage. • Sustainable urban Drainage Systems (SuDS) - aims include: applying research knowledge to practice and reducing the risk of surface water flooding. (Newcastle University, n.d. and NCC, 2016). The project was considered to address the following sustainability challenges:

- Climate action for adaptation, resilience and mitigation (SDG 13)
- Water management (SDG 6)
- Green space, habitats and biodiversity (SDG 15)
- Economic development and decent employment (SDG 8)

Sources: Northumbrian Water, 2016, Newcastle University, n.d.; NCC, 2016

3.4 TYPE OF ORGANISATION RESPONSIBLE FOR OVERSEEING NBS IMPLEMENTATION

In terms of governance arrangements, 44% of the identified NBS (428 projects) were implemented jointly by governmental and non-governmental actors. 289 (30%) and 259 (26,5%) were managed solely by governmental or non-governmental bodies, respectively. Among those NBS where non-governmental actors were leading or co-managing the process, private sector organisations, citizens or community groups and NGOs or civil society organisations were the most commonly involved (see Figure 9).

Government was the most common actor in charge of parks or urban forests and blue areas or green areas for water management (35 – 38%). Green buildings and allotments or community gardens were more frequently managed exclusively by non-governmental organisations: 54% of all green buildings and 44% of all community garden/allotments. Co-governance was more frequent than the average, above 50%, for NBS that involved green areas for water management and blue areas. Since projects in these urban settings were also more likely to be the largest and the most well-funded projects, we hypothesise that these NBS projects might be more strategic and systematic ecologically, economically and/or politically.

The analysis also shows that NBS led by non-governmental actors are more likely to take place at the street or building level and larger, district or city-level projects are more likely to be government-led or co-governed. Similar conclusions were drawn in terms of the financial scale of the studied NBS. Projects led by non-governmental actors were predominantly smaller (below EUR 50 000) and government-led projects were more commonly larger projects (above EUR 4 000 000).

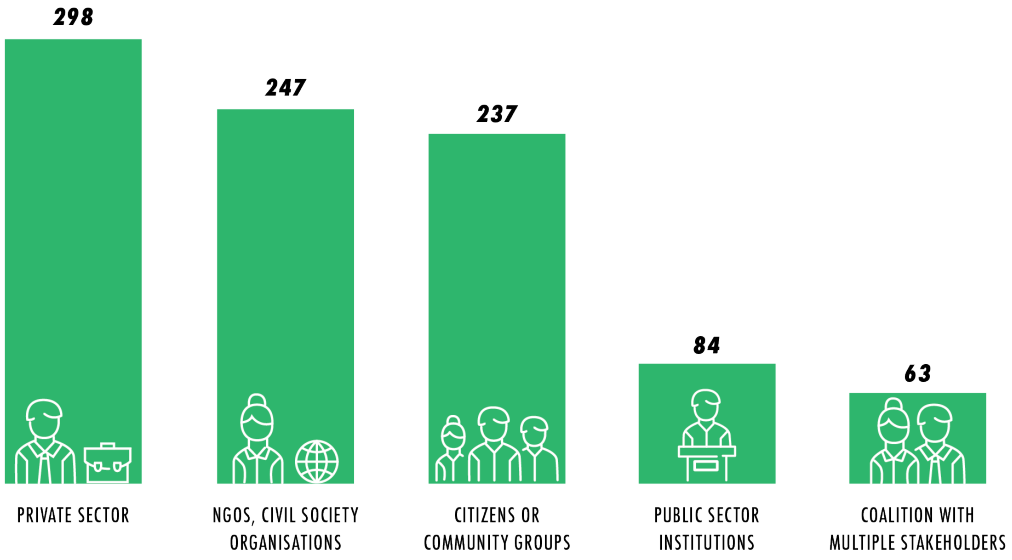


Figure 9: Type of stakeholders involved in overseeing the implementation of nature-based solutions in co-governance or hybrid projects and in projects led by non-governmental actors.

4.WHAT DRIVES AND ENABLES THE IMPLEMENTATION OF NBS?

This section discusses what has driven and enabled NBS, including governance arrangements, policies and financing. In this chapter, trends over time are discussed based on the start date of the project planning (as opposed to the start of project implementation). As there was only a maximum of ten entries per year between 1990 and 2000, the results should only be seen as indicative given the small sample size in these years. Also, the percentages for each aspect in this chapter do not necessarily add up to 100%, as multiple entries were allowed.

4.1 RESPONDING TO CHALLENGES AS A MOTIVATION FOR CREATING NBS

NBS address a variety of sustainability challenges (see Chapter 3.2), in fact often addressing more than one issue in parallel. In some cases, NBS are motivated by the wish to fulfil a single dominant objective. Due to their nature, however, wider challenges are usually addressed alongside the original aim and are considered to be co-benefits. In the case of the "Social garden in Wolfartsweier" (Karlsruhe, Germany), for example, the "social garden" was initiated in 2009 to facilitate access to the labour market for disadvantaged individuals having experienced long-term unemployment (BNN, 2014; Initial Karlsruhe, 2010). While this central aim is achieved through the integration and teaching of employees on how to take care of the garden and its produce, the project also creates a number of additional benefits. The provisioning of healthy, local food to a local farmers market and to homes of socially deprived citizens supports sustainable production and consumption, and the regeneration of an older property provides a new green space in the city.

However, many NBS recognise this multi-functionality potential from the start and design NBS with the specific aim of addressing multiple challenges in parallel. This reflects an understanding that sustainability challenges are often systemically linked and addressing them effectively requires high-leverage NBS that address several problems at the same time. In Liège, Belgium, for example, the project VERDIR - "Sustainable Rehabilitation and Responsible Innovation" - was initiated to develop local economic activities based on urban and peri-urban agriculture, by converting brownfield sites into a large-scale site of production of vegetables and plants. Alongside the improvement of environmental quality through the regeneration of 'waste' lands, the project also improved quality of life and health of urban residents through access to fresh produce, the conversion of waste land into a more attractive landscape, and the promotion of social cohesion and economic development through

Box No: 2

CO-INITIATION AND IMPLEMENTATION OF A GREEN PUBLIC SQUARE IN UTRECHT, NETHERLANDS

Neighbourhood Green Plans ('Wijkgroenplannen') was a co-initiative of Utrecht Municipality and the local NGO Natuur en Milieu Utrecht to address urban heat stress and air pollution. The planning of the initiative began in 2012, with the implementation taking place from 2013 to 2015. Citizens were involved in the design, implementation and monitoring of the initiative, starting with Natuur en Milieu Utrecht encouraging citizens to propose plans to enhance their neighbourhood by means of green spaces that promote social cohesion. With the help of architecture firm AM Landskab, proposed plans were submitted to the municipality, which then evaluated the plans against set criteria and their respective budgets. The co-planning of this initiative further draws on citizen involvement through ongoing maintenance of the created green spaces, which becomes the responsibility of a neighbourhood task force.

Sources: Gemeente Utrecht (2013), NMU (2015), AM Landskab (2017)

the creation of skilled jobs and the hiring of low-skilled workers in urban areas (Rentier, nd; VERDIR, 2013 ; EIO, 2015).

4.2 GOVERNANCE ARRANGEMENTS AND PARTICIPATION

Various types of (polycentric) governance arrangements are possible within the context of initiating/planning, implementing and monitoring NBS, ranging from policy mandated top-down processes to bottom-up grassroots initiatives or a combination thereof. Each of these processes, in turn, has the potential to involve an array of stakeholder groups from the public, private or other sectors. Historically, public institutions and governance bodies have been the main initiators of NBS projects (EC, 2015; Raymond et al., 2017) as many of the challenges they target can be traditionally viewed as topics or areas for government management, e.g. urban spatial planning and zoning, flood management, designation and use of public spaces, coastal defence, etc. Yet, increased support of NBS research and innovation in policy agendas and available funding streams has promoted a diffusion and awareness of the concept and its potential to provide multiple benefits in parallel (Eggermont et al., 2015). As a consequence of these developments and the often-increasing climate-related threats facing cities, the frequency of grassroots-based involvement in NBS design and implementation has increased, involving local populations and communities far more than has been the case until now (Dennis and James, 2016; Raymond et al., 2017).

While the general governance issues were highlighted in section 3.2, this section elucidates the type of actors involved in starting NBS projects and that are involved in various forms throughout implementation and potentially monitoring activities, as well as trends in how their participation varied over time. The dates provided for the various entries are based on the year in which the project implementation began for the respective projects (as opposed to when project planning began).

On this basis, Figure 10 highlights the type of organisation (public, private or other) responsible for initiating NBS projects. By taking account of these considerations, the database entries identify the type of stakeholders that have been involved in the NBS projects, distinguishing between public, private, or other and allowing for multiple entries to signify the existence of collaborations. *Public stakeholders* include EU bodies, multilateral organisations and national/regional/local/ governments, while *private stakeholders* include non-governmental organisations, business associations/ companies, and private foundations. A final '*other*' category includes transnational networks, communities, individuals, or any other type of participant. Of the total 976 projects included in the Urban Nature Atlas, only 841 projects had known project implementation dates with some form of initiating organisation. Calculations did not take into consideration multiple entries within one category (public, private or other), and only count

the binary presence of one initiating organisation per category. For example, if a project had EU bodies and multilateral organisations as initiating actors (both groups in the 'public' category), it would only be counted as one for public initiation, so as to reduce double counting. As Figure 10 shows, an increase in the number of all initiating organisations can be seen over the years, though *public* initiation can be observed as the dominant initiator in all years between 1990 and 2016. *Private* and *other* actor groups have become more active over time, while still remaining less active than public organisations. Collaboration projects are not illustrated in Figure 10 below, but can be seen in the illustrative example of the "Green Public Square" in Utrecht (NL) (see Box 2).

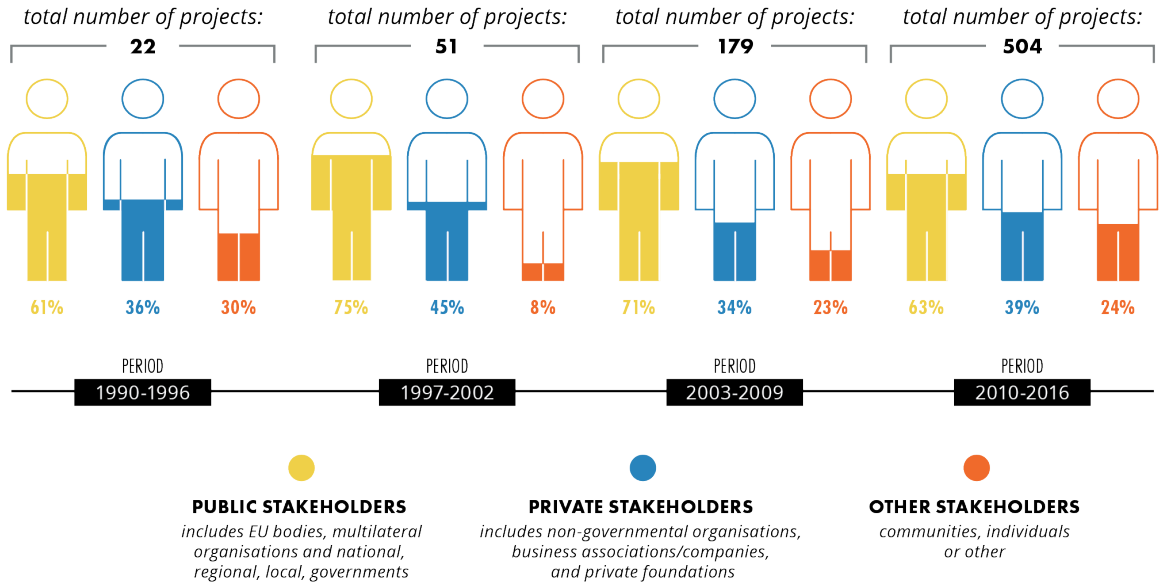


Figure 10: Percentage of nature-based solutions per initiating organisation type at the start of project implementation (1990-2016)

Active stakeholder participation in NBS projects has been widely found to create more legitimate and informed planning processes, which account for and deliver to society's needs (Wilker et al, 2016). In particular, partnerships amongst different actor groups during the design, implementation and monitoring phases can serve to more efficiently utilise available resources, experiences and expertise and therewith generate more locally applicable NBS designs while also building social capital (Hansmann et al., 2016).

Based on the year that the project implementation began, the analysis reveals the trend in stakeholder involvement overall. As opposed to the calculations done for Figure 10 and initiating organisations, this analysis does count the multiple entries for all projects with known information (841). This calculation allows for the representation of multiple forms of stakeholders within one category. As illustrated in Figure 11, public actors have been heavily involved in almost all projects with known information between 1990 and 2016. The role of 'other' actors has increased over this period, as can be seen in the involvement of private actors, though both are less represented than public actors.

Ten overarching types of participation were identified to learn more about the type of involvement of these stakeholder groups in the various NBS projects, plus an 'other' and an 'unknown' category. These forms of participation include: 'citizen monitoring and review', 'citizen oversight', 'citizen science', 'co-management/ joint implementation', 'consultation', 'co-planning', 'crowd-sourcing/ crowd funding/ participatory budget', 'dissemination of information and education', 'joint implementation', and 'taskforce groups'. The percentage of projects employing these methods was reviewed over time (1990-2016), drawing attention to positive or negative trends in deployment. Again, it was possible to identify several forms of participation within a single project – meaning that the percentages do not add up to 100%. Keeping this in mind, the analysis

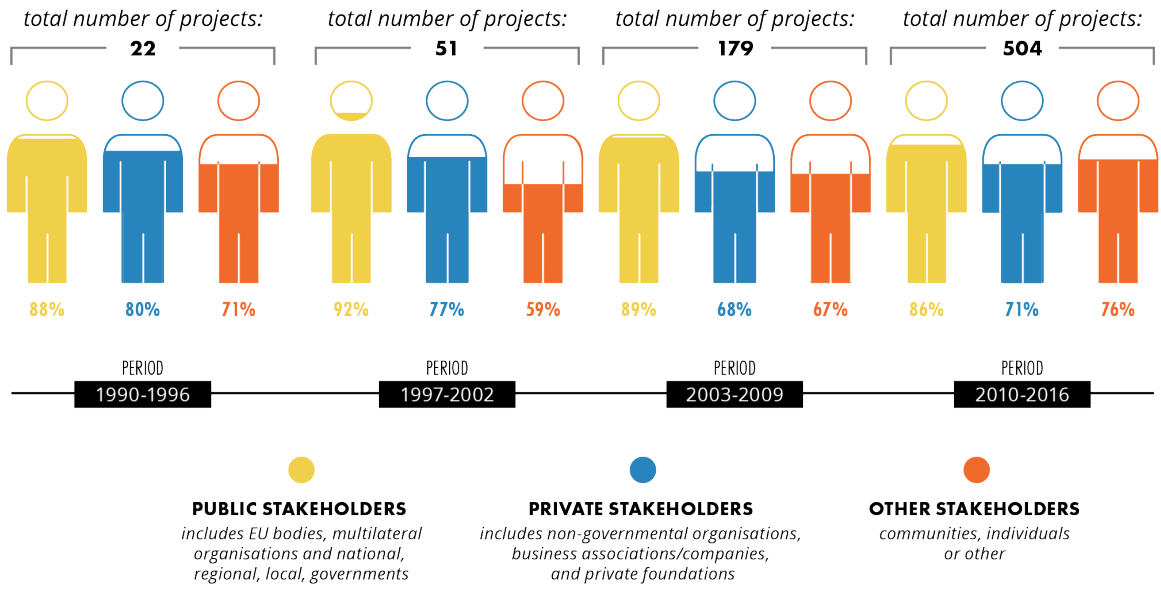


Figure 11: Percentage of nature-based solutions involving public or private stakeholders at the start of project implementation (1990-2016)[18]

reveals that three of the ten categories increased over time (i.e. 'co-planning', 'joint implementation' and 'crowd-sourcing'), two remained fairly consistent (i.e. 'co-management' and 'citizen science', remaining around 18% and 3%, respectively), and one decreased significantly (i.e. 'dissemination of information and education'). The rest, all displayed slight declines in use over time, but nothing too significant as seen for 'dissemination of information and education'. An example of a project employing citizen science, citizen monitoring, and other forms of engagement (e.g. an exchange network for disseminating knowledge) is "The Green and Blue Urban Network Project" in Montpellier, France (see Box 3).

Box No: 3

CITIZEN SCIENCE AND OTHER FORMS OF PARTICIPATION IN THE GREEN AND BLUE URBAN NETWORK PROJECT IN MONTPELLIER, FRANCE

The Green and Blue Urban Network project in Montpellier aimed to promote species migration and ecosystem resilience in the face of habitat threats and climate change and strengthen nature in the city, as well as public awareness. Planning for the project started in 2006, implementation taking place between 2012 and 2015. The city of Montpellier identified areas important to biodiversity and established a network corridor with the focus on the preservation of species movement while integrating social capacities to observe nature. Efforts to regenerate the area included planting local species and controlling invasive alien species, while construction efforts improved public access through platforms, benches, and discovery areas. To further integrate local citizens, a Green and Blue Urban Network Exchange Group was established to disseminate knowledge and share experiences between experts and practitioners. Furthermore, online citizen science tools such as "Tela-Botanica" enable citizens to become involved and provide observations. The public can also visit the network corridor virtually through an online platform, supporting the initiative's public outreach and engagement activities along with its awareness-raising panels, naturalist outings and guided tours.

Sources: Montpellier (2017a, b, c, d); Trame verte et bleue (2017)

[18] The "total number of projects" accounts for all projects with known implementation year in the referenced period. The percentages of "nature-based solutions involving different groups of stakeholders" were calculated for all projects with known project implementation dates and with some form of known stakeholder involvement. Since various groups of stakeholders may have been involved in the implementation of a project, the percentages showing the share of public, private and other stakeholders during a given implementation period do not add up to 100%

Looking at the periods between 1990-1999 and 2000-2016, several trends can be identified in comparing participatory approaches utilised within older versus more recently initiated NBS projects. Generally, projects initiated in the 1990s focused on 'dissemination of information and education' (average use in 65% of all projects between 1990-1999) and 'consultation' (average of 40%), and 'joint implementation' (average of 24%). Since 2000, 'dissemination of information and education' decreased sharply from ca. 65-35%, yet still remains one of the most frequently used methods of engagement within projects initiated in this period. Other methods like 'consultation' and 'co-management' showed declines as well (-15% and -8%, respectively), though these are not as severe as for 'dissemination of information and education'. The increasing use of 'co-planning' and 'crowd-sourcing' in projects is also evident between 1990-1999 and 2000-2016, showing an increase of 8% and 6%, respectively, over these time periods. 'Joint implementation', on the other hand, showed only a slight decrease of 1% between these two periods, maintaining its importance as a key participatory method used. An example of joint implementation can be seen in the "Planting Tree Month" initiative in Craiova, Romania (see Box 4). These trends across NBS projects are consistent with the increasing interest in more involved general participatory processes since the late 1990s in related fields such as participatory planning, scenario analysis, assessment and evaluation. Overall, it can be concluded that more recently initiated NBS projects tend to use different forms of participatory processes than those that began earlier, reflecting a change in participatory processes within urban governance.

Box No: 4

PARTICIPATORY PLANTING OF TREES IN CRAIOVA, ROMANIA

The "Planting Tree Month" (*Luna Plantarii Arborilor*) in Craiova is part of a national campaign of the Forest Guard that was first initiated in 1936 in which local authorities and public institutions planted trees. Though the initiative remained dormant for some time, the national government and the Forest Guard resumed this tradition in 2008 and continue to provide ongoing support and materials for afforestation. Between March and April every year, local authorities join with the Forest Guard to coordinate volunteering events. The traditional activity provides the opportunity to raise public awareness on the importance of forests in maintaining ecological balance. Volunteers are encouraged to plant forest seedlings with the participation of forestry staff, pupils, students and members of rural and urban communities. Participating cities, like Craiova where the initiative was resumed in 2008, also conduct events aimed at developing forest consciousness among younger generations and provide participants with planting tools, protective gloves and drinking water.

Sources: Pătru (2017); Stuparu (2017)

4.3 POLICY DRIVERS AS MOTOR FOR DEPLOYING NBS PROJECTS

A key question in NATURVATION is to what extent local, national and EU policies drive the deployment of projects in specific urban settings (e.g. parks or buildings) and whether there have been any changes in their importance over the last 25 years. In many cases, there was no information provided on policy drivers of NBS projects within the entries (accounting for 182 projects); however, although this information was lacking, it does not mean that policy drivers had not been influencing the projects but rather that there was no explicit reference to the drivers within the cited sources. As the analysis shows (see Figure 12) all three policy levels explored (EU, national and local) play a role in driving the deployment of NBS projects. Importantly, as some projects mentioned multiple policy drivers, the analysis results assess the number of projects in specific urban settings that indicated one or more policy drivers. As such, the results do not add up to 100%. Of the projects assessed with known information on policy drivers (794 projects), the majority of them (62%, 489 projects) claiming influence by local policies, with lower shares attributed to influence by national and EU policies (29%, 234 projects; and 24%, 192 projects, respectively). For certain types of projects, the influence by policy drivers varies. For example, green areas for water management had the highest percentage of influence by local policy drivers, while blue areas claimed the highest influence for both national and EU policy drivers (see Figure 12).

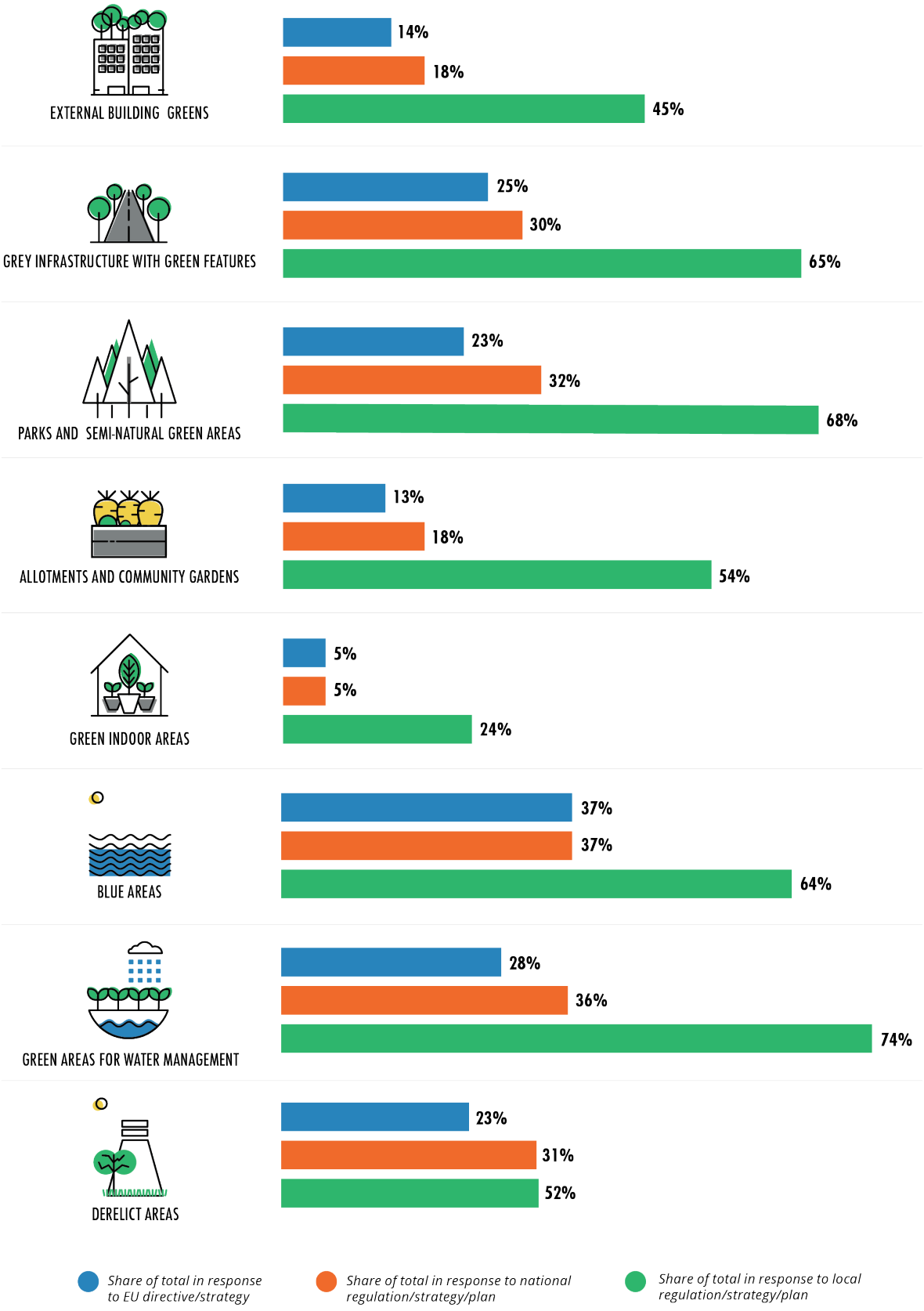


Figure 12: Share of projects in various urban settings in response to an EU, national or local policy as a % of total [19]

[19] The percentages of total projects calculated per urban setting do not add up to 100% because in many cases no evidence was found on policy drivers, while in other cases a project may have been influenced by more than one type of policy.

The example presented in Box 5 illustrates the variety of the role that policy can play in the deployment of NBS projects, though it is not necessarily representative of larger trends. With regards to EU policy-driven NBS projects, the "Ligurian Wetlands Emys Orbicularis Ingauna Conservation Program" in Genoa, Italy, was in part a response to the EU Habitats Directive and Regulation on Invasive Alien Species and led to the restoration of Ligurian wetland habitats and the eradication of invasive alien species. The "Green Spotted Toad Programme in Malmö, Sweden", presents a similar case but responded to specific national action programmes for Endangered Species and resulted in the uptake of conservation measures through a partnership between city administrations, landowners and the County Administrative Board. In particular, projects driven by local policies and initiatives present a high diversity of projects and objectives, which go beyond the protection of biodiversity and natural resources, see for example the "Rose Gardens in Kijewo in Szczecin, Poland".

Box No: 5

LOCALLY DRIVEN AND SUPPORTED ROSE GARDENS IN KIJEWO IN SZCZECIN, POLAND

To address Szczecin's increasing noise pollution, local citizens developed a project proposal and applied for government funding in 2016 to plant roses and other bushes in Szczecin's district of Kijewo. The project attempts to mitigate the area's heavy traffic along its main roads and neighbourhood squares through the use of rose gardens. Project proposals had to be in accordance with the city's plans, programmes and strategies, especially with respect to the city's local development plans. Thus, not only would these gardens serve as acoustic screens, they would also enhance the aesthetics of the area in line with the "Szczecin floating garden 2050" strategy. The project was successful in acquiring funding for its greening plans, with planting efforts started in 2017 and are ongoing.

Sources: City of Szczecin (2016, 2017)

As illustrated by the Green factor initiatives in Helsinki (see Box 6), some of the analysed NBS projects do not respond to policy from only a single governance scale (i.e. local, national or EU), but rather address several scales at the same time.

Box No: 6

COMBINING MULTIPLE POLICY SCALES: THE GREEN FACTOR IN HELSINKI, FINLAND

In 2015, two residential blocks in Helsinki were selected as sites to test the Green Factor tool, i.e. Jätkäsaari and Kuninkaantammi. The Green Factor tool has evolved as a collaborative product of multiple countries since the 1990s. The tool is now being applied and further developed as part of the project iWater (integrated storm water management), which aims to improve urban planning through the development of integrated and multifunctional storm water management. The Green Factor tool is an Excel interface that calculates the quantity and quality of an area's green spaces per unit area. The project is expected to be completed in 2018 and has direct policy relevance to implementing the EU Water Framework Directive and Floods Directive, the national-level Finnish Water Services Act, as well as commitments at the local-level to the City of Helsinki's Strategy on Storm Water Runoff and the Helsinki Metropolitan Area Climate Change Adaptation Strategy.

Sources: Ariluoma (2016); City of Helsinki Environment Centre (2016); HSY (2012); Rakennusvirasto Byggnadskontoret (2008); Stadin Ilmasto (2017a, b)

With regards to the evolution of NBS projects responding to EU, national and/or local policies from 1990 to 2016, Figure 13 shows a similar dynamic to Figure 12. Projects with a known implementation date and claiming influence from EU, national, or local policy represent only 688 projects out of all 976. The only identifiable trend is the dominance of the local policies over the national and EU policies as a driver for NBS implementation. During this period, most of the analysed NBS projects were influenced by local policies and strategies, with an increasing trend from 2011 to 2016. The number of NBS projects influenced during this period by national policies has increased over time, but represent a decreasing share of total projects in a year between 2004 and 2016. EU policies and strategies have influenced some of the identified NBS projects, but also show a declining trend in the proportion of all projects since 2002 towards 2016. It should be noted that these numbers do not reflect multiple answers in the Urban Nature Atlas, i.e. that many projects have been designed or implemented in response to one or more of the aforementioned policy scales.

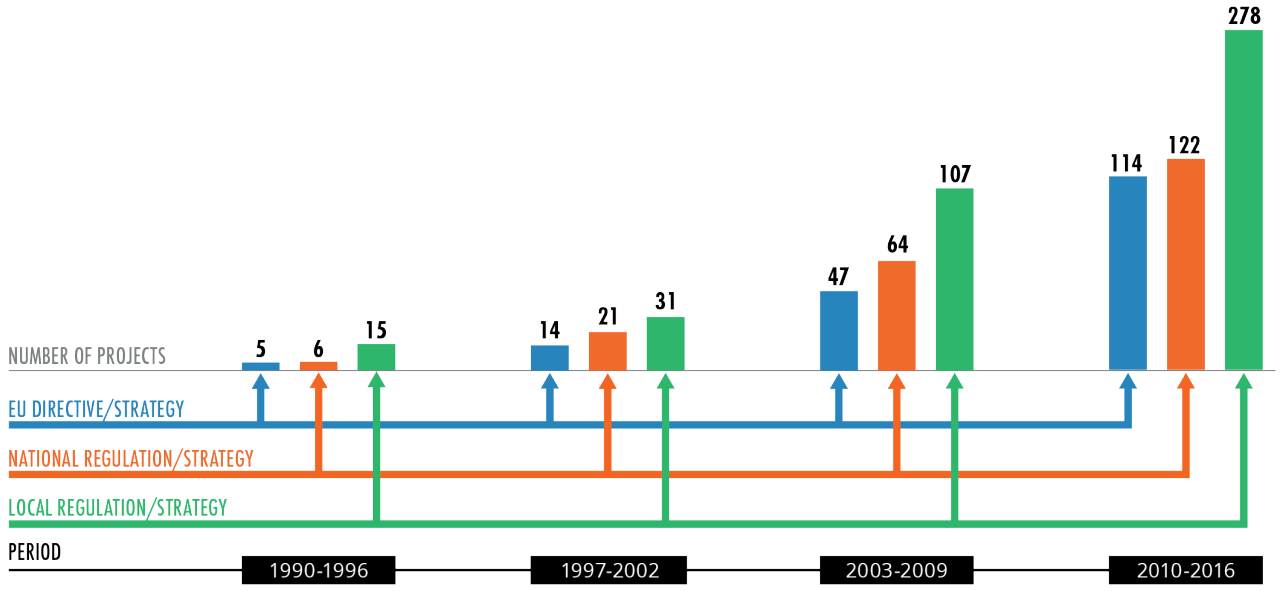


Figure 13: Number of nature-based solutions implemented in response to EU, national or local policy by year 1990-2016 (project implementation start)

Overall, these results can be interpreted to highlight the continuing importance of local policy as a driving force for deploying NBS projects and encourage such communities and decision makers to recognise this role by assuming more leadership in deploying NBS.

4.4 FINANCING NBS PROJECTS

The implementation of NBS projects is made possible largely by the availability of sufficient financing, whether from a single or multiple sources for individual projects. Sources of financing can be public funds (EU, national, regional, and local) and private funds (foundations, corporate investment, crowd-sourcing, and NGO). Our analysis shows that the type of funding source does not correspond to the levels of funding, highlighting that there are some projects with unknown sources of funding. Of the 976 projects, 73 projects had unknown sources of funding, which were excluded from the subsequent analysis. As illustrated in Figure 14, the majority of the NBS are financed through the budget of local authorities. Local financing was in particular significant for all urban settings with the notable exception of green indoor areas, which received a majority of funding from corporate investment and private foundations (21% each). External building greens also receive corporate financing (24%), though still less than public local budget sources (28%). This, in some way, can explain the influence of local policies on NBS projects, as seen above in Figure 13.

Although public funding occurred with the highest frequency and as the highest percentage by urban settings (see Figure14), the *amount* of this type of funding is assumed to be limited by public budgets, competing priorities and political agendas. Thus, a potential conclusion based on these assumptions is that the importance of private financing is increasingly being

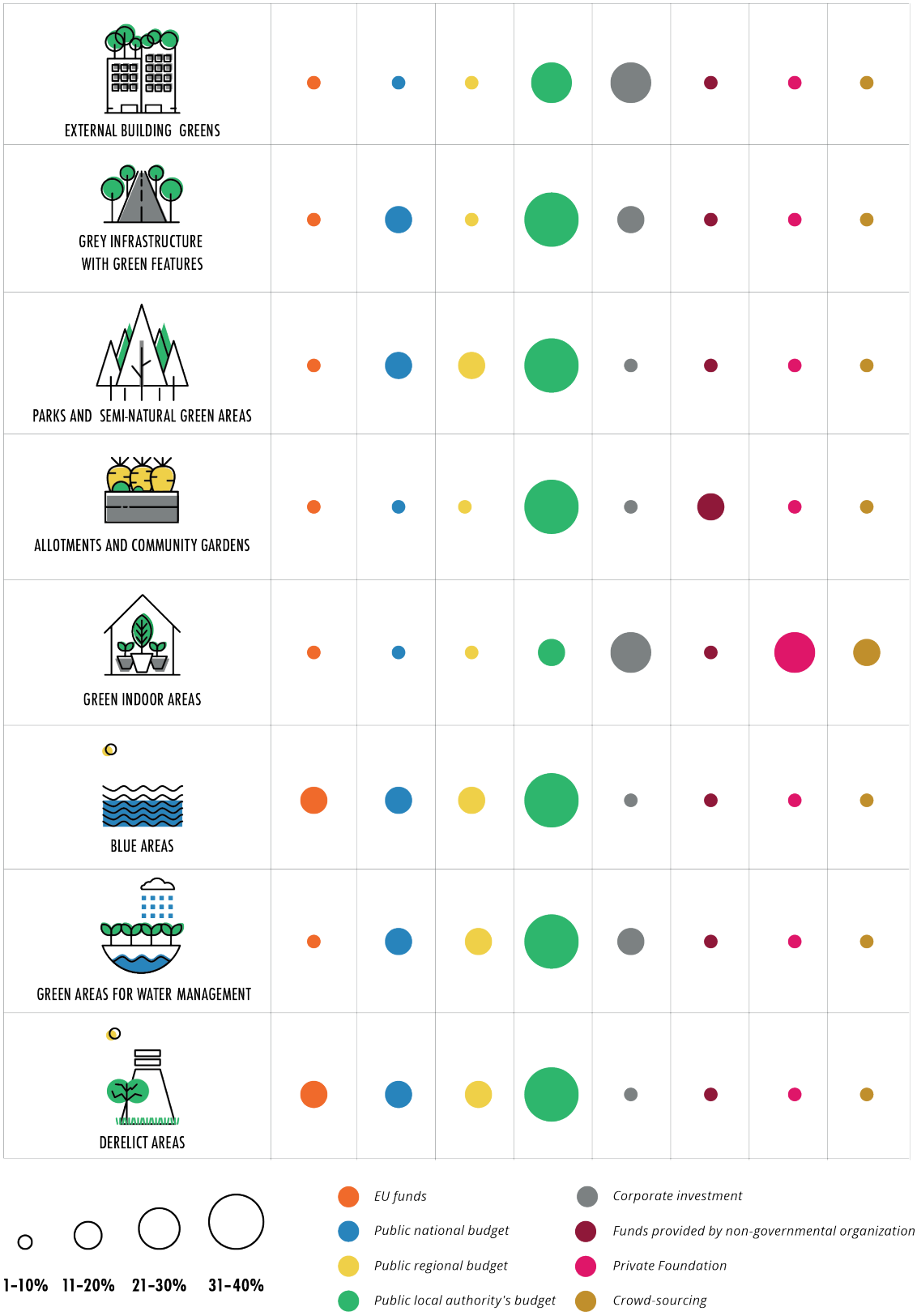


Figure 14: Urban setting of nature-based solutions disaggregated by funding source[20]

[20] The percentages of nature-based solutions calculated per urban setting do not add up to 100% since data on funding source was not found in all cases and one project may have been financed by more than one type of funding.

recognised as a necessary complement to public funds. Two examples are outlined below, illustrating how private financing (in this case corporate investments, see Box 7 and private foundations, see Box 8) are currently being utilised in select NBS projects. Looking at these examples more broadly, they provide useful illustrations of how human health and well-being can be combined with the restoration of ecosystems as core project objectives.

Box No: 7

CORPORATE INVESTMENT: DEVELOPING AN ECO-DISTRICT AT THE BANKS OF THE BOHRIE OSTWALD IN STRASBOURG, FRANCE

Starting in 2000, Strasbourg Eurométropole, in collaboration with the City of Ostwald, conducted research and consultations to develop a project idea for a new residential area on the banks of the Bohrie Ostwald and its seasonal wetlands in line with sustainable development. This plan for the 'Eco-District' was eventually adopted in 2009. In 2011, SAS Rives of Bohrie, a private company of two developers CM CIC SAREST and Nexity - Foncier Conseil, won a competitive bid to develop the eco-district. SAS Rives of Bohrie made a corporate investment of €40,000,000 into the area's development, covering 50 hectares and includes green roofs, 90 house and community vegetable gardens, composting, and green infrastructure. Development started in 2012 and initial residents moved into the region in 2014; completion is expected in 2026.

Sources: Strasbourg Eurometropole (2017a,b,c,d); Les Rives du Bohrie (2017); Mattlé (2017)

Box No: 8

PRIVATE FOUNDATION: KINGLAMBRO – CITY REGENERATION IN MILAN, ITALY

The KingLambro project or "ReLambro" project centres itself on the metropolitan perspective that nature is an occasion to regenerate the city. The project started in 2012 and aimed to investigate better connections between urban areas and natural spaces. The measures envisaged in the project concerned improving ecosystem quality of the river rod, containing invasive species, redeveloping the windmill of the San Gregorio mill, upgrading of the wetland in via Feltre, and expanding the natural spaces of the ecological corridor on the right bank of the river. Implementation actions are still ongoing, though they are expected to end in 2018. These activities seek the natural reconversion of degraded areas, with a view towards general environmental regeneration. The project was entirely funded through the private foundation Fondazione Cariplo, which invested €3,763,192 into these efforts.

Sources: Longo et al. (2016); Adnkronos (2017)

Looking at the evolution of the different funding sources for the period between 1990 and 2016, several trends become evident. It should be noted, however, that these should be interpreted with a degree of caution as the number of NBS projects implemented over the years – which forms the basis for the conclusions - varies greatly. As Figure 15 demonstrates, public funding as a percentage of total NBS projects per year has remained relatively stable, averaging 76% between 1990 and 2016; private forms of funding tend to be much lower, averaging 24% over the same period. This calculation refers to projects with known implementation dates (841) and compares types of funding for these NBS projects within each year. As can be seen in the figure, though the number of projects has increased over time, so too have public and private funding of NBS projects; this has maintained a relatively stable ratio between the two funding sources over time. When broken down to the individual funding streams, the funding percent of total NBS projects per year through the local public budget has always

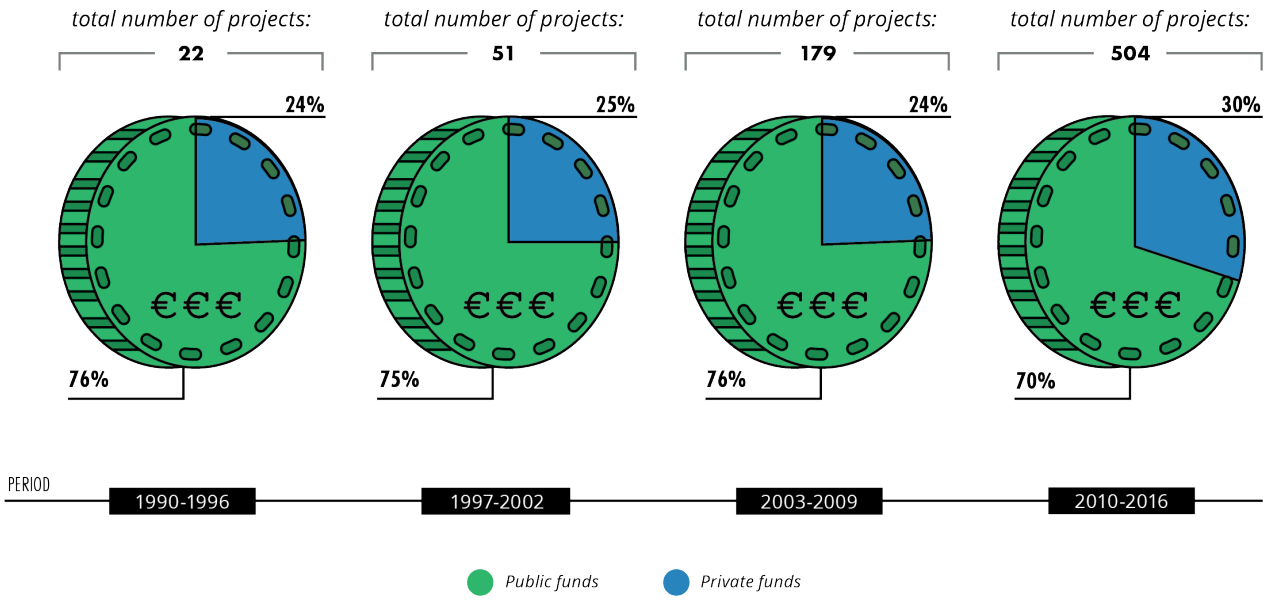


Figure 15: Percentage of public or private funding sources per total projects by year (1990-2016)[21]

been high, occurring in an average of 64% of projects over the analysed period. Declining trends can be observed for the frequency of NBS projects financed by public regional budgets (with an average frequency of 19%, but declining since 2002) and EU budgets (with an average frequency of 21%, and declining since 2009). Interestingly, private financing was already utilised in the 1990s, having a higher average rate for corporate investments (19% of projects) than NGO funding (1% of projects) until 2000 as compared to the period from 2000 to 2016 when they switched trends (corporate investments: decreased to 15% average rate, NGO funding: increased to 10% average rate). Crowd-sourcing also started to appear in before 1990 and since 2007 continues to be used at an average rate of 7% of projects per year. No clear trends can be revealed regarding the use of funds from private foundations (average 7% of projects) and national budgets (average 19% of projects) during the reviewed period. Though not displayed in the figure below, many NBS projects which began implementation in the 2000s had budgets above EUR 2 000 000. More recently, however, the trend in the amount of funds for NBS projects has shown an increase in projects of less than EUR 50 000.

[21] The "total number of projects" shows all projects with known implementation year in the referenced period. The percent of public or private funder sources were calculated for all projects with known implementation year and available information on founding sources.

5. WHAT ARE THE IMPACTS OF NBS?

NBS solutions can deliver a range of ecological and socio-economic benefits to improve urban sustainability (Cohen-Shacham et al., 2016; European Commission, 2015; Raymond et al., 2017; Kabisch et al., 2016). The data collection thus also aimed to explore the reported ecosystem services (ES) delivered by the identified NBS, as well as to define their perceived beneficiaries. Other reported impacts and benefits, defined in a broader sense and linked to the NBS sustainability challenges established within the NATURVATION project, were also explored.

5.1 TYPE OF ECOSYSTEM SERVICES DELIVERED BY NBS

Ecosystem services are defined as the "benefits people obtain from ecosystems" (Millennium Ecosystem Assessment, 2005 p 52). Three international classification systems are established in order to classify ES: (a) The Millennium Ecosystem Assessment (MA), (b) The Economics of Ecosystems and Biodiversity (TEEB) and The Common International Classification of Ecosystem Services (CICES). The concepts are related (Maes et al., 2013), but within the NATURVATION project the TEEB classification system was adopted to classify the ecosystem services delivered by NBS. This system distinguishes provisioning, regulating, habitat or supporting and cultural services.

The analysis of the collected data revealed that the vast majority of the identified NBS claimed to deliver multiple ecosystem services. When reviewing the results, it is to be noted that these results are based on the analysis of the project documentations, thus they are rather claims about what ES they deliver, than actual evaluations of the services.

- Cultural services: The project documentations indicated that 87% of all NBS delivered some type of cultural services. 70% of the NBS were claimed to deliver recreational and/or health services, 56% aesthetical benefits and 25% other not-predefined services, which mostly related to education and awareness-raising.
- Habitat and supporting services: 69% of all NBS reported to deliver such services, with 54% of all studied NBS were claimed to support or safeguarded habitats for species and 38% the maintenance of genetic diversity.

- Regulating services: 65% of all NBS project claimed to deliver regulating services. Under 31% of the studied NBS were reported to contribute to air quality regulation, while 29% to local climate or temperature regulation. 25% was also found to support flood regulation and 16,19% carbon storage from GHG emissions. Other, not-predefined ES under this category included general pollution control, soil quality improvement, water quality regulation.
- Provisioning services: 31% of NBS were reported to produce provisioning services 21% of all studied NBS were reported to provide food and 6% fresh water.

The figure below provides an overview of the various types of ES delivered by the NBS and followed by an analysis.

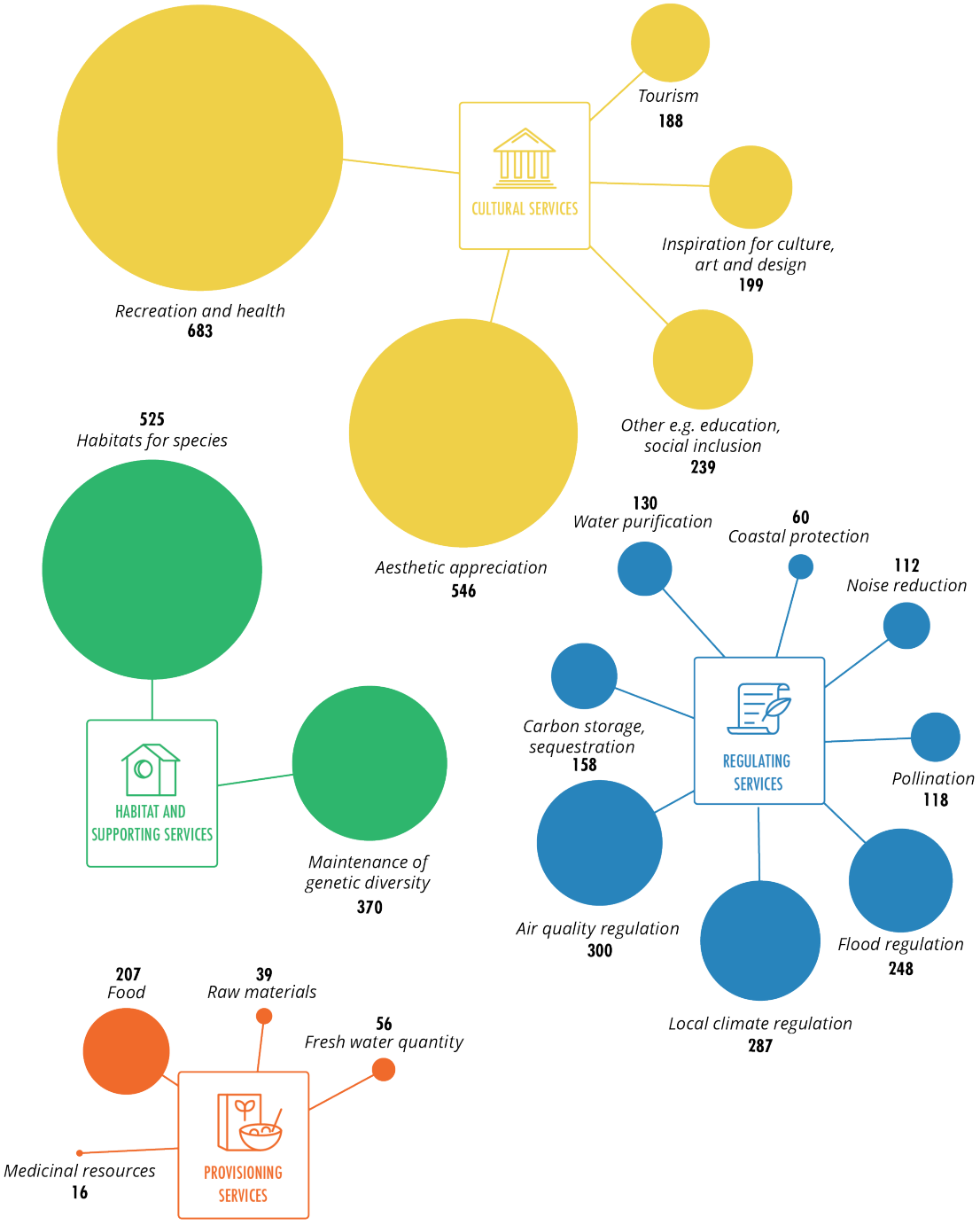


Figure 16: Number of ecosystem services delivered by the studied nature-based solutions

The analysis of the data also revealed certain variations in the delivery of ecosystem services according to the specific urban setting of the NBS.

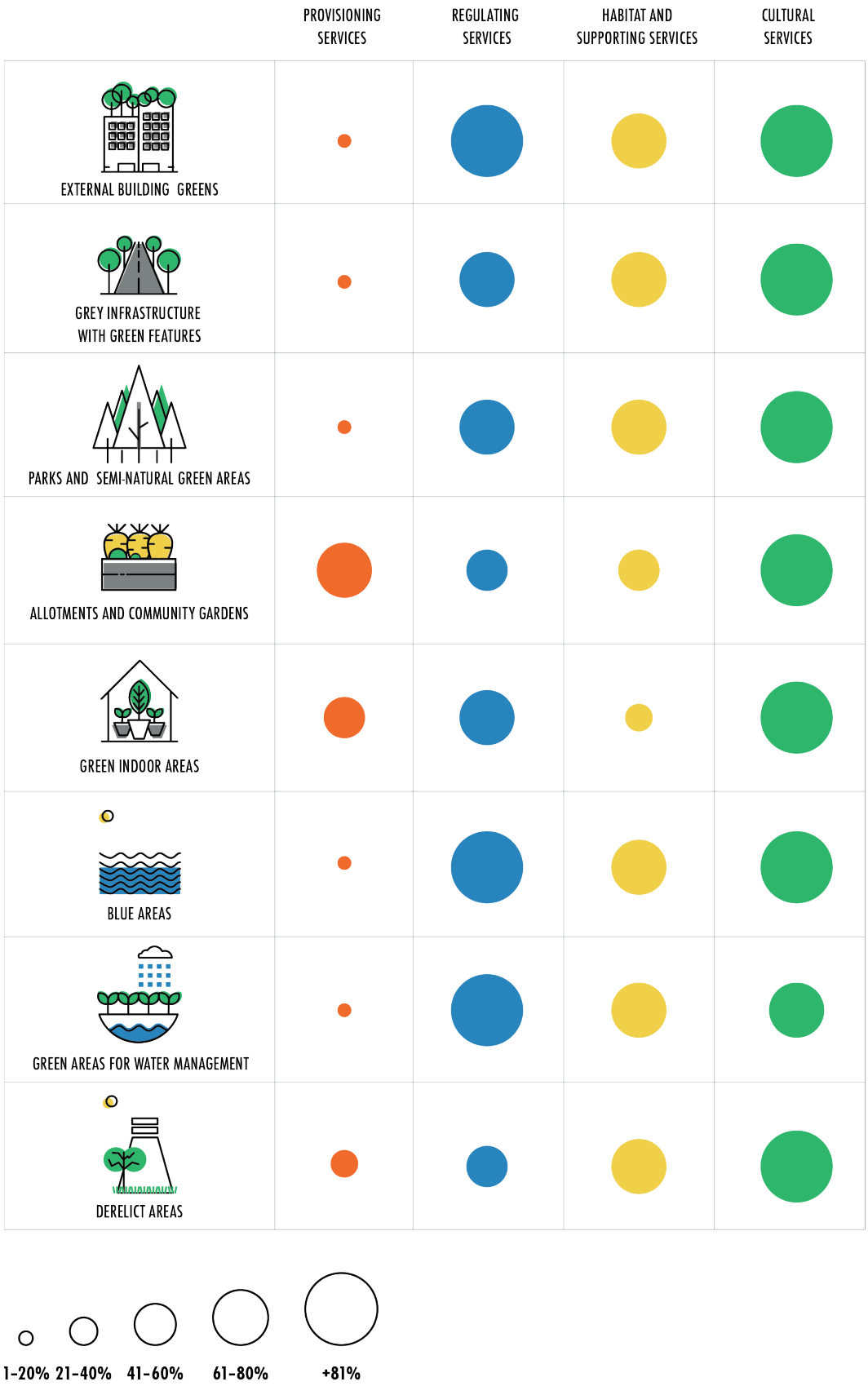


Figure 17: Frequency of ecosystem-service delivery by nature-based solutions per different urban settings

According to the studied documents, allotments and community gardens were more likely to deliver provisioning services than NBS in other urban settings. More than 70% of all NBS taking place in community gardens were reported to provide food or other raw materials or medical resources compared to an average 31%, in case of all studied NBS. NBS in community gardens were also somewhat more frequently claimed to deliver cultural services, but less commonly reported to ensure regulating and habitat supporting services. An example of a community garden delivering both provisioning and cultural services is presented in Box 9.

NBS taking place in blue spaces rarely documented to offer provisioning services and were less likely to be reported to deliver cultural services. At the same time, project documentations were more frequently associated these with regulating and habitat supporting services. An example of such NBS and the ES delivered are explained in Box 10.

External building greens and green areas created for water management were claimed to provide regulating services well above the average: in 84% and 92% of cases compared to the average, 69%. Explanation of the ES delivered by a green roof project in Poland can be found in Box 11.

Box No: 9

ALLOTMENTS FOR IMMIGRANTS IN THE INTERNATIONAL GARDEN, BONN, GERMANY

In 2006, parts of the international garden of Bonn, covering 3,000 sqm were turned into 20 smaller plots and allocated for gardening to 20 migrant families from 15 different countries, living in the deprived neighbourhood of Bonn-Dransdorf. A project evaluation document also noted that social cohesion was strengthened by the coplanning and participatory character of the project, as well as contributed to the health and well-being of a group by providing them with the opportunity of working and playing outside. In addition, for many of the participants the project terminated their social isolation and feeling of worthlessness, which again contributed to their well-being.

Source: Wissenschaftsladen Bonn (2017)

Box No: 10

REWETTING SANDALL BEAT WOOD, DONCASTER, UK

To address the too low water levels and low water quality in Sandall Beat Wood and Cantley Park, a project was introduced in 2016 to improve the water flow and to create net wetland habitat while engaging local communities (Doncaster Council, 2014). The project resulted in the creation of 718m^3 of flood storage and 2 ha of habitat improved, thus regulating water quality and supporting wetland habitats.

Source: River Torne Catchment Partnership, (2016)

Box No: 11

GREEN ROOF ON THE 'CASTLE TERRACES' SHOPPING MALL, LUBLIN, POLAND

The largest green roof in Lublin, Poland, designed to cover 16,700 square meters rooftop area of the shopping mall 'Castle Terraces' (Tarasy Zamkowe), with around 5,000 square meters being accessible to the public and the other 10,000 square meters serving as an intensive cultivation area for the endemic greenery. Plants were selected to create an endemic ecosystem of regional character. The purpose of the green roof is to serve as an ecological solution for heat mitigation, reduce the heat island effect and help with water retention in the city as well as a green recreational area for relaxation and public events.

Sources: Stankiewicz (n.d.) and Mazus (2015)

5.2 IMPACTS AND BENEFITS OF THE PROJECTS

Besides ecosystem services, NBS are also expected to produce a range of wider environmental, social and economic impacts. Under impacts, we understand the tangible and non-tangible, positive and negative influence of the intervention on the society or the environment. The type of impacts distinguished twelve categories, in line with the NATURVATION sustainability challenges (3.3 for detailed explanation).

The analysis of the NBS found that 80% of all studied NBS claimed impacts or benefits related to green space, habitats and biodiversity; 53% to urban development or regeneration and 49% to health and well-being. Perceived and reported impacts on economic development, governance, SCP and cultural heritage were recognised in less than 20% of all studied NBS. Selected NBS examples and their perceived impacts are presented in Table 3.

TABLE 3. EXAMPLES OF IMPACTS IDENTIFIED BY THE PROJECTS

TINERETULUI PARK, CRAIOVA, ROMANIA
The Tineretului Park is a special vegetation and touristic area, a forest park stretched over an area of over 60 hectares, on the left bank of the Jiu River. It was rehabilitated in 2009 by the municipality and it is the second largest park in the city. Before its rehabilitation it was seen as a dangerous area, high in petty crimes. Its rehabilitation was also much needed since Craiova is one of the Romanian cities with the lowest number of green spaces. Impact of the park rehabilitation included the improvement of recreational and entertainment conditions for the inhabitants of Craiova and for those from neighbouring localities and counties, in special hygienic and sanitary conditions and without the risk of unwanted injuries. Secondly it raised the local budget revenues, and increased the quality of life for the inhabitants of Craiova. *Sources: Parcul Lunca Jiului (2009) , Craiova Info (2009)*
GREEN ROOF IN PORTO, PORTUGAL
Porto's largest green roof consist of an urban park with 50 olive trees on top of a semi-open gallery of shops, restaurants, and cafés with an underground parking garage. Besides enhancing the attractiveness of the city, it serves as an urban park escape for the citizens and creates a space for community in an area in decline. It also contributes to the increase of property values in the area. Environmental impacts include regulating air quality; CO_2 sequestration; enhancing soil protection with CO_2 and NO_2 sinking; maintaining humidity, lowering temperatures as well as reducing stormwater runoff and ground drainage. *Oppla (2013), Gail at Large (2016)*
JOINING TWO PARKS WITH A GREEN MASS CORRIDOR, ATHENS, GREECE
A planned project in Athens aims to join the two parks (Pedion Areos and Lofos Likavitou) with a green corridor, bringing back the greenery to an area that used to be a green zone in the outside of the old Athens walls. The intervention is expected to result in 27,9t/y CO_2 captured, 85% reduction of dust particles, increase of 2.43m^2/habitant in green area access and 30% rising biodiversity in the area. *Source: Behance (2013)*

The analysis also aimed to investigate the impacts of the NBS in relation to the urban sustainability challenges (section 3.2). The challenges targeted by the NBS were more likely to be reported to result in impacts in the case of issues related to governance, social justice and cohesion as well as cultural heritage preservation. The analysis also found evidence for 92% of the projects aiming to address challenges related to green space, habitats and biodiversity that reported concrete outcomes of the NBS projects. Evidence for concrete impacts were found less frequently in the case of NBS aiming to address challenges related to water management, sustainable consumption and economic development or provision of jobs. An overview of the number of NBS that perceived to address certain challenges in relation to the number of NBS that were considered to have an impact or benefit for the same challenges is presented below.

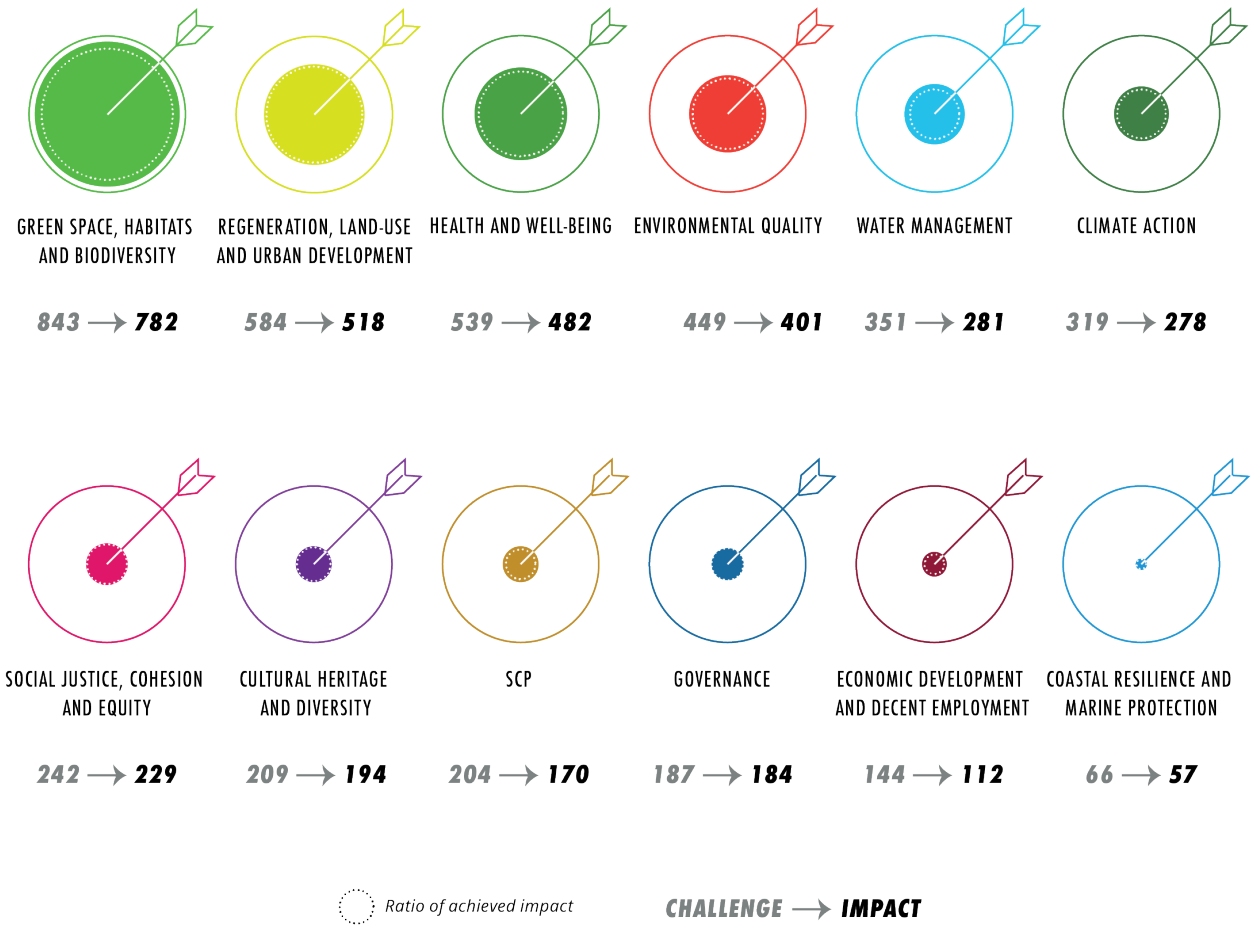


Figure 18: Comparison of the number of challenges aimed to be addressed by the nature-based solutions and the number of identified impacts

5.3 BENEFICIARIES AFFECTED BY NBS PROJECTS

The data collection also investigated the primary beneficiaries of the NBS, those groups that directly benefit from the challenges addressed or the services/benefits provided by these projects. It is important to emphasise here that as the research was based on the analysis of secondary sources presenting specific NBS, the identified group of beneficiaries were also derived via discourse analysis of the studied documents. In short, the analysis shows us who was *intended* to or *thought to have* benefited from NBS, rather than necessarily which groups benefited in practice.

The data analysis revealed the following patterns about the type of beneficiaries:

- 90% – 880 NBS – indented to deliver benefits to citizens or community groups, including individuals, groups of local people, and association of individuals working for a public benefit.
- Within this, almost 15% were reported to support disadvantaged groups (e.g. older or disabled people, families with small children).
- 45% of the NBS were found to be beneficial to local government bodies and 11% to other public sector institution (e.g. school or hospital). Local government bodies were more likely to benefit from NBS undertaken in blue areas, in derelict areas and from water management solutions in green areas.
- NGOs or civil society organisations, research institutions or universities and for-profit organisations were also among the perceived beneficiaries in 12, 13 and 17% of all NBS. Private sector organisations and research institutions and universities were beneficiaries of green building NBS well above the average – from all green building initiatives, in 36% and 22% respectively.

An overview of the main beneficiaries' groups is provided in Figure 19.

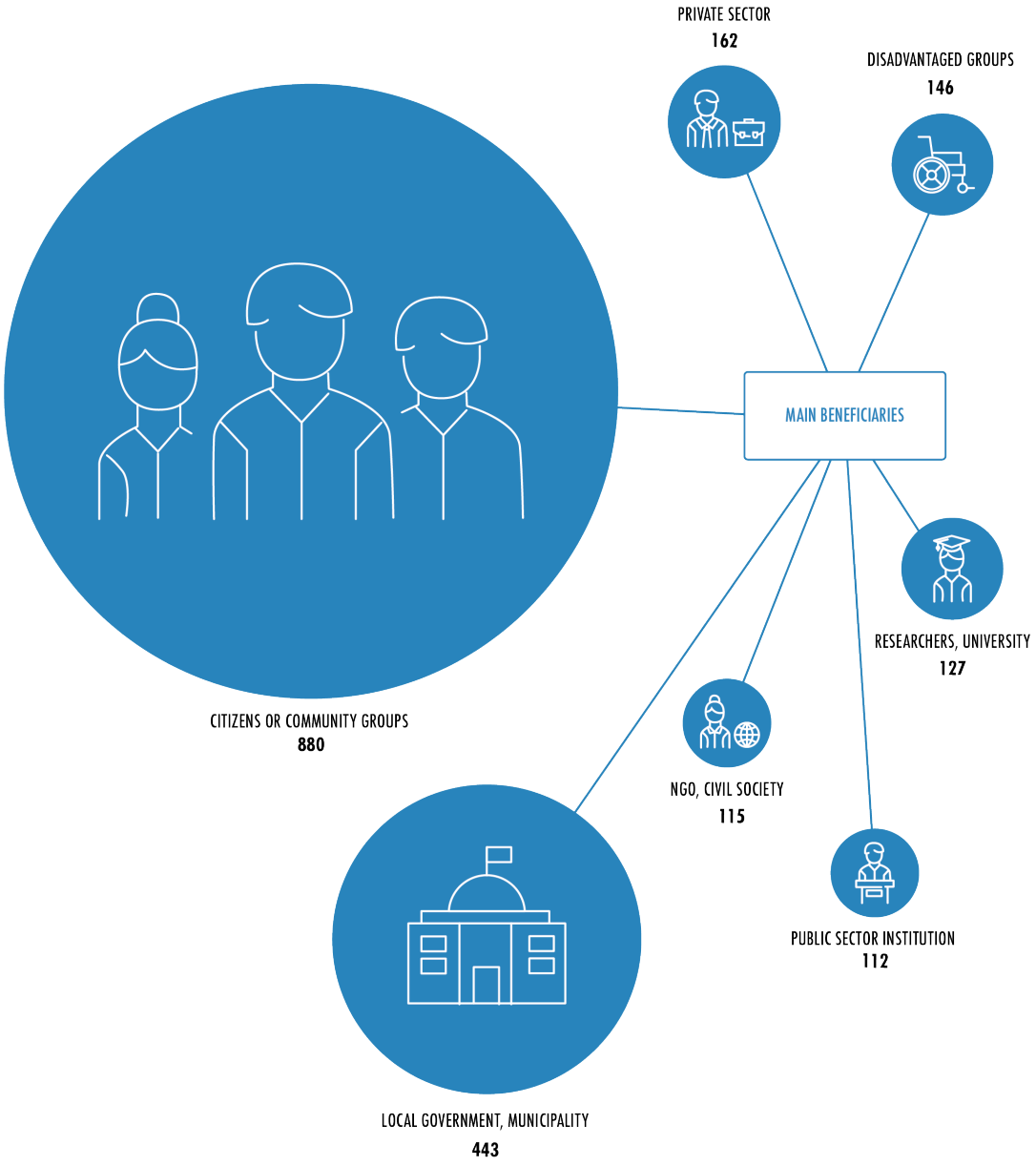


Figure 19: Main beneficiaries of the identified nature-based solutions

Citizens and community groups were almost always identified as the primary beneficiaries of parks and urban forests, allotments and community gardens as well as derelict areas. At the same time, they were somewhat less frequently perceived to benefit from green building initiatives – presumably because not all green buildings were accessible by the public. Disadvantaged groups were marked as primary beneficiaries of community gardens and allotments more frequently than the average of 15%: in 28% of all NBS of this type. Many of the studied community garden and allotment projects targeted migrants, those living in poverty, and older people.

The documentation of the studied NBS indicated that public sector institutions, NGOs and disadvantaged groups are more likely to be perceived to benefit from provisioning services of NBS. Local government bodies claimed to profit more frequently from regulating and habitat supporting services provided by NBS, while private sector and research organisations were also more likely to be the perceived beneficiaries of regulating services than the overall average.

5.4 QUANTIFICATION OF IMPACTS AND IDENTIFIED IMPACT ASSESSMENT TOOLS

The assessment also revealed that most of the studied NBS claimed to produce multiple impacts. However, evidence for quantified assessments of the impacts was found less frequently and further analysis is required to understand which kinds of NBS, in terms of actors, urban setting, financing and spatial scale were more likely to carried out such analysis.

In terms of applied assessment tools, evidence was only found for around 10% of the NBS projects. These identified assessment tools were diverse and for the purpose of this analysis were grouped into different types of assessment tools.

More than half of the identified assessments focused on the environmental impacts of the NBS, such as:

- General environmental impact assessments (Science Central Blue Green Infrastructure, Newcastle), (Slussen and a new water regulation plan for Lake Mälaren, Stockholm, A historic and innovative governance model for maintaining Town Moor, Newcastle);

- Water: water consumptions and audits (Pilestredet park, Oslo), evaluation of the water pollution rate (Rain gardens in Kviberg, Göteborg), hydrological performance modelling tools (Sheffield University Green Roofs, Sheffield), monitoring water consumption as well as costs of the green areas maintenance (Bio-Habitat, Bologna), drainage impact assessments for the SuDS innovation in the city (Glasgow's sustainable urban drainage system, Glasgow), the integrated catchment model can be used to assess the risk of flooding and test surface water management measures (Ouseburn River Restoration Project, Newcastle);

- Air quality: *AirCare* measures environmental performance focusing on air quality (CityTree green walls, Budapest and Cracow), air quality measurement tools aimed at measuring how the quality of the air has improved since trees have been planted (Making Ljubljana city centre an Ecological Zone, Ljubljana);

- Evaluate tree planting and growth, examining plant nutrition and assessing the presence of eventual environmental stressors (Vertical Forest, Milan), numerical model implemented in ENVI-met tool to analyse the thermal effects of green roofs (Flaminio Project, Rome);

- Green spaces: parks quality assessment framework (Morningside Park, Edinburgh), the green infrastructure assessment tool includes different categories to evaluate the multiple impacts of GI such as safety, social and cultural benefits, as well as economic benefits and ecosystem services (Weaver Park, Dublin).

Part of the identified assessment tools, approx. 9% of them, were related to the assessment of climate change impacts such as the ADAPT tool which monitors urban climate change resilience (The Bio Washing Machine, Utrecht), national flood risk assessments and measurement tools (Catchment management approach to flash flood risks, Glasgow) (The water garden at Haute Deule River Banks, Lille), or strategic flood risk assessments (Wakefield Flood Defence Scheme, Wakefield) (Wirral Waters project, Wirral)(Rewetting Fairham Brook Nature Reserve, Nottingham), and wetlands vulnerability assessment matrix (Wetland adaptation in Attica Region, Athens).

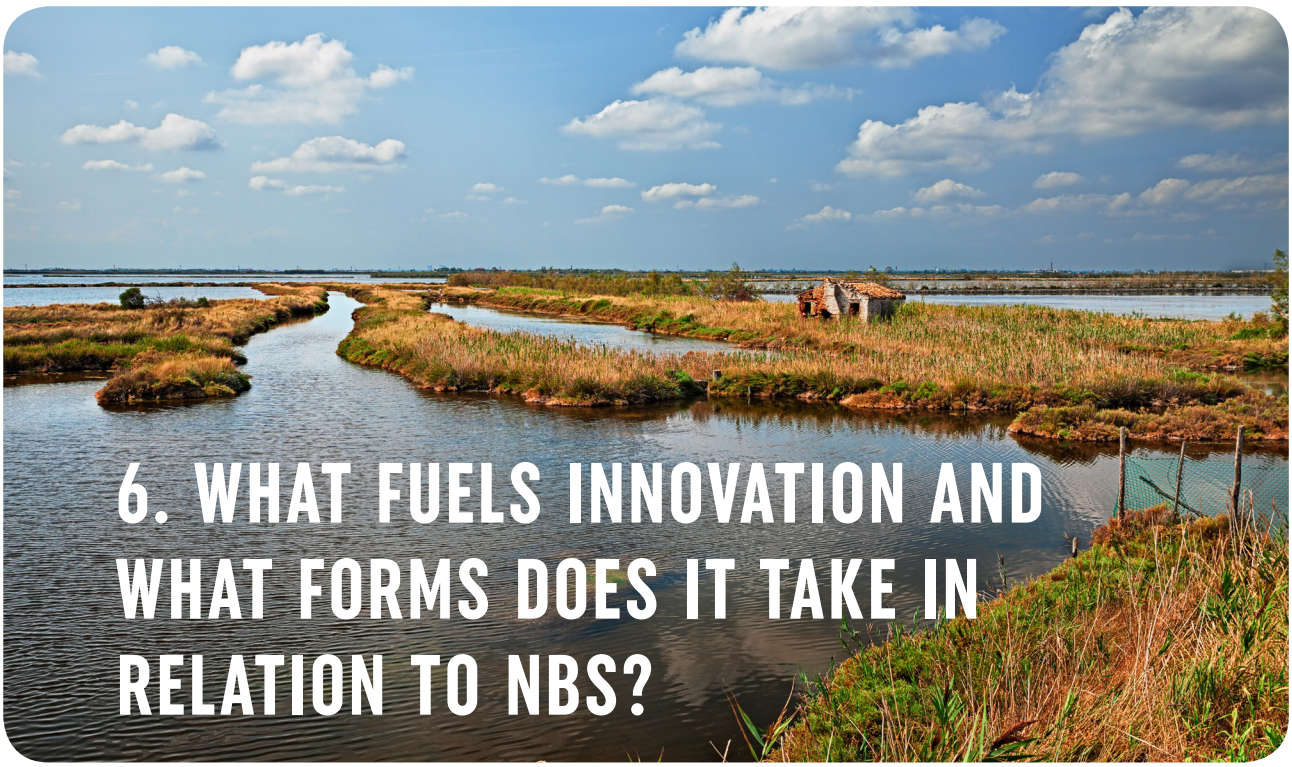
Around 16% of the identified assessment tools were related to biodiversity assessments such as biodiversity monitoring assessment tools (Monsanto green corridor, Lisbon) as well as biological diversity (Renovation of the Serralves Park, Porto), census of plants species and wild pollinators species (DICTAMNUS, Bologna), the continuum suitability index related to the identification of target species, evaluation of habitat quality, population census and intra-species genetics variability (KingLambro, Milan).

Some NBS projects used certifications as assessment tools like the Building Research Establishment Environmental Assessment Method (BREEAM) sustainability assessment method (Roofscape Sveavägen 44, Stockholm; The Green- Sustainable Student Village, Bradford; Friargate Coventry, Coventry; The Hub (Green Roof), Coventry; The Faktory eco-building, Liège; Vine Court Halls of Residences, Liverpool).

Among all identified assessment tools, 7% focused on economic evaluation while 5% focused on social impact assessments.

Examples of economic assessments were also identified, such as the development of economic valuations based on assessments of GI investments (Vesdre River Greenway, Liège), evaluations of NBS effects on the economy, society and environment were analysed by means of a benefit-cost analysis in which the intervention benefits are compared to their costs (Shore Park Austraße, Stuttgart), and indicative economic assessments (Tree planting scheme, Wirral).

There were also a few examples of assessment tools related to the evaluation of social impacts of NBS, such as the equality impact assessment (Gosford Street (Public Realm Scheme), Coventry) and other tools which ensure fairer and more sustainable access to greenspace (Balne Lane Fields project, Wakefield), the transtheoretical model which evaluates the readiness of an individual to act on a new behaviour (Greening Wingrove, Newcastle), the Igloo footprint is a shared commitment which its methodology includes health, happiness and well-being as one of its main themes as well as environmental aspects and urban design and regeneration (Lower Ouseburn Valley Redevelopment, Newcastle), and the public benefit recording system (PBRS) designed to measure public benefits achieved through regeneration (associated with social, economic and environmental factors) (Bidston Moss project, Wirral).



6. WHAT FUELS INNOVATION AND WHAT FORMS DOES IT TAKE IN RELATION TO NBS?

Understanding the relationship between sustainability and innovation is at the heart of NATURVATION. The project aims to contribute to the evidence base by both advancing how the contribution of NBS are assessed, and by producing new knowledge about how innovation in this domain is taking place and can most effectively be supported (Bulkeley 2016). In order to achieve this, the data collection aimed to uncover the innovation potential of the studied NBS and investigate whether they contained an element of technological and social innovation as well as focus on its novelty level and its transferability potential. Innovation aspects were identified via a discourse analysis of various documents about the projects. Thus, the following analysis is to be understood a context-specific discourse-based evaluation of the innovativeness of the identified NBS projects.

6.1 WHAT FORMS DOES INNOVATION TAKE IN THE STUDIED NBS?

For the data collection and analysis, we distinguished between technological, social and system innovations of NBS based on the following definitions:

- **Technological innovations** comprise new products, production processes or technological infrastructures or significant technological changes in them.
- **Social innovations** comprise new or significant changes in policies, economic frameworks, governance structures or cultural framings.
- **System innovations** lead to systemic changes in both social (values, regulations, attitudes) and technical (infrastructure, technology, tools, production processes) dimensions and, most importantly, in the relations between them.

According to the analysis, 59% of the studied NBS (572 projects) perceived to involve some type of technological innovation and 45% were reported to produce social innovations (438 projects). Almost 5% (48 projects) were found to deliver

systematic innovations. However, it is to be noted here that certain forms of systemic transformations may have occurred in additional, large scale projects that might not have been considered as system innovations as such.

The figure below presents an overview of what forms of innovation have taken place within the identified NBS.

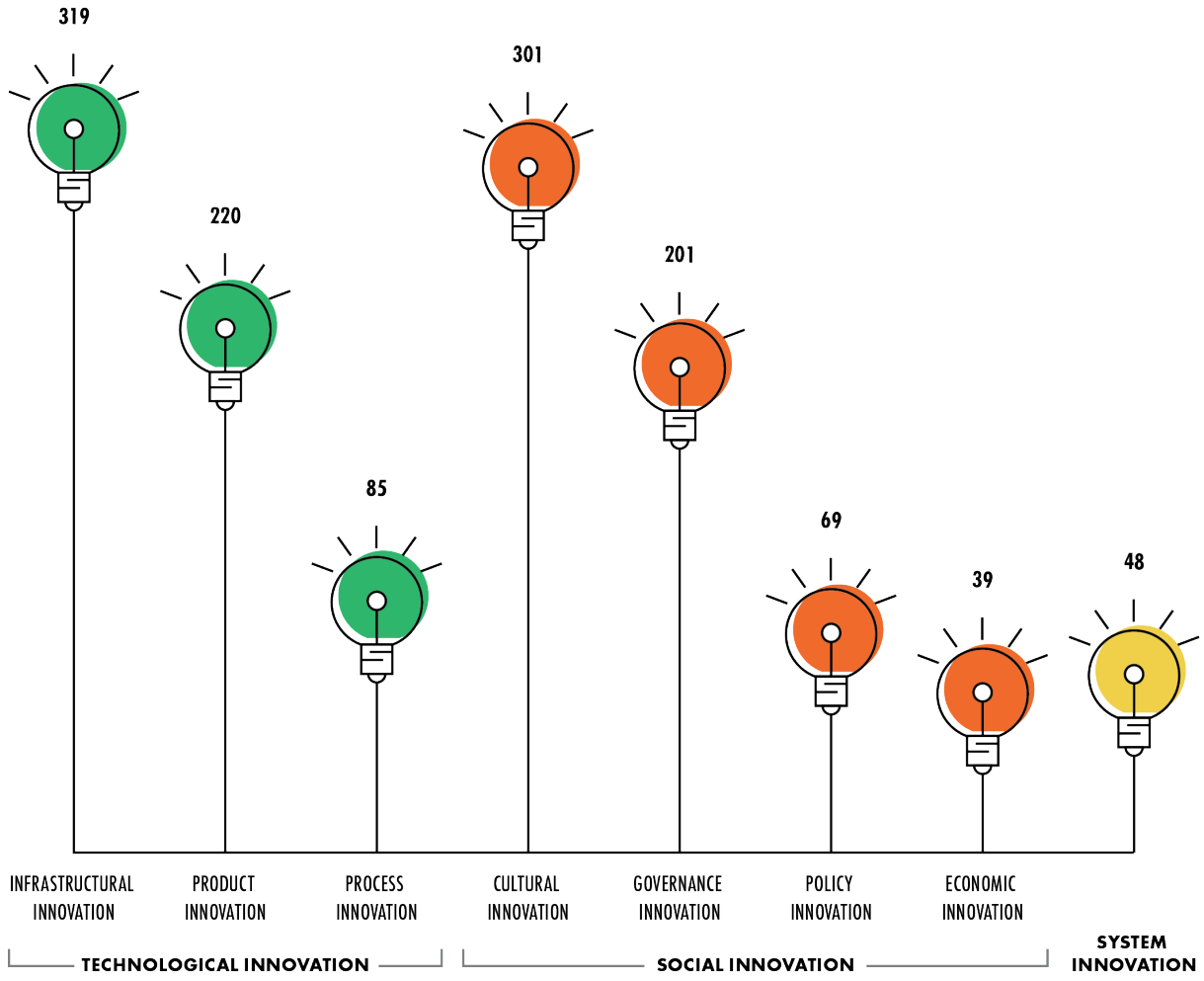


Figure 20: Overview of innovation forms among the identified nature-based solutions

Among the technological innovations, 319 NBS (33% of all projects) were recorded as infrastructural innovations and 220 (23% of all cases) as product innovations. Examples of infrastructural innovations included the creation of a green belt, habitat protection infrastructures, SuDS, river recovery or renaturalisation works, coastline or wetland restoration projects etc. Among product innovations green walls, green roofs, green playgrounds, community gardens, species protection products were recorded most frequently. In this category, process innovations such as planting approaches, cultivation schemes, various water management solutions were identified less frequently – in 8,7% of all cases.

Among the social innovations, 301 NBS (31%) were considered to realise some kind of cultural innovation and 201, 21% of the projects, were reported as governance innovations. Cultural innovations consisted, but were not limited, to education and awareness-raising activities aiming to promote behavioural changes, efforts for inclusion of disadvantaged groups is the social and economic sphere, provision of recreation opportunities. Governance innovations mainly included participatory solutions for planning, management, implementation and monitoring of various NBS. Policy and economic innovations were recorded much less frequently, in 7 and 4% of all cases. Novel policy solutions were identified as new policies, planning tools

or assessment methods while economic innovations were recorded as solutions to generate jobs, attract private investment, promote tourism or delivered funding programmes for various NBS.

It was also concluded from the analysis that the technological innovation potential was higher – above or around 80% of all projects - in case of buildings and green areas for water management and lower in case of community gardens (below 40%). On the other hand, cultural, governance and economic innovations were delivered the most frequently by community gardens and allotments. Policy innovations were somewhat more often identified in case of blue spaces and derelict areas.

Furthermore, it was concluded that government-led projects were more likely to produce infrastructural and policy innovations, while NBS co-led or led by non-governmental actors delivered product innovations as well as governance and cultural innovations more frequently. In terms of financial scale, similar conclusions were drawn: NBS with a total cost above 500 000 EUR were increasingly likely to produce infrastructural and policy innovations, while social innovations were the most common among projects below 50 000 EUR.

The data collection also identified 48 system innovations that delivered complex socio-technical innovations. Examples include:

- Eco-districts such as the Hammarby Sjöstad in Stockholm, Sweden; the Los Pajaritos neighborhood in Sevilla and the Las Cigarreras district in Alicante, Spain; the'Rozemaai', a neighbourhood in Antwerp, Belgium or the Cherry Garden Sustainable Neighbourhood in Utrecht, the Netherlands. These projects brought forward or planned to introduce various combinations of GI and BI solutions while fostering economic and socio-cultural changes.

- Large-scale river or coastal regeneration projects like the restoration project of the Haukaas Marshlands and the Moellendalselven River Park in Bergen, Norway, which introduced various technological and social NBS innovations or city-wide green infrastructure development projects completed, such as the Educational Trail in Münster, Germany which combined aspects of a green corridor in the inner city of Münster through a nature trail that crosses the whole inner city with vast recreational as well as educational functions.

- Multifunctional green areas, such as the Navarinou Park, which was developed on a former parking lot and managed by the community of Exarcheia in Athens, Greece or a guerilla gardening movement at the Kalastama area in Helsinki, Finland where empty spaces waiting to be built upon are used for growing food.

It is to be noted however that in some cases it might be questionable whether the intervention was a system innovation or simply combined various social and technological innovation elements. This is to be subject of further analysis carried out in a subsequent research task of the project, concerning the innovation aspects of the NBS across European cities.

Regarding governance arrangements, 18 of the identified system innovations were government-led while 20 projects were co-managed by public and non-governmental actors and ten were led by non-governmental actors. The analysis also found that almost half of all system innovations had a budget above 4 million EUR, while eight of them had a total cost above 500 000 EUR.

6.2 NOVELTY LEVEL AND REPLICABILITY OF NBS

The analysis also aimed to investigate whether the innovation delivered by the NBS had built on previous projects and whether the innovation was transferred to new initiatives. However, this information proved to be difficult to deduce from secondary sources.

In almost 45% of all identified NBS, it was not possible to evaluate the novelty level of the project and in case of another 11% of all projects, the assessment was ambiguous. Among those where the novelty level was possible to assess:

- 102 NBS were found to be copied/derived from previous initiative(s) without substantial adaptation;
- 159 were copied/derived from previous initiative(s) with substantial adaptation;
- 171 were considered as completely new without connections to previous initiative(s).

However, it is to be noted when an NBS was assessed as "new", the innovation may only have been new in the local, country-level context but not necessarily new to at world level. Examples in this category included, the world's first vertical forest – the Bosco Verticale in Milan, Italy – see Box 12 for further description – ; Sweden's first national city park in Stockholm; the UK's first air pollution garden in Sheffield and the first pedestrian biodiversity course in Lisbon, Portugal.

Box No: 12

BOSCO VERTICALE OR VERTICAL FOREST IN MILAN, ITALY

Two residential towers of 110 and 76 m height were built between 2009 and 2014, hosting 900 trees and over 20,000 plants from a wide range of shrubs and floral plants. On flat land, each Vertical Forest equals, in amount of trees, an area of 20,000 square meters of forest. According to a publication by Giacomello and Valagussa (2015) the facade temperature registered during the summer is 30 degrees lower thanks to the steam emitted from the watered plants. In addition, the 100 different plant species host more than 20 species of birds and several species of bugs have been introduced to fight pests without the use of pesticides, such as ladybugs. An indicator that turned out negatively for this NBS was the time and a result cost, dedicated to tree maintenance.

Source: Giacomello and Valagussa (2015)

As for the replicability of the projects, it was also not possible to assess in more than half of the studied projects whether the delivered innovations were transferred to other projects. Moreover, in case of 15% of the identified NBS the assessment outcomes were ambiguous. Evidence was also found that 180 NBS have not been transferred yet. As for the remaining cases: 87 NBS were assessed to be transferred to other projects without substantial adaptation, while 62 NBS were transferred with substantial adaptation. For example, the Bosco Verticale inspired the construction of a similar buildings in Lausanne, Switzerland as well as in different Chinese cities (Attribune, 2017); the idea of the regeneration of the Zabalburu square as a forest area was transferred to another initiative that resulted in the creation of the Ramon Basterra park and urban gardening projects introduced in Zagreb, Croatia were copied by other cities in the country (24 sata, 2016).

7. IS THERE A SYSTEM TO MONITOR AND COLLECT DATA AND IS THERE A SYSTEM TO ENABLE LEARNING?

One of the aims of the NATURVATION project is to create a novel assessment approach to analyse the multi-functional and systemic impacts of NBS from diverse perspectives and evaluate their contribution to urban sustainability goals (Bulkeley, 2016).

The data collection thus also aimed to understand if evidence has been provided on whether any kind of evaluation has been carried out for existing NBS projects and – if so – what type of assessment tools were developed to measure impacts. Evidence may encompass information on the application of different ways of monitoring, such as: formal monitoring systems, the use of indicators in reporting, the publication of monitoring or evaluation reports, the use of web-based monitoring tools or GIS mapping, and/or the involvement of citizens in monitoring efforts. Accordingly, this section presents the outcomes of the data collection on monitoring practices applied by the identified NBS projects.

Figure 21 below provides an overview of the share of projects that carried out different monitoring projects and followed by an analysis as well as case study examples.

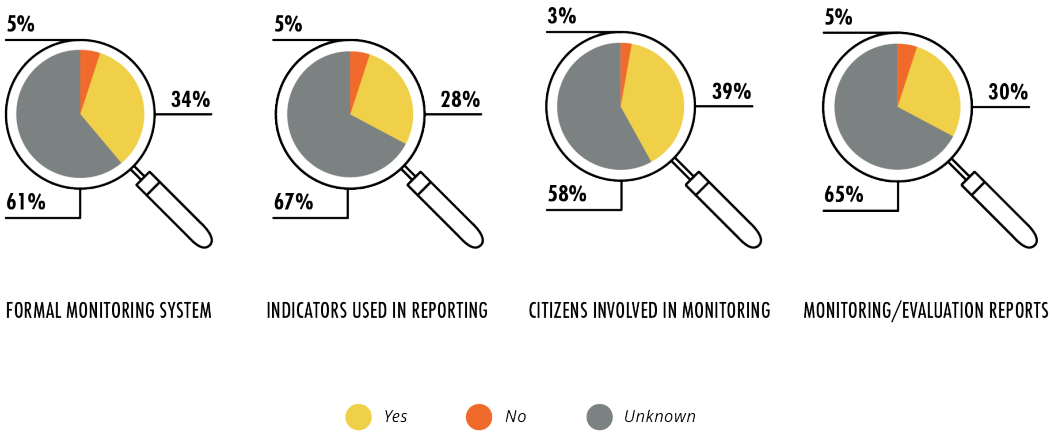


Figure 21: Percent of the studied nature-based solutions with formal monitoring systems in place; of using indicators in reporting; involving citizens in monitoring and publishing monitoring or evaluation reports.

Regarding the existence of a formal monitoring system, Figure 21 reveals that the majority (595 out of 976 NBS projects, or 61%) of entries were listed as 'unknown', meaning that no evidence was found during the review of the available project documentation sources for the use of such systems. In roughly a third (335 projects, 34%) of all entries, a formal monitoring system was identified as being in place, while 46 (5%) of all project entries indicate that no formal monitoring system is in place.

When investigated whether or not indicators were used in reporting, the percentage of positive responses decreased to 272 (28%), while the percentage of 'unknown' responses increased to 658 (67%) (see Figure 21). These 'unknown' responses could indicate that no information was identified regarding the use of indicators in reporting, or that a high percentage of projects are lacking indicators. Should the latter be true, the results could be interpreted as concerning given that indicators are quite critical in determining the progress of a project towards reaching its targets and objectives. An example of a positive response (i.e. one confirming the use of indicators in the implementation and monitoring of a given NBS project) is the "The green roof of the Ministry of Economics and Finance" project in Athens, Greece (see Box 13).

Box No: 13

THE GREEN ROOF OF THE MINISTRY OF ECONOMICS AND FINANCE IN ATHENS, GREECE

A green roof on the Ministry of Economics and Finance building in Athens was conceptualised and ultimately implemented to pursue research interests. Specifically, the roof was meant to provide a means to study the thermodynamic impacts of a green roof in a warm Mediterranean city. The project set forth performance targets including e.g. achieving energy savings and improving biodiversity on the rooftop area. Renovations commenced and finalised in 2008, with a thermal monitoring and observation system in place to ensure that these targets could be assessed. Studies in 2009 found that energy savings of 50% were observed for air conditioning on the floor directly below the green roof, corresponding to overall savings totalling EUR 5,630 per year (9% savings in air conditioning; 4% savings in heating bills). Furthermore, a plethora of new plant, bird and insect species were observed over time, highlighting the increase in biomass of the roof and its impact on local biodiversity.

Source: Green Roofs (2017)

Interestingly, evidence on whether citizens were involved in a project's monitoring activities was provided more frequently within the entries. The percentage of positive responses increased to 379 projects out of 976 (39%), with only 34 (3%) listed as not involving citizens (see Figure 21). Nevertheless, the majority (563 projects, 58%) of responses are listed as 'unknown' and once again draw attention to the lack of information regarding the monitoring efforts of NBS projects. Citizen involvement in monitoring efforts can be quite useful in some cases, helping authorities and researchers conserve their limited budgets while expanding their eyes and ears in terms of on-the-ground activities. Though not useful for every project (Conrad and Hilchey, 2011), citizens indeed have the potential to make a difference towards environmental management in some cases; the "Peri-urban natural park of Collserola" in Barcelona, Spain (see Box 14) provides an example of such a case.

Much of the above analysis emphasises the lack of data regarding the monitoring of NBS projects. This is further supported by the analysis results, in which the majority (639 projects out of 976, 65%) of cases stated 'unknown' as the response, indicating that no monitoring reports were possible to be identified (see Figure 21). Monitoring or evaluation reports were only possible to be identified for less than a third (289, 30%) of all projects. Evidence was found for a small proportion (48, 5%) of projects that no such monitoring or evaluation reports were developed. This lack of publication of findings and results, or the difficulty in attaining such publications hampers the ability of researchers and practitioners to learn from other monitoring processes, further refine and advance such schemes and indicator sets, and therewith improve the implementation of effective NBS projects.

Box No: 14

PERI-URBAN NATURAL PARK OF COLLSEROLA IN BARCELONA, SPAIN

Since 1987, the Natural Park of Collserola in Barcelona has been managed under a special protection plan. The roughly 8,000-hectare park is jointly managed by a consortium including the Catalan government, the Barcelona Provincial Council, and the Metropolitan Area of Barcelona, as well as adjacent municipalities. Management of this park aims to promote the respectful and sustainable use of the space while preserving its natural values. Each year, objectives and quantifiable targets are set, which are then assessed within annual reports of the park's activities. Targets range from habitat loss prevention, infrastructure development, educational initiatives and public engagement. Monitoring of these targets can help to point out areas and issues for the park's improvement. Citizens and visitors to the park are encouraged to leave suggestions for the park's improvement at the information centre. Comments from visitors regarding vandalism of the park and degradation of the area resulted in the park administration regulating access to the park, limiting it to smaller groups.

Sources: Parc de Collserola (2017a, 2017b, 2015)

When looking at urban setting, differences between urban area monitoring forms are generally minimal. Calculations were based on the number of monitoring forms within an urban setting. These results show a slightly higher percentage per urban setting for citizen monitoring and formal monitoring systems. For some areas of NBS, these forms of monitoring are more prevalent, as can be seen for allotments and community gardens and green indoor areas, respectively (see Figure 23).

Though parks and (semi)natural urban green areas and urban space connected to grey infrastructure represented the majority of projects overall (497 and 319, respectively), these projects also displayed the presence of multiple forms of monitoring (792 and 571, respectively). Despite the relatively even spread of monitoring forms per urban area, the ratio of the sum of these monitoring forms per total projects per urban setting showcase some differences (see Figure 22). Interestingly, blue areas, represented in only 252 projects, displayed the most monitoring forms (529) to NBS projects—a ratio of over two monitoring forms per one NBS project within that setting. Green indoor areas, on the other hand, displayed the lowest ratio with 21 projects having only 16 forms of monitoring between them.

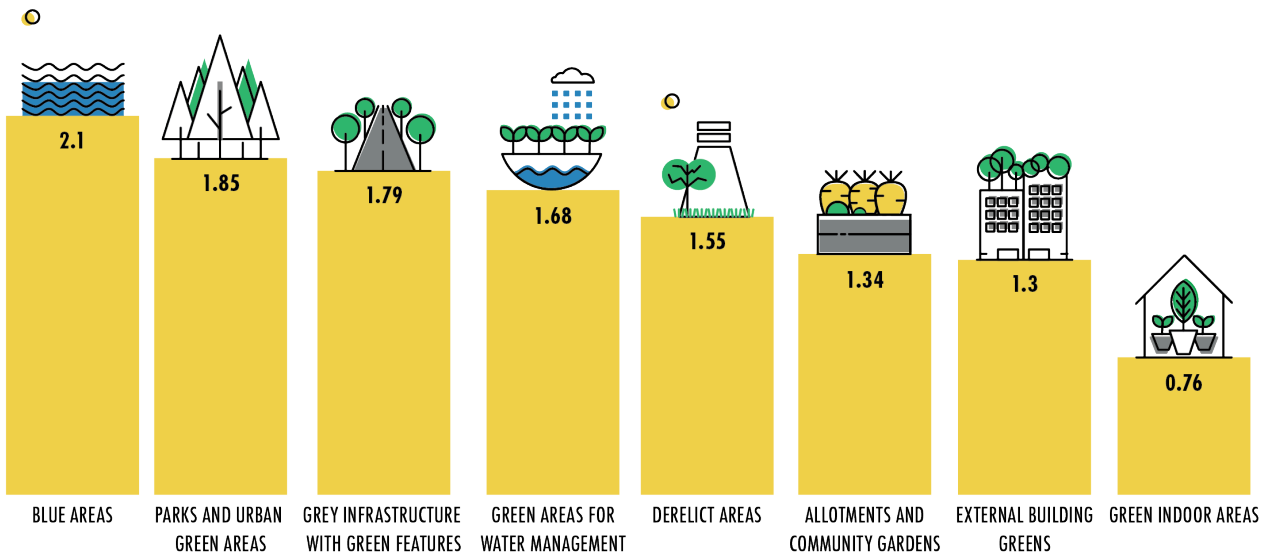


Figure 22: Average number of monitoring forms per nature-based solutions by urban setting

The analysis also showed that only 8% (74 and 77, respectively) of the NBS projects were confirmed to use web-based monitoring tools or GIS mapping. Of the remaining projects, 18% (173) stated that such tools are not used, and 75% (729) stated that it was unknown whether a web-based monitoring tool was used. GIS mapping, on the other hand, had a lower percentage of confirmed negative responses (8%, 76), but a higher percentage of unknowns (84%, 822) as it was unclear whether or not the projects utilise such a tool. The urban settings in which these tools had a higher percentage of use were in green indoor areas (19% for web-based monitoring tools, 0% for GIS mapping) followed by blue areas (8% for web-based monitoring tools, 6% for GIS mapping) (see Figure 23).

Though monitoring is generally not performed in the majority of NBS projects, some were found to take steps to undertake an impact assessment. Evidence was found that a little over 10% out of all projects considered, studied or carried out impact assessments. Interestingly, some projects without a formal monitoring system still had available impact assessments. An example of one project that undertook an impact assessment is the "Vesdre River Greenway" in Liège, Belgium (see Box 15). Further details about the type of impact assessment mechanism are presented in chapter 5.4.

Box No: 15

VESDRE RIVER GREENWAY - LIÈGE, BELGIUM

The project aimed to reconnect the local residents and businesses with the river and to create new functions, such as recreational and economic activities, around the river Vesdre. A new cycle path has been studied and a terrace has been constructed on the river bank allowing the inhabitants to re-discover the river and enhancing its beauty. According to an Input-Output analysis, every Euro spent on the VALUE investment generates approximately EUR 1,40 for the regional economy or an additional EUR 0,40. The Local Multiplier Analysis also calculated the project's economic contribution to the local economy. It examines a project's initial income and analyses, how income will be spent on different budget lines and how local residents and businesses will re-spend their money on local economy. Following three rounds of analysis, for every Euro spent on the VALUE Investment, additional EUR 1,42 is generated for the local economy.

Sources: VALUE (2017), VALUE (2012)

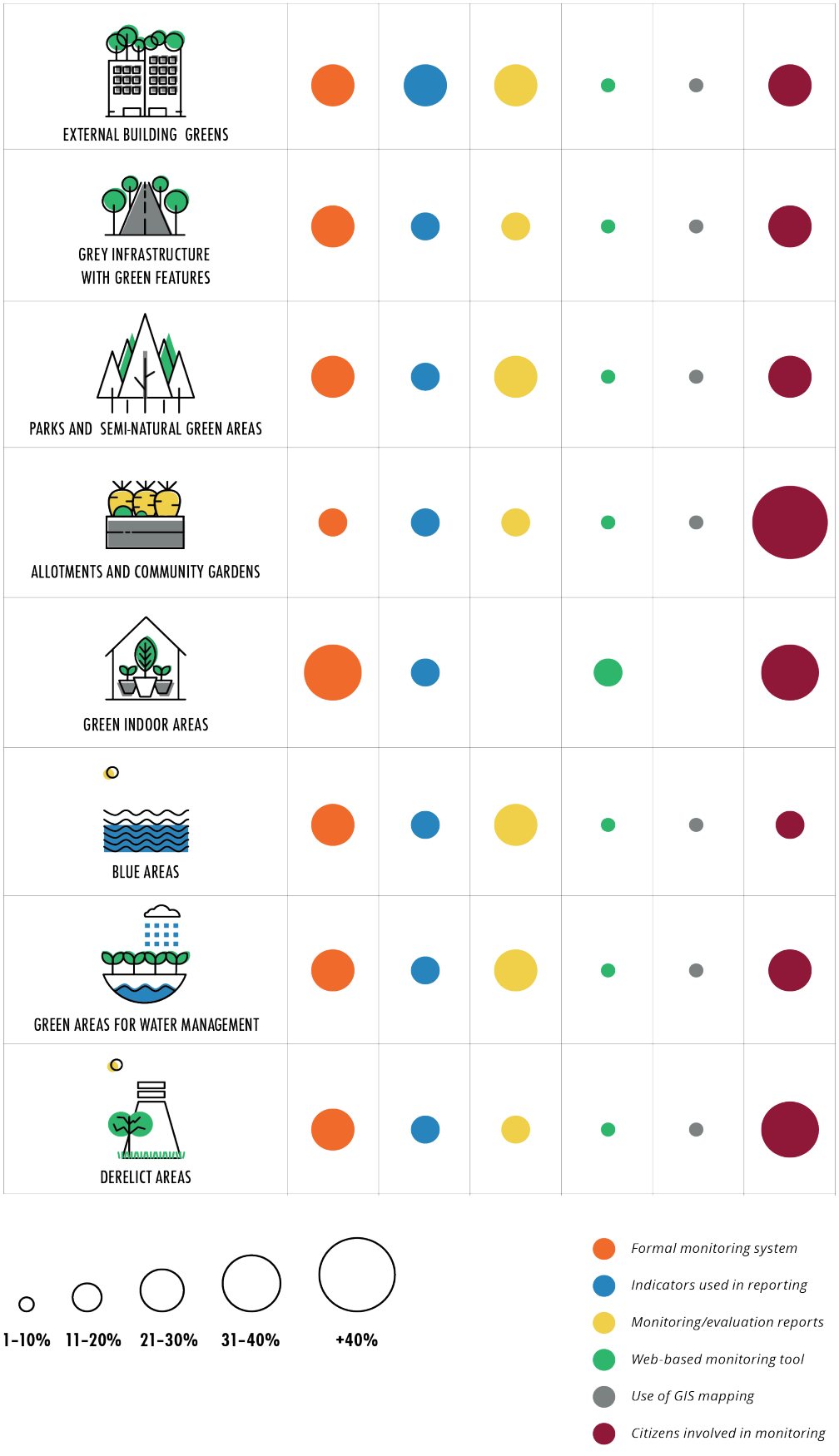


Figure 23: Monitoring of nature-based solutions by urban setting

8. CONCLUSIONS

The quantity and diversity of NBS projects included in the NATURVATION Urban Nature Atlas provide a unique opportunity to better understand the breadth of implementation taking place in this field across Europe. While the outcomes should not be interpreted as blanket conclusions for all European NBS, they nevertheless are founded upon the most extensive European NBS database to date and can be seen as a starting point for further research in this field. As such, the main findings of the preliminary analysis conducted within the framework of this report are summarized below, providing an overview of trends and significant outcomes.

The **general analysis** indicates a steep increase in the number of NBS projects which have begun since 2005. Noting that single projects could take place in multiple urban locations, the physical distribution was as follows: almost half of the studied projects took place in parks and urban forest areas, followed by those in smaller green areas connected to a grey infrastructure, projects involving blue infrastructure solutions and community gardens or allotments. Projects taking place in blue areas and green areas for water management were generally found to be larger, both in terms of spatial and financial scale, and also to have multiple stakeholders involved in their initiation and management. Such NBS projects are thus thought to be amongst the most likely to bring about systematic, transformative changes.

In terms of the **challenges addressed**, some NBS are motivated by a single objective and others are designed to produce several benefits; however, the majority of projects ultimately address multiple societal challenges in parallel. The most frequently reported challenges addressed were the creation of green space and protection of biodiversity and habitats. Half of the projects also tackled issues related to urban development and health and well-being. However, core environmental problems to which NBS are frequently seen as providing solutions within national and EU policy contexts (e.g. climate change, air pollution, etc.) are currently only being addressed to a far lesser degree.

Governance arrangements were also explored in the Urban Naure Atlas, distinguishing between the initiators of NBS projects and other forms of involvement. A strong increase in all forms of initiation can be observed between the oldest entered NBS projects and the most recent, though *public* initiation retains its lead over *private* and *other* actor groups. These two groups have also increased, though they still remain behind *public* initiation. *Public* actors are most frequently involved in NBS projects, followed by similar involvement levels of private and other actors. There has, however, been a slight decreasing trend in the use of most participatory methods. 'Dissemination of information and education' remains the most

frequently utilised engagement approach, although it has decreased significantly since 1990. On the other hand, there have been moderate increases in 'co-planning', 'crowd-sourcing' and 'joint implementation', while 'citizen science' is still highly underutilised, despite its high potential for contributions to e.g. monitoring.

The impact of different **policies as a driver for NBS deployment** was explored within the Urban Nature Atlas, focusing on EU, national and local policies. Local policies were found to most frequently drive NBS implementation as in comparison to national or EU level policies. In particular, local policies have been gaining importance since 2011 in motivating the implementation of green areas for water management, parks and semi-natural urban green areas, and greening grey infrastructure and blue areas. Such a trend would highlight the importance of increasing local leadership and support amongst decision-makers to drive NBS implementation. EU and national policies, while decreasing in importance over the last decade as a driver of NBS deployment, are nevertheless mostly linked to promoting blue areas and green areas for water management.

With regards to the evolution of different **funding streams**, the majority of the NBS projects across almost all urban domains (with the exception of green indoor areas) were reported as being financed/supported by local authorities' budgets. This is consistent with the aforementioned importance of local policies for NBS deployment. However, the analysis indicates that the number of NBS projects financed by public regional budget and public EU budget is in fact declining. Private funding streams have remained at the same level (ca. 24%) over the 25 years and have not shown a real increase despite the growing number of NBS projects. Significant potential remains to increase all financing streams, but particularly the currently underutilised private sector funds.

Regarding the **delivery of benefits and particularly ecosystem services**, evidence was found for 90% of all NBS projects highlighting their delivery of cultural services. Almost two thirds of projects also provided regulating and habitat and supporting services, with only a third being reported to produce provisioning services. The large majority of projects aimed to benefit citizens or community groups, within which 15% were reported to support disadvantaged groups (e.g. older or disabled people, families with small children). Almost half of the projects claimed to support local government bodies, and approximately 10% aimed to benefit other public sector institutions (e.g. school or hospital).

The question of whether or not different **forms of innovation are delivered by NBS** was also explored in the analysis. Around half of the studied NBS projects involved some type of technological innovation and a bit less than half were reported to produce social innovations. Only around 5% of the projects were found to deliver systematic innovations. Looking at the types of actor groups responsible for leading these projects, the analysis revealed that government-led projects were more likely to produce infrastructural and policy innovations, while NBS that were co-led or led by non-governmental actors more frequently delivered product innovations as well as governance and cultural innovations. Limited information was found in the reviewed secondary sources regarding whether the innovation delivered by the NBS had built on previous projects and whether it was transferred to new initiatives.

Little evidence was found in the reviewed sources as to whether or not **monitoring within NBS interventions** is taking place. In fact, only about a third of all interventions provide evidence that some form of monitoring system is in place. Evidence of the use of 'modern' monitoring options such as web-based tools and GIS mapping is very rare, with 8% of all NBS projects able to confirm the use of such tools. The use of citizens in monitoring efforts is the most frequent form of monitoring, with over a third of NBS interventions having evidence to this role. The overall lack of evidence of monitoring and indicators could be due to funding deficits, spatial and temporal monitoring challenges, difficulties in identifying monitoring indicators, lack of materials/ expertise needed, or other causes.

The preliminary analysis summarised above and throughout this report is a starting point for further in-depth analyses that are foreseen within the scope of the project. Future work will focus in particular on ecosystem service provisioning, innovation, financing, monitoring and governance and delve deeper into the potential implications of the information gathered.

REFERENCES

24 sata (2016) Samobor otvara gradski vrt. URL: http://www.24sata.hr/lifestyle/samobor-otvara-gradski-vrt-do-ite-i-sudjelujte-u-programu-465409

Adnkronos (2017) "L'ecologia del fiume rigenera la città, è il progetto per il Lambro Milanese". URL: http://www.adnkronos.com/sostenibilita/in-pubblico/2017/03/06/ecologia-del-fiume-rigenera-citta-progetto-per-lambro-milanese_vmg2Iz34Ev862VeuBPkZGN.html?refresh_ce

AM Landskab (2017) Roerplein wordt Groenplein. URL: http://www.amlandskab.nl/participatie/roerplein-wordt-groenplein/

Ariluoma, M. (2016) What is Green Factor? Site-scale solutions for stormwater management. URL: http://www.integratedstormwater.eu/sites/www.integratedstormwater.eu/files/materials/gf_what_is_green_gactor.pdf

Atribune (2017) Boschi verticali e grattacieli gentili. Il futuro delle città. URL: http://www.artribune.com/progettazione/architettura/2017/03/bosco-verticale-stefano-boeri-grattacielo-citta/

Behance (2013) Re-Think Athens: Towards a new city centre. 2013. URL: https://www.behance.net/gallery/7191429/Re-Think-Athens-Towards-a-New-City-Centre-Proposal.

BNN (2014) 'Mitgärtnern erwünscht. Am Rand der Rahel-Strauß-Straße in der Südstadt-Ost gedeiht Gemüse', Badischen Neuesten Nachrichten (BNN). URL: http://sozialergarten.initial-karlsruhe.de/wordpress/wordpress/wp-content/uploads/BNN-v.-18.7.14.pdf

Braquinho, C., Cvejić, R., Eler, K., Gonzales, P., Haase, D., Hansen, R.,Kabisch, N., Lorance Rall, E., Niemela, J., Pauleit, S., Pintar, M., Lafortezza, R., Santos, A., Strohbach, M., Vierikko, K., Železnikar, Š. (2015) A Typology of Urban Green Spaces, Ecosystem Provisioning Services and Demands. URL: http://bit.ly/2qENbhu

Bulkeley, H. (2016) NATURVATION: NATure-based Urban innoVATION. Project proposal.

Bulkeley, H., Bracken, L., Almassy, D., Pinter, L., Naumann, S., Davis, M., Reil, A., Hedlund, K., Hanson, H., Dassen, T., Raven, R. and Botzen, W. (2017) State of the Art Review : Approach and Analytical Framework. Deliverable 1.3. Part I.

City of Helsinki Environment Centre (2016) Developing the City of Helsinki Green Factor Method. URL: https://www.integratedstormwater.eu/sites/www.integratedstormwater.eu/files/report_summary_developing_a_green_factor_tool_for_the_city_of_helsinki.pdf

City of Szczecin (2016) Szczecin's participatory budget 2017, 'Rose gardens in Kiejewo' ('Różane ogrody w Kijewie'). URL: http://konsultuj.szczecin.pl/konsultacje/files/857C3314B976401EA556984AD4B9FC5C/060_I.pdf

City of Szczecin (2017) Rules for submitting applications to the Szczecin citizens 'budget 2017' ('Zasady składania wniosków do szczecińskiego budżetu obywatelskiego 2017') URL: http://konsultuj.szczecin.pl/konsultacje/chapter_116147.asp

Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (2016) Nature-Based Solutions to address societal challenges. doi: 10.2305/IUCN.CH.2016.13.en.

Craiova Info (2009) Parcul Tineretului din Craiova. URL: http://www.craiova.info/ghidul-orasului-craiova/92-parcul-tineretului-din-craiova

DBU (2011) Beweidungsprojekt Stadtwald Augsburg. URL: https://www.dbu.de/OPAC/ab/DBU-Abschlussbericht-AZ-22925.pdf

Dennis, M., and James, P. (2016) User participation in urban green commons: Exploring the links between access, voluntarism, biodiversity and wellbeing. Urban Forestry & Urban Greening, 15 , pp. 22-31

Doncaster Council (2014) Doncaster Green Infrastructure Strategy. URL: http://naturvation.eu/sites/default/files/nbs/files/doncaster_green_infrastructure_strategy_1.pdf

Ecologic Institute (2011) Assessment of the potential of ecosystem-based approaches to climate change adaptation and mitigation in Europe. URL: http://ecologic.eu/sites/files/project/2013/2345_eba_ebm_cc_finalreport_23nov2011.;

Eggermont, H., Balian, E., Azevedo, J.M.N., Beumer, V., Brodin, T., Claudet, J., Fady, B., Grube, M., Keune, H., Lamarque, P., Reuter, K., Smith, M., van Ham, C., Weisser, W.W., Le Roux, X. (2015). Nature-based Solutions: New Influence for Environmental Management and Research in Europe. GAIA - Ecological Perspectives for Science and Society, 24(4), pp. 243-248(6). URL: http://www.ingentaconnect.com/content/oekom/gaia/2015/00000024/00000004/art00010?crawler=true

EIO (2015) Eco-innovation in Belgium: EIO Country Profile 2014-2015. URL: https://ec.europa.eu/environment/ecoap/sites/ecoap_stayconnected/files/field/field-country-files/belgium_eco-innovation_2015.pdf

European Commission (2015) Towards an EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities. doi: 10.2777/765301.

Ndubisi, F., DeMeo, T., Ditto, N. D. (1995) Environmentally sensitive areas: a template for developing greenway corridors. . Landsc. Urban Plan. 33, 159e177.

Gail at Large, A Canadian in Portugal Blog (2016) Jardim das oliveiras: Porto's urban rooftop garden. URL: https://gailatlarge.com/blog/2016/04/08/43033

Gemeente Utrecht (2013) Wijkgroenplan Zuidwest. Utrecht: Gemeente Utrecht. URL: https://www.utrecht.nl/wonen-en-leven/parken-engroen/groenbeleid/wijkgroenplannen/zuidwest/

Giacomello, E. and Valagussa, M. (2015) Vertical Greenery: Evaluating the High-Rise Vegetation of the Bosco Verticale,Milan. Chicago: Council on Tall Buildings and Hurban Habitat, 1-96. URL: http://ctbuh.org/Portals/0/Research/SeedFunding/2013/BoscoResearchReport.pdf

Green Roofs (2017) The Hellenic Treasury – Constitution Square. URL: http://www.greenroofs.com/projects/pview.php?id=1722

Hansmann R., Whitehead I., Krajter Ostoić S., Živojinović I., Stojanovska M., Jones N., Bernasconi A., Benamar S., Lelieveld C., Barstad J. (2016) Partnerships for Urban Forestry and Green Infrastructure Delivering Services to People and the Environment: A Review on What They Are and Aim to Achieve. Southeast Eur for 7 (1): 9-19.

HSY (2012) Helsinki Metropolitan Area Climate Change Adaptation Strategy. Helsingin seudun ympäristöpalvelutkuntayhtymä. URL: https://www.hsy.fi/sites/Esitteet/EsitteetKatalogi/Julkaisusarja/11_2012_Helsinki_Metropolitan_Area_Climate_Change_Adaptation_Strategy.pdf

Initial Karlsruhe (2010) 'Gesundheit für alle 2009'. URL: http://sozialergarten.initial-karlsruhe.de/wordpress/wordpress/der-garten/wie-alles-begann-video-der-garten-2009/

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K. and Bonn, A. (2016) 'Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action', Ecology and Society. The Resilience Alliance, 21(2). doi: 10.5751/ES-08373-210239.

Les Rives du Bohrie (2017) Charte De L'Ecocitoyen Du Quartier Des Rives Du Bohrie. URL: https://www.lesrivesdubohrie.fr/leco-quartier/charte-de-lecocitoyen/

Liebig, N. (2011) Management von Flussschotterheiden in Augsburg. URL: http://lpv-augsburg.de/files/Downloads_Neu/Liebig_Heidemanagement.pdf

Longo, A., Masotti, D. and Giacomel, A. (2016) RE LAMBRO. Il fiume nuova infrastruttura ecologica della metropoli milanese. Studio di fattibilità per la rete ecologica del Lambro milanese. Milano: Fondazione Cariplo 2012, piano di azione "realizzare la connessione ecologica" ERSAF (capo!la), Comune di Milano, PLIS Media Valle del Lambro, DAStU Politecnico di Milano, Legambiente Lombardia, 1-228.

Maes, J., Teller, A., Erhard, M., Liquete, C., Braat, L., Berry, P., Egoh, B., Puydarrieux, P., Fiorina, C. and Santos, F. (2013) Mapping and Assessment of Ecosystems and their Services, Agriculture, Ecosystems & Environment. Luxembourg. doi: 10.2779/12398."

Mattlé, S. (2017) Les Rives du Bohrie, un nouveau mode d'habitat primé. Published in L'est agricole et viticole on 6 January 2017. URL: https://www.cmcic-foncier.fr/fr/special/Publication_06_01_2017_page_40_web.pdf

Mazus, A. (2015)'Gardens on the roofs: non-expensive, effective and ecological' ('Ogrody na dachach: niedrogo, efektownie, ekologicznie') dziennikwschodni.pl. URL: http://www.dziennikwschodni.pl/dom/ogrody-na-dachach-niedrogo-efektownie-ekologicznie,n,1000001091.html

Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-being: A Framework for Assessment. URL: https://www.millenniumassessment.org/en/index.html

Montpellier (2017a) "Le réseau vert". URL: http://www.montpellier.fr/2851-reseau-vert.htm

Montpellier (2017b) "Biodiversité". URL: http://www.montpellier.fr/3313-biodiversite.htm

Montpellier (2017c) "Réseaux d'observation citoyens". URL: http://www.montpellier.fr/3312-reseaux-d-observation-citoyens.htm

Montpellier (2017d) "Virtual Platform of the Discovery of the Green Network of Montpellier". http://www.montpellier.fr/externe/Visite%20aerienne%20r%C3%A9seau%20vert/A%20la%20d%C3%A9couverte%20du%20r%C3%A9seau%20vert%20de%20la%20Ville.html

NCC (2011) Core strategy and Urban Core AAP. Joint Technical Papers. Gateshead Council. NCC.

Newcastle University (nd) About Science Central. URL: http://www.newcastlesciencecentral.com/about/

NMU (2015) Groen plan voor Roerplein. Published online in Natuur en Milieufederatie Utrecht (NMU). URL: http://www.nmu.nl/nieuws/groen-plan-voor-roerplein/

Northumbian Water (2016) New research show a role for blue and green alongside Newcastle's classic black and white.

NWRM (2017) Natural Water Retention Measures, Case Study: Restructuring the effluent web in Italy. URL: http://nwrm.eu/case-study/restructuring-effluent-web-italy

Oppla (2013) Case studies, Porto: Fifth Façade project Jardim Das Oliveiras: Porto's Urban Rooftop Garden. URL: http://oppla.eu/casestudy/17626

Parc de Collserola (2015) Consorci del Parc Natural de la Serra de Collserola: Memoria Gestio 2015. URL: http://www.parcnaturalcollserola.cat/pdfs/memories/MEMORIA_GESTIO_2015.pdf

Parc de Collserola (2017a) Serra de Collserola Natural Park. URL: http://www.parcnaturalcollserola.cat/en

Parc de Collserola (2017b) Future Challenges. URL: http://www.parcnaturalcollserola.cat/en/pages/reptes-de-futur

Parcul Lunca Jiului Blog Posts (2009) URL: http://www.luncajiului.ro/

Pătru, C. (2017) "A început „Luna Plantării Arborilor""published in Cuvantul Libertatii on 16 March 2017. URL: http://www.cvlpress.ro/16.03.2017/a-inceput-luna-plantarii-arborilor/

Rakennusvirasto Byggnadskontoret (2008) City of Helsinki Strategy on Storm Water Runoff (Helsingin kaupungin hulevesistrategia) URL: https://www.hel.fi/static/hkr/julkaisut/2008/hulevesistrategia_2008_9.pdf

Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., Geneletti, D. and Calfapietra, C. (2017) 'A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas', Environmental Science and Policy. Elsevier, 77(June), pp. 15–24. doi: 10.1016/j.envsci.2017.07.008.

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

RÉV8 (2012) Magdolna Negyed Program: Integrált Szociális Városrehabilitációs Program, Volume 4. Budapest: Józsefvárosi Önkormányzat.

River Torne Catchment Partnership (2016) Progressing our projects. URL: http://www.ywt.org.uk/sites/default/files/170324torneicpjm1.pdf

Stadin Ilmasto (2017a) iWater - Integrated storm water management. URL: http://www.stadinilmasto.fi/en/adapting-to-climate-change/iwater-integrated-storm-water-management/iwater-integrated-storm-water-management/

Stadin Ilmasto (2017b) Adapting to climate change. URL: http://www.stadinilmasto.fi/en/adapting-to-climate-change/

Stankiewicz, M. (nd) 'Sample projects of green roofs and green walls in Polish municipalities. Overview of financing sources.'('Przykładowe realizacje zielonych dachów i żyjących ścian w polskich gminach. Przegląd źródeł finansowania.'), DAFA. URL: http://www.dafa.com.pl/pliki/mariastankiewicz.pdf

Stefano Boeri Architetti (2017) Vertical Forest. URL: https://www.stefanoboeriarchitetti.net/en/portfolios/bosco-verticale/

Strasbourg Eurometropole (2017a) L'ile du Bohrie: Au coeur de l'écoquartier des Rives du Bohrie à Ostwald. URL: http://media.strasbourg.eu/alfresco/d/d/workspace/SpacesStore/0d68a7a3-2b64-467c-8a6e-a5dc932628db/2015%2009%20plaquette%20i%CC%82le%20Bohrie%20finale.pdf

Strasbourg Eurometropole (2017b) Eco-Distric projects. URL: http://www.en.strasbourg.eu/en/great-projects/eco-distric-projects/

Strasbourg Eurometropole (2017c) Les Rives du Bohrie: un quartier au cœur de la nature. URL: http://www.strasbourg.eu/developpement-rayonnement/urbanisme-logement-amenagement/projets-urbains/rives-du-bohrie

Strasbourg Eurometropole (2017d) Ostwald, ZAC des Rives du Bohrie. URL: https://www.slideshare.net/agencedunumerique/smartcities-2015-strasbourgeu

Stuparu, M. (2017) "O lună de împăduriri în Dolj" published in Gazeta de Sud on 20 March 2017. URL: http://www.gds.ro/Local/2017-03-20/o-luna-de-impaduriri-dolj/

Tapia C., Guerreiro S., Dawson R., Abajo B., Kilsby C., Feliu E., Mendizabal M., Martinez J. A., Fernández J. G., Glenis V., Eluwa C., Laburu T., Lejarazu A. (2016) "RAMSES Deliverable 3.1: High level quantified assessment of key vulnerabilities and priority risks for urban areas in the EU", RAMSES Project. Grant Agreement 308497, Bilbao and New Castle

Trame verte et bleue (2017) "Groupe d'échange TVB". URL: http://www.trameverteetbleue.fr/vie-tvb/groupe-echange-tvb?language%3Den=fr

UN General Assembly (2015) Transforming our world : the 2030 Agenda for Sustainable Development, 21 October 2015, A/RES/70/1. URL: http://www.refworld.org/docid/57b6e3e44.html

US EPA (2017) Performance of Green Infrastructure. URL: https://www.epa.gov/green-infrastructure/performance-green-infrastructure

VALUE (2017) Vesdre River Greenway online project description, URL: http://www.onlinegreencity.com/case-study/vesdre-river-greenway/

VALUE (2012) VALUE project report. URL: Valuing Attractive Landscapes in the Urban Economy Work Package 4, Action 4.2: Report on the estimation of non-market values from different scenarios in Verviers - Cycling and walking path along the river Vesdre. URL: https://orbi.ulg.ac.be/bitstream/2268/113592/1/VALUE_Final_report_7.08.2012.pdf

VERDIR (2013) VERDIR project brochure. URL: https://www.ulg.ac.be/upload/docs/application/pdf/2013-01/verdir-brochure_2013-01-25_15-01-35_540.pdf.

Wilker, J., Rusche, K., Rymsa-Fitschen, C. (2016) Improving Participation in Green Infrastructure Planning. Planning Practice & Research, 31(3), pp. 224-249.

Wissenschaftsladen Bonn (2017) Internationaler Garten. URL: https://www.wilabonn.de/themen/lokal/internationaler-garten.html

Xing, y., 1, Phil Jones, P., Donnison, I. (2017) Characterisation of Nature-Based Solutions for the Built Environment. URL: https://orca.cf.ac.uk/97729/1/Xing%202017%20NBS%20BuiltEnvironment.pdf

ANNEX A

ECOLOGICAL DOMAINS AND SUB-DOMAINS INCLUDED IN THE QUESTIONNAIRE

ECOLOGICAL DOMAINS	SUB-DOMAINS
External building greens	• Green roofs • Green walls or facades • Balcony green • Other
Urban green space connected to grey infrastructure	• Alley and street trees/hedges/greens • Railroad bank and tracks • House gardens • Green playground/ school grounds • Institutional green space • Green parking lots • Riverbank greens • Other
Parks and (semi) natural urban green areas	• Large urban park or forest • Pocket parks / neighbourhood green spaces • Botanical garden • Green corridor • Other
Allotments and community gardens	• Allotments • Community gardens • Horticulture • Other
Green indoor areas	• Indoor vertical greeneries (walls and ceilings) • Atrium • Other
Blue areas	• Lake/pond • River/stream/canal/estuary • Delta • Sea coast • Wetland/bog/fen/marsh • Other
Green areas for water management	• Rain gardens • Swales / filter strips • Sustainable urban drainage systems • Other
Derelict areas	• Abandoned and derelict spaces with growth of wilderness or green features • Other

ANNEX B

LIST OF STUDIED CITIES

- Belgium: Antwerpen, Liège
- Bulgaria: Sofia, Plovdiv
- Croatia: Zagreb
- Czech Republic: Brno
- Denmark: Århus
- Estonia: Tallinn
- Finland: Helsinki / Helsingfors
- France: Toulouse, Strasbourg, Lille, Montpellier, Saint-Etienne, Nancy, Clermont-Ferrand, Aix-en-Provence, Marseille, Rouen
- Germany: Hamburg, München, Frankfurt am Main, Essen, Stuttgart, Bremen, Hannover, Nürnberg, Bielefeld, Augsburg, Bonn, Karlsruhe, Münster, Wuppertal, *Leipzig*
- Greece: Athens
- Hungary: Budapest, *Györ*
- Ireland: Dublin
- Italy: Roma, Milano, Napoli, Palermo, Genova, Bari, Bologna, Catania, Venezia
- Norway: Oslo, Bergen
- Poland: Kraków, Poznan, Szczecin, Bydgoszcz, Lublin, Białystok, Gdynia
- Portugal: Lisboa, Porto, Sintra
- Romania: Bucuresti, Timisoara, Craiova, Iasi
- Slovakia: Bratislava
- Slovenia: Ljubljana
- Spain: Sevilla, Zaragoza, Málaga, Murcia, Palma de Mallorca, Bilbao, Córdoba, Alicante/Alacant, *Barcelona*
- Sweden: Stockholm, Göteborg, *Malmö*
- The Netherlands: Amsterdam, s-Gravenhage, Utrecht
- United Kingdom: Leeds, Glasgow, Bradford, Liverpool, Edinburgh, Greater Manchester, Cardiff, Sheffield, Belfast, Portsmouth, Coventry, Greater Nottingham, Wirral, Wakefield, Doncaster, Sunderland, Medway, Reading, *Newcastle*

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ent environment & management

ICLEI Local Governments for Sustainability

Leibniz-Institut für Länderkunde

GRIMMA

Malmö stad

Newcastle City Council

PBL Netherlands Environmental Assessment Agency

MTA KRTK

UAB Universitat Autònoma de Barcelona

LUND UNIVERSITY

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