HORIZON 2020

Coordination and support actions

thinknature

Development of a multi-stakeholder dialogue platform and Think tank to promote innovation with Nature based solutions

WP5: Identification of barriers and uptake of the necessary decision-making mechanisms of the various local authorities and stakeholders

Deliverable D5.1

Barriers Landscape and Decision-Making Hierarchy for the Sustainable Urbanisation in Cities via NBS

Authors: A. Bernardi (CNR-ISAC), S. Enzi (CNR-ISAC), M. Mesimäki (UoH), S. Lehvävirta UoH, J. Jurik (GIB), D. Kolokotsa (TUC), K. Gobakis (TUC), S. van Rompaey (E2ARC,) E. Goni (E2ARC), E. Mink (EUDA), P. Sansoglou (EUDA), J. Porter (OPPLA), F. Lemaitre (FRB), A. Streck (ECTP), H. Elgar (WENP)

Contributors: J. Simpson (OPPLA), G. Adell (ECTP)

January 2019

Executive Summary

This report intends to outline the procedures that were followed by the ThinkNature project WP5, T5.1, concerning the formulation of the ThinkNature Questionnaire and interviews on NBS barriers and drivers, and the elaboration of the results obtained, in order to define a decision-making hierarchy for a sustainable urbanization through NBS.

Version history

Version	Comment
1.1	First release to all partners
1.2	Implementation with the contributions received
1.3	Circulation of the new draft among the partners
1.4	Contribution from Oppla and FRB
1.5	Contribution from GIB, E2ARC
1.6	Circulation of the new draft among the partners
1.7	Contribution from TUC and EUDA
1.8	Contribution from ECTP
2	Final version
3	Submission of deliverable to the Coordinator

Table of contents

1. Introduction

Climate change presents one of the greatest challenges to the society today. Effects on ecosystems and society are strongly felt in cities, as about half of the human population globally lives in urban areas. In addition to climate change, urbanisation and the continuous increase in the number and size of cities are impacting ecosystems with various threats, often related with each other. These threats include, for example, loss or degradation of natural areas, soil sealing and the densification of built-up areas.

However, nature-based solutions have the potential to successfully cope with these negative effects of large urbanization and climatic change. Nature-based Solutions (NBS) can foster and simplify implementation actions in urban landscapes by taking into account the services provided by nature. They include provision of urban green, such as parks and street trees that may ameliorate high temperature in cities or regulate air and water flows, or the allocation of natural habitat space in floodplains that may buffer impacts of flood events. Architectural solutions for buildings, such as green roofs and wall installations, may reduce temperature and save energy"[1].

All these solutions are not still completely known, implemented and widespread, due to existing barriers of different kind and in different fields.

The major output of the WP5 is the development of strategies to overcome existing barriers and to provide a decision-making hierarchy coupled with the engagement of local stakeholders in addressing NBS as part of EU, regional and local communities' strategies.

Although the deterioration of the environment is well understood, and techniques and technologies are available to deal with this, there are different technological and non-technological barriers that hinder the adoption and implementation of NBS. Opportunities for local and regional stakeholders as well as business actors and experts to explore comprehensive nature-based solutions may be missed due to barriers to the introduction of new technologies and new approach to the management of urban and rural areas. Therefore, it is important to understand how current actual/perceived barriers prevent uptake.

---

[1] Kabisch et al., Nature□based Solutions to Climate Change Adaptation in Urban Areas. Linkages between Science, Policy and Practice, p. 2, Springer open, 2017.

This work results to a decision-making hierarchy with general guidelines that will help stakeholders to identify the best options for the NBS integration.

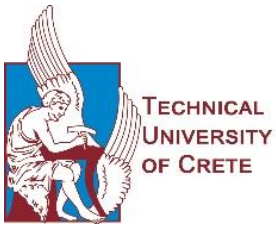
Consequently, this WP will carry out technical, market, legislative and policy landscape assessment to identify the factors that discourage large-scale nature-based solutions deployment. This can only be achieved by the involvement of main stakeholders in each participating country, which will be enabled by the National NBS Contact Points to identify local and/or regional perceived barriers as well as with interviews with the partners involved in ongoing Horizon projects. This WP will ensure the involvement of a wide variety of stakeholders under the umbrella of the ThinkNature Platform.

To achieve the target of T5.1, we developed a questionnaire aimed to explore the barriers and drivers related to NBS; the questionnaire was uploaded in the Think Nature Platform and website, and the results were analysed, in order to reveal critical factors, actors and processes in decision-making to promote NBS in cities. The same questionnaire was used also as a base for direct interviews, that deepen and complete the information gathered by the survey.

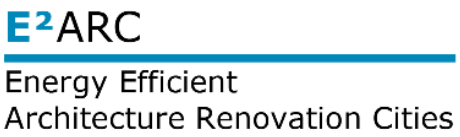
The participants in this Task of the ThinkNature Project are:

- Consiglio Nazionale delle Ricerche (CNR), Task Leader
- Technical University Crete (TUC)
- Energy Efficient Architecture Renovation Conservation (E2ARC)
- Global Infrastructure Basel (GIB)
- Centre Scientifique et Technique du Batiment (CSTB)
- European Construction Technology Platform (ECTP)
- International Society of City and Regional Planners (ISOCARP)
- University of Helsinki (UoH)
- Foundation for Research and Technology Hellas (FORTH)
- OPPLA
- Fondation pour la Recherche sur la Biodiversité (FRB)
- Region of Crete


ISAC


TECHNICAL
UNIVERSITY
OF CRETE


HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI


E²ARC
Energy Efficient
Architecture Renovation Cities


CSTB
le futur en construction


Global
Infrastructure
Basel


ECTP
INNOVATIVE BUILT
ENVIRONMENT


FRB
FONDATION
POUR LA RECHERCHE
SUR LA BIODIVERSITÉ


oppla


ISOCARP
Knowledge for Better Cities


FORTH
Foundation for Research & Technology - Hellas


HELLENIC REPUBLIC
REGION OF CRETE

2. Designing the questionnaire

During the first period of work, all the involved partners were actively engaged in designing the survey, especially the CNR ISAC with the University of Helsinki(Lehtimäki et al., 2017; Von Hertzen et al., 2015).

Concerning T5.1, i.e. the creation of a survey for Sustainable Urbanization in Cities, different kinds of approaches were discussed. After several brainstorming via Skype meetings among the partners, a document on the methodology was produced, and sent to the Commission: “NBS Barrier Landscape Assessment: Methodological Framework” (CNR ISAC, UoH, OPPLA, FRB, see Annex 1).

Next, we designed the questionnaire (Annex 2), following the Methodological Framework. All the partners contributed with their comments and suggestions to this profound process. The major issues concerning the development of the questionnaire were: what kinds of solutions could be listed under NBS-concept, compared with other umbrella concepts, e.g. Green Infrastructure, and how to address the demand for both quantitative and qualitative data. The challenge was the multifaceted and complicated character of possible barriers, and the local contexts likely having effects on the formation of barriers. As a result, a mixed-methodology survey was produced, including several options for the respondent to answer. The survey was designed to collect both qualitative and quantitative data, via open and close-ended questions. Furthermore, also drivers for NBS were included, as the phenomenon of barriers is not unambiguous: something may be seen as a barrier in one place, it may serve as a driver in another context. A key idea was also to collect data about drivers of NBS, not only barriers, in order to better recognise how to overcome the barriers by consciously harnessing drivers.

The questionnaire was structured in two main sections, dividing in the beginning the respondents in experts who have own experience of NBS (‘YES’ section) and experts who have not yet worked with NBS (‘NO’ section).

After choosing yes/no in the first question, i.e.: “Have you worked with Nature-based Solutions or closely followed planning or implementations of them?”, the respondent was redirected in the related section. The questions, both open and closed, set to the first group (YES), were about which kind of NBS they have worked with, their direct experience on them, and the success/unsuccess of the projects, followed by a series of open questions, asking the respondent to offer more specifications and explain their opinion on both the barriers and the drivers they have experienced.

In the “NO” section, the respondents were asked to give their opinion about which NBS they consider relevant, now or in the future, in cities, and which they consider the drivers or the barriers to them, again with open questions where they were able to explain their suggestions to overcome barriers or apply drivers.

The goal was to create a questionnaire where the respondent could think of the barriers and drivers in a realistic, concrete situation. This would offer understanding of the local context where barriers and drivers take shape.

All the relevant or not commonly recognised concepts were followed by an explanation, visible by clicking on a symbol ⓘ in the text of the question.

After finalizing, the questionnaire was uploaded online (TUC, ISOCARP), both in the Platform and in the website of ThinkNature.

Before the release of the final version, an online test with 12 experts was performed, and their comments and advice for finalising the questionnaire were collected in order to improve the questionnaire as much as possible.

2.1 Choice of the questions

The choice of the questions was a result of various discussions among the partners of the Task 5.1. For collecting the list of NBS to be included in the questionnaire, literature on the topic was considered and evaluated, in particular:

https://publications.europa.eu/en/publication-detail/-/publication/fb117980-d5aa-46df-8edc-af367cddc202 and https://www.biodiversa.org/898/download.

Based on this, the following NBS were included in the questionnaire, to illustrate the scope of solutions for the respondent:

Green infrastructure, e.g.

- Green roofs or roof gardens
- Green walls or green facades
- Green corridors
- Street plants and trees
- Parks
- Rain gardens, vegetated ditches
- Urban farms, allotments or community

- Private gardens
- Urban/peri-urban forests or woodlands
- Restoration of industrial

Blue Infrastructure, e.g.

- Blue corridors
- Rivers or streams
- Use of balancing ponds and underground storage systems
- Sustainable Urban Drainage Systems
- Buffers, e.g. River bank restoration
- Floodplain restoration
- Coastal habitat restoration/maintenance
- Wetlands

Technical approaches and materials in support of NBS, e.g.

- Infiltration trenches
- Permeable pavements
- Bio-waste based growing materials
- Waste effluent management through e.g. biodegradation and bioconversion

(Other)

The information expected was both quantitative and qualitative. For example, the first question was about the experience of the respondents in the NBS field, aimed at producing information of how many respondents actually had worked or not with NBS. Those respondents who had not experience in working with NBS, were asked to specify which NBS they consider important now or in the future, giving an idea of which kinds of solutions the decision-making systems should be prepared for.

The respondents having experience on NBS project(s) were asked to specify what kind(s) of NBS they had worked with, and the successfulness or failure of the projects with each NBS. This part of the survey was expected to offer quantitative information on the specific NBS the respondents worked with, and which NBS need special attention as regards the barriers for implementation, in case certain NBS projects would be considered failed more often than other NBS projects. On the basis of the open-ended questions on the

barriers/drivers categories, where the respondents were asked to specify the categories (closed question), and to explain how they can be overcome (for barriers) or pushed (for drivers), both quantitative information of the barrier/driver categories and qualitative information on how these affect the implementation of the specific NBS in local cases could be collected.

2.2 Choice of the barrier- and driver categories

The barriers to be investigated, following the Project Proposal, were:

- Technological
- Policy or legislative
- Market
- Communication

Literature searches for various categories of barriers were made, resulting in a broader perspective than the one in the project proposal (in order to cover all kinds of categories); sub-categories of barriers were collected, as examples of each barrier-category to illustrate the wide variety of possible barriers. These were not comprehensive lists, but the idea was to feed the imagination of the respondent and to make them focus and reflect on concrete situations.

The result was a slightly different and larger list of fields in which barriers, but also drivers, could be identified. The choice for the respondents was formulated as follows:

- Technical drivers/barriers
- Policy drivers/barriers
- Market drivers/barriers
- Communication drivers/barriers
- Knowledge drivers/barriers
- Process and tradition-based drivers/barriers
- I do not know
- I think there are no drivers/barriers for this NBS
- Other (please specify)

2.3 Open-ended questions

Another choice in the structure of the questionnaire that required discussion among the Task's partners was that between closed and open-ended questions. As suggested in the Project's proposal, the decision was to use both, resulting in a semi-structured questionnaire.

The argumentation was that, even though faster to answer, pre-defined solutions (close-ended questions) for, e.g. how to remove the barriers, would not reveal all possible mechanisms and solutions to overcome the barriers. Furthermore, as NBS should be multifunctional, there might be cases where some aims are reached, and some not (e.g. a green roof may function technically but does not optimally produce social benefits). Thus, there could be different barriers concerning different aims of the same NBS. For example, silo-thinking and lack of cross-administrative discussion and systems may hinder social benefits to be considered with an otherwise functional NBS-solution. Therefore, the respondents were steered to think of the (non)successfulness of the project as widely as possible.

Asking about NBS projects was a conscious choice, targeted at making the respondent to think of the process, and e.g. various stakeholders in different phases of the projects. The aim was to collect information on those mechanisms, processes, actors etc. that the respondents identified to hinder or promote NBS in local cases, in order to gain valuable information of how to overcome barriers.

2.4 Distribution of the questionnaire

A list of experts and stakeholders, i.e. potential respondents to the questionnaire, was drafted, in collaboration with all the partners of the Task. The link to the questionnaire was widely distributed by all the partners, with an argumentation of the importance of the survey for the decision-making. This list consisted of approximately 250 names. It included Think & Do Tank members, Local Representatives and other stakeholders.

In the Introduction of the Questionnaire, it was specified that it will remain anonymous and treated following the privacy rules (see D1.1): "The outcome of the questionnaire will be published on the ThinkNature website but individual responses will remain anonymous. All responses will be treated with confidentiality and reported only in aggregate form. All the

information that you provide will be used only for the purpose of developing knowledge and policies to support NBS, and for scientific studies." (see Annex 2).

The distribution was implemented via mailing, phone calls and face to face meetings and seminars, in order to sensitize the potential respondents of the importance of their role.

As the questionnaire was online, anyone interested could directly enter the questionnaire and fill it in.

3. The online questionnaire

The questionnaire was online from 4th April 2018, both on the ThinkNature Project website (Figure 1), and the ThinkNature Platform (Figure 2), until 31st October 2018.

The initial version of the questionnaire was based on integrated tools provided (webforms) by the Open Atrium software which the ThinkNature Platform is based on. Due to the complexity and size of the questionnaire (100 different question grouped into 20 sections) and multiple path in the question, based on the answers given during the questionnaire's execution, the decision was made to move to a dedicated questionnaire software. After exploring the available options, the open source software LimeSurvey was chosen. LimeSurvey provided all the necessary options to overcome the shortcomings of the previous solutions, like custom programming of questionnaires using JavaScript programming language, more options on conditional and overall flow of the questionnaire and more. Due the size and complexity of the questionnaire, a significant amount of time was spent in creating and debugging its final version.

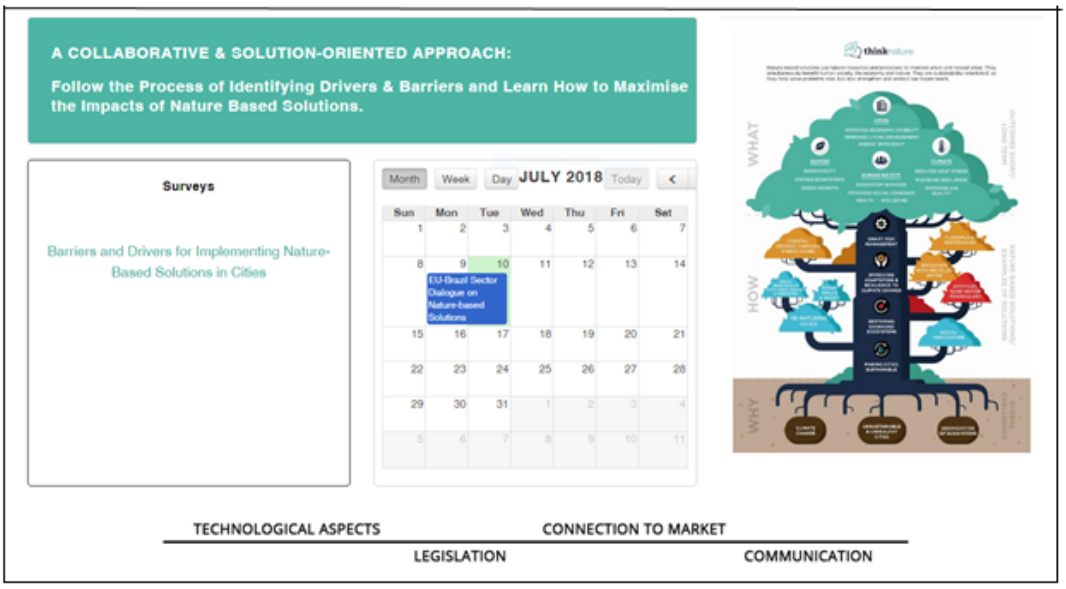


Figure 1: The link to the survey on the ThinkNature website

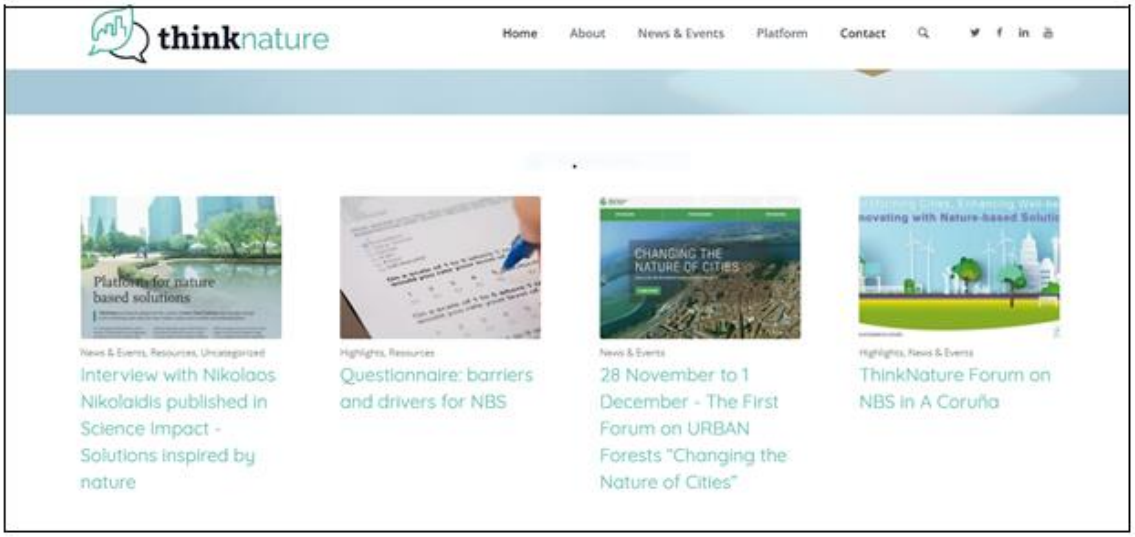


Figure 2: The link to the survey on the ThinkNature Platform

4. Interviews

The same questionnaire was used also for the direct interviews, performed by some of the T5.1 partners (UoH, OPPLA, GIB, CNR-ISAC) among their contacts (stakeholders) and by some of the Regional Think and Do Tanks components to the Local Representatives of their Region (see Deliverables 3.3 and 3.4).

The direct interviews consisted of filling in the survey directly (face to face or by phone/skype) with each stakeholder involved as respondent, helping them with the language and possible doubts on the questions, motivating them to answer also to the open questions, and discussing in a deeper way the topics of main interest. The characteristics of the direct interviews is, beside a significant deepening of the respondents' ideas and perceptions on the barriers to NBS and drivers to overcome them, the fact that they were performed in the local languages, so that also respondents not speaking English (the language of the online questionnaire) were reached.

The respondents were selected experts in the field on NBS, chosen by the partners involved in this Task and participants of Think and Do Tanks. The selection criteria were:

- Personal connection with the interviewer
- Sound expertise of the respondent in NBS
- Motivation in participating to the interview.

5. Materials and results

In this chapter, we display the materials and results of the survey and interviews that were conducted using the online questionnaire. Chapter 5.1 presents the background of the respondents and the NBS asked in the survey, as well as describes the overall distribution of the drivers and barriers the respondents indicated. Chapter 5.2 offers analysis and discussion of the results with practical examples and cases. In chapter 5.3, we provide conclusions concerning the barrier landscape assessment. The following Chapter 6 is composed of three exemplary case studies reflecting drivers and barriers of NBS in various local contexts. In Annexes 3 and 4, we offer supplementary material and templates to support and complement the results.

5.1 The survey respondents and the NBS considered

5.1.1 Expertise, experience, age and sex ratio of the respondents

Altogether 57 respondents offered complete enough answers to the survey, to be used in the analysis. Forty of them completed the whole survey autonomously or as interviewees, while 16 quitted the survey uncompleted, with no apparent major quitting point suggesting too difficult a question or other reason for quitting. In the results, here, the number of respondents that a question is based on is given when it may make a difference for the interpretation and may vary slightly because of the incomplete answers.

The respondents represented a wide variety of expertise, giving a balanced sample of knowledge in business, research, policy-making, authorities and NGOs (see Tables 1 and 2, Fig. 3). Some of them indicated a wide range of expertise by choosing more than 10 (up to 18) kinds of expertise and professional or other experience while eight respondents only chose one type of expertise among all the provided ones. Altogether, 70% of the respondents answered this question.

Table 1. The fields of expertise covered by the respondents.

Field of expertize	**Business**	**Research**	**Policy-maker**	**Autho-rity**	**NGO**
Architecture/Landscape architect-ture/Urban planning/Neighbourhood	16	13		7	7
Biological sciences/Geography		9			
Civil engineering		2			
Climate action			5	4	4
Communication				2	
Constructing/Landscape constructing	7		1	6	
Consultancy/Development and cooperation/Professional association	8		5	3	3
Culture/Cultural heritage/Museum/Art			2		3
Ecosystem restoration/Earth & related environmental sciences/Nature conservation	2	8			5
Energy			3	3	
Environment/Environmental engineering		5	10	10	11
Horticulture/Agriculture/Urban farming	4	2	1		1
Humanities/Social/Health/Leisure	1	2	1		1
Innovation and research/Technology			4	5	
Investing/Economic and monetary affairs	1		2		
Maintenance	3				
Multi- or interdisciplinary research/Systems science		2			
Water/Waste management				4	
TOTAL	**42**	**43**	**34**	**44**	**35**

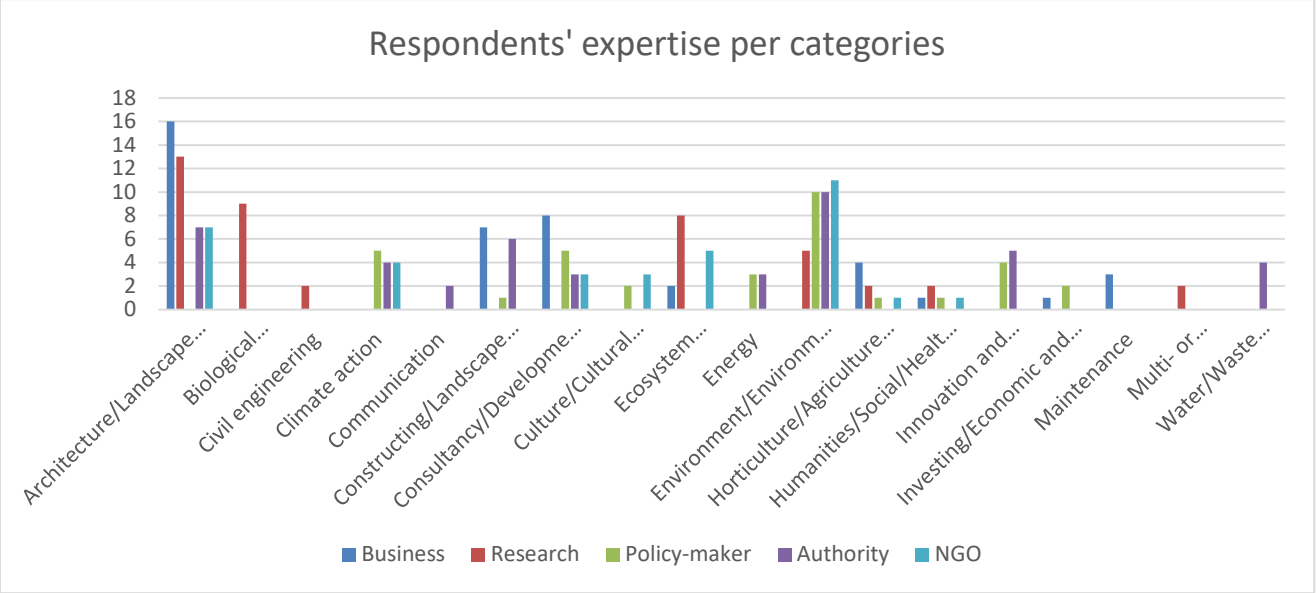


Figure 3. The representation of the fields of expertise by categories.

Table 2. Levels of actions of policy makers and authorities.

Level of action:	**Policy maker**	**Authority**
Municipal	7	5
Provincial	3	4
National	2	2
EU-level		2
International	6	3

The respondents had gained their main expertise in 17 different countries, and their former activities had taken place in cities of different sizes (Table 3, Fig 4). The sex ratio of the respondents was equal with 18 females, 18 males, two “prefer not to say”, and 19 respondents having not answered this question. Their age varied between 29 and 61 years, the median age being 37 years.

Table 3. The number of cities in different size categories as indicated by responding to "Please name maximum two municipalities or cities that most of your work/activity/expertise has been focused on."

<10 000	1
10 001-100 000	8
100 001-500 000	18
500 001-1 000 000	11
1 000 001-5 000 000	11

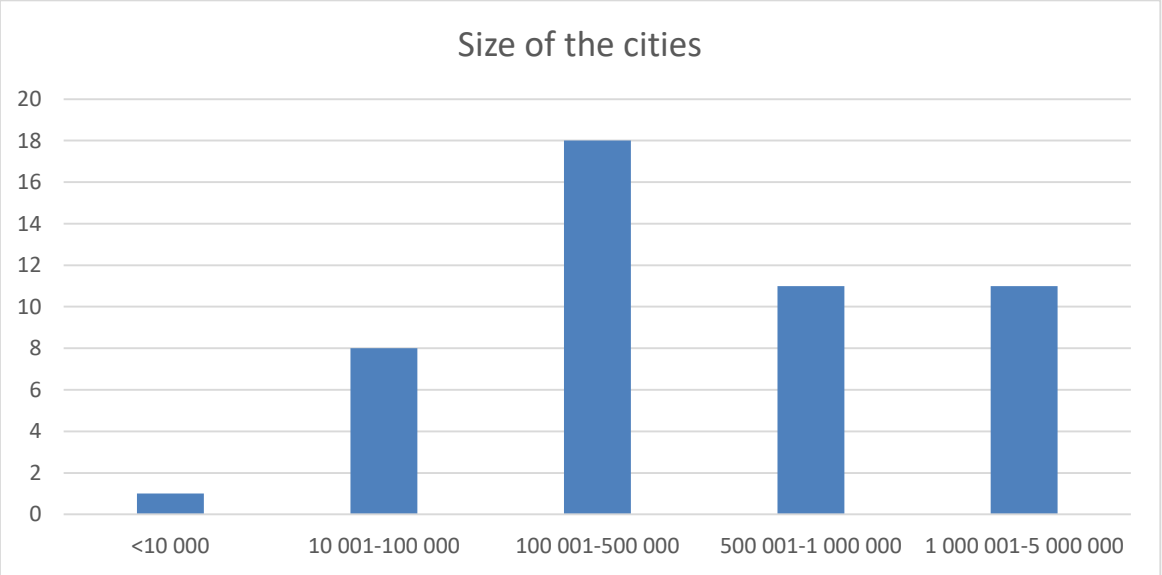


Figure 4. The size of the cities where most of the work/activity/expertise of the respondents had focused on.

5.1.2 NBS that respondents had experience of

The respondents were asked to indicate whether they had worked with NBS or not. If the respondents had worked with NBS, they were asked to choose all those that they had experience of, from the predefined list of 22 NBS-categories with an open 'other' option (see Chapter 2.1) and categorise those as successful or failed ones. 31 of the respondents had worked with NBS while 25 had not. Green roofs or roof gardens scored highest in terms of respondent experience, while flood plain restoration was not covered at all.

Those who had worked with NBS reported 122 successful and 15 failed ones (Table 4, Fig 5). Some of the NBS projects were not realized, i.e. constructed, so their final success in

terms of functionality was not yet known. Moreover, often both failures and successes occurred during planning and implementation of the focal NBS.

Table 4. The categories of NBS among which the respondents could choose to report their experience and whether it concerned successful or failed NBS**.**

NBS projects	**Successful**	**Failed**
Green roofs or roof gardens	13	4
Green walls or green facades	6	4
Green corridors	8	3
Street plants and trees	7	2
Parks	8	
Rain gardens, vegetated ditches	6	
Urban farms, allotments or community gardens	6	
Private gardens	10	
Urban/peri-urban forests or woodlands	5	
Restoration of industrial sites	4	
Blue corridors	6	
Rivers or streams	5	
Use of balancing ponds and underground storage systems	7	
Sustainable Urban Drainage Systems	6	
River bank restoration	2	
Floodplain restoration		
Coastal habitat restoration/maintenance	1	
Wetlands	3	
Infiltration trenches	5	
Permeable pavements	5	1
Bio-waste based growing materials	6	
Waste effluent management through e.g. biodegradation and bioconversion	3	1
TOTAL	**122**	**15**

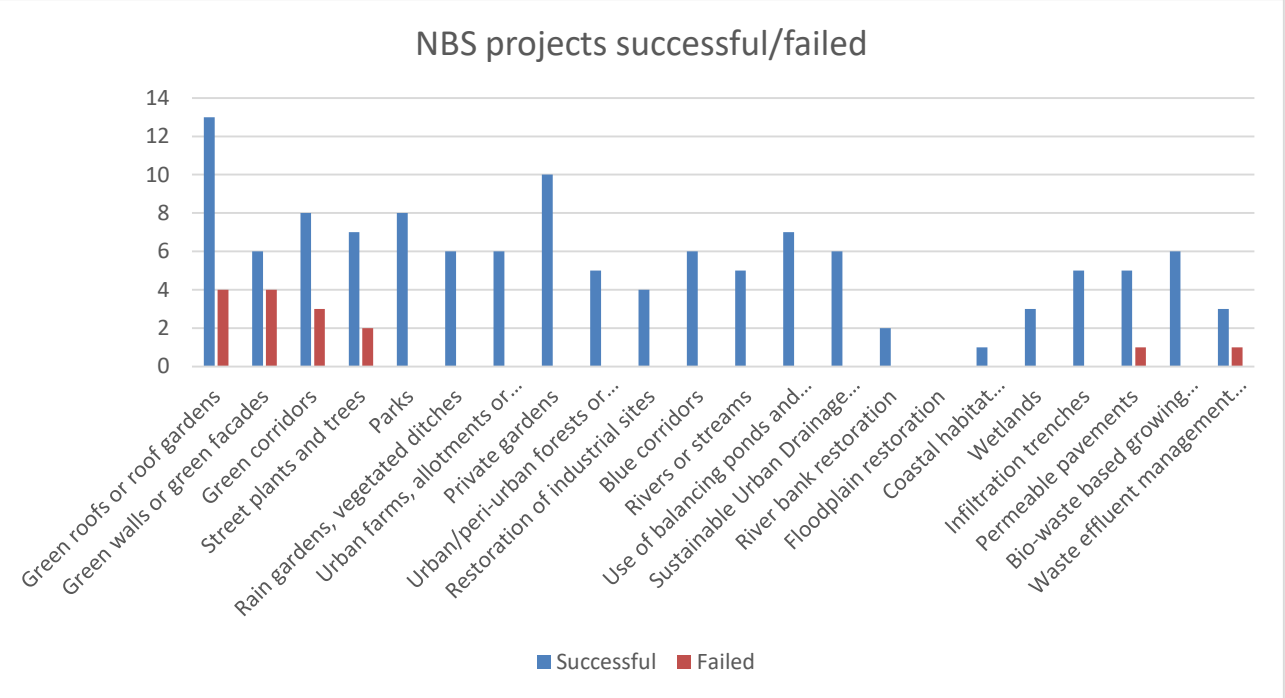


Figure 5. The number of NBS the respondents reported to have experience of: successful and failed projects.

5.1.3 NBS that were considered important by those having not worked with NBS

Those who had *not* worked with NBS, altogether 25 respondents, were asked to choose NBS they considered important now or in the future in cities from the same list of 22 different NBS categories with an 'other' option. All the 22 categories were represented among the chosen ones (Table 5, Fig. 6), the respondents having not worked with NBS listing important on average 14 (min 6, max 21) out of the 22 categories provided. Furthermore, systemic perspectives to NBS were emphasised in the "Other" category: how to think of NBS as systems, not as single solutions.

It seems there is no apparent structure as regards the choice of important NBS: both the high-scoring and low-scoring NBS included small-scale or typically privately-owned elements (e.g. Green roofs or roof gardens scored 23, while Rain gardens, vegetated ditches scored 9 and Private gardens 8).

Table 5. The number of NBS the respondents who had not worked with NBS reported as important, now or in the future in cities.

NBS category	Number

Parks	23
Street plants and trees	22
Green roofs or roof gardens	21
Sustainable Urban Drainage Systems	20
River bank restoration	20
Restoration of industrial sites	19
Green corridors	18
Urban/peri-urban forests or woodlands	18
Waste effluent management through e.g. biodegradation and bioconversion	17
Urban farms, allotments or community gardens	16
Blue corridors	16
Use of balancing ponds and underground storage systems	16
Floodplain restoration	16
Coastal habitat restoration/maintenance	16
Wetlands	16
Bio-waste based growing materials	16
Permeable pavements	14
Green walls or green facades	13
Rivers or streams	12
Infiltration trenches	11
Rain gardens, vegetated ditches	9
Private gardens	8
TOTAL	**357**

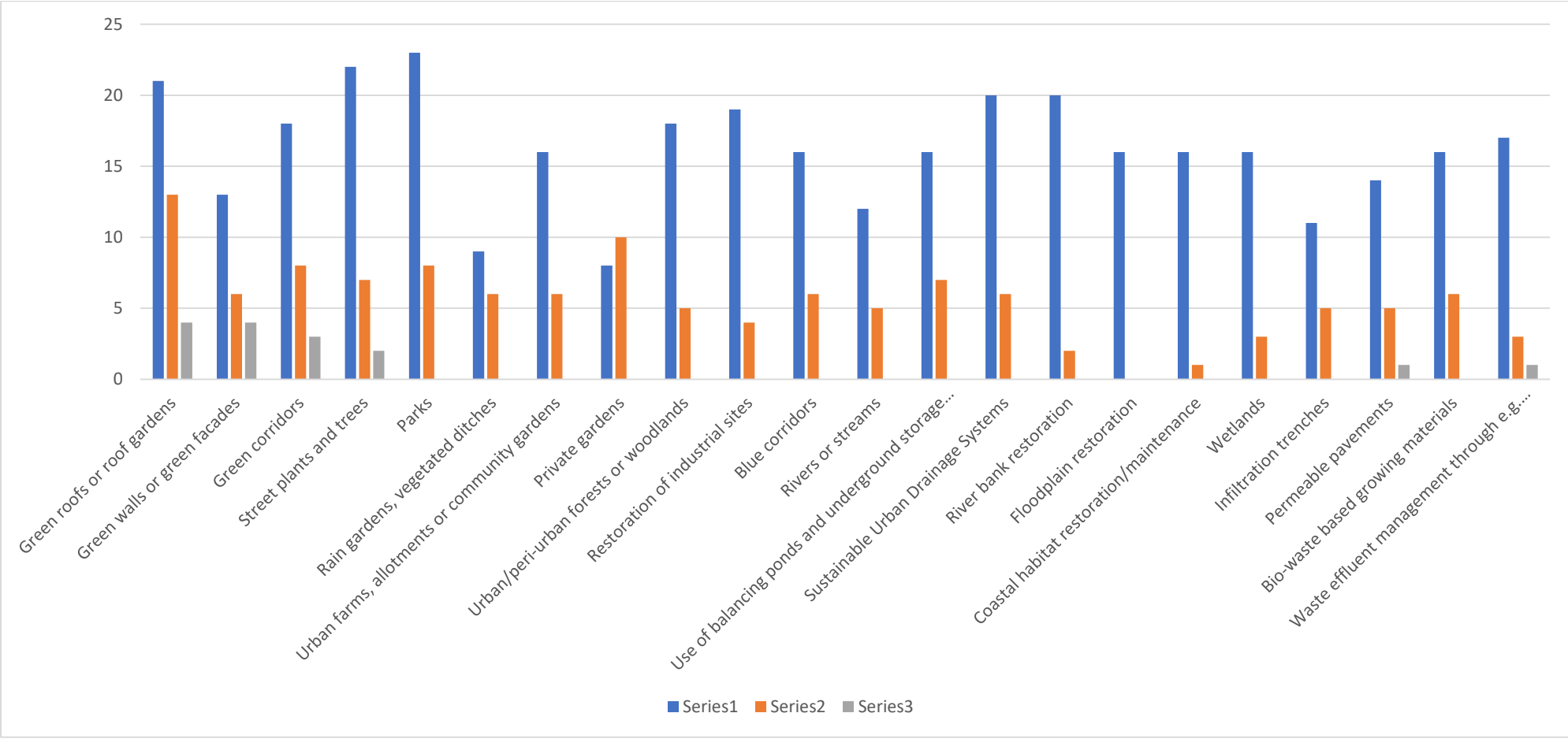


Figure 6. Summary of the numbers of all the NBS chosen by the respondents among the 22 categories listed in the survey. Respondents who had not worked with NBS chose the ones they considered important in cities now or in the future (Series 1). Respondents who had worked with NBS categorised the ones they had worked with as successful (Series 2) or failed (Series 3).

5.1.4 Additions to the list of 22 NBS

The category 'other' was filled in by some respondents, offering perspectives to NBS that could be incorporated in the evolving list of NBS. One of the respondents noted that *peat land/bogs/mires* are lacking from the list – in fact the recognition of peat lands as an NBS would be important, e.g. due to their capacity to retain water. Also *biofiltration, the capacity of living systems to filter out pollutants e.g. from water and air*, was brought up by a couple of respondents and could be an obvious addition to the list of NBS. Another interesting comment was that concerning the importance of the *microbial interphase, i.e. the importance of being in contact with beneficial microbes*, is an emerging topic and could be added to the list of NBS if it proves to be effective and useful (Hertzen et al. 2015; Lehtimäki et al. 2017).

5.1.5 The NBS chosen for closer reflection in the survey

The respondents described altogether 88 cases when instructed to choose one or two NBS for more detailed answers concerning drivers and barriers of those NBS (Table 6, Fig. 7). Even though 98 NBS-projects were chosen for the more detailed answers, 88 projects were in fact described with further data. There were four categories of NBS that received no answers, and four with only one answer. Seven of these no/low-answer categories dealt with blue infrastructure, however, blue infra nevertheless received 17 answers through other NBS-categories.

While successful NBS were more frequently reported, the free-form answers in this section of the survey made it obvious that even the NBS categorised as successful included less successful or failed features, and that defining success is a complicated issue.

Table 6. Number of each NBS-category chosen for detailed answers. The respondents were asked to think of NBS that would best exemplify barriers and drivers for implementing NBS. The respondents having actually worked with NBS were also asked to categorise the projects as "successfully completed" or "failed to reach the targets".

NBS chosen for detailed answers	Successful	Failed	Important	Total
Green roofs or roof gardens	4	3	9	16
Green walls or green facades	5	4	2	11
Green corridors	5		6	11
Street plants and trees	1	3	6	10
Parks	1		6	7
Rain gardens, vegetated ditches	1		2	3

Urban farms, allotments or community gardens	3		2	5
Private gardens	2			2
Urban/peri-urban forests or woodlands	1		6	7
Restoration of industrial sites			3	3
Blue corridors				0
Rivers or streams				0
Use of balancing ponds and underground storage systems	1		2	3
Sustainable Urban Drainage Systems	1		1	2
River bank restoration				0
Floodplain restoration			1	1
Coastal habitat restoration/maintenance	1			1
Wetlands	2		1	3
Infiltration trenches	1			1
Permeable pavements		1		1
Bio-waste based growing materials				0
Waste effluent management through e.g. biodegradation and bioconversion	2		6	8
Other	3			3
TOTAL	**34**	**11**	**53**	**98**

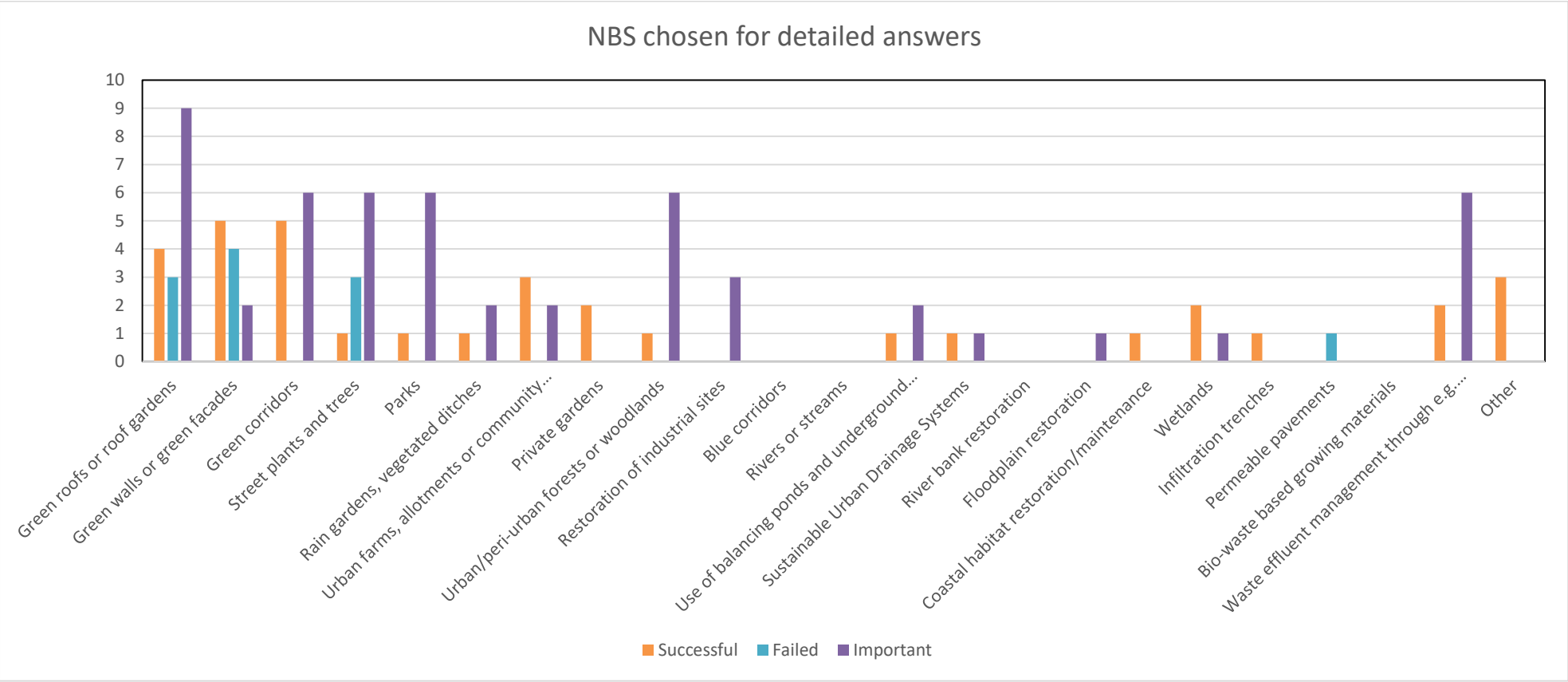


Figure 7. Number of each NBS-category chosen for detailed answers by respondents having or not experience of NBS.

The countries where these projects had been realized were Belgium, Canada, Finland, Germany, Great Britain, Greece, Italy, Latvia, Netherlands, Norway, Romania, Slovakia, Spain, Switzerland, and the United States, thus covering all the regions of ThinkNature project and including also a more global perspective. The cities that the detailed NBS descriptions covered the range from towns smaller than 10 000 inhabitants to metropolises in the category of 1 000 001 - 5 000 000, thus representing various local conditions and contexts.

5.1.6 Drivers and barriers in numbers

All the respondents to this question (54 respondents, describing 85 NBS) thought there were drivers that helped the projects to proceed, and/or barriers that hampered the projects in one way or another. All kinds of drivers and barriers were recognized (Fig. 8 and Table 7).

Altogether, the respondents chose 168 drivers from the given list of categories (see the list in chapter 2.2) plus three in the “Other” category (Table 7, Fig. 9). Policy drivers represented the most frequently mentioned ones, and process- and tradition-based drivers the least frequently mentioned ones, together with communication. The respondents chose 135 barriers, the most frequent one again being policy, and the least frequent one again the process- and tradition-based ones. Across all the barriers and drivers, also market, knowledge and technical ones were frequently mentioned. This means that most of the barrier-driver landscape was portrayed in the fields of policy-making, market, knowledge and technical issues while the process- and tradition-based ones played a relatively smaller role. However, it may be that the concepts of, e.g. tradition-based barriers/drivers were difficult as concepts, and thus not described so often. Therefore, a closer inspection with in-depth interviews might be needed to confirm the role of tradition and processes in the barrier landscape.

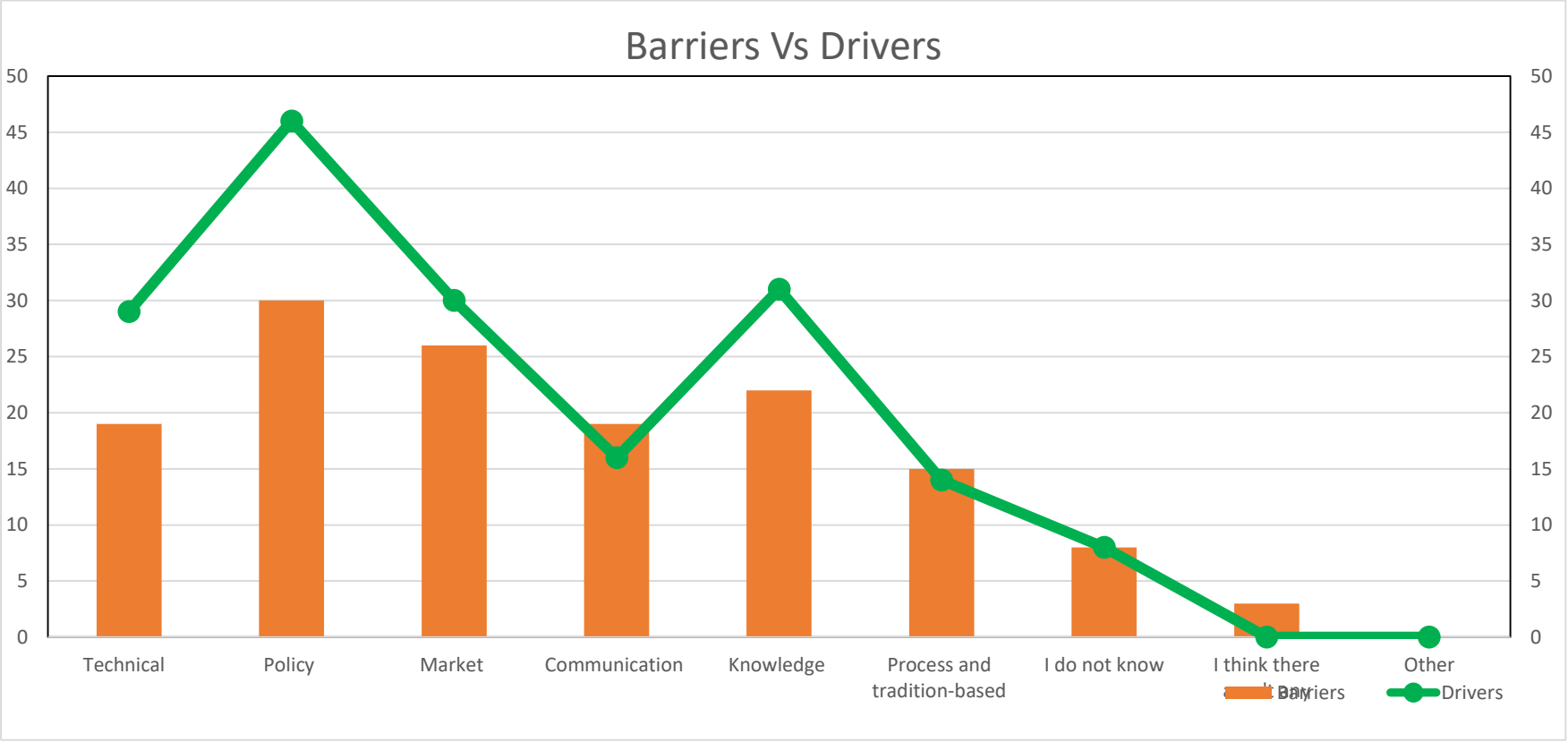


Figure 8. The total numbers of barriers and drivers across all respondents.

There were no great differences between respondents having worked with NBS or not having worked with them – the largest difference was that those who had not worked with NBS portrayed even more policy drivers and barriers than those who had been working with NBS (Table 7).

The respondents focusing on successful NBS reported a much richer barrier-driver landscape than those having worked with NBS that failed to reach the targets. For example, for the successful NBS, 14 technical barriers and 10 technical drivers (=24 in total) were described while for the failed NBS only four technical drivers and no technical barriers were given. The failed NBS also portrayed only one market- and one knowledge driver and no barriers while the successful cases portrayed a number of them. Even if focusing on learning from successful cases might seem a reasonable conclusion, we want to emphasize that failures may sometimes reveal phenomena that success stories cannot.

Table 7. Number of drivers and barriers chosen by the respondents. Have and Not columns give the total number of barriers + drivers among respondents having worked with NBS (Have), and not having done that (Not). The column Tot is the sum across the drivers and barriers (equal to the sum across the Have and Not -columns). The columns Failed and Success report the number of NBS that the respondents had worked with and that they focused on in the survey, categorised as "failed to reach the targets" or "successfully implemented" by the respondents.

Driver/ barrier category	**Drivers tot.**	**Barriers tot.**	**Have**	**Not**	**Tot**	**Failed (n=11)**	**Success (n=34)**
Technical	29	19	28	20	48	4	24
Policy	46	30	31	45	76	9	21
Market	29	26	28	27	55	1	25
Communication	16	19	18	17	35	1	15
Knowledge	31	22	21	32	53	3	17
Process/tradition	14	15	14	15	29	3	11
Other	3	4	4	3	7	0	1
Total	**168**	**135**	**144**	**159**	**304**	**21**	**117**
Does not know	8	8	1	15	16	0	3
No drivers/ barriers	0	3	3	0	3	0	0

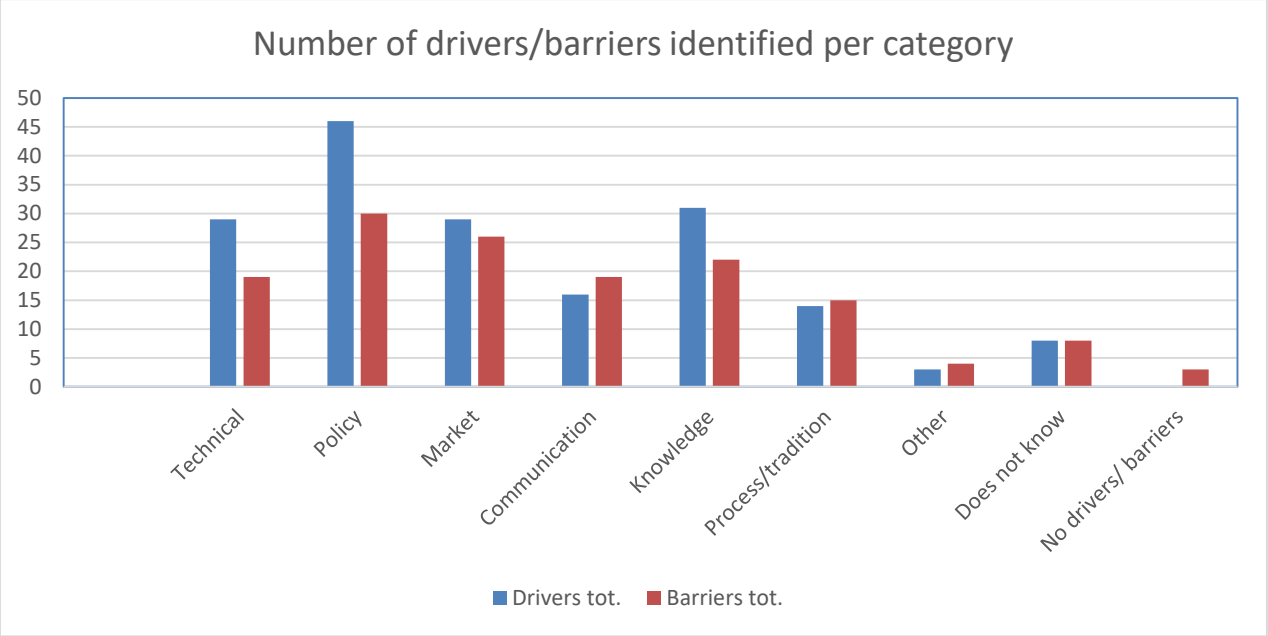


Figure 9. The number of drivers and barriers identified per category.

5.1.7 Methodological considerations and future use of the data

While our results are instructive, complementing the dataset with targeted interviews in a selection of countries and sectors, including those NBS that were not covered by the data would make the results stronger. For example, blue corridors, rivers or streams, river bank restoration, flood plain restoration and the use of bio-waste based growing materials were not covered with the free-form answers. Furthermore, the respondents chose many more successful than failed cases, thus explicitly targeting failed cases could be informative of those issues that determined failures.

Even the data that we collected here would allow for further in-depth understanding through time consuming but usually very informative thematic content analysis. The next tasks in ThinkNature should revisit this deliverable and the data, to gain insight e.g. to the development of the ThinkNature Handbook, the definition and description of the driver-barrier landscape, and the creation of the decision-making hierarchy. The summer school and the dialogue steering should use these results and target practical local solutions.

We recommend always considering the full driver-barrier-landscape when evaluating the possibilities to support NBS. To fully understand the barrier landscape, it is essential to visit the drivers, as recognising the drivers will help remove or alleviate barriers. Furthermore, it is important to run both quantitative and qualitative analysis, as they may highlight different and complementary aspects, and relying on only one approach might result in fatal misconceptions of the barriers and drivers regarding NBS. In our survey for example, the frequency of choices among driver and barrier categories may not fully reflect the importance of communication, as that aspect was inherent in some of the answers in other categories – it may be difficult for the respondent to disentangle the role of communication e.g. in a situation where insufficient knowledge of a stakeholder seems to be the obstacle.

5.2 Analysis of the results

In this chapter, an analysis of the results is displayed with reflection to selected literature and exemplary NBS projects. The approach is solution-oriented: we analysed the drivers and barriers so as to find ways to overcome the barriers and offer concrete examples for actions.

By making the respondents think of real projects, we aimed at more concrete ideas and perspectives than an abstract context would have offered. Even though the respondents were thinking of concrete projects and NBS, the results are displayed at a more general level, not connected with particular NBS. Also, the number of answers was too modest for drawing general conclusions concerning drivers and barriers for a certain NBS. However, we present some examples of drivers and barriers for specific NBS that were mentioned by the respondents, and exemplary cases that reflect the local context of drivers and barriers.

By barriers, we here mean the factors that in one way or another hinder the adoption and implementation of NBS, and by drivers, we refer to the factors that in one way or another enable the adoption and implementation of NBS and help overcoming the recognized barriers. Wicked environmental problems, such as climate change and biodiversity crisis, and negative consequences of urbanization are the 'root drivers' for using NBS, but here we focus on more concrete drivers that actualize at the local level, such as developing suitable policy instruments.

First, we display a short summary of stakeholders and actors identified. Chapters for each driver/barrier category (5.2.1–5.2.6) contain an overall analysis of the answers combined with reflection to other materials and literature, followed by selected examples for NBS-specific drivers and barriers (coloured boxes), as well as examples derived from the case studies on Oppla/ThinkNature Platforms. Finally, concrete examples and ideas for actions and decision-making to promote NBS – push drivers and overcome barriers – are offered in summarizing tables. Tables serve as inspiration for recognizing the actions at various levels and are not encompassing descriptions of required actions.

References

von Hertzen, Leena; Beutler, Bruce; Bienenstock, John; et al. (2015). Helsinki alert of biodiversity and health ANNALS OF MEDICINE 47:3, 218-225.

Lehtimaki, Jenni; Karkman, Antti; Laatikainen, Tiina; et al. (2017). Patterns in the skin microbiota differ in children and teenagers between rural and urban environments. SCIENTIFIC REPORTS 7, Article Number: 45651.

Overview of stakeholders

The stakeholders who could push forward drivers and remove barriers for NBS implementation were recognized at various regional and organizational levels, mostly, however, at local and national level (Table 8). The list is not comprehensive but offers some examples of actors that could be initiators, or responsible for concrete actions described in the Tables 9 - 14 (chapters 5.2.1 – 5.2.6).

Table 8. Examples of actors and stakeholders recognized to have leverage in NBS implementation at various regional and organizational levels.

Local level	National level	EU-level	Global level
Municipal administration: authorities and decision-makers e.g. in urban planning, forestry, green area management, construction, water management, social and health care, transportation, sports, safety City councils, boards and committees (e.g. above-mentioned fields) Local schools and other educational organizations Public housing cooperatives Regional administration, e.g. for metropolitan areas covering several municipalities	National administration: authorities and decision-makers, e.g. in environment, construction, law, education, social and health-care, transportation, energy, agriculture, waste, sports, cultural heritage Political parties Regional administration, e.g. counties National organizations of municipalities Associations of local and regional authorities Research organizations and centers, e.g. universities, universities of applied sciences, national research centers for environment, such as Finnish Environmental Institute SYKE Botanic gardens	EU-authorities and decision-makers, e.g. environment (incl. disaster risk reduction, climate, biodiversity, green infrastructure, ecosystem services, circular economy), sustainability, urban and regional policy, construction, health and well-being, agriculture, energy, transport, waste, education EU-financed projects in relevant fields Networks of cities, e.g. European Green Cities (EGC). Companies, industry, consultancies in relevant fields Industry/trade associations	United Nations, e.g. The United Nations Environment Programme UN Environment, e.g. Finance Initiative UNEP FI Networks of cities International companies, industry, see e.g. Natural infrastructure for business[2] Investors, e.g. World Bank World Business Council for Sustainable Development International NGOs, such as the Nature Conservancy, International Union for Conservation of Nature IUCN

[2] https://www.naturalinfrastructureforbusiness.org/case-studies/

Companies, industry, e.g. in construction, (landscape) architecture, plant- and material producing for NBS, maintenance etc. Consultancies, e.g. in climate change adaptation and mitigation, sustainability Investors (e.g. real-estate developers) Guardians of business interests, such as local chambers of commerce Land owners Private housing cooperatives Media NGOs, e.g. in urban development, nature conservation, environmental education Local residents Local communities, e.g. neighborhood associations	Umbrella organizations for research and education Development agencies, such as Swiss Agency for Development and Cooperation SDC National financing organizations, such as Swiss Sustainable Finance SSF National research, innovation and development agencies; business forums Investors, banks, insurance companies Umbrella organizations of the business field Chambers of experts in relevant fields/ trades, e.g. technical/ geotechnical National private financing organizations, e.g. private foundations, lottery funds (can be also public) Media National NGOs National umbrella organizations of local NGOs	Investors and banks, such as European Investment Fund and European Investment Bank European NGOs, such as Bremen Overseas Research & Development Agency BORDA Umbrella organizations of NGOs Umbrella organizations of industry/ trade associations, e.g. European Landscape Contractors Association ELCA	International professional societies, such as Society for Urban Ecology SURE, International Association for Landscape Ecology IALE, International Federation of Landscape Architects IFLA Umbrella organizations of NGOs and industry/ trade

To offer some examples of the different roles of various stakeholders, municipal administration was considered an important actor to offer resources, e.g. for pilot projects and cross-sectorial cooperation, and also to take the role of an intermediator of partnerships, knowledge-transfer and capacity building. Urban planning offices are hotspots for concrete actions to promote NBS, e.g. via coercive instructions for including NBS in the local plans, or developing NBS-related strategies, guidelines etc. to steer the urban construction to more sustainable direction.

As the concepts and technologies for NBS are rapidly developing, the role of research organizations was emphasized as knowledge producers and partners of pilot projects, e.g. with companies. Thus, the capacity of research organizations to offer applicable knowledge based on long-term follow-up of, e.g. experimental NBS should be ensured.

Non-governmental organizations (NGOs) were mentioned as actors to promote NBS, e.g. as partners in cross-sectional projects with different stakeholders. Local NGOs can be efficient in grass-root, agile projects involving local residents and communities, whereas national and international NGOs are powerful actors to share best practices, arrange events, and participate in developing policy-making etc. strategic-level actions for proliferating NBS. Therefore, representation of NGOs should be ensured, e.g. in expert panels and other actions for producing knowledge for NBS at large scale.

5.2.1 Technical drivers and barriers

In total, 29 out of 57 respondents indicated technical drivers that could support the realisation of NBS, and 19 respondents indicated technical barriers that could hinder the realisation of NBS. Altogether 19 respondents gave free-form answers concerning 23 NBS, regarding the technical barriers and drivers.

Obviously, technical drivers and barriers were considered very important in the overall implementation and up-scaling of NBS. The results from the free-form answers portray a lack of both deep understanding and technical skills in implementing and selecting the most appropriate NBS as presented and discussed below.

Simple and cost-efficient techniques are attractive

"SUDS[3] makes it simpler to manage rainwater and stormwater. This decreases the need for traditional infrastructure and its maintenance." [quote from the data]

Technical drivers may be forceful when they offer a simple solution. Technical authorities in municipalities may be a lead actor here to adopt new NBS, but training regarding emerging techniques is needed for planners, developers, and construction professionals to make things happen.

The cost of the techniques for NBS should be reasonable (including maintenance) – and in fact, NBS may often be more cost-efficient than other solutions. This, however, is still lacking

[3] Sustainable Urban Drainage Systems.

thorough formal assessment that could help triggering urban practitioners to choose NBS over the more established, business-as-usual grey solutions to solve an urban problem.

In this line, there is lack of technical products ready and easy to be installed. Therefore, the cost of single NBS projects can be very high. Digitisation or smart technologies may be cost efficient via reducing the maintenance costs, e.g. via automated irrigation systems. For example, irrigation of green walls and facades is laborious and costly, and here automated sensor-based irrigation systems could save a lot. In a nutshell, to put forward replicability and even industrial scale-up of NBS solutions (e.g. green roofs or green walls complete solutions with automated irrigation in packs) would be high impact drivers: when confronted with a serious choice between a NBS and a grey solution, an informed decision-maker will, no doubt, choose the NBS over the latter if its technical performance alongside life-cycle cost (installation, running and maintenance costs) are demonstrated to be competitive.

Here, industrial actors and their association are a resource that can be tapped into in a win-win perspective: from the policy-maker and governance side the take of NBS needs concrete backing-up by simple-industrialised and cost-effective offer of solutions that can be provided and promoted jointly with industrial associations, like the European Federation of Green Roof Associations EFB.

Finally, development of cost-efficient technologies will make the solutions accessible for less wealthy countries and municipalities.

Multifunctionality may be a key argument for realizing NBS

Multifunctionality supports the promotion of NBS, i.e. that with one NBS, multiple benefits/ecosystem services can be achieved, e.g. architectural, ecological, economic, safety, storm-water management etc. Thus, the technical development of NBS requires knowledge considering the optimization of various benefits simultaneously, always taking into account the implementation context. To provide for this knowledge, the EC has already taken action from the start of the NBS funding action within the Horizon 2020 programme, by launching two RIA projects in 2016: *Naturvation* and *Nature4Cities*.

On this topic, the latter has retained the “Urban Challenge” category to show how NBS usually would offer more than one ecosystem services related to more than one urban challenge or problematic:

> “Moreover, NBS could contribute to the enhancement/provision of different ecosystem services in different grades of intensity, and those Ecosystem Services could also contribute to solve different urban challenges more or less

effectively. Actually, how you design and implement an NBS and the specific cultural/biophysical factors and barriers of its context may have an effect on the supply of Ecosystem Services. In other words, the surrounding physical and socio-ecological context itself is a relevant factor in the relation between NBS and Ecosystem Services."[4]

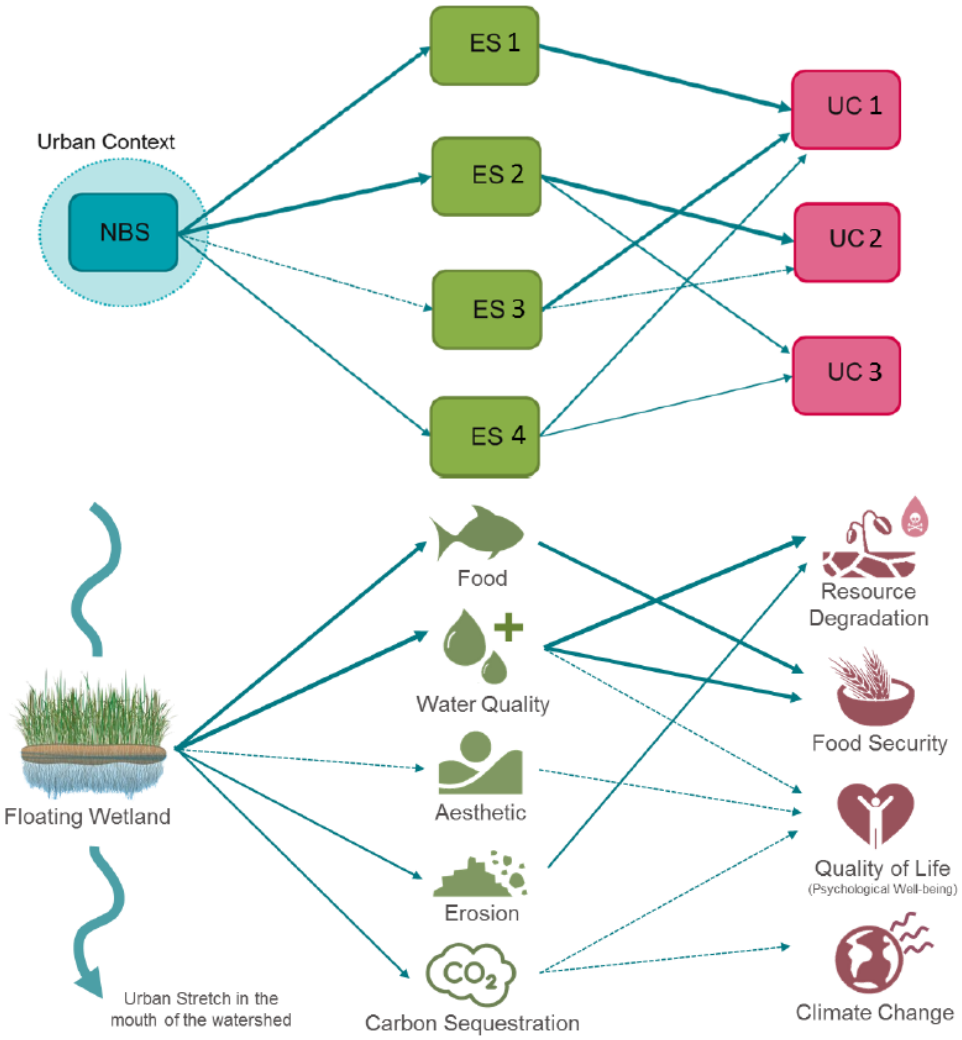


Figure 6 : : Relation NBS-ES and urban challenges (UC) and illustrative example (Diagrams: Javier Babi Almenar)

[4] Graphic and quote from: Nature4Cities Deliverable D1.1, "NBS multi-scalar and multi-thematic typology and associated database", 2018. Nature4Cities in an H2020 project funded by the EC under Grant Agreement No.: 730468. https://www.nature4cities.eu/blog/nature4cities-multi-scalar-and-multi-thematic-nature-based-solutions-typology

In line with considering the multifunctionality of solutions, various technical solutions offer more alternatives for establishing an NBS, for example different green roof systems and establishment methods. Different options allow for a wider repertoire of products, considering various needs of the client and the case/context, for example as regards the aims for a specific performance that should be prioritized. NBS should also be flexible enough to be adjusted in different situations, e.g. climatic conditions.

Technical support needed

Knowledge and technical support for the construction and maintenance of NBS should be available, especially concerning novel solutions (e.g. artificial ecosystems, building-integrated vegetation). Technical instructions for implementation and maintenance for all kinds of NBS are needed. Designers may encounter difficulties in implementing NBS when compared with traditional solutions, as they are more familiar from a technical point of view and with respect to legal compliance (Jurik et al., 2018). For example, how to retrofit a school yard by using NBS and beneficial, human-health supporting microbes, or how to choose the right plants for a road verge? Reference cases and practical examples of various alternative NBS, with drawings and photos included, are effective to concretely display the possibilities.

As plants and/or other living organisms are an integral part of NBS, the technical instructions must include lists of suitable plants (organisms) for the local conditions and instructions for their maintenance. Furthermore, it is advisable to also give instructions about how to avoid invasive species, and guidelines to use invasive species databases, such as NOBANIS (https://www.nobanis.org/).

There are powerful authorities and organisations that could push forward the creation of guidelines and handbooks – for example for the road verges it could be the transport authority, and for the school yards a national umbrella organization in the construction field. An umbrella organisation could steer a cross-disciplinary working group to reach a consensus of the best practices and then disseminate it widely to the end-users and practitioners. For example, in Finland, so-called Building information files are published by a well-respected national organization in the construction field. The contents are produced by a diverse expert group.

To provide for required knowledge and technical support on NBS and specially to help decision making at the right time, for all kind of stakeholders, the abovementioned RIA H2020 project Nature4Cities is developing a knowledge and decision support platform. The platform launch is planned for 2020. It will provide, with a single point entry, knowledge repositories, software tools for the assessment of benefits, co-benefits and costs of NBS projects, as well as tools to manage stakeholder's participation processes.[5]

Research, innovation support and investment is critical

"*Support for NBS innovators - on EU, national, regional and local level*" – this was one reaction to the question "How could effective technical drivers be created?". Engineers and other experts, scientists and practitioners are needed to develop technically feasible solutions. Research, experiments, models and pilot projects are indispensable, together with private investment and companies' experimental activity.

Proper facilities should be guaranteed for piloting/innovating projects by, e.g. municipalities and research organizations, and EU, including resources for long-term follow-up (e.g. devices, work force). Follow-up monitoring should be integrated in the organizational culture of financing bodies at all levels. The evaluation of pilot projects should be structured so that lessons learnt also from unsuccessful projects/failures would be taken into account.

Technical knowledge and expertise, both practical and scientific, concerning the performance and longevity of NBS are needed to support implementation and long-term use of NBS. A solid technical knowledge-base creates courage to realize NBS, and also helps estimating the costs of various solutions. Knowledge of existing technical solutions should be spread, e.g. in exhibitions and other events.

An important technical viewpoint is also the overall performance of the NBS during its lifetime, plus the resource consumption and benefit production. Life cycle analysis/assessment LCA, Material input per service unit MIPS or other overall system cost-benefit and environmental evaluation should be a basic requirement for all NBS to ensure their overall sustainability. For example, green roof and façade systems should be such that they increase the longevity of buildings and are based on sustainable materials.

Production of knowledge-base for NBS-technologies, e.g. with demonstration projects, could be first initiated by public or third sector actors, such as municipalities, state

[5] https://www.nature4cities.eu/the-n4c-project

authorities, research organizations, or NGOs. For example, NGOs can establish innovative small-scale projects that involve local actors. skilled personnel in municipal level help justifying the use of NBS in various contexts: this makes the process of adopting innovative NBS smoother and offer arguments for why NBS should be used.

Depending on the project, a multi-actor effort may be needed for the development of NBS, involving, e.g. residents, land owners, administration, material producers etc. Thus, in-depth stakeholder-mapping is essential when establishing a demonstration project for collecting knowledge and experience of the functionality of NBS. A model or handbook for action, e.g. for local NGOs, could be helpful, including issues such as: how to establish an NBS-demonstration project, who should be involved, financing opportunities, instructions for applying resources and evaluating the outcomes etc. issues.

Material development is urgently needed

The materials used for NBS are not always environmentally friendly. For example, green roofs may contain plastic, mineral wool and LECA that have a heavy environmental footprint. Though this may not per se prevent the proliferation of NBS, it is nevertheless counterintuitive to use such materials as environmental benefits and sustainability are the key arguments for using NBS. Proof-of-concepts, proven benefits and products based on it are in great demand.

Sometimes, availability of waste materials, together with an innovative attitude, may be the key driver for technical innovation. Excess materials can be used e.g. as substrate components for plants. Companies and authorities producing or governing such materials could have a high motivation to be creative with the supplies. While recycled materials and circular economy are the way to go, special attention should be given to avoid extra environmental burden when using waste-based NBS. As discussed in the the case study with building-integrated vegetation, moisture control has to be taken into consideration in the implementation and design.

Interplay with policies, market, knowledge and tradition barriers

Obviously, the existence of technical barriers and drivers is highly intertwined with other barriers and drivers. To begin with, the creation of a technical solution may need extra support in terms of policies, or a new NBS may need change of regulation to become legally feasible (e.g. NBS based on recycled materials). Another example of the interplay of policies is that of spatial policies with technical: planning has to recognise the physical space that is

needed for NBS – examples given by the respondents included wetlands, rain gardens and urban farming. Also, the lack of ready to use technologies and ready to apply scientific results and concepts can make the adoption of NBS challenging even if a certain policy receptiveness exists (Jurik et al., 2018).

Expensive technology in turn may become a barrier that stands at the cross-section of the technical and market spheres. Or, a technically feasible solution is not really available for the end-users until it reaches their conscious, making the technical development hit a knowledge barrier. Finally, the spread of a technical innovation may be highly a social matter, e.g. process- or tradition-based, because the new technology has to fit in the daily culture and routines of the end-users (see also Case study I in chapter 6).

Examples of technical drivers that could help implementing NBS:

- **NBS: Bioinfiltration fields**

  DRIVER: **Infiltration performance parameters** (performance = polluting removal and technical time of use)

  HOW DOES IT SUPPORT IMPLEMENTATION: Helps in designing infiltration sites; knowing the performance also helps in evaluation of life-cycle costing

  HOW TO CREATE THE DRIVER: Produce knowledge of infiltration performance of bioinfiltration fields

  WHO COULD PUSH FORWARD: Research organizations, pilot projects

- **NBS: Street trees and plants**

  DRIVER: **A phytotechnical study** taking into consideration the climate, the altitude etc., to specify what kinds of plants are able to grow at the area

  HOW DOES IT SUPPORT IMPLEMENTATION: Optimize the choice of plants for each area, guarantee survival.

  HOW TO CREATE THE DRIVER: Require a phytotechnical study as part of integrated technical study when developing and constructing new roads.

  WHO COULD PUSH FORWARD: Ministry of Transport Infrastructure

Examples of technical barriers that may hinder the adoption and implementation of NBS

- **NBS: Green roofs or roof gardens**

BARRIER: **Load capacity of the roof was modest; the roofing material was not optimal for green roof and the construction company had no knowledge about green roofs and what do they require**.

HOW DOES IT HINDER THE NBS: E.g. no irrigation system was provided even though it was crucial for the successful establishment of the roof.

HOW TO OVERCOME THE BARRIER: Compulsory professional education and easily available technical information.

WHO COULD PUSH FORWARD: Organisations responsible for continuous professional education in construction sector, together with universities. NBS as a compulsory part of basic education in construction sector.

Examples of technical barriers that may hinder the adoption and implementation of NBS

- **NBS: Green corridors**

BARRIER: **Disagreement between the landlords, municipality and NGO regarding the type of permeable pavement;** the landlord felt that pebbles would be difficult for users and management.

HOW DOES IT HINDER THE NBS: A compromise was found between the technical and biodiversity solution - pebbles allowed infiltration and soil biodiversity but there was no above ground diversity.

HOW TO OVERCOME THE BARRIER: Offering best practice and working solutions which can illustrate the benefits.

WHO COULD PUSH FORWARD: Knowledge centres and knowledge holders who have implemented solutions.

Technical drivers in case studies: ThinkNature Platform and Oppla - examples

Bristol - NBS for ensuring a sustainable future
https://oppla.eu/bristol-nbs-ensuring-sustainable-future

- Highly skilled experts working for urban green areas in the municipality and/or in connected research institutes.

Collaborative Planning – Nottingham
https://oppla.eu/casestudy/17548

- The project brought together technical expertise of key stakeholders from local authority, industry and academia with different specialisations and skills.
- This has helped to shape the process by drawing from expert insights and accounting for a collective and multidimensional perspective. This approach of collaborative planning showed its benefits in maximising results, hence it could be useful to apply the same approach in different locations.

Green roof Experiment - Barking Riverside
https://oppla.eu/casestudy/17556

- The project received financial resources, green roof design, and biodiversity expertise in addition to land availability. Working with the development provided an opportunity for scaling-up positive results through incorporation within the development project.

Table 9. Summary of technical drivers and examples of possible actions at various regional levels. See Table 8 for the possible stakeholders and actors that could be responsible for initiating and/or taking responsibility of the actions at various levels.

Drivers/ actions	Local	National	EU	Global
Practical and scientific knowledge and expertise of the technical performance and longevity of NBS	Municipalities and state authorities to allocate personnel with expertise and knowledge; NBS pilot projects to produce knowledge; Locally tuned best practices become learning processes; NGOs as knowledge producers.	Development of Curricula in education at various levels; Train practitioners and formulate a quality assurance of the NBS projects; Set specific key performance indicators; Recognize knowledge gaps for research and development (R&D) of companies,	Allocate resources for producing knowledge for the recognized knowledge gaps of the performance of various NBS; Guarantee easy availability of technical knowledge for professional communities in their key databases with their own professional language.	Databases of the knowledge, best practices, cases to be developed and maintained; Follow up of conferences; Companies participate actively in forums, exhibitions and competitions for the implementation of NBS; Develop methods for the assessment of

				performance and longevity
Knowledge and technical support for the maintenance of NBS.	Overview of the implementation of the NBS in local level by following the instructions and standards developed in National level	Provide information and instructions developed by an authorised national organization and assign specific national working groups	Support the development of standards and performance assessment	Spread knowledge of devices supporting maintenance in a sustainable way, e.g. technique to locate leaks on green roofs without extensively removing the vegetation layer.
Engineers and other experts to develop knowledge/solutions	Involve experts of various fields to upscale experiences: create guidelines based on the experiences.	Establish working groups under suitable national umbrella organization in construction field; Technical Chambers of Engineers	Organize expert panels around technical challenges with future-oriented approach (e.g. Delphi)	
Development-, innovation- and demonstration/pilot projects	Broad stakeholder mapping to involve relevant actors covering all the technical aspects needed in the project.	Cities, public sector as an innovator, clear and successful demonstrations: technology needs to be in place before companies enter the scene in a bigger scale.	Continuity of EC R&D Programmes financing Innovation actions in the NBS domain (demonstration projects)	
Facilities for piloting/ innovating projects	Experts in the municipal organization facilitate projects developing new NBS technologies for local solutions.	Instructions for financing organizations; Companies participating in public projects	Resources for long-term follow-up in Horizon projects; Pool of EU cities willing to implement pilots on NBS projects	ICLEI, UN Habitat and other advocacy organisations to recognise NBS as crucial
Spreading knowledge of existing technical solutions.	Companies participating in fairs and seminars; NGOs arranging seminars.	National knowledge-based instructions for building and land-use including NBS	Provide clear instructions for technical realisation and maintenance in EU level and promote retrofitting that include NBS.	

Various technical solutions → more alternatives → wider repertoire of products meeting various needs of end-users.	Develop apps that perform interaction with local users for NBS implementation	Resources for R&D for companies; Performing experiments	Promote R&D in private sector for NBS implementation	Support digital technologies for NBS, IoT
Flexible enough NBS → adjustable for different situations (e.g. climate)			Support for R&D for optimizing multifunctionality	
Reasonable cost of the techniques for realizing NBS (including maintenance)	Cost effective technologies through digital technologies		Support the implementation of digital technologies	
Knowledge of the cost-efficiency of NBS compared with grey infrastructure	Support the development of pilot projects to understand the cost parameter of NBS	Develop cost analysis guides for NBS in national level	Guidelines for cost analysis of NBS in general; Long-term feedback on NBS project alongside a grey baseline	
Sound business models around NBS for market uptake	From local needs may arise suitable BM to provide NBS materials (plants, living organisms, etc.).		Support on emerging BM around NBS; Support clustering of NBS industrials or service providers	

5.2.2 Policy drivers and barriers

In total, 46 out of 57 respondents indicated policy drivers that could support the realisation of NBS, and 30 respondents indicated policy barriers that could hinder the realisation of NBS. Altogether 26 respondents gave free-form answers concerning 32 NBS, regarding the policy barriers and drivers. This was the highest number of free form answers per type of barriers and drivers – the results of which are presented and discussed below.

Wide toolkit of policy instruments

Effective coercive and long-term policies with an overarching NBS approach are needed for the implementation of NBS. For example, in Oslo regulations are a good driver for implementing a variety of NBS in new building projects: all buildings have to take care of the stormwater in open natural-like systems. The city itself has made a decision to invest in NBS in their own projects, to get knowledge useful for private investors.

The policies could include laws, norms, strategies, planning instruments, funding programmes, and investment in research. This is in agreement with Kallio et al. (2014) who suggested in their study concerning Finnish green roof regulation, that a wide toolkit should be applied to guide sustainable development of this NBS. As possibly effective and useful policy instruments, they listed land-use planning, authorisation procedures, information steering, fees, payment facilities (e.g. exemption from storm water charges), tax deductions, jurisprudence, penalties, agreements, persuasive guidance (e.g. expert assistance, and knowledge-based facilitating, cf. Suvantola & Lankinen 2013), obligations to implement NBS along with new construction projects, and investment support. Obviously, creation of regulation should be done in collaboration with experts of law, and NBS-experts, and the users. The key to change is to support new ways of thinking the policy instruments comprehensively.

Financial instruments should support multi-stakeholder collaboration and capacity building through investing in experimental NBS and research. Here the key actors are those providing national level financing. Financial sanctions are also needed for not realizing NBS. For example, the city of Helsinki has used penalty payment to force establishment of a green roof.

Nevertheless, policy-only instruments in the long term will not substitute market uptake. The best policies will be oriented towards measures seeking to, by creating a critical mass of examples, gather evidence of cost effectiveness, environmental and ecosystem services

and suitable business opportunities behind the implementation of NBS instead of today's mainstream solutions. The best NBS policy will help turning NBS in the mainstream solutions for the urban challenges of tomorrow.

Forecast the consequences of coercive policies, update existing regulation

Coercive policies that already exist can be an asset for or a barrier against NBS. The national and EU policies regarding protected species make a positive example: a respondent reported a successful implementation of an NBS where compensation in the form of a new habitat was required to be completed before the construction site was released. If there is no coercive regulation or other strong incentives, prejudices, lack of knowledge and experience may profoundly hamper the wide-scale implementation of NBS. Then again, coercive regulation can seriously hamper the realisation of an NBS, for example if it bans the use of available materials – e.g. recycled materials for substrate. In summary, the existing regulation may need to be updated to be more flexible, at the same time as the written law should be applied to its full extent, accompanied with penalties when needed. Here both the EU and the national legislation, as well as the judiciary have a key role in achieving the wanted NBS targets.

Power of land use policies

"…there is also lack of "stimulation" of proper decisions at the level of releasing land development decisions, nobody really pay attention if new construction leave any space for NBS" [quote from the data]

Spatial policies, such as NBS-oriented guidelines that require the use of NBS and are implemented via master plans were considered important (also reported as important in Finland by Kallio et al 2014). Inventories of existing NBS will reveal spatial gaps, which can be used as a starting point for developing targets and timelines to achieve environmental equity across the city. Updates of existing guidelines as well the creating of new guidelines will be needed. The key organisations to do this are the planning administration. Furthermore, activating people to strive for NBS on private land is needed. Both local, regional and national authorities and the media were named as key actors, as well as the public that has the power to demand change.

Indeed, innovative approaches to sustainable land use and land use planning, including the use of NBS are needed, alongside policy and tax incentives helping to boost the use and regeneration of brownfield instead of consuming more greenfield. For this, the role of NBS

in the remediation, restoration and prevention of formation of brownfield and their potential role in providing beneficial ecosystem services and social inclusion/economic redevelopment should be put high in the policy agenda. In this sense, ongoing initiatives like UIA are crucial.[6]

Furthermore, the relationship between brownfield redevelopment and restoration, which is the key to limit land consumption and future city sustainability, has been highlighted by the Urban Agenda for the EU since its inception in 2016. In the words of one of its EU Urban Partnerships, the one on the Sustainable Use of Land and Nature-based Solutions (SUL_NBS): "the brownfield redevelopment presents a valuable opportunity to not only limit land take and prevent urban sprawl, but also to make cities more liveable. Brownfield regeneration also offers the chance to implement NBS."[7]

The long-term protection of land as green space was also brought up in the responses to our survey. The decision to design and maintain a piece of land as a park with no major construction activities is essentially a policy issue. Maintenance and citizen support are likely important for the long-term survival of green space, so the decision should include these perspectives from the beginning and facilitate the necessary research and budgeting to guarantee their success. One way to guarantee protection is to give a special status to the land area or a site. An instance of such are the national urban parks[8].

Focus on the synergies and efficiency of policy-making at various levels

Local actors subscribing to global, EU-wide or local policies or targets may help create responsibility, effort and motivation. For example, in Milan[9], EU's research and innovation funding strategy has been beneficial for the city's administration, and the city of Bristol10 embeds the GI concept in its planning documents, facilitated by the national planning policy framework. Raising awareness of existing policies is needed as policies do exist without people really notifying them. Furthermore, increasing understanding of what the policies

[6] Urban Innovative Actions (UIA) is an Initiative of the European Union that provides urban areas throughout Europe with resources to test new and unproven solutions to address urban challenges. Based on article 8 of ERDF, the Initiative has a total ERDF budget of EUR 372 million for 2014-2020.

[7] Urban Agenda for the EU, Sustainable Use of Land and Nature-Based Solutions Partnership, DRAFT ACTION PLAN, July 2018.

[8] For example: https://www.visitstockholm.com/see--do/attractions/royal-national-city-park/; http://www.hameenlinna.fi/nationalurbanpark/.

[9] https://oppla.eu/milan-nbs-urban-regeneration

[10] https://oppla.eu/bristol-nbs-ensuring-sustainable-future

mean to our daily work and how it should be applied in our routines is urgently needed. Local authorities should allocate work time to fully exploit all existing policies, and NGO's could offer essential support in recognising the policies and the critical actions to reach the targets.

For example, following EU-policies support NBS implementation: The Habitats Directive[11] requires a certain percentage of protected valuable habitat relative to the size of the country: the need to compensate for impact on natural zones is a useful instrument. Water Framework Directive[12] and The EU Floods Directive[13] require that concrete measures are implemented to achieve the goals of the directives. All these measures are related to NBS, be it in rivers, canals and their riparian zones. In a wider context, the EU Biodiversity policy[14] supports NBS implementation in many ways.

Policy-making through special designation of years or happenings may help actors focus on specific NBS and targets.

"2010 global year for biodiversity and the municipality was a subscriber to the countdown process to help achieve the 2010 target [--] …
used the opportunity to sit down and turn the promise into action - a bland greenspace became a more biodiverse space."

One example of a positive stimulus could be the annual selection process for 'Green capital of Europe'. In that selection process a number of quantitative ratios could be tested as policy instruments, for example minimum area of green space in urban zone: area green space / total urban area; number of trees/ha; maximum walking distance to the nearest park< x kilometers.; area of green space/inhabitant etc. A similar approach is conceivable for non-urban zones and landscapes. However, the ratios should be selected so that they are equivalent across, e.g. various geographical areas.

"City strategies should be developed in the local context, to meet the local needs, but the knowledge and experiences should also be efficiently shared among cities nationally and internationally. Knowledge is needed of how various policy instruments to promote NBS really work. At the moment there is not too much information of that (assessment of the effectiveness of policy instruments)."

---

[11] http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm
[12] http://ec.europa.eu/environment/water/water-framework/index_en.html
[13] http://ec.europa.eu/environment/water/flood_risk/implem.htm
[14] http://ec.europa.eu/environment/nature/biodiversity/policy/index_en.htm

Internationally available scientific and practical information of the efficiency of various policy instruments would help creating functional local instruments. Assessment of different policy instruments are needed as there is a shortage of knowledge concerning the policies for NBS. For example, green roofs are supported by a wide range of various instruments at national and city level, but there is not much information of the effectiveness of these instruments.

One barrier for efficient policy-making to promote NBS is the disconnection between short term actions and long-term goals (see also Kuban et al. 2018). As noted in the A Coruna Forum (Jurik et al. 2018) the short-term action- and decision-making cycles within municipalities do not always match with the long-term requirements of the whole life cycle of NBS projects.

Co-creation of norms: recognize relevant stakeholders

Associations of municipalities could take the responsibility of creating quantitative and qualitative norms for key NBS, in collaboration with all stakeholders. The key stakeholders here are the users (residents, urbanites, visitors, teachers, students, patients, staff, management personnel, owner), the NBS producers (construction companies, green constructors, material producers), and researchers. Municipalities' environmental departments, entrepreneurs in the field and climate adaptation consultants could help push forward such processes. NGOs were mentioned as important drivers to push politicians as well as the so-called 'early adopters', brave persons, that pave the way for novel thinking and changing the traditions. An example is to provide norms for the self-sufficiency of neighbourhoods in water management. This would make sure that sufficient space is provided for water management locally.

Concrete guidelines for multifunctional NBS

"Also sustainability should be thought of: how to steer the construction so that the overall sustainability is achieved as regards materials used etc."

Clear obligations and concrete guidelines are needed – it may not be enough to state in a policy document (e.g. strategy) that a specific type of NBS needs to support biodiversity or be sustainably built. Instead, concrete alignments need to be given as regards how to achieve the wanted (i.e. materials to be used, habitat characteristics, substrate qualities, plant species, etc.). For example, at the level of releasing land development decisions, certain investments like SUDS, green roofs, permeable surfaces, trees or phytotechnical

studies of the most suitable plants to the site should be required. Importantly, the authority needs to follow up that the implementation of the required NBS really happens. Penalty payments may be a strong incentive in the case of insufficient completion of NBS. Setting city goals, together with educating the municipal authorities, investors, planners and construction companies will allow smooth collaboration.

The creation of norms, clear targets, requirements and restrictions needs to be backed with arguments and information about the multifunctionality of NBS. This will help understand the importance of NBS, and that they are not only for one purpose, which in turn may help create political commitment (see also Szkordilisz et al., 2018). Furthermore, evaluation systems are needed for the follow-up of the achievement of the policy targets so that the decision makers can take necessary measures.)

Instruments for favouring the multiple benefits of NBS over grey infrastructure

"Currently the only well working right is removing conflicts between trees and infrastructure by cutting the trees."

Overcoming the confrontation between green and 'grey' infrastructure may help implementing NBS (see also Depietri & McPhearson, 2017). The need for NBS should be recognized in land use policies: in case there is no political commitment concerning NBS, grey solutions may win over NBS (very common when there is limited space). All municipal strategies, whether they concern flood risk mitigation, noise abatement, health, equity, or else, should consider NBS as an essential part of the strategy. At the same time, the multifunctionality of NBS should be emphasised and result in budgeting that takes into account the multiple functions that NBS provide. Silo policies may lead to silo budgeting approaches where each authority focuses on fulfilling their main targets in the cheapest way, ignoring the synergies that multifunctional NBS would provide, resulting in a lower total cost across the different sectors. For example, a park that activates people for mobility, is aesthetically interesting, supports biodiversity, cools down the city environment and handles storm water may be lower in cost that targeting each of these benefits individually via other solutions.

For example, many actors in municipalities may see street trees as aesthetic but fail to consider the capacity of trees in climate change adaptation and flood risk mitigation. Municipalities should create policies that state the quota for tree density. While many norms exist for public spaces (street width, parking place size, etc.) norms for trees and plants may be lacking, making them outlaws. Norms for street trees may legitimize designs with trees.

An effective normative policy paper should provide arguments for preserving trees, to balance the numerous existing arguments for removing trees (e.g. reducing maintenance cost, need for space). A comprehensive inventory of street trees that reveals their spatial distribution, condition and circumstances will allow for a proper spatial and maintenance plan.

Another example are the school yards that could offer NBS for learning and restoration during school days but where NBS may be considered just an extra cost from the management point of view. In the latter case such norms and standards should be provided for learning and well-being regarding school yards. Here the ministries of education and environment should work together with umbrella organisations in the field of education, policy makers and researchers, to create the norms, guidelines and other regulative instruments (see also Case stydy II, Chapter 5.4.2 for this kind of a challenge).

The planning culture may favour grey solutions because of too rigid guidelines focusing on grey infrastructure, without any exceptions allowed, and thus hamper the use of NBS. The regulation should be revised, to include equally professional guidelines for NBS as there are for the ‘hard infra’.

Policies to support collaboration and co-design for local empowerment

Communication, collaboration and co-design are key drivers, and policies supporting and demanding such are needed. An interesting possibility is the empowerment of urbanites. Unused land can be turned into green space, existing green space can be co-managed with urbanites, new activities facilitated, or new collaborative space can be created. Such possibilities include e.g. the temporary or long-term transformation of forgotten or unused places into urban farms; permeable zones at the borders of private and public land, with certain management activities of private owners allowed to extend into the public land; the release of planting boxes to citizens who can position the boxes in public space; and vegetated roofs or roof gardens on residential or educational buildings. The city would benefit from the creation of frameworks for these activities, in collaboration with neighbourhood associations. The frameworks should describe the resource allocation, for example in the case of urban farming the municipality could prepare the disused land, and the neighbourhood associations could generate the rules and management plan for the urban farmers.

Two concrete examples of the above activities include projects in Turku, Finland and Sletten, Denmark. The city of Turku authorities decided to deliver planter boxes for the

residents[15]. The city offers the planting boxes, mull, with a permission to place the box on public land. The residents are responsible for the plants, irrigation and upkeeping of the site. The city has hundreds of planter boxes around the city since the year 2016 and has published a "friend book" that shares the experiences of the urban gardeners[16], In Holstebro, Denmark, the citizens participate the maintenance of a so-called co-management zone between their backyards and the public woodland (Fors & Nielsen 2016). Fors et al. (2018) found that participation positively affected the experienced woodland quality and provided social benefits. In the light of this study, participation in the maintenance of NBS may create support for them and also help building social capital.

Holistic, far-reaching policies

In summary, multiple policy instruments, both 'carrots and sticks', are needed to promote NBS: EU-, national and municipal-level policies, coercive legislation, guidelines, instructions and recommendations, concrete enough local strategies (e.g. stormwater management strategy, green roof strategy, strategies at neighbourhood level,) and plans (e.g. tree- and woodland plan) as well as follow-up and evaluation systems for the strategies. As NBS is still an evolving concept, policies should create positive stimuli, and good practices effectively disseminated.

Broad enough frameworks and platforms for action allow for comprehensive thinking, to achieve a broad mutual understanding of the importance of NBS. All relevant stakeholders, including local actors, associations and residents, should be involved in planning and implementation of NBS. For example, umbrella organizations in the construction field may be good allies.

"A key challenge is how we implement high level decision making and demonstrate the importance of NBS to the wider thematic partnerships such as health, transport, and air quality. NBS has a significant role to play in partnerships that promote the livability and adaptability of a modern city."

Policies are needed to implement NBS to improve people's long-term quality of life as well as ecological networks, and the implications of the upper-level policies for the local-level practical work need to be clearly explicated. Strong, bold and visionary leadership reaching beyond electoral terms and across sectorial borders is needed. 'Phenomenon-based policy'

[15] https://www.turku.fi/laatikkoviljely
[16] https://www.turku.fi/sites/default/files/atoms/files/kaupunkiviljely_ystavakirja. pdf

could be an approach to develop governance and decision-making for complex issues like NBS.

Examples of policy drivers that could help implementing NBS:

- NBS: green roofs or roof gardens

  DRIVER: **Municipal NBS-strategies that operate at a concrete level**

  HOW DOES IT SUPPORT IMPLEMENTATION: Offer support for new solutions and way of thinking.

  HOW TO CREATE THE DRIVER: General strategic aims should be concretized, and responsible stakeholders named especially in cross-sectional strategies that involve several administrative units. Concrete solutions should be offered, e.g. not just mention that biodiversity has to be supported but also offer information and examples of how it is achieved (e.g. green roofs should have thick enough substrate, consist of native species etc.).

  WHO COULD PUSH FORWARD: Municipal administration

- NBS: biofiltration fields; green roofs and roof gardens

  DRIVER: **Municipal storm water strategies with funding for experimental NBS**

  HOW DOES IT SUPPORT IMPLEMENTATION: encourages multi-stakeholder communication and projects

  HOW TO CREATE THE DRIVER: Transfer knowledge at national level, convince the funding organizations to fund multi-stakeholder projects and pilot cases

  WHO COULD PUSH FORWARD: National financing organizations; professional umbrella organizations

Examples of policy barriers that may hinder the adoption and implementation of NBS:

- NBS: Urban and periurban forests

BARRIER: Inappropriate guidelines, lack of effective policies and planning guidelines

HOW DOES IT HINDER THE NBS: it's complicated to preserve and convert land for forest as an integrated and organised part of the city

HOW TO OVERCOME THE BARRIER: policy dialogue, peer pressure, civil movement

WHO COULD PUSH FORWARD: Planning administration, NGO's, citizens

- NBS: Green roofs and roof gardens, green facades and green walls

BARRIER: **Too restrictive coercive waste regulation**

HOW DOES IT HINDER THE NBS: the new innovative substrate based on recycled materials could not be used

HOW TO OVERCOME THE BARRIER: legislation needs to be updated and made more flexible

WHO COULD PUSH FORWARD: The EU

Policy drivers in case studies: ThinkNature Platform and Oppla - examples

Amsterdam - NBS for greening the city and increasing resilience
https://oppla.eu/amsterdam-nbs-greening-city-and-increasing-resilience

- The city provided a budget of 20 million euro for the Green Agenda 2015-2018. The public, not-for-profit organisations, companies and authorities had to invest money themselves to be able to obtain a subsidy. This co-financing approach was very successful, with in total more than 55 million euro being invested in a greener Amsterdam.

Basel, Switzerland: Green roofs: Combining mitigation and adaptation on measures
https://oppla.eu/casestudy/18381

- A comprehensive suite of mechanisms was applied, from incentives to statutory regulations
- The growing medium should be native regional soils — the regulation recommends consulting a horticulturalist

Berlin - NBS for urban green connectivity and biodiversity
https://oppla.eu/berlin-nbs-urban-green-connectivity-and-biodiversit

- Bottom-up citizens' initiatives have helped to create important green infrastructure, influencing and transforming public policies. Public policies have to a certain extent tolerated and sometimes integrated these bottom-up activities into mainstream policies
- Legal obligations provide resources to create or improve green areas. Combined with strategic, proactive planning this allows funds to be allocated for implementing connectivity measures.
- Good integration of urban and green planning.

Szeged - NBS for urban regeneration and adaptation to climate change
https://oppla.eu/szeged-nbs-urban-regeneration-and-adaptation-climate-change

- Information about EU funding mechanisms and operational programmes for green infrastructure, nature-based solutions and green areas was identified crucial for developments in the city.
- There were many discussions on how to finance the expected high costs of maintaining the grass between the tram tracks as maintenance is usually not supported by EU funds. In fact, the costs have not exceeded the planned budget and can be managed by the city, which shows that more knowledge and experience are needed to make more exact calculations and better project planning possible.
- Key success factors include the dedication of city leaders and specific financial sources. These are complemented by tailored trainings for city officials on green area development from the perspective of climate change, organised by Szeged University and a national NGO that deals with energy and climate change issues.

Green roof Experiment - Barking Riverside
https://oppla.eu/casestudy/17556

- When aiming to integrate innovative Green Infrastructure design elements in site master planning and overall development schemes, it is critical that both planning authority and developers are fully engaged in the process (beyond a single member of staff)

Table 10. Summary of policy drivers and examples of possible actions at various regional levels. See Table 8 for the possible stakeholders and actors that could be responsible for initiating and/or taking responsibility of the actions at various levels.

Drivers/ actions	Local	National	EU	Global
Create a wide toolkit of policy instruments	Assess the possibilities of coercive norms and voluntary actions: find most efficient tools for the toolkit	Update existing regulation to include NBS promotion		
Forecast the consequences of coercive policies		Conduct an evaluation of relevant laws for recognizing multiplicative effects promoting or hindering NBS		
Include NBS in land use policies	Require NBS in city- and master plans	Take actions to include NBS in regional plans.	Ongoing EU UIA and Urban Agenda for the EU initiatives should be supported, disseminated and replicated	
Focus on the synergies of policy-making at various levels	Include NBS in planning documents of cities, following national policy framework	National planning policy framework steering the municipal planning to take NBS into account, e.g. national laws for urban planning		
Raise awareness of policies that could support NBS implementation	Offer knowledge for decision-makers to recognize the interrelation between various policies.		Launch various awareness-raising campaigns	
Co-creation of norms	Engage local communities to the development of city plans and other policy instruments; develop participatory methods.	Ensure the representation of NBS-experts in the working groups for developing legislation of relevant fields (also other than environmental).		

Concrete guidelines for multifunctional NBS	Provide strategies and plans for promoting NBS at various scales with concrete instructions how to achieve the aims, and who is responsible for actions.			
Policies to support collaboration and co-design for local empowerment				
Strive for holistic, far-reaching policies	Recognize the consequences of silo-policies and silo-budgeting; ensure that NBS are resourced in municipal projects.	Prepare far-reaching policies and strategies to ensure continuity for NBS projects		

5.2.3 Market drivers and barriers

In total, 29 out of 57 respondents indicated market drivers that could support the realisation of NBS, and 26 respondents indicated market barriers that could hinder the realisation of NBS. Altogether 23 respondents gave free-form answers concerning 26 NBS, regarding the market barriers and drivers. These results are presented and discussed below.

Market, promote and disseminate

Greater promotion and more widespread usage are seen as main market drivers for NBS, together with a detailed analysis of the benefits that NBS provide to the community, to illustrate the benefits to local administrations and financial institutions. Project capital expenditures of NBS-projects depend heavily on the scale of the solution and the context. In general, the projects are financed from municipal budgets, private companies, or investors, as well as supported by the European Commission, depending on the purpose of the infrastructure and the stakeholders receiving services or other benefits. However, the financing mechanisms available for cities are complicated to apply for (requiring additional administrative staff and time resources) and, more importantly, require co-financing, which many cities, especially small ones, cannot afford (Jurik et al. 2018).

The IUCN Business Engagement Strategy (2012) define the potential values and role of linking the private sector and associated market forces to managing biodiversity:

> "In implementing the global vision and targets for biodiversity, business can add complementary perspectives to those of governments and civil society. In particular, knowledge of markets, ability to harness advanced research and development to deliver solutions and management experience can be valuable assets when applied to conservation."

These roles are reflected in how market forces can help to advance the use of NBS along with other roles including marketing and promotion, collaboration and innovation. The NBS market is still one in constitution, with some technology providers whose solutions are already in the market, but other actors in the value chain still strive to be recognised (specific consultancy, service providers, established supply and retail chains). In this landscape of a still consolidating market sector, a real marketing campaign is difficult to plan and implement. The lack of a critical mass of companies providing all the elements in the commercial value chain hinders the implementation of a really aggressive marketing campaign in favour of NBS.

Nevertheless, a tailored and well-targeted communication campaign for nature-based solutions would be a first step in this direction, and could ensure greater trust in the system,

as well as a further development of the technology adopted, with a consequent decrease in its costs and higher economic benefits for developers and financiers. Such communication approach should highlight the advantages of NBS in comparison to grey infrastructure, for example, in terms of provision of ecosystem services and protection of biodiversity (e.g. wetlands, urban and peri-urban forests and woodlands) as well as natural capital that companies rely on (companies assets), in terms of cost reduction (e.g. natural areas increasing water retention capacity) or in terms of health and human wellbeing (e.g. green public spaces), and also in terms of business opportunities for private sectors to expand their market at a national and international level (e.g. green tramlines). Such promotion could also be carried out by universities and research centres, via specific courses and knowledge media about case studies and overall benefits.

Develop incentives and monetize NBS

The promotion of NBS should also ensure increasing the awareness of policy makers and development agencies, which could define economic incentives for their development, and thus catalyse similar projects. Indeed, a precise and accurate cost-benefit analysis is seen as an essential element to demonstrate for each specific NBS its convenience and feasibility. For example, parks and green areas projects that embrace the NBS approach prove to be cheaper, as is the example in Finland where meadow-like solutions are preferred to manicured lawns. In addition to that, monetisation of indirect benefits such as health benefits, provision of recreational activities and/or area beautification would also push NBS forward.

The knowledge of the cost-efficiency of NBS should be widely available for those who make decisions of the solutions. This, however, requires coming out of silos, e.g. in municipal organizations: the same construction. e.g. a street renovation, may involve several departments that have separate budgets, hindering a comprehensive cost-benefit analysis.

The incentives could be calculated on the basis of the benefits provided by the NBS on the area, for example by calculating the mitigation saved costs for protecting an area from flooding provided by a square meter of greenspace. In general, the monetisation of the benefits offered by NBS interventions could definitely and effectively drive the market in the right direction. Moreover, appropriate and innovative financial incentives are considered a key driver for NBS, as well as policies and nature-oriented regulations. Public procurement should be efficiently channelled to prefer solutions that embed NBS in every sector (e.g. transport, energy, water, etc.).

For example, cities should prefer a provider of a tramline who would integrate green features instead of concrete ones. In this way not only an economic advantage is fulfilled, but also the environmental values are safeguarded. In a similar respect Network Rail, when redeveloping Birmingham New Street Station, UK[17], used trains to transport materials for the development; this reduced the carbon load of the project by eliminating road transport to the site and also saved on monetary costs. NBS were considered throughout the redevelopment with the creation of a 325m² green wall using 25 different plant species along the Moor Street link to the station and a green roof on and the adjacent accommodation building; efficient water spray taps to conserve water; combined heat and power; natural ventilation; and rainwater harvesting which provides 60% of toilet flushing demand. Alternative materials such as carpet tiles with yarn made from recycled fishing nets were incorporated and waste was designed out and reused where possible.

Budgeting programs shall be based on putting the costs on the functions/services provided and not on the cost of the item. Also, local governments should come up with new financial instruments dedicated to long-term management of NBS (development & maintenance). In this respect Danone has worked with four municipalities in the Volvic catchment[18], to create new governance arrangements to achieve long-term improvements for the delivery of environmental and social benefits. Five environmental and social benefits of water quality, water availability, landscape, rural vitality, and biodiversity were identified. These are all interconnected but water related services are dependent on the rest. Danone understood that the groundwater's value comes partly from intrinsic characteristics of water, and partly from the whole resource system (value of the natural environment) and that market's drivers play a central role in the production of the services. The public-private partnership does not offer payments for ecosystem services as such, because it would be too costly for local public authorities to maintain this payment over a longer period of time. Rather, it pays for land related activities which support farmers in the maintenance of extensive practices thus protecting the water quality and mineral content. The Volvic governance structure has been transferred to other watersheds managed by Danone-owned companies: Evian, Badoit and Salvetat ensuring the long-term management of NBS across all of the water catchments in order to protect the water resource.

[17] https://oppla.eu/casestudy/19186
[18] https://oppla.eu/casestudy/18375

Innovate, collaborate and exchange knowledge

"There should be a wider selection of ecologically sustainable materials for landscaping and the use of NBS." [quote from the data]

Simultaneously, the private sector (architecture and construction companies) should enlarge their portfolio and put their expertise at the service of public authorities and project developers. For example, plant material producers should include in their offer endangered and rare species, which retain a high interest from the perspective of nature conservation and biodiversity, and eventually prioritise them on their billboards.

The creation of umbrella groups within the construction and architecture sectors to share best practice and to create a body of evidence-based findings which could support the values of NBS would help to embed NBS within the planning system. It would encourage and strengthen uptake by municipal authorities as well as spreading the concepts and values within the architecture and construction sectors.

Davis and Naumann (2017), describe the value of expanding on this approach to include a wider range of stakeholders and market actors to enable better understanding and expedite the mainstreaming of Sustainable Urban Drainage Systems (SUDS) as a nature-based solution:

> "The targeted involvement of groups that are perhaps not traditionally interested in drainage matters, such as those in the health or transport sectors, and encouragement of exchanges between companies having implemented SUDS and those pursuing purely grey solutions can also benefit the mainstreaming of SUDS."

This is relevant to all kinds of NBS; working collaborative across market sectors enables awareness raising, innovation and better investment in NBS. The 'Greenest of the Green Block' in Helsinki, Finland,[19] illustrates the value of cross-sectoral collaboration, innovation and knowledge sharing. The City of Helsinki in collaboration with universities, private sector companies and communities to research methods to explore the functionality of green areas on the roofs of apartment buildings and to gain insight into the impacts green roofs may have on housing and the sense of community. The green roofs provided circular economic benefits by cooling down the microclimates on the roofs and helping in the management of storm water. The mix of plants is being studied to inform future approaches, particularly in respect of climate change and the potential for extreme weather events e.g. heat and wind.

[19] https://oppla.eu/casestudy/18875

The results are expected to inform other developments in the Helsinki metropolitan area as well as being more widely applicable to other cities in Nordic and Baltic countries.

The capacity of the private sector to lead new innovations and generate new knowledge is crucial for mainstreaming NBS at a wider level. In this sense, young generations in general are seen as more eager to embrace and advocate the philosophy behind the NBS approach, on the environmental and sustainable point of view. Changing the general mindset within the construction sector towards a greater use of NBS would be a considerable market driver: the so-called “early adopters” would have a major role in paving the way for novel thinking and revolutionizing the way projects are traditionally planned. In this context, municipalities could offer pilot sites for testing the innovations and spread the NBS vision.

Examples of market drivers that could help implementing NBS

- NBS: Parks

  DRIVER: **NBS may be cheaper than traditional solutions**

  HOW DOES IT SUPPORT IMPLEMENTATION: NBS are favoured because of the lower price, e.g. in Finland meadow-like solutions instead of manicured lawn are nowadays favoured for the lower cost

  HOW TO CREATE THE DRIVER: There should be knowledge of the costs and benefits

  WHO COULD PUSH FORWARD: E.g. research organizations could produce cost-benefit analyses: decision makers should adopt this knowledge.

- NBS: Urban Farms, allotments or community gardens

  DRIVER: **Capacity of the construction and real estate development field to adopt new innovations and new (all the time evolving) knowledge. Visionary people** in the field are crucial in the phase were NBS are not yet established their role in the business-as-usual, everyday decision making.

  HOW DOES IT SUPPORT IMPLEMENTATION: Partly the question is about generations: young professionals have been perhaps more educated to understand, e.g. environmental issues and hazards. Still, the more traditional actors should be educated and informed, too, because there is not too much time to waste for making the construction field adopt NBS (and sustainable solutions in general).

  HOW TO CREATE THE DRIVER: Change the mindset of the construction field

  WHO COULD PUSH FORWARD: Big construction companies, education organizations in the field.

Examples of market barriers that may hinder the adoption and implementation of NBS

- NBS: innovative vegetation management techniques to create ecological corridors along the routes of the high voltage lines

BARRIER: **Short term view on the costs and benefits of the solution compared to traditional management (mowing).**

HOW DOES IT HINDER THE NBS: Project developers do not see the value.

HOW TO OVERCOME THE BARRIER: Development of a cost-benefit analysis (CBA) specific to a project.

WHO COULD PUSH FORWARD: Research Institutes in collaboration with project developers and project owners.

Market drivers in case studies: ThinkNature Platform and Oppla - examples

Szeged - NBS for urban regeneration and adaptation to climate change
https://oppla.eu/szeged-nbs-urban-regeneration-and-adaptation-climate-change

- There were many discussions on how to finance the expected high costs of maintaining the grass between the tram tracks as maintenance is usually not supported by EU funds. In fact, the costs have not exceeded the planned budget and can be managed by the city, which shows that more knowledge and experience are needed to make more exact calculations and better project planning possible.

Milan - NBS for urban regeneration
https://oppla.eu/milan-nbs-urban-regeneration

- The city of Milan supports partnership with private or semi-private companies for the maintenance of its green areas. 'Adotta il verde pubblico' (Adopt a green area) is a city initiative to encourage local residents to become involved in the administration of green areas and to seek sponsorship to help the city's finances.

Cloudburst Management Plan, Copenhagen
https://oppla.eu/casestudy/18017

- Establishing urban ecological waterscapes while balancing sound investment and economic opportunities with social benefit improvements.
- Insurance damage savings and the increase in real estate value.

Ecuador: The Socio Bosque Program
https://oppla.eu/casestudy/18372

- Conservation actions must be coupled with income in order to generate activities for long-term sustainability.

Table 11. Summary of market drivers and examples of possible actions at various regional levels. See Table 8 for the possible stakeholders and actors that could be responsible for initiating and/or taking responsibility of the actions at various levels.

Drivers/ actions	Local	National	EU	Global
MARKETING, PROMOTION AND DISSEMINATION				
Share knowledge of successful implementation of NBS to ensure the quality of products.	Cities and local NGOs facilitate the knowledge sharing on the local level.	Knowhow for companies to understand the requirements of plants in local conditions.	Platforms such as Oppla and ThinkNature have the key role for the knowledge exchange among EU states; All the EU countries should hold regular dialogues on the experiences with NBS.	Ensure that results can be adapted and replicated across the world with appropriate adaptation to local conditions and species.
Knowledge of the possibilities of NBS for business actors	Involve companies in local projects.	Seminars and education days.	Support projects investigating business opportunities in the NBS field.	
Strategic tools to include NBS in private projects	Develop municipal tools, e.g. green factor.		Support for projects developing strategic tools for various levels.	Develop various certificates, e.g. LEEDS, to include NBS.
FINANCIAL INCENTIVES AND MONETIZING NBS				
Financial policy instruments	Financial support from municipalities for implementing NBS in construction projects.	Instruments on offsetting natural capital (e.g. if a project cuts trees they need to be replanted).		

Economic advantage of using NBS as opposed to traditional methods	Partnership approaches leading to innovation and reducing costs across a range of parties	Produce information of the monetary benefits of NBS for various sectors; cost-benefit analyses for various NBS technologies.	Develop tools for monetization of intangible ecosystem services (recreation, health etc.)	
Offer funding for successful approaches	Support for sustainable products, e.g. favour NBS promoting biodiversity in public projects.			Multi-national companies ensure their global operations are uniformly applying NBS where appropriate e.g. sustainable food production, construction of SUDs in developments, climate change adaptation technologies and resource management designed into buildings.
INNOVATION				
Local pilot studies scaled up into success at various levels	E.g. methods used in redeveloping Birmingham New Street Station are replicable in other station refits across the country and can be applied in a wider European or global context.			

Companies as market leaders with a larger share of the available market at all scales	Municipal authorities favouring construction incl. NBS, e.g. via invitation for tenders.	Research and development offering the opportunity to create new solutions National instructions for how to include sustainability/ NBS in invitations for tenders in specific fields.		
Implement the vision and targets for NBS-promotion into business strategies.				
COLLABORATION				
Engage a wider range of sectors to become involved in NBS solutions (e.g. health and social care, transport, financial sectors)	Communicate the benefits that NBS provide to the local communities.	Illustrate the values and examples that can cascade from NBS implementation to various sectors.		

5.2.4 Communication drivers and barriers

In total, 16 out of 57 respondents indicated communication drivers that could support the realisation of NBS, and 19 respondents indicated communication barriers that could hinder the realisation of NBS. Altogether 17 respondents gave free-form answers concerning 18 NBS, regarding the communication barriers and drivers. These results are presented and discussed below.

Promote the concept of NBS

At the moment, one of the key communication barriers is that, in spite of the rapidly growing knowledge-production, the concept of NBS in general is not yet widely known. For example, practitioners may get confused of all the time evolving terminology (e.g. green infrastructure, ecosystem services), and their interrelations. Wide dissemination and concrete examples of the NBS as a concept are needed to make clear how they can be used for the benefit of, e.g. urban planning and construction.

Pauleit et al. (2017) suggest that the concept of NBS is defined vaguely, and the relationships with existing concepts require clarification, namely ecosystem-based adaptation (EbA), urban green infrastructure (UGI) and ecosystem services (ESS). Pauleit et al. argue that the concepts are interrelated, complementary and mutually reinforcing, but NBS can be considered as an umbrella concept.

In the report of the ongoing Nature4Cities -project (2018), NBS is seen as complex concept at the interface of multiple actors and disciplines that generates multiple definitions and interpretations. The report offers, e.g. an overview on the origin and principles of the concept, relations with pre-existing neighbour concepts: ecosystem services (ES), Green Infrastructure (GI), and sustainable urban development, and reflects various definitions for the concept. The report suggests an operational classification that is multi-scalar (city, neighbourhood or entity), and is based on the form of intervention (forms or strategies) and on the support of the NBS (water, ground or building).

While the seminal EC expert group report on NBS was launched only four years ago (2015)[20], and the first wave of RIA projects on NBS (with *Nature4Cities* and *Naturvation*) is still ongoing, care should be taken in formulating clear and understandable ideas around

[20] EC, DG Research, 2015: “Towards an EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities”, Final Report of the Horizon 2020 Expert Group on 'Nature-Based Solutions and Re-Naturing Cities'.

the concept, and even more important, to capitalise on pre-existing concepts that are related and have already gained momentum both in the scientific literature and technical disciplines, and in the political and urban planning agenda, like “green infrastructures” and albeit less clear for general public, “ecosystem services”.

NBS must build on top of these concepts and start from the space in the urban agenda that they have already attained, and be combined to other social topics that are included in the NBS concept like participatory urban governance and social justice, which again, have more tradition in the urban and social arena.

Promote the systems for NBS

Some solutions, like, e.g. Sustainable Urban Drainage Systems (SUDS), are relatively new in many places. The novel systems, their benefits, and establishment methods have to be communicated widely to companies, developers, construction industry etc. stakeholders, to make them understand and adopt those as relevant solutions to urban challenges.

Positive and open atmosphere for developing and implementing NBS systems can be created by communicating what can be achieved by using the solutions, and what kinds of benefits do they offer for various stakeholders. The benefits are best understood via concrete examples. Thus, illustrating examples of NBS systems should be effectively communicated, but also failures offer good learning opportunities. A crucial question is, though, how to communicate ‘negative’ examples of NBS (Kabisch et al. 2016). On one hand ‘failures’ are good learning opportunities, but on the other hand they can be scary and cause preconceptions.

Go for cross-sectional cooperation and communication

Cross-sectional networking, cooperation and communication are crucial for promoting NBS, sharing knowledge and running projects including co-development, co-creation, co-design, and co-management of NBS. Stakeholders at various decision-making levels can be involved - ministries with NGOs and municipalities, research organizations with companies etc.

Cooperation with investors – those who have the money and leverage – is an efficient way to achieve concrete NBS projects. For example, in a construction project with building-integrated vegetation, cooperation between real estate developers, constructors, planners, municipal authorities and research organizations may produce innovative and courageous

outcomes that would not be realized without open-minded collaboration. Communication between departments, co-creation and cooperation was emphasized also in ThinkNature A Coruna Forum (Jurik et al. 2018) as well as strategic communication, trans-disciplinary mechanism for collaboration, and awareness and capacity building.

Cooperation and cross-sectional communication can take place in internal communication of an organization, e.g. between different departments at municipal level, and when communicating with external stakeholders. In big cities it may be challenging to recognize and find the stakeholders needed in each NBS project. A facilitating actor may be needed, e.g. a specific office to supervise cooperation, or an existing office to take care of developing cooperation and cross-sectional communication. The decision-makers have to be aware of these kinds of needs, to be able to allocate resources for cross-administrative activities.

Avoid jargon

Attention should be paid to a coherent and understandable use of concepts and avoiding professional jargon. A coherent terminology is needed from science to practice. For example, systems for urban drainage include a myriad of various abbreviations (LID, WSUD, SUDS, BMP etc,) that may cause major confusion among cross-professional cooperation. “Given the need for the urban drainage profession to increasingly engage with other professions, the potential for miscommunication can and should be minimised, through the careful and explicit use of terminology” (Fletcher et al. 2015). A review of Prudencio and Null (2018) suggest standardizing of green stormwater infrastructure terminology, to provide a more cohesive field of study instead of diverse and redundant terminology currently in use.

The lack of common language may hinder successful cooperation in many ways, e.g. by causing conflicts and misunderstanding. Thus, already in the early phases of an NBS project, the core concepts, methods etc. should be discussed and made sure that all stakeholders understand the basics of various fields of expertise. Openness for rethinking one’s attitude and language and being tolerant for representatives of other professions is crucial. A problem-based approach can be used here. For example, if solving a flooding problem, conserving biodiversity and saving energy in buildings at the same time is the target, the responsible people should gather around the table to discuss and offer multiple expertise to be shared among the group. There may be cultural conventions that do not support open discussion, e.g. expressing one’s knowledge gaps. Cross-professional cooperation should allow ‘dumb questions’, to make all the concepts clear.

Communicate with local communities, engage residents and NGOs

"Sometimes the citizens do not know it is at their hand to participate or to push local policy to the direction of city restoration." [quote from the data]

Involving local residents, communities or, e.g. schools in an NBS project may produce positive reactions for novel solutions, and also bring good ideas and local tacit knowledge into the agenda. Citizen science is an option to engage residents for gathering follow-up data, or even continuing a project after a sufficient amount of briefing and support, by e.g. an NGO. These kinds of grass-root initiatives and local projects raise the awareness among residents of the state of their own environment and may empower them to actively take part in the societal debate for better environment including NBS. Citizen science can be used as part of learning at schools and link the teaching in real-life projects. Authorities should be agile to support grass-root level initiatives and deliver models for involving residents. As experienced in Edinburgh[21], community-led initiatives benefit when they receive a high level of support (e.g. finance, advisory and/or material support) and trust from the local authority.

However, as the case study of Dresden (NBS for sustainable urban transition[22]), shows, sensitivity is needed in interaction between research and local initiatives, as the goals and objectives of researchers and local activists do not necessarily coincide. EKLIPSE report (Balian et al. 2016) suggests advancing flexible regulations to allow people to develop their own idea, e.g. a list of species that can planted in the public space, making sure that they are non-invasive, non-obstructive, non-allergenic etc.

Individual commitment and sense of ownership are good tools for appreciating natural environment. Local communities can be engaged in NBS-projects, and e.g. involve specific user groups in planning and management of their own neighborhood. For example, potential could be explored for co-management of green spaces between recent migrants and long-term residents (Balian et al. 2016). Participative management, participative urban planning, and e.g. IT platforms to tag individual favourite green infrastructure, e.g. trees, or adopting and sponsoring trees could be used as citizen engagement (Balian et al. 2016).

[21] https://oppla.eu/edinburgh-nbs-enhancing-health-wealth-and-sustainability
[22] https://oppla.eu/dresden-nbs-sustainable-urban-transition

Be prepared for resistance and prejudices

Prejudices are common among construction companies and affect to the readiness of adopting and implementing NBS in various projects. As presented in the case study (Chapter 6.1), traditions and routines of the construction field may change slowly, and thus a persistent attitude towards changing the mindset of the field is necessary. Communication at various levels, and education for the different actors in the construction field are needed. For example, structural engineers should also be aware of the requirements of vegetation, not only e.g. landscape architects and architects. Basic knowledge of vegetation should be disseminated in the early phases, and through the whole construction project, to all relevant stakeholders of the project.

Essential target groups are also those that are responsible for the maintenance and governance of the solution after the NBS is constructed. For example, in projects including building-integrated vegetation, the landlords should be aware of the vegetated structures, and know what kind of workforce and equipment is needed for successful maintenance. A task for, e.g. umbrella organizations in the real estate field would be to develop detailed instructions for these kinds of projects, and suitable further education for various fields of expertise in cooperation with educational organizations.

Sensitivity is needed to recognize what lies behind a resistant attitude for adopting NBS, e.g. safety issues cannot be overlooked. For example, showing that safety is considered, may help overcoming barriers. Also discussing the multiple benefits of NBS may lower down the barriers among practitioners. For example, in a project for constructing or retrofitting a school yard to include NBS, the safety of water elements has to be communicated to teachers. Linking NBS to the educational aims may be an argument that helps adopting new sustainable solutions.

Attention should be paid also to how local residents accept and adopt new NBS. There may be strong prejudices against novel solutions that challenge the traditional urban construction. For example, small urban farming projects may offer baby-steps for adopting NBS – something that is close to the health and everyday living of the urbanites.

Streamline knowledge-production and efficient communication

There should be information of NBS, targeted for various stakeholders, not only of the performance and other technically oriented evidence, but also, e.g. of the funding possibilities for piloting NBS. Gathering and disseminating knowledge of an all-the-time evolving issue like NBS is a challenging task. For example, in municipal administration,

there could be a governmental body to take care of gathering the growing knowledge, e.g. collect scientific results and case examples for NBS-based storm water management for practitioners. This could be a local project, involving, e.g. cooperation between research organizations and city administration. In large cities with good resources, urban planning offices/ departments/ units could recruit a scientist with broad inter- and transdisciplinary knowledge of NBS, to support with the daily work of the planners, and also consult decision-makers - 'researcher at the house' -model.

Urban planners are often key persons in either hindering or promoting implementation of NBS. Also, architects have a lot of power to decide whether NBS are included in the plans and designs. Landscape architects should master at least the basics of ecological knowledge. Thus, there should be education and training of NBS, targeted specifically for planners and designers. For example, in Szeged, Hungary[23], tailored trainings for city officials on green area development from the perspective of climate change were organised by Szeged University and a national NGO that deals with energy and climate change issues.

Established, wide knowledge-sharing communities, such as Oppla, offer platforms for sharing best practices and communication in order to learn from others. New NBS that are in the innovation phase, need local groups of actors and intermediating organizations for the knowledge transfer. For example, an NGO may be an interpreter of nature in a project involving residents, e.g. offer knowledge of the requirements of plants. Science-policy interfaces, such as urban laboratories serve as communicative platforms for various concrete projects and offer possibilities for long-term learning while including experimenting and follow-up beyond a lifespan of a single project.

Find effective communication tools

Effective and targeted communication tools and methods are needed to inform various stakeholders about NBS, and to support cooperation and collaboration. Various forums are needed to spread and transfer the information, both general-level seminars, conferences etc., but also, e.g. education days going into definite details of a certain NBS or field. If a seminar or educational activity is targeted at a very broad audience, the information may be too shallow for someone who is looking for specific answers to specific problems.

[23] https://oppla.eu/szeged-nbs-urban-regeneration-and-adaptation-climate-change

The general atmosphere of the society can be a powerful driver for adopting innovations. General environmental awareness has effect on how the knowledge of NBS is understood and the benefits valued. Changing the general values and attitudes requires wide discussion and awareness raising involving various stakeholders and using multiple channels. Popularizing of science, e.g. in major media may increase general awareness of the importance of urban nature, and of the state of the environment and nature in general. Role of education is obviously important in raising environmental awareness.

General awareness and interest in NBS can be promoted by local (e.g. newspaper, radio channel), and social media. PR-value of innovative solutions is an asset to reach publicity and raise awareness, and thus get, e.g. decision makers, authorities and general public interested in NBS. Awards for innovative NBS can be used for making use of the the PR-value. For example, the Greenest of the Green Block in Finland[24] was awarded by national and international prizes, and gained a lot of positive publicity in media, concluding in the will of the owner to adopt a broad 'green attitude' for the real estate developing and construction.

Various awareness campaigns could be arranged, but the message should not be too complicated. In Urban GreenUp -project (Kuban et al. 2018), strengthening information on NBS through leaflets, web, television, radio, etc., organizing forums for investment in implementing NBS, strengthening the exchange of relevant information, and creating favourable conditions for the private sector to participate in the socialization of NBS were mentioned as communication drivers for promoting NBS.

[24] https://oppla.eu/casestudy/18875

Examples of communication drivers that could help implementing NBS

- NBS: walls or green facades, here incl. scientific research

DRIVER: **Availability of networking and collaboration between university, investor** (here: real estate developer/constructor)**, planners, and city**

HOW DOES IT SUPPORT IMPLEMENTATION: Real-time and fast knowledge transfer among the stakeholders is possible.

HOW TO CREATE THE DRIVER: Make use of the PR-value of innovative NBS solutions create efficient, cross-sectional, trans-disciplinary networks in the field

WHO COULD PUSH FORWARD: Municipal authority making explicit that they want this kind of collaboration, e.g. during building permission process.

- NBS in systemic level

DRIVER: **NBS are attached to the effect they have on the health of various groups of citizens**.

HOW DOES IT SUPPORT IMPLEMENTATION: It draws the debate of using NBS into a higher level → comprehensive thinking, multifunctionality.

HOW TO CREATE THE DRIVER: In this case, a guide was developed, analysing the effect that local urban planning initiatives have on inhabitants' health, which brought NBS and the access to urban-natural spaces to the front of the debate. Publication: http://www.udalsarea21.net/Publicaciones/Ficha.aspx?IdMenu=892e375d-03bd-44a5-a281-f37a7cbf95dc&Cod=c7b41c06-c532-4925-a64b-06a248edcfc9&Idioma=es-ES

Examples of communication barriers that may hinder the adoption and implementation of NBS

- NBS: green roofs or roof gardens

BARRIER: **Strong prejudices against green roofs among construction companies**

HOW DOES IT HINDER THE NBS: Make the working environment tough for the others in the project and may slow down and discount the whole team's willingness to work with green roofs in the future.

HOW TO OVERCOME THE BARRIER: Education, successfully completed projects, national legislation and municipal strategies, easily available instructions, urban laboratories made as an established form of collaboration and joint experimentation in all major cities in the EU.

- NBS: Green walls or green facades

BARRIER: **Prejudices and lack of common language in a multi-actor planning- and construction project**

HOW DOES IT HINDER THE NBS: The planning team did not work optimally, and during the process there were conflicts and division lines within the team, also misunderstanding and lack of respect, e.g. between landscape architects and environmental specialists.

HOW TO OVERCOME THE BARRIER: Learn by running cross-sectional, multidisciplinary projects, and systematically gathering information of the process, stakeholders, values, attitudes, power relations etc. for smooth collaboration and knowledge-exchange.

Communication drivers in case studies: ThinkNature Platform and Oppla - examples

Urban hybrid dunes in Barcelona
https://oppla.eu/casestudy/17274

- The case is of interest for local media, schools and for citizen science.
- Social mapping and instruments for cultural ecosystem services valuation useful to improve communication between big administrations and citizens.

Medmery managed realignment scheme
https://platform.think-nature.eu/content/medmery-managed-realignment-scheme

- Engaging with local residents to answer questions and address concerns is critical to carrying out a successful project and creates an environment of trust.

Adaptation of Bratislava city to Climate Change
https://oppla.eu/casestudy/19033

- Communication: not only towards the public but also towards other governance bodies and municipal organisations.
- Co-creation: can be done with research organisations, but also together with the citizen, e.g. participatory designs of new public spaces can contribute to better quality of living but also help reduce climate change risks.

Bristol - NBS for ensuring a sustainable future
https://oppla.eu/bristol-nbs-ensuring-sustainable-future

- Engagement with local communities enables specific cultural and user groups to be involved in planning their neighborhood, and the Localism Act 2011 facilitates this.

Ecuador: The Socio Bosque Program
https://oppla.eu/casestudy/18372

- Individual commitment, sense of ownership: people are more committed to protect and nourish the land.

Szeged - NBS for urban regeneration and adaptation to climate change
https://oppla.eu/szeged-nbs-urban-regeneration-and-adaptation-climate-change

- Key success factors include the dedication of city leaders and specific financial sources. These are complemented by tailored trainings for city officials on green area development from the perspective of climate change, organised by Szeged University and a national NGO that deals with energy and climate change issues.

Table 12. Summary of communication drivers and examples of possible actions at various regional levels. See Table 8 for the possible stakeholders and actors that could be responsible for initiating and/or taking responsibility of the actions at various levels.

Drivers/ actions	Local	National	EU	Global
Promote the concept and systems of NBS	Offer concrete examples of various NBS; communicate benefits			Conferences for science and practice
Cross-sectional cooperation and communication	Promote cooperation and communication between constructors, planners, municipal authorities and research organizations.	Establish multi-actor science-policy interfaces, e.g. urban labs,		

Harmonize terminology, avoid jargon	Ensure cross-administrative discussion in the beginning of a project; Allow 'dumb questions'.	Offer easy-to-use handbooks for various concepts and expert terminology.	Harmonize the concepts across cross-sectorial strategies, add glossaries and open up abbreviations in strategic documents.	Ensure the uniform understanding of core concepts at global level.
Involve residents and NGOs	Use citizen-science in NBS projects; promote participatory urban planning			
Communicate with local communities	Offer information of an NBS project and its benefits for neighbourhood.		Support engagement of local communities in projects via communication: allocate resources for communication.	
Prepare for prejudices	Be sensitive for preconceptions, do not judge, be positive			
Streamline knowledge-production with -transfer	Ensure the availability of the latest scientific research for practitioners. Offer courses for urban planners at a reasonable cost.	Support cooperation between research organizations and public/ private sector practitioners		
Make use of existing knowledge platforms		Offer information of various knowledge platforms		
Utilize PR-value of innovative solutions	Press releases for novel solutions; local fairs (e.g. housing) incl. interesting new NBS		Awards for innovative and outstanding NBS	

5.2.5 Knowledge drivers and barriers

In total, 31 out of 57 respondents indicated knowledge drivers that could support the realisation of NBS, and 22 respondents indicated knowledge barriers that could hinder the realisation of NBS. Altogether 20 respondents gave free-form answers concerning 25 NBS, regarding the knowledge barriers and drivers. These results are presented and discussed below.

Tackling the "Fear of the unknowns"

"Knowledge makes the difference in the success of NBS" [quote from the data]

The knowledge drivers and barriers concern both producing new, and collecting existing evidence of the benefits, performance and functionalities of various NBS, as well as transferring the knowledge to practitioners and decision-makers. It is obvious that, as NBS is new as a concept and also as regards the concrete systems (cf. Chapter 5.2.4), a significant barrier is the lack of knowledge that creates the so called "fear of the unknowns". In our dataset, expressions, such as "Urban farming is not considered in current practices of city planning due to lack of knowledge coupled with legislative gaps", and "For streets plants and trees there is a lack of cross sectoral knowledge" represent this phenomenon. According to Kabisch et al. (2016), the fear of the unknowns considers both an operational unknown, described as "uncertainties and risks of implementing NBS in cities, as well as the resulting changes this may induce in city planning", and performance unknown: "NBS have not yet received assessments of their effectiveness in dealing with climate mitigation and adaptation targets such as carbon offsets" that may be related to the lack of awareness regarding climate change-induced problems and the benefits NBS can bring. Kabisch et al. (2016) suggest that NBS must be handled differently than other approaches and require new protocols for implementation and maintenance.

"Experimental attitude by public actors could support innovation and testing. EU could support practical experiments with NBS. Also national actors could support experimenting with NBS, e.g. innovation policies could target NBS."

According to the answers of the survey, it is important to understand that NBS are constantly evolving systems, and thus experimental attitude is needed: even though we do not completely know how they function, or what kinds of benefits they are able to produce, there should be courage and resources to start pilot projects for knowledge production and developing various designs step by step. Thus, projects should have long enough timeline and resources guaranteed for long-term development and monitoring. This is a cross-sectional issue that is emphasized with all categories of barriers and drivers.

Especially in the early phases of adopting new NBS, support is needed from the research organizations. Research and development projects are effective as they can be connected with communicating the results via real-time channels to the wider society, and also education and training of professionals can be a part of these projects. The multiple purposes of experimental projects should be recognized already when making plans for the projects and described in financing applications.

Related to the abovementioned topics, the proactive action of the European Commission should be highlighted as going in the good direction and showing the way to national and regional governments, on how to include NBS on their own R&D agenda and funding mechanisms. Indeed, the irruption of the NBS agenda in Europe and more precisely in Horizon 2020 has had a considerable impact in research organisations embracing the concept and actively participating in creating new knowledge, thanks to dedicated funding instruments and a clearly established common research agenda. The H2020 funded still ongoing NBS Innovation Actions, with new topics still open including cooperation with overseas regions like China and CELAC, around NBS, clearly paves the way on how the concept deserves attention, not only from the scientific community, but from urban planning practitioners and urban stakeholders, worldwide. Cities from the EU, associated countries and from those overseas areas are engaging in projects as pilot sites, contributing at the same time to generate new knowledge, technical feedback and wider political acceptance of the NBS concept and its related implementation models trough adaptations to local contexts.

Comprehensive knowledge-production

An essential feature of the knowledge-production of NBS is cross-sectional and transdisciplinary cooperation, as in urban areas, single NBS is typically a part of a larger entity and wider land-use policy. Cooperation and collaboration is emphasized especially when designing for multipurpose NBS that require knowledge and expertise of different fields and administrative sectors (see also Kabisch et al. 2016 for these challenges). Thus, representatives of various fields should define the knowledge gaps for a certain solution together, to recognize the expertise needed, e.g. not only technical, but also ecological and social.

Similarly, as ‘phenomenon-based policy’, ‘phenomenon-based co-production of knowledge’ could be a way forward: experts from different fields gather around the design of NBS, or solving a problem, to discuss the knowledge gaps and think of effective methods for

producing this knowledge. For example, cross-sectional brainstorming workshops could be arranged by city administrative, NGO or research organization. Cross-sectorial specialist groups can manage complex issues, such as habitat management, and also when, e.g. archaeological findings may have impact on the construction timelines.

Furthermore, there should be genuine interest in filling the knowledge gaps, and resources allocated accordingly for required research and development. Case studies with comparable designs were mentioned as efficient ways to produce knowledge, for example, monitor streets with and without trees, e.g. measure temperature, humidity and thermal comfort, as well as experiential quality.

Various stakeholders, e.g. researchers, decision-makers, companies and local residents, can have different perceptions of what kind of knowledge is useful and how to produce the required knowledge. For example, construction companies do not necessarily understand the nature of academic research, e.g. what does scientific experimental design mean – that it is laborious, costly and takes time. Practitioners may rely on a single one-year test of an NBS, results of which can be delusive because of the lack of replicates and long enough follow-up.

The larger societal context and overall aims of NBS frame the knowledge-production. For example, NBS should be cost-effective, and thus knowledge concerning, e.g. costs versus benefits is needed for various solutions. For example, in their review, Ovando and Brouwer (2019) show that forest conservation or forest management is an economically efficient nature-based solution to supply the watershed services, but still there are several knowledge gaps, e.g. the limited availability of geo-referenced data and information, including the often complex and confidential nature of cost and price data, and the high data demands of more advanced spatial econometric models. (See for more examples of knowledge gaps recognized in academic literature in Appendix 3).

Produce user-friendly, reliable knowledge

“There are many options for roof soil, however their properties and the benefits and costs of different options are not yet all quantified.”

The evidence-base and knowledge for implementing NBS needs to be concrete: what to do, how, when, with whom. Practitioners need knowledge of the availability of various alternatives to produce various benefits/co-benefits, and also practical, detailed knowledge for designing NBS. For example, as regards green roofs and walls, knowledge about materials of required layers, suitable vegetation, how are these linked with local and

regional conditions (climate etc.), how to maintain these NBS so that they thrive, but are sustainable at the same time etc. questions have to be addressed.

Furthermore, for renovation projects, there should be a database of the existing buildings with information of the load capacity and other essential information that is needed for producing suitable and safe solutions. One respondent pointed out that in some places the land owner registers are still lacking information, and thus prevent the building of NBS on such land. Land survey institutes are the key actor here to update the registers. Could some areas be prioritised in order to get the registers completed? Or, could citizen campaigns be arranged to get information?

There should also be opportunities for reflection about the quality of knowledge: is it well-established by the academic community or are there serious deficiencies. For practitioners, e.g. business actors, it may not be clear that the performance of an NBS cannot be based on a couple of studies only, but the evidence, e.g. to be used in marketing, has to be more solid. The challenge is, how practitioners can get this knowledge (cf. easy access to knowledge below). This emphasizes the responsibility of research organizations to offer academic knowledge in an understandable and applicable form, and also, e.g. involving business actors in research projects with well-established communication protocols.

Ensure efficient knowledge-transfer and easy access to knowledge

"The knowledge is not uniformly gathered for this purpose in one place but spread among various sources."

Practitioners and decision-makers need evidence-based, easily available, understandable and ready-to-apply information, reference cases and best practices to learn from. For example, municipal environmental and urban planning sectors could join their forces to start a web page to collect and communicate best practices and positive experiences of NBS. International examples are also helpful, in parallel with cases at the local level.

The awareness of the key powerful people in municipal environmental and urban planning sector of the performance of NBS is in the core of overcoming knowledge barriers (cf. Kabisch et al. 2016). Knowledge- transfer to these groups should be fast and efficient, so that they are able to make use and disseminate the knowledge wider in the society via multiple channels.

Obviously, there is lack of knowledge among market actors of the possibilities of NBS for business. For example, companies in construction and architectural fields should master

the knowledge needed to apply NBS in the operational level. Companies of the field can obtain knowledge of NBS, e.g. by taking part in events, conferences and fairs and also in meetings and discussions with local authorities, e.g. in the environmental and urban planning fields. Research institutions and umbrella organizations in the field could offer special courses for business actors.

International conferences dealing with NBS are needed, including both research and practical knowledge-creation and transfer to a wide range of end-users of the knowledge. On-line participation in the conferences should be arranged, to maximize the impact, and to make the environmental footprint of the event smaller. Visiting various experimental sites is an efficient way of gathering knowledge. Excursions can be arranged for specific stakeholders, e.g. as part of a seminar or conference.

"Multi-sourcing of information, open-mindedness and curiosity are needed".

Insufficient access to knowledge affect accepting, adopting and implementing NBS. Access to the knowledge is often a bottleneck even though the knowledge existed, e.g. in the academic literature. Open access publishing, open databases, 'intermediate researchers', web-based knowledge hubs with practical information and examples, fairs, seminars, conferences, mentoring programs, further education etc. can be used to ease the availability and usability of knowledge. The information should be targeted to meet the special needs of practitioners and converted into the language of the various end-user groups, to guarantee applicability. For example, Nobanis-database[25] is helpful in choosing plants for NBS.

At its best, searching for information can be an inspiring adventure for, e.g. a cross-sectorial team and lead to fruitful co-production of knowledge. Then again, the lack of knowledge of how to navigate for the information, may be the barrier, and thus the team should have a joint "knowledge searching compass".

Overall, optimistic attitude paves the path to successful solutions. It is not too fruitful to become depressed by the huge environmental challenges we have, but instead, try to set ambitious aims and reach those step by step for better future. Similarly, in futures studies, the approach is that we can consciously construct positive future: research can take a

[25] https://www.nobanis.org/

stance, e.g. that solving environmental problems means better future for the planet and people.

Examples of knowledge drivers that could help implementing NBS

- NBS: Bioinfiltration fields

DRIVER: **Availability of knowledge of the benefits of the solution, and practical detailed knowledge for designing** (e.g. alternatives for the design, materials of layers, vegetation, region-specific knowledge for how to select the materials and vegetation, maintenance in the long run etc.).

HOW DOES IT SUPPORT IMPLEMENTATION: Knowledge helps to avoid uncertainty.

HOW TO CREATE THE DRIVER: Effective knowledge sharing and sufficient follow-up monitoring of implemented NBS.

WHO COULD PUSH FORWARD: Research organizations, municipalities, companies, umbrella organizations in the field

- NBS: Green corridors

DRIVER: **Knowledge of increased flood risk due to heavy rainfall.**

HOW DOES IT SUPPORT IMPLEMENTATION: The will to prevent flood and insurance risk.

HOW TO CREATE THE DRIVER: Communication and awareness raising.

WHO COULD PUSH FORWARD: Municipalities and knowledge centres.

Examples of knowledge barriers that may hinder the adoption and implementation of NBS

- NBS: Street plants and trees

BARRIER: **Lack of knowledge of urban planners for how trees and plants can be successfully integrated in the urban landscape.**

HOW DOES IT HINDER THE NBS: Urban designers do not know what a tree needs to be healthy, including underground constructions.

HOW TO OVERCOME THE BARRIER: Create easy-to-use guidelines, and courses for architects and urban planners, including basic knowledge of trees, as well as what kinds of trees fit in different places → attractive, affordable courses with a recognizable certificate that is required for getting a job in climate friendly cities

WHO COULD PUSH FORWARD: Research/educational organizations, municipalities

- NBS: Green roofs or roof gardens

BARRIER: **Companies do not have knowledge of alternative NBS products to offer suitable solutions to meet different needs**

HOW DOES IT HINDER THE NBS: The best possible performance in local conditions is not reached.

HOW TO OVERCOME THE BARRIER: Well-informed companies offer suitable products for various needs and local contexts, both ready-made and customized solutions.

WHO COULD PUSH FORWARD: Umbrella organizations in, e.g. landscape contracting field offer courses for companies, including presentations of various alternative products and their performance and suitability for different situations (e.g. arranging excursions).

Knowledge drivers in case studies: ThinkNature Platform and Oppla - examples

Climate Proof Glasgow: Nature-based solutions as indicators towards a climate-just transition
https://oppla.eu/casestudy/19235

- The city lab collaborated closely across the 'academy-industry' divide. The city was instrumental in giving the researchers access to the relevant data. The city authorities enumerated the policy aims and the challenges facing decision makers in equitably implementing these policies. Researchers brought to the table prior knowledge on relevant ecosystem services, underpinned by literature-based evidence. This indicates that the research choices, while being made by researchers, are informed by policy makers and practitioners so as to be relevant for practical application
- As broad limitations to the used approach, data quality, as well as wider validity of assumptions underpinning the study and scalability were recognized.
- Improved data quality (especially in terms of extent, health and quality of the GI data) and more robust (i.e. evidence based) assumptions valid for the local context could increase the confidence in the approach.

Table 13. Summary of knowledge drivers and examples of possible actions at various regional levels. See Table 8 for the possible stakeholders and actors that could be responsible for initiating and/or taking responsibility of the actions at various levels.

Drivers/ actions	Local	National	EU	Global
Tackle the "Fear of the unknowns"	Support innovation, testing and experimental projects; Require communication plans for projects	Innovation policies targeting at NBS proliferation Emphasize communication of the benefits of NBS	Support innovating with NBS and knowledge-transfer of NBS; concrete projects	Offer platforms for effective knowledge-change for NBS
Comprehensive knowledge-production	Cross-sectional workshops for recognizing knowledge gaps and planning of projects; Help local companies of NBS field to continuously keep up with latest knowledge, e.g. of the benefits of NBS and applicability in local conditions	Support case studies with multi-disciplinary approach efficiently offering multi-purpose knowledge Offer basic knowledge for business sector of reliable knowledge-production and how to use it in marketing.	Support interaction with various EU-funded projects to recognize key knowledge gaps in NBS field, and interrelations of multipurpose knowledge-production; offer tools for business sector to understand fact-based marketing	
Produce user-friendly knowledge	Offer concrete instructions and guidelines for various NBS with	Companies are required to offer concrete and fact-	Require research projects to offer handouts of the results, targeted	

	detailed knowledge of materials, stages for implementation etc. Pay attention to the language used (e.g. that an architect understands the requirements for irrigation etc.)	based information of NBS products; Establish databases of real estates /buildings to help with renovation projects incl. NBS	separately for various key stakeholders; establish a web-page, database or corresponding tool to collect easy-to-use material of various projects from different fields (cross-sectorial communication)	
Ensure the quality of knowledge	Take local conditions into account when applying models and best practices from other climatic etc. conditions	Offer possibilities for the business sector to update the knowledge of NBS; Educational days for policy-makers around NBS-issues	Quality check for case studies of NBS offered via various channels, e.g. concerning the sustainability of NBS.	
Collaborative knowledge-transfer	Municipal environmental and urban planning sectors start together a web page to communicate best practices and positive experiences of NBS.	Collect and share international best practices to national actors in the NBS-field; Establish and ensure the efficient knowledge-transfer in networks of cities and regional actors	Develop protocols for quality check of, e.g. web-based information	Offer online participation in international conferences, webinars etc. web-based tools; arrange excursions
Ensure access to knowledge for various actors	Educate municipal authorities and decision-makers to harvest relevant information (navigation skills	Support open access publishing (e.g. requirements in national funding)	Establish/ offer resources for mentoring programs for various groups of stakeholders in NBS field.	Establish easy-to-use databases for research-based information, and ensure that existing databases are user-friendly

5.2.6 Process- and tradition-based drivers and barriers

In total, 14 out of 57 respondents indicated process- and tradition-based drivers that could support the realisation of NBS, and 15 respondents indicated process- and tradition-based barriers that could hinder the realisation of NBS. Eight respondents gave free-form answers concerning 11 NBS, regarding the process- and tradition-based barriers and drivers, giving the lowest number of free form answers per type of drivers and barriers. These results are presented and discussed below.

Recognize, appreciate, disseminate and discuss the multiple benefits of NBS

"Local administrations should be aware of NBS and request their presence in the plans."
[quote from the data]

Appreciating the benefits is essential for the adoption of NBS. It is not enough to be aware of the solutions and their benefits, but the benefits have to be also valued. Furthermore, as multifunctionality is an important aspect of NBS in urban areas, various benefits should be recognized and appreciated equally. For example, social and experiential benefits are important, not only technical and ecological.

Knowing about and appreciating NBS requires wide dissemination of knowledge and discussion at the societal level. The stakeholders responsible for producing and disseminating the knowledge should address a number of questions, concerning, e.g. the shared understanding of the importance of the various benefits, and how to measure the benefits, to be able to communicate them. For example, there could be a website where the benefits of NBS are shared, and instructions for implementing solutions in practice. All stakeholders should be able to get this information, and it should thus be widely spread.

Appreciation goes often hand in hand with monetary value. For example, aesthetic and recreational benefits are challenging to monetarize, but these benefits may have considerable effect on the health and well-being of urbanites, meaning savings in the healthcare budgets in the long run. Methods for calculating these kinds of benefits, often concerning cultural ecosystem services, should be further developed. Joint efforts from various stakeholders, e.g. research organizations and municipalities, are needed to agree the key knowledge gaps (note also the conceptual and terminological coherence, see Chapter 5.2.4).

There may be ideological resistance for new kinds of solutions that may effectively hinder NBS proliferation, or at least make processes much more laborious. For example, buildings

and parking places may be valued over street trees because they are considered more productive and economically beneficial than natural elements. Too small areas for street trees may lead to removing them, as the trees do not thrive in such conditions. Solid and persistent argumentation for NBS, e.g. among decision-makers is inevitable to overcome these kinds of barriers. Positive examples, successful case studies and other references of the performance of the solutions, showing that they really work, are needed, as well as concise enough information that is easily digestable, including monetarization of the benefits of NBS.

Evaluate traditions and routines to support NBS implementation

Conventional traditions and routines can hinder adopting and implementing NBS in many ways. Traditions are linked, e.g. with societal and organizational cultures and structures, as well as ideological issues and perceptions of citizens. Organizational traditions and routines should be modified so as to effectively transfer and process the information for implementing NBS. For example, there should be work time allocated in the continuous updating of knowledge among authorities, because new evidence of NBS is created in fast pace. As authorities may not have access to the scientific databases, and their ability to read and understand scientific publications may be limited, there should be real-time knowledge transfer between authorities and researchers, e.g. via joint projects.

The municipal planning systems and guidelines may be outdated, and not able to take NBS into account. A change of these systems and developing new guidelines and instructions for NBS are needed. One example of systemic issue is the equal access to NBS: how to guarantee the geographical diversification of NBS (Jurik et al. 2018), and access to NBS by vulnerable groups, such as the elderly and long-term hospital patients. Cross-administrative approach is needed to understand the various needs of different groups of urbanites, to guarantee equality in NBS supply and demand.

Construction field often relies on traditional solutions and routines and adopting new solutions may be challenging because of restricted views and lack of expertise. NBS may represent risky and expensive terra incognita that is avoided by constructors. An example of these challenges is given in Chapter 6.1.

Traditional understanding and perceptions of nature may be both drivers and barriers for adopting NBS, depending on the context. The perceptions of nature – what kind of nature is considered acceptable, aesthetically pleasing etc. – are intertwined with local traditions and cultural contexts. For example, NBS favouring biodiversity, ‘wild designs’, are

sustainable and can also be cost-efficient because of the low maintenance (see e.g. Sikorski et al. 2018 for low-maintenance green tram tracks). However, negative perceptions and preferences for wild nature in cities may cause resistance for NBS with biodiverse vegetation, as they are, e.g. seen as a signal of neglect (Riley et al. 2018). For example, in Finland, 'wild nature' is usually appreciated, and there is not a strong tradition to 'tame' the nature, e.g. in cities. Formal parks requiring high maintenance can usually be found in the centres of big cities, and otherwise the urban nature may be quite natural, thus creating positive attitude for NBS, e.g. meadows instead of highly manicured lawns in urban areas.

"People are afraid that these structures [Sustainable Urban Drainage Systems] *attract pests/gather trash."*

This is linked with the question of how natural environments and elements are 'socially constructed'. For example, a 'thicket' might be seen as untidy and 'ugly', but if the role of those kinds of environments for urban biodiversity is understood, the same natural element may be seen as useful and even beautiful. However, the change of attitude requires knowledge of the benefits of these natural elements. Kabisch et al. (2017) point out that "even though a number of urban planners are aware of the benefits urban green areas provide, as shown by the increasing number of green infrastructure strategies being developed, some policy makers and/or residents may not be as aware or might even have the perception that green installations on roofs and walls are harmful, e.g., 'dirty and host insects'". As shown in the Case study (chapter 6.1), risk assessment is also a routine task in the beginning of a construction process, possibly resulting in a situation where green roofs, initially considered as aesthetic elements that communicate environmental responsibility, turn to risks and avoidable elements as regards functionality of roof structures.

Then again, as, e.g. Finland is still rich in nature, it may be taken for granted, and there is no understanding that urban nature, or nature under intensive use may require special solutions. This may lead to lack of investment in NBS. Vice versa, degraded nature may be a strong driving force in cities. Especially when the state of environment is a threat to the health of urbanites, grass-root initiatives, when communicated widely, e.g. in social media, may push decision-makers to take actions.

Traditional habits and experiences may not only hinder, but occasionally also help overcoming bottlenecks to adopt NBS. For example, using forests routinely for recreation and for being in contact with nature, can have effect also on the ability to adopt novel NBS. If nature is seen 'scary', it may, again, hinder the use of NBS.

Sometimes it is beneficial to look for the traditional solutions of the past: some forgotten techniques, materials or organizational models could be functional to be used as, or with NBS. An example of awareness for the surrounding environment, and comprehensive thinking, is offered by the Venetian Republic, the survival, safeness and richness of which was based on the Lagoon where it lies. Since its early times (13rd century), the government carried out a strict control aimed to maintain the ecosystem, through a designated Office. This Office released, during the centuries (after various changes in names and competencies, finally closed in 2014) several rules for the conservation of the lagoon's health, such as the prohibition to plant poles in its waters (a proverb still exists in Venice: "palo fa paluo", i.e. "pole makes swamp") in order to avoid the creation of swamps in the low and closed waters. The laws covered all the aspects of the conservation of the environment of the lagoon, including its inlands.

Share and synchronize the expectations for NBS – know the nature, be realistic

"Clear targets help stay on focus."

For the NBS to be realized so that the expectations set to the solution are fulfilled, these expectations need to be uniform and shared already in the early phases of planning. As described in the case study (Chapter 6.1), it may happen that all kinds of aims, more or less realistic, are attached to the NBS, and if these are not shared, it may cause, in the worst case, a situation where nobody is happy with the outcome, nor knows how to maintain this NBS. It is also important to realize that NBS are often very different from the grey solutions. For example, vegetation is a living element that changes overs time, and cannot thus be totally 'tamed', to stay the same during seasons and years. This may mean that the performance of the NBS also changes over time. Thus, linking ecological knowledge in construction processes with NBS is inevitable (cf. Chapter 5.2.4).

The aims set to the performance of NBS should be realistic and reflected with the capacity of the chosen solution. For example, a sedum mat with a thin substrate on a green roof does not produce optimally all kinds of benefits from stormwater management to cooling, and from noise abatement to experiential benefits. Here, the availability of alternatives and variety of NBS-products is important, so that the best solutions to meet the requirements of local conditions and needs can be chosen.

Clear targets help to stay focused during the process. This is especially important with large and complicated projects, involving several stakeholders of various fields. Cross-professional discussion and networking, and information sharing among, e.g. construction

authority, planners, real-estate managers, landscape architects, material providers and researchers helps reaching a consensus about the targeted benefits of NBS. As regards construction projects, cross-sectional teams could be required already in the building permission by the municipal authorities.

Manage projects – customize processes – appreciate failures

Projects and their processes are different. As there is no one-size-fit-all NBS, there is no standard NBS project. For example, the size of the project affects the modes of action, stakeholders etc. Large projects require planning at a different level than small ones. Agile small projects can offer baby-steps for more large-scale experimenting. They are relatively cheaper to realize, and thus unsuccessfulness is not that detrimental than in large projects. Large projects often require cross-administrative efforts, but small ones can be realized with lighter bureaucracy and less effort from the authority administration. Small projects can also be more easily adjusted in the everyday environment of urbanites, and there is also a possibility for participatory experiments. For example, teachers can adopt nearby NBS as part of the everyday teaching, and like that help adopting and appreciating the NBS.

Too high aims for the successfulness of an NBS-project may lead to judging the project as ‘unsuccessful’, and thus possibly creating negative atmosphere. A project may be successful and unsuccessful in many ways, and sometimes just establishing a project is a success, no matter what kind of an outcome it might have. The time-frames for NBS to evolve and reach their optimal performance may be long. NBS are not ‘readymade’ in the same sense than grey infrastructure is. Ability to see far enough in the future is needed, to avoid blaming a project, or NBS, as failed too early.

The long time-frame of NBS-projects also means that new knowledge is produced while the NBS are developing over time, sometimes causing changes to the aims set for the projects, and adjustment of the solutions to make use of the new knowledge. Furthermore, NBS are based on living nature, and it may not always function as people might want. For example, a ‘green’ roof is not always green. If this is not realized, many projects and NBS may seem failed.

To achieve knowledge of the success of living elements, and to optimize the return of investment, long-term follow-up of NBS-projects should be guaranteed and resourced accordingly. In participatory projects with residents the challenge is that voluntary participation may change during the project, as people cannot be forced to join with the

same intensity during the whole project. Thus, new 'carrots' should be used, to keep the interest on.

Kabisch et al (2016) paid attention to stakeholder involvement in long-term projects, and the time-scale concerning the immediate and long-term concerns. In their study, disconnect between short-term actions and long-term goals was recognized as a barrier to the implementation and up-scaling of NBS as regards the life-span of NBS, e.g. how to address implementation and maintenance after the project and related funding end, and monitoring of the impacts NBS have in terms of human-environment relationships over time.

Accelerate adoption of innovation – avoid silo-thinking, support agility, creativity and visionary thinking

Quick adoption of innovation is a key to get new ideas realized. New action patterns and routines, and possibilities for organizational learning may be needed for creating a platform for effectively adopting and implementing NBS. This, again, is linked with the flexibility of administration and the overall attitude in an organization – is it able to create positive new traditions and make the new routines business-as-usual. For example, in Spain, Bilbao's history of successfully managing severe crises with commitment and creativity has been helpful also with NBS[26].

Often, overcoming silo-thinking and rigid hierarchies, is the key to the agility of an organization. This seems to be an issue that is discussed a lot, but answers and best practices are scarce. Working in silos was noticed also in the Urban GreenUp -project (Kuban et al. 2018) as one of the major types of organizational barriers that, e.g. hinder the adoption and effective implementation of renaturing urban plans, and vertical hierarchy was recognized to create rigid hierarchical relationships and poor communication. Silo-thinking may have effect on how well the multifunctionality of NBS is considered, e.g. due to the language and terminology used in different sectors (Kabisch et al. 2016, Kuban et al. 2018, see also Chapter 5.2.4 for terminology). Complex and inherently cross-sectional nature of NBS implementation challenges the traditional ways of, e.g. organizing municipal activities that, do not optimally support the efficient operations but limit the tray of choices for actions (cf. path dependency theory).

[26] https://oppla.eu/bilbao-nbs-dealing-extreme-temperature-and-rainfall-events

In NBS-projects with several stakeholders, win-win-situations can be achieved, and different 'carrots' be offered for various stakeholders: references, visibility and research data for companies, knowledge and new partnerships for authorities, new funding and publication possibilities for universities, etc. New innovation partnerships can be created and supported by research organizations, municipalities, companies, umbrella organizations, and the policies at national level that encourage innovation and cooperation in innovating. A new culture for innovations is needed, and failures should not be stigmatized: one can learn from failures and do better in the future.

Raising new generations of actors (e.g. urban planners) with up-to-date education of the environmental challenges we face today, and fresh ideas for how to solve them, pave the path for the acceptability and broad use of NBS. For example, in Finland there has been a change in this sense: when the generation of engineers and planners educated to use grey infrastructure has mostly retired, there is a new generation that is educated to understand global and local environmental challenges, and these people are much more open to NBS than the older experts in the field. NBS are considered as good motivators to design more sustainable alternatives, as they offer solutions to wicked problems, such as climate change and biodiversity loss.

It is also important to recognize emergent actors: totally new fields of expertise may be needed to solve problems, and develop new techniques etc. Thus, also educational organizations should be sensitive to the societal change and be ready to quickly react to various educational needs. Mentoring programs can be useful for educating experts, as it allows for learning from peers and reflecting the knowledge with everyday work and, e.g. recognizing organizational restrictions.

Enthusiasm, creativity, open-mindedness, courage and solution-oriented atmosphere are required to adopt new solutions, start innovative projects, and to override the bottlenecks of implementation. Front-runner stakeholders can see opportunities in unlikely combinations of fields and actors. For example, companies may get interested in integrating biodiversity in their business models during a cross-sectional pilot project for new NBS and transfer this enthusiasm to peers.

Brave, visionary people – a group of early adopters - are a valuable resource for getting NBS projects going, and also spreading knowledge. They may have a considerable effect on, e.g. changing the traditions of the construction field. It is necessary that these trailblazers are supported, not anticipated for trying to push novel kind of thinking. A crucial question is how to get more enthusiastic people in NBS field, make key actors inspired by

new solutions, especially in fields with slowly-changing, traditional thinking and use of solutions like construction field.

Municipal authorities can have a significant role in proliferating NBS in many ways: push cross-sectional communication, be open to new initiatives and help various stakeholders (e.g. NGOs) to realize pilot-projects, help building capacity, adjust or create city strategies to support use of NBS, include NBS in building permissions and city plans (cf. policy drivers and barriers), and communicate the multifunctionality of NBS, e.g. how biodiversity can contribute to the wellbeing of citizens, as well as participate in national and international city networks to exchange knowledge etc. Regional authorities may serve as hubs to connect cities and offer information of NBS to be adopted by municipal actors.

Think big – think wide – think future

For overcoming process- and tradition-based barriers, major shift in the societal foci is needed at various levels and among different sectors. For example, societal well-resourced and far-reaching development projects with wide enough targets are efficient to get the actors at various levels, from national to local, to establish concrete actions for implementing NBS. This does not concern only the environmental or urban planning sectors, but the possibilities of NBS should be considered as part of many different societal sectors, such as education- and social- and welfare sectors, financial organizations etc. Continuous involvement of various stakeholders is important, not only occasionally taking part in single projects that come and go.

Looking far enough in the future is important: what kinds of systems, solutions, expertise etc. are needed, e.g. in 20-30 years. The methods of futures studies should be used among the researchers and practitioners in the NBS-field. Various scenarios are needed, to be able to respond to the rapidly changing challenges of the contemporary world.

Examples of process- and tradition-based drivers that could help implementing NBS

- NBS: Urban/ peri-urban forests or woodlands

DRIVER: **Creation of new action patterns, routines and experiences in a pilot project**

HOW DOES IT SUPPORT IMPLEMENTATION: New models become business-as-usual, positive traditions are created

HOW TO CREATE THE DRIVER: Support the capacity to produce innovations

WHO COULD PUSH FORWARD: Emerging actors, e.g. in NGOs

Examples of process- and tradition-based barriers that may hinder the adoption and implementation of NBS

- NBS: Parks [project for retrofitting asphalt school yards with NBS, and at the same time offer learning environment to support teaching]

BARRIER: **Silo-thinking and lack of cooperation and coordination among professionals.**

HOW DOES IT HINDER THE NBS: In the field of environmental education, there are good ideas and models for linking natural environment in teaching, but the places for realizing these in practice are lacking. The school yards are often covered with asphalt, and the benefits of NBS are not considered when constructing the yards.

HOW TO OVERCOME THE BARRIER: In national educational curricula, the possibilities of school yards should be considered as part of teaching and implemented in the everyday practices of schools. Educational decision-makers and authorities should discuss with environmental/construction/landscape contracting stakeholders: the whole chain and actors from decision-making to the construction-level activities and cooperation should be re-considered to include NBS.

WHO COULD PUSH FORWARD: Ministry of Education, educational professionals, umbrella organizations for environmental education, local stakeholders in the field, incl. education, urban planning and design, construction etc.

Process- and tradition-based drivers in case studies: ThinkNature Platform and Oppla - examples

Bilbao - NBS for dealing with extreme temperature and rainfall events
https://oppla.eu/bilbao-nbs-dealing-extreme-temperature-and-rainfall-events

- EU projects raised awareness in local authorities about the importance of networking and co-creation.
- Multiple benefits of NBS are appreciated by the local authorities.
- Connection to local policies: Bilbao's upcoming Master Plan strongly promotes NBS as a means to achieve the city's four main objectives.
- Positive societal atmosphere and tradition: Bilbao's history of successfully managing severe crises with commitment and creativity has helped it to adopt innovative measures.

Basel, Switzerland: Green roofs: Combining mitigation and adaptation on measures
https://oppla.eu/casestudy/18381

- It is important to involve all stakeholders from the beginning of the initiative to address questions and concerns and ensure that everyone's goals are being met.

Cloudburst Management Plan, Copenhagen
https://oppla.eu/casestudy/18017

- interdisciplinary approaches, moving away from isolated thinking. A common vision aligned engineers, hydraulic experts, GIS and information technologists, architects, planners, biologists, economists, communication specialists, and landscape architects with local citizens, investors and politicians.

Table 14. Summary of process- and tradition-based drivers and examples of possible actions at various regional levels. See Table 8 for the possible stakeholders and actors that could be responsible for initiating and/or taking responsibility of the actions at various levels.

Drivers/ actions	Local	National	EU	Global
Recognition of the benefits of NBS	Use and support participatory projects and citizen science; Popularize science via mass and social media.	Develop further education for urban planners (landscape) architects etc. experts in the field.	Produce and disseminate knowledge; Raise general environmental awareness and appreciation of nature.	Arrange conferences for companies in NBS-field; Share remarkable NBS-projects in social media.
Appreciation of the various benefits of NBS.	Emphasize the multifunctionality of NBS in urban planning; Support co-creation of knowledge; common language; Assess values in decision-making for	Include NBS as part of various societal programs (e.g. developing health-care environments for the elderly); Support inter-and transdisciplinary research for comprehensive	Include benefits of NBS in core policy instruments for sustainable urban development; Develop tools to measure the benefits of NBS (also intangible like aesthetic experiences).	Include benefits of NBS in the communication of international environmental umbrella organizations.

	overcoming ideological barriers.	understanding of NBS.		
Re-evaluation of organizational traditions and routines	Allocate work time in the continuous updating of knowledge among authorities; real-time knowledge-transfer between authorities and researchers (e.g. joint projects)	Adjust construction processes to take natural elements into account; include ecological knowledge in the projects	Include assessment of decision-making and governance systems in the funding applications: how do the systems support adoption and implementation of NBS (municipalities, companies)	
Shared expectations and realistic aims for the performance of NBS	In NBS-projects, discuss the aims explicitly with all stakeholders - reach consensus of the desired outcome.	Fact-based marketing of the performance/ benefits of NBS; variety of products/ alternatives to meet various needs	Set standards for various functionalities of NBS-products.	Develop classifications of various NBS-products to support creation of standards
Clear targets in multi-actor NBS-projects	Cross-sectorial and cross-professional discussion and networking; require cross-sectional teams in building permission for NBS-projects			
Promote understanding of the features of nature among construction professionals	Guarantee resources for multi-actor pilot projects to ensure long-term monitoring and knowledge-transfer of the performance of NBS	Require expertise to implement NBS in a construction process (e.g. ecological/ biological knowledge)		
Adjust actions according to the size of an NBS project	Establish small, agile grass-root projects to experiment participatory methods	Offer alternative products and guidelines for large and small projects.	Ensure cross-administrative involvement in large projects; be flexible and support small NGO projects	

Accelerate adoption of innovation	Develop flexible and agile governance and decision-making; overcome silo-thinking and rigid hierarchies	New routines for including NBS in construction.		
Support visionary people and early adopters	Encourage out-of-box thinking and networking. Support for municipal authorities as change-makers	Develop mentoring programs; Make key actors inspired by NBS	Offer platforms for visionary thinking and ambitious projects for brave people.	
Enhance positive and open atmosphere, new culture of innovation	Create win-win-projects with 'carrots' to all stakeholders; allow and learn also from failures	Offer possibilities for experimental projects with researchers;		
Raise environmental awareness and new generation of actors	Offer support for local NGOs in environmental field, e.g. for campaigns	Set ambitious aims for the education of urban planners and architects; recognize emergent actors and forecast expertise needed in the future		
Utilize traditional culture and habits	Foster contact with nature by biodiverse solutions			

References

Balian E. et al. (2016). Social innovation and nature-based solutions. EKLIPSE/EPBRS/BiodivERsA. Joint Foresight Workshop: Brussels, 6-7 December 2016. Workshop Report. http://www.eklipse-mechanism.eu/apps/Eklipse_data/website/EKLIPSE_WP4-WebReport_June2017.pdf

Davis M. & Naumann S. (2017) 'Making the case for sustainable urban drainage systems as a nature based solution to urban flooding'. In Kabisch, Korn, Stadler and Bonn (Eds.) Nature-based Solutions to Climate Change Adaptation in Urban Areas: Linkage between science, policy and practice, Cham, Switzerland: Springer Nature, p. 135.

Depietri, Y. & McPhearson, T. (2017). Integrating the Grey, Green, and Blue in Cities: Nature-Based Solutions for Climate Change Adaptation and Risk Reduction. In Kabisch, Korn, Stadler and Bonn (Eds.) Nature-based Solutions to Climate Change Adaptation in Urban Areas: Linkage between science, policy and practice, Cham, Switzerland: Springer Nature, pp. 91–110.

Fletcher, T.D. et al. (2015). SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage, Urban Water Journal, 12:7, 525-542. DOI:10.1080/1573062X.2014.916314

Fors H. & Nielsen, AB (2016). Sletten (DK) – offering residents spaces for activities between the garden and the woods. Scape' Dossier The international magazine for landscape architecture urbanism 2016:114-115.

Fors H. et al. (2018). The Impact of Resident Participation on Urban Woodland Quality—A Case Study of Sletten, Denmark. Forests 2018, 9, 670; doi:10.3390/f9110670

The International Union for Conservation of Nature, (2012) IUCN Business Engagement Strategy, IUCN. p 5.

Jurik, J. et al. (2018). Report on Dialogue Steering Statement Papers and Dialogue Outcomes for Sustainable Urbanisation in Cities. Deliverable 4.1, ThinkNature project.

Kabisch, N. et al. (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 21(2):39. http://dx.doi.org/10.5751/ES-08373-210239

Kallio P., Lehvävirta S., Mesimäki M. (2014). The multifunctionality of green roofs and the Finnish Land Use and Building Act. Finnish environmental law review 2/2014:98–138. (Available only in Finnish, English abstract).

Kuban, B. et al. 2018). Barriers and Boundaries Identification. Urban GreenUp D1.5 Report. Available at the project site: http://www.urbangreenup.eu/insights/

Nature4Cities (2018). D1.1 – NBS multi-scalar and multi-thematic typology and associated database1/76. https://docs.wixstatic.com/ugd/55d29d_edfeaac106ef412482402cefe76b5159.pdf

Ovando, P. & Brouwer, R. (2019). Review of economic approaches modeling the complex interactions between forest management and watershed services. Forest Policy and Economics 100, 164-176. https://doi.org/10.1016/j.forpol.2018.12.007

Pauleit, S. et al. (2017). Nature-Based Solutions and Climate Change – Four Shades of Green. In: Kabisch, Korn, Stadler and Bonn (Eds.) Nature-based Solutions to Climate Change Adaptation in Urban Areas: Linkage between science, policy and practice, Cham, Switzerland: Springer Nature, pp. 29-48.

Prudencio, L. & Null S.E. (2018). Stormwater management and ecosystem services: a review. Environmental Research Letters 13(3). http://iopscience.iop.org/article/10.1088/1748-9326/aaa81a/meta

Riley et al. (2018). Asset or Liability? Ecological and Sociological Tradeoffs of Urban Spontaneous Vegetation on Vacant Land in Shrinking Cities. Sustainability 10(7), 2139. https://doi.org/10.3390/su10072139

Sikorski et al. (2018). Low-maintenance green tram tracks as a socially acceptable solution to greening a city. Urban Forestry and Urban Greening 35, 148-164. https://doi.org/10.1016/j.ufug.2018.08.017

Suvantola, L. & Lankinen, A. (2008). Jätteen synnyn ehkäisyn uudet ohjauskeinot. [New policy instruments for preventing the generation of waste]. Report of the Ministry of Environment 24:2008, Helsinki, Finland. https://helda.helsinki.fi/handle/10138/41458?show=full

Szkordilisz et al. (2018). How to use nature-based solutions in urban planning systems of Europe? ICUC10 - 10th International Conference on Urban Climate, 6-10 August 2018, New York, NY, USA. https://docs.wixstatic.com/ugd/55d29d_8e9a6e5b391e4d8491d9066eb017a08e.pdf

5.3 Conclusions

The power of policy and best practices

Based on the qualitative and quantitative results, the importance of policy issues is fundamental in the driver-barrier landscape. However, the full driver-barrier landscape of NBS is multifaceted and fine-grained. There is no one single barrier, sector or group of actors that would mainly be responsible for hampering NBS adoption and implementation, or a magic wand to remove the barriers. The continuum of barriers covers issues from personal experiences and attitudes to those at a wide societal level. Broad generalizations with uniform decision-making hierarchies are not easy to create, as the drivers and barriers are both locally constructed and simultaneously dependent on wider systems, e.g. EU policies.

Thus, the important message from the survey is that barriers and drivers for NBS are context- and case-specific. It is essential to understand the complex interrelations and multiplicative effects of various barriers and ways to overcome those. As various environmental, social, economic and cultural issues are intertwined, and require attention from different fields of sectors and actors at the same time, one important step for overcoming barriers is to recognize the local conditions and needs and adapt the actions accordingly (see Annex 4). For example, if regulation is very rigid, it may prevent the adoption of new NBS, but also lack of clear, locally adapted regulation and guidelines may lead to an unwanted situation with uniform and poorly fitting NBS. Thus, there is no one-size-fit-all solution to remove barriers for NBS, but the actions should be discussed and defined in a collaborative and communicative manner.

Based on our results we suggest that immediate effort should be put on policy development at all levels in the society, and all sectors, from health and well-being targets to market incentives, and from waste regulation to innovation and co-design policies, to name a few. Technical innovation with LCA or other sustainability evaluation tools should be supported, as well as knowledge creation through pilot projects and academic/applied research.

The NBS market sector would likely profit from creating solutions that are cheaper than the grey infrastructure. Here, silo budgeting e.g. in municipalities may prevent the recognition of the total overall savings created by an NBS vs. sectoral grey infra solutions. Therefore, monetizing the benefits gained by NBS would be helpful. Policy making is in a key position towards the market sector in creating trust so that the market-sector will invest in R&D – decision-making systems can be forced to create demand for the NBS market. Furthermore,

and beyond policy issues, the structuration of a full NBS industrial value chain is a necessary condition, in the long term, to guarantee the sustainability of the sector and availability of cost-effective NBS for all. This structuration is still ongoing and will take more or less time depending, among others, on the creation of a favourable market context, leveraging knowledge and acceptance, but also on policy incentives and R&D subsidies available for SMEs, which are at the heart of any emerging industrial sector in the EU.

One way the EU could boost policy creation, knowledge and communication would be to provide a database of policy instruments related to NBS from different countries and contexts at various levels and offer guidelines to help applying the instruments in local contexts ('cook book'). This database would offer models for policy-instruments and policy-making mechanisms for various NBS and scales, e.g. from neighbourhood-level involving housing cooperatives, to city-district-level involving local citizen associations, and further to the level of the whole city involving relevant sectors, such as urban planning, construction, and finally to the actions needed for larger scale, e.g. city networks and regional cooperation[27].

"Think globally, act locally" offers the framework for overcoming barriers, and pushing drivers to enable NBS: the explicit aim should be to tackle the wicked problems of our time, such as climate change, biodiversity crisis, and consequences of urbanization, and thus be included as an overarching aim in the decision-making at all levels, even though the actions inherently require attention at the very local level.

The survey showed the importance of various concrete examples for the proliferation of NBS. Case studies and best practices have been collected by numerous projects locally, nationally and internationally, and can be found in reports, databases, websites, handbooks, educational materials and other sources. We suggest attention to be paid on the meta-analyses of different cases and examples, from various perspectives. Case studies could be analysed, and best practices offered for meeting various needs, concerning e.g. above-

[27] In this line some initiatives are already ongoing. For instance, as a part of the Nature4Cities project, one-entry point platform will guide any stakeholder related to NBS, to dedicated databases of solutions, ranging from typology, implementation models (governance and practical frameworks to NBS) and an ever-growing observatory of successful NBS interventions worldwide. See https://www.nature4cities.eu/

mentioned policy issues, various technical solutions, performance assessment methods, communication tools and channels, as well as how to adapt traditions and processes to streamline NBS implementation, what kind of stakeholder collaboration and administrative models could help overcoming silo-thinking etc. Modern technology could be used in large scale to support sustainable knowledge-creation, e.g. virtual excursions on various NBS-sites and simple and easy interactive on-line participation in seminars and conferences.

The power of motivation and trust

Removing barriers is linked with, e.g. the local political system, traditions of policy-making and urban planning, level of knowledge, and overall societal values and attitudes. For example, in Scandinavian countries, with long traditions of democracy, equality and, e.g. appreciation of nature, combined with high-level education and well-trained professionals, adoption of NBS is relatively easy, and municipalities are open for experimental projects.

Indeed, the conditions for a major market uptake of NBS might already be within reach. In an NBS conference held in Budapest, an expert in marketing, addressing the market landscape and future for NBS, stated confidently to the audience:

> You have everything needed to win… you are not selling anything strange or disruptive, or a complicated new technology: you are selling trees, plants, water ponds, green spaces and fresh air… Who will not want to have more of those in the neighborhood?[28]

At systemic level, innovating with NBS should be based on co-creation of motivation and trust (Fig. 10). This is a continuous process of wide co-production of knowledge and -sharing, cross-sectorial support, solidarity and communication. Societal atmosphere including trust to the decision-making system and low corruption, is a prerequisite to, e.g. successfully apply policy instruments.

Finally, we emphasize a proactive and future-oriented attitude to recognize challenges and develop functional solutions. Far-reaching scenarios are needed for creating a positive future, e.g. steering decision-making and long-term strategies. An important aim for national- and EU-level policies is to build trust for the societies and market to invest in pilot

[28] "Keynote introduction to markets, trends in green infrastructure" by Manfred Peritsch, IMG Innovation-Management-Group GmbH, on 29/11/2017 at EUGIC 2017, Budapest, 29/30 November 2017. The quote is not literal but written down from the speech.

projects, product development and education, and to foster the role of NBS in urban planning and construction.

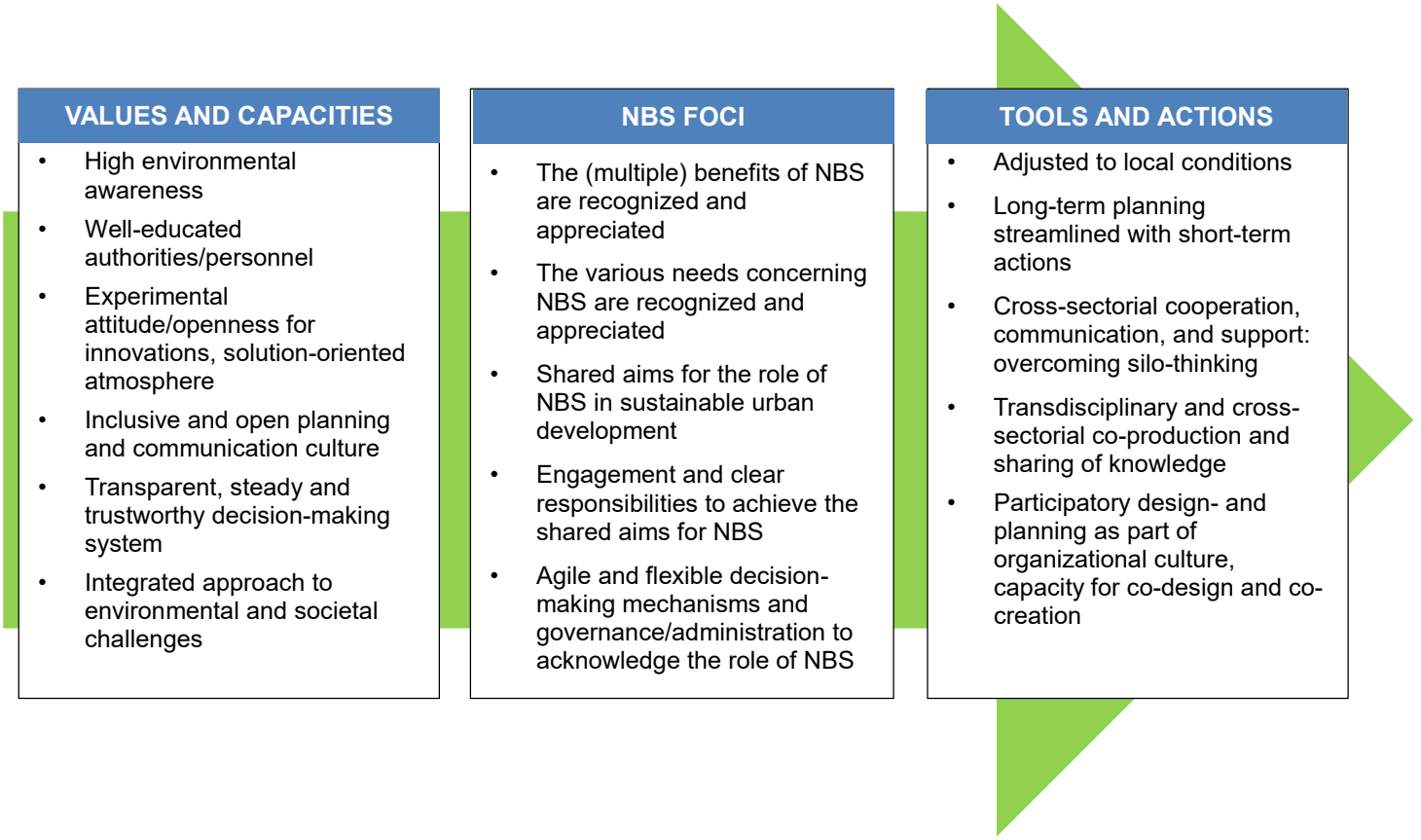


Figure 10. Elements for the creation of co-motivation and trust-building for successful NBS-adoption and implementation at various organizational and societal levels, e.g. municipal, company, and nationwide decision-making.

SUGGESTIONS FOR STEPS TO OVERCOME BARRIERS AND PUSH DRIVERS TO ADOPT AND IMPLEMENT NBS

- Support recognition, appreciation and communication of the multiple benefits of NBS by decision-makers and authorities.
- Develop policies at all levels from municipal strategies, guidelines and funding to national standards and regulation and to EU-wide targets and financing.
- Invest courageously in multi-actor pilot designs and construction projects with NBS.
- Provide incentives to make NBS affordable where they are not yet (the return of investment for private investor may not be sufficient while the societal benefits are obvious).
- Finance transdisciplinary and cross-sectional knowledge-production of the benefits and performance of NBS.
- Establish projects with guaranteed resources for long-term development and monitoring, communication of results and collaboration with stakeholders.
- Conduct comparative cost-benefits assessments based on life cycle analysis and experiences from real cases between NBS and mainstream grey solutions for the same challenge faced.
- Innovate and test sustainable materials based on circular economy, including an analysis of the ecological-environmental impact of the new materials.
- Ensure efficient knowledge-transfer and easy access to reliable knowledge.
- Offer practical, detailed and locally adapted knowledge and education for NBS.
- Evaluate routines, planning processes and organisational traditions, and change where needed in order to support NBS.
- Learn from failures: improve processes from the idea to planning, construction and maintenance.
- Accelerate adoption of innovation
  – avoid silo-thinking, support agility, creativity and visionary thinking

THINK NATURE – THINK FUTURE!

6. Exemplary case-studies

The three case studies illustrate the various barriers and drivers in NBS projects at the local level.

The first case study of two green roof projects shows the whole process of implementation from planning and design to construction and maintenance, and the various challenges and opportunities during the process. The study concretizes many of the various barriers that are discussed on the basis of the survey above, revealing, e.g. the consequences of the lack of knowledge and cross-professional cooperation, the challenges for reaching the goals due to the various aims and expectations set to the solutions, and the problems of fitting NBS in the traditional routines of construction field. It shows the context-specific nature of barriers and drivers, e.g. how financial feasibility is connected with the local situation, as well as reveals, e.g. the role of various actors and power relations during the processes.

The second case study illustrates learnings from the West of England region in the United Kingdom in implementing NBS projects. Key challenges faced in implementation include financing, as there are no specific funding streams for such schemes (as this is an emerging area), and ongoing maintenance. A key driver is the recognition that well-designed NBS schemes can provide multi-functional benefits across varying ecological, hydrological, economic, landscaping, planning, health and wellbeing needs, that can prove more cost-effective and longer-lasting than traditional schemes. These examples emphasise the importance of both effective community engagement and partnership working in the ongoing success of NBS schemes.

The third case-study refers to a number of examples where rivers or waterways crossing urban areas have been given new life. In many towns and cities rivers or canals had been covered because of poor water quality (open sewers). ‘Daylighting’ or ‘de-culverting’ is now an option because water quality has been improved. Restoring and enhancing the natural features of those waters has multiple benefits. This type of NBS enhances quality of life in the city, provides protection against flooding and stimulates biodiversity. Typical benefits and barriers are listed.

6.1 Case study I

Premises of realizing novel green infrastructure in construction processes – case green roofs.[29]

Abstract

Nature-based solutions to environmental challenges, such as climate change, are considered increasingly important in urban areas. Various modes of green infrastructure are seen as a means to offer ecosystem services and protect biodiversity. Vegetated roofs represent a modern way to green the urban environment and offer several benefits, including the management of storm waters and improving amenity values. The aim of this study is to explore how green roofs are adopted and realized in large construction processes in Finland, and what kinds of constraints or facilitating agents there are in the process. Our study reveals that integrating vegetation to building structures challenges the conventions and traditional roles of the construction field. The successful realization of such solutions requires integrative know-how and comprehensive planning and co-design with all key players involved from the beginning to the end.

1. Introduction

1.1 Green roofs in urban planning and construction – why?

One of the key roles of urban planning is to develop cities into an ecologically sustainable direction, while also maintaining them as high-quality places to live. Combating and adapting to climate change will contribute to urban planning and to the exploitation and development of various solutions, such as new green infrastructure. In addition to traditional green areas, the benefits of urban nature can be achieved by using vegetation covers as part of buildings.

---

[29] Mesimäki Marja & Nieminen Hanna and Lehvävirta Susanna 2015. Premises of realizing novel green infrastructure in construction processes – case green roofs. Originally published in The Finnish Journal of Urban Studies, Finnish Society of Urban Planning. Nieminen and Mesimäki are the corresponding authors of this paper. The paper is based on a study carried out in the research programme Fifth Dimension – Green Roofs and Walls in Urban Areas. The study and the related master's thesis of Nieminen were funded by Helsinki-Uusimaa Regional Council, Helsinki Metropolitan Region Urban Research Program, Maiju and Yrjö Rikala garden foundation, Olvi-foundation and KIINKO foundation of real estate field in Finland. The article was translated from Finnish to English and re-published in this Report with the permission of the original journal.

Various natural elements form together the green infrastructure of a city. It is, according to the report Finnish Environment Institute SYKE (2013, 16-17), following the definition by the EU Commission, “A strategically designed network including both natural and man-made green spaces, vegetated areas of private gardens, small water systems and water areas and other physical natural elements [–]”. From the point of view of green infrastructure, urban planning, strategic development, construction and management are viewed as an activity aimed at actively safeguarding the diverse benefits of nature, i.e. ecosystem services (e.g. Colding 2011; Tzoulas et al. 2007). Ecosystem services refer to the 'tangible and intangible benefits that a person derives from the structure and functioning of ecosystems' (Finnish Environment Institute 2013, 18–19).

Understanding nature as infrastructure highlights the deliberate construction of new types of green solutions alongside the preservation of existing natural values and ecosystem services (Benedict & McMahon 2012). Systems containing various natural elements, typically vegetation and water elements, can be designed to meet a variety of purposes (Ahern et al. 2014; Montalto et al. 2013), such as cooling the urban structure or providing recreation to residents. Modern green roofs are multifunctional green structures (The Multifunctionality of Green Infrastructure 2012) that can be used to create entirely new vegetation areas while utilizing the roofs of buildings.

A green roof is a roof of a building which has been installed over the roof structure (including a waterproofing layer), and consisting of plants, the substrate they require and other necessary structural layers, such as root barrier (Veuro et al. 2012). In Finland the commonly used term is green roof. Internationally, other terms are in use, for example vegetated roof and living roof (Dunnett & Kingsbury 2008, 8-9) or ecoroof, common in the United States (Ngan 2004). In this paper, by green roof we mean all purposefully vegetated roof surfaces.

The use of vegetation on the surfaces of buildings as architectural elements, in gardens or living areas is not a particularly new phenomenon (Oberndorfer et al. 2007). However, modern green roofs have been included in the selection of means of urban planning in a more purposeful manner in different parts of the world (Dunnett & Kingsbury 2008; Ngan 2004), which also means that various regulatory and non-regulatory policy instruments are aimed at their construction. This is because green roofs are known to produce many benefits. Green roofs, for example, retain and delay rainwater and can thus prevent urban floods (e.g. Mentens et al. 2006). They can mitigate noise and bind dust and other air pollutants (Oberndorfer et al. 2007), extend the cycle of repair of roof structures beneath

them (Getter & Rowe 2006; Liu & Baskaran 2003), cool buildings and the entire urban structure, thus relieving the so-called urban heat island effect that is feared to have adverse health effects also in Finland (e.g. Suomi 2014; Castleton et al. 2010; Näyhä 2007). Green roofs provide an opportunity to create habitats that enhance and maintain the diversity of urban nature (Gabrych et al. 2016, Páll-Gergely et al. 2014, Madre et al. 2014, Brenneisen 2006). Green roof features, such as substrate and plant species, as well as local conditions, affect the efficiency of producing the above-mentioned benefits (e.g., Ouldboukithine et al. 2014 and 2012, Alexandri & Jones 2008).

The uncontrolled flooding caused by stormwaters in a densely built urban environment and preparedness for climate change require measures in Finnish conditions (Hulevesiopas 2012). This has raised green roofs to the discussion as part of the toolkit for holistic stormwater management (Laurila et al. 2014). However, green roofs have not yet been included in the range of methods in the urban design and construction; they are sometimes even considered to be mostly experimental construction (Kallio et al. 2014; Laurila et al. 2014). However, the potential of green roofs has been identified and examples of the development and use of various policy instruments already exist. In May 2013, the City of Helsinki decided to develop a green roof strategy (City of Helsinki 2013). In Vantaa, a goal for land use planning is that roof vegetation is used in all new urban structures, in urban intensification and in all areas where there is little vegetated area and permeable surface (City of Vantaa 2014).

1.2 From general conditions for activities to local interpretations

It is a long way from the level of strategies and experiments to established practices (e.g. Ahern et al. 2014). Introducing new ideas into building practices is not straightforward, as the construction industry is not very agile and responsive (eg Blayse & Manley 2004). Heikura and Lindman (2011), who studied the innovation potential of the built environment in Finland, argue that new solutions in the construction sector are largely based on old solutions, whereby technologies, techniques and construction methods change slowly. The industry follows customary practices, and new or complex issues are often treated with caution (ibid.).

Barriers to the realization of green roofs that have previously been noted, include, among others, higher costs and worries about financial risks (e.g. Nurmi et al. 2013; Williams et al. 2010; Ngan 2004); difference of green roofs from accustomed roof alternatives and lack of

knowledge, as well as suspicions and misconceptions about the technical functionality of green roofs (Fernandez-Cañero et al. 2013; White & Gatersleben 2011; Hendricks & Calkins 2006). The benefits of green roofs may seem unclear or not appreciated (Jungels et al. 2013; Kuper 2009). In addition, the benefits are often public, but the costs fall on a private entity (Nurmi et al. 2013). Efforts have been made to promote the construction of green roofs internationally, at local, regional and national level, but the effectiveness of the policy instruments depends on local circumstances, and the access to project-specific material has been limited (Carter & Fowler 2008).

If the aim is to promote novel green structures integrated into buildings as part of urban structure, for example by various policy instruments, it is necessary to identify the challenges and possibilities connected with adopting them. Research on practical experiences - such as various (pilot) projects - is considered important for the development of new forms of green construction (Pauleit et al. 2011, 284).

Construction projects are characterized by the unique nature of the processes: the construction site, the actors involved, and the specific requirements of the project are case-specific (Malvalehto et al. 2011, 60; Blayse & Manley 2004), which may also allow new openings (Koskela 2000). Building innovations are often multidimensional (Slaughter 1998; see also Heikura and Lindman 2011) and involve a wide range of actors (Blayse & Manley 2004). The realization of new ideas can be greatly facilitated by their variability and flexibility. In this case, attention must be paid to processes where targets and objectives are set for new solutions, such as technologies, and where they are introduced and used. (Harty 2010.) Case examples, such as green roofs, allow us to see how ideas are implemented in practice, how they are applied in the design and construction process, what kind of uncertainties they involve, and what kind of process development it may require for them to become more common. The dynamic nature of the vegetation in the strictly technical and scheduled design environment adds an interesting tension - after installation, a green roof is not immediately in its final form, but changes throughout its existence.

The aim of this study is to understand the realization of green roofs in construction projects involving multiple actors in Finland. The focus is on factors that influence the realization of green roofs at different stages of the process. Our study is a case study which 1) describes how green roofs have been realized in two different construction projects and 2) examines the conditions of green roofs as part of construction processes. The case study enables us to map the meanings of green roofs and the relationships between actors, as well as their variability and dynamics.

1.3 Cases and tools for analysis

The aim of the case selection was to obtain two large enough construction projects involving a sufficiently large number of actors, different from each other based on location, time of construction, purpose of the building and the installation method of the green roof, which we assumed to bring out various types and levels of conditions for green roof realization. Based on the initial mapping, we chose a public and a private construction project from ten possible sites, because we assumed they represented a wide range of actors involved in the realization of green roofs. Our cases are the construction projects of the catering and maintenance building (Picture 1) of the Koukkuniemi Home for the Elderly located by the lake Näsijärvi in Lapinniemi, Tampere, and the Derby Business Park in Espoo (Picture 2).

Completed in 2008, Koukkuniemi catering and maintenance building is a new building constructed and owned by the municipally owned company Tampereen Tilakeskus (center for real estates of the city). It has been implemented as a public procurement and as part of the first phase of the region's improvement and development plans. The Koukkuniemi Home for the Elderly is an important site from the perspective of both architecture, culture and the townscape, with a high degree of originality. The urban area development plan/town plan requires that the defining characteristics of the townscape are not altered. (Tampereen Tilakeskus 2012.) The green roof at Koukkuniemi was produced on site as a seeded meadow roof.

Derby Business Park, on the other hand, is a private enterprise of a cluster of three office buildings and their immediate environments for various client companies, constructed during the years 2011-2013 in Perkkaa, Espoo. The building project achieved the highest Platinum grading level for the LEED environmental certificate in the building frame category. There are three separate green roofs in Derby where ready-made sedum mats were used.

Picture 1. Aerial photo of the Koukkuniemi area. The catering building is ringed. Lentokuva Vallas Oy/Hannu Vallas

Picture 2. A rendering of Derby Business Park. SRV Rakennus Oy.

The material of the study consists of semi-structured theme interviews (N = 10) of the most central actors of the realization of green roofs in construction projects and e-mail interviews where specifying questions were asked (N = 7), as well as documents concerning the construction projects, such as construction (method) reports, project and realization plans, construction drawings and work drawings. In addition to the initial survey, the interviewees were identified with the help of so-called snowball method: new key actors emerged in interviews. These actors can thus be considered experts who witness the green roof

realization process (see Alastalo & Åkerman 2010, 373–374). By interviewing them, we aim at learning, in addition to identifying the processes, their interpretations of the events and the phenomenon under examination, that is, the realization of novel green infrastructure in the construction processes. Research literature provides a background to and supplements the material collected through interviews.

The processing of the material is based on a theory-driven content analysis, in which theory and previous knowledge help to make the analysis (see Tuomi & Sarajärvi 2009). We first made detailed process-oriented and thematic descriptions of the cases, and then we compared and interpreted the cases side by side. This enabled us to consider both common and specific features, which we then used to analyze the conditions for realization of green roofs in these cases.

In reviewing the factors that influence the enabling and realization of green roofs, we use the concept of 'operating space' introduced by Taru Peltola (2007) for examining choice of options for energy solutions. The concept represents the choice and action possibilities, a space for operation, formed in case-specific interactions, and conditions that define them. Operating space can be used to describe how and within what limits new operational opportunities are created alongside previously established practices. The conditions for the operating space may both enable and limit actions. Different actors may have different interpretations of the possibilities and conditions for action and the accuracy, usefulness and necessity of different solutions. (ibid.) For the realization of green roofs, it is important, for example, to find out what benefits, problems and expectations the various actors attach to them. Peltola (2007) has drawn inspiration for her concept of operating space from the actor network theory. According to the theory, when explaining societal phenomena, everyday practices and the material basis of the phenomena must be considered in addition to social relationships (see Latour 2004). In this sense, especially interesting in construction projects are the ways to organize actions, the properties of roof structures and, especially, the vegetation. The use of living and transforming vegetation as a part of the structures brings a new dimension to the construction process, which can be assumed to give rise to contradictory feelings (cf. the barriers to green roof realization in the introduction).

The case studies with their expert interviews produced versatile material that allowed us to form a comprehensive picture of the realization of green roofs in these two sites, and to bring into discussion the conditions defining the operating space for realization of green roofs and possibilities for redefining them.

2. Green roofs in two construction projects

In this chapter, we describe in a concise manner how a green roof was formed in the construction processes of both of our cases from an idea to a design and finally a concrete solution through various phases and the participation of various actors. Table 1 shows the key areas, actors, tasks and titles of the examined construction processes.

Part	Actor	Task	Titles
Initiating the project and its starting points	User/tenant	Defining need for space Functional / qualitative requirements and objectives	User/tenant (K) Main tenant (D)
Constructing	Builder: executive	Leads the building process and makes the decisions	Construction manager of the client (K) Head of design (D)
Constructing	Builder: operative	Leads the actual construction work	Project engineer (K, D)
Design	Head designer	Coordinating the whole design process Basic and initial information for special design	Architect (K) Head of design (D)
Architectural design	Architectural designer	Architectural solution: functional, technical, aesthetic and economic	Architectural designer and their office (K, D)
Structural engineering	Structural engineer	Structural solution, structural design and functionality of building technology	Structural engineer (K, D)
Garden and landscape design	Landscape designer	Garden and planting design	Landscape designer (K, D)
Planting arrangement	Landscaping contractor	Realizing garden and planting plans	Landscaping contractor (K, D)
Materials	Material suppliers	Green roof materials	Green roof company (D)
Care and maintenance	Expert of maintenance	Maintenance	Maintenance supervisor (K) Maintenance company (D)

Table 1. The roles of the key players in the realization of green roofs and the job descriptions corresponding to the case description in construction projects (according to Building Information Foundation RTS 1989). K = Koukkuniemi, D = Derby

2.1 Green roof as an architectural design solution

In the Koukkuniemi project, the green roof of the catering and maintenance building was enabled by the location: for the sake of its value to the cityscape, the roof that was located lower than other built environment had to be landscaped, and the head designer suggested green roof. The main purpose of the green roof was to create an architectural design solution that could improve the visual appearance of the area.

> *There, because we saw it too, and it felt like a good idea. Exactly to that situation with the cityscape, because it's at the bottom of the valley, that roof. Everyone sees it. So, it is basically a good idea that it is a green, like a growing green roof rather than a bitumen or shingle or gravel roof with one or two birch twigs growing. (Head designer)*

In addition, the builders' representatives (the construction manager and the project engineer) raised arguments based on their own interests, such as following trends in construction, pioneering, i.e. experimenting with new practices, as well as the message of environmental friendliness and the image benefits it brings.

The choice of the roofing solution was influenced by the risk and economic assessment according to the responsibilities of the builder, where the green roof was considered a "special case in design and construction", for example for waterproofing. The reasoning behind this was whether the realization of a green roof was in the interest of the builder, whether it achieved benefits and/or whether it could potentially generate an economic advantage. The construction manager was particularly concerned about the risks to the building, such as the possible structural disadvantages of green roofing and the resulting water leaks. From the point of view of the project engineer, the "green stuff" of the alternative solution was exceptional compared to customary practices. From the point of view of risk management, the challenge was the lack of information on, for example, green roof repair, care and maintenance practices.

The starting points for the design were the requirement of lightness and other technical requirements of the roof structure, the criteria for the appropriateness of the design, and the ease of care and maintenance of the green roof. These crystallize in the categorization of the green roof, when the head designer forged the idea into a recognizable form, here RT 85-10709 instruction card "Deck and Roof Gardens and Green Roofs" (Building Information

Foundation RTS 1999) VIH3 vegetation type[30], which also served as the basis for the structure type[31]. This made the selection easier and simpler and was evaluated as 'reliable and functional'.

> *[–] here this is very clearly described from the viewpoint of architect and engineer and these instructions are given for the structure so it really is easy following this. Easy to make when you have an example. [–] So when it is examined and written down and even printed and there are also photographs. (Head designer)*

On the other hand, the utilization of the RT card essentially limited the possibilities for realizing a green roof, because the main designer considered the card's very narrow range of possibilities as the only possible options. The VIH3 type responded to the requirements of lightness and easy care and appeared to the head designer as a "natural grassland".

Green roof introduced a new stage, new actors and tasks for the design and construction of the roof structure, especially designing vegetation as part of the roof structure, and green contracting. It is noteworthy that green design was not immediately recognized as part of the roof construction process. For example, according to the construction manager, it was not part of the landscape designer's tasks to design green roofs. Instead, the role of the structural engineer was highlighted in the form of mitigating possible risks. A more detailed planning of the vegetation of the green roof was not done until together with the garden and landscape design, separately from the design of the roof structure.

The green roof was given new meanings when it became part of the duties of the landscaping contractor and later the maintenance personnel. For the landscaping contractor, the green roof was a "meadow", for which, for example, mowing was defined as the annual maintenance measure - "as is usual in the case of meadows". The green roof was interpreted here through a familiar vegetation element, and so familiar maintenance practices could be applied. Those in charge of care and maintenance, on the other hand, treated the green roof as a lawn area that must be kept clean and even, "so that there won't be so-called bushes there."

---

[30] VIH3 is an arid, naturally renewing ecosystem of low-growing plants not requiring constant care. According to the Building Information Foundation card (1999), VIH3 could be installed on a substrate 3 to 10 cm thick. There was not supposed to be constant access on the roof.

[31] Structure types are basic solutions that facilitate the selection of structures by giving, for example, the conditions and guidelines for more detailed design and the layers found in the roof structure (Betonirakenteiset pientalot 2010). As a structure type, the green roof is a part of the roof structure described as planes and layer thicknesses.

All in all, the responsibilities and practices related to the realization of the green roof were unclear in the process and the flow of information between the various stages and actors was insufficient, which is summarized in the comment of the supervisor responsible for maintenance:

> *[–] It would have been good to find out before getting it, how it should be taken care of and what should be done and who should do it. Who's in charge, so to speak.*
> *(Maintenance supervisor)*

In the case of Koukkuniemi, the design of the green roof was framed by general standards of roof construction, familiar and simple solutions and the planning situation. The prerequisites for realizing the green and vital green roof in accordance with the objectives could not be taken into account during the construction process. The result was a roof that did not match the perceptions and expectations of a green roof of all actors. For example, the head designer considered the realization of the green roof to be unsuccessful because, according to him, it was not visually appealing. A "soil roof" did not correspond to the vision of the green roof of the maintenance supervisor.

> *[–] if there was a turf or something similar, then it would be more like a green roof. Or at least what I understand on a green roof. [–] That we ought to have done something to benefit from it, so to speak. (Maintenance supervisor)*

2.2 Green roofs for earning LEED points

In Derby Business Park project, the installation of three different green roofs was made possible by the aspiration for the LEED32 Gold environmental certificate, initiated by the main tenant committed to the construction project. The selected grading system guided all roofing solutions in accordance with the LEED criteria, which affected the project's economic analysis. The design manager considered the certificate an economically sensible solution, because besides the visual benefits, the solutions needed for the

[32] LEED (Leadership in Energy and Environmental Design) is a US grading system designed to improve the environmental performance of real estate and construction projects. The system rewards environmentally responsible choices, and the certificate can be achieved by meeting the requirements of different scores. For example, in the grading system chosen for Derby's implementation, green roofs were part of the "Sustainable land use and neighbourhood" category. The category looks at ways to reduce the adverse effects of a building on its surroundings by design. Green roofs and other roofs that meet the requirements are presented as a way to reduce the heat island effect, the heating up of the urban structure. (See U.S. Green Building Council 2009.)

certificate were “reasonable”. The project engineer also stressed that green roofs were a "reasonable additional cost".

> *So, the green roof was chosen purely from the premise that we wanted to get all the points in accordance with the environmental grading system. There are also solar panels and similar stuff on the roof. [–] Well, yes, we did not think very carefully, because this environmental grading system made it so clear that we should make green roofs. (Design manager)*

Although the main purpose of the roof options in the certificate was to reduce the urban heat island effect, the builders' representatives did not bring up the theme in the discussion. For example, the design manager and the project engineer justified the choice of green roofs through their own goals of benefits to corporate image, achieved by the message the green roof sends of environmental responsibility. To the architect, the main purposes were aesthetic and landscaping aspects. From the design manager's point of view, the three rather small green roofs also served as an opportunity to gain experience of these solutions.

As in Koukkuniemi, the risks associated with vegetation, the uncertainty and the lack of knowledge and experience led to the selection of safe and tested solutions. According to the design manager, the vegetation of the green roofs can be a 'point of risk', which made green roofs seem an unprofitable solution as roof structure. The problems were crystallized in growing vegetation, which, based on previously learned practices, was perceived as a structural disadvantage and a threat to, for example, waterproofing and thermal insulation.

> *Then, the extent to which it involves risks, it is of course something you’d think about. [–] So, on the one hand there are the risks and on the other these green… things. Whichever is more important, then, there’s enough to ponder. [–] it’s not usually in houses in general, so if we think of normal buildings, then we try not to get any vegetation. [–] It's sort of considered a risk that it will start leaking. [–] So, such a greenish roof like this is considered a little like, it is not a mistake, but over the years it has become something that may not be desired in buildings. (Planning manager)*

In this case, the means of exceeding the risk threshold and making it into an identifiable form was a commercial roofing product, a ready-made sedum mat – a simple and easy-to-maintain 'basic model' that was perceived as a functional, reliable, manageable and affordable solution.

> *And so, we then searched through the contractors. [–] To really have solutions that work and that the contractor dares to give a guarantee. And says they are inexpensive. So that’s what we use. And with every procurement, and also in the case of green roof, we thought about it. (project engineer)*

Efforts were made to manage risks through traditional construction tasks and roles, where the role of the structural engineer, for example, as the guarantor of the technical functioning

of the roof structure was emphasized. However, a more detailed design of the green roof solution was assigned to the landscape designer as a separate phase, similarly to the Koukkuniemi project. The green roof design was finally simplified to choosing one from the selection of ready-made products, which the landscaping contractor then bought and installed. In this case, sedum mats and the information shared by companies served as a 'standard' – as a guideline and model for realizing a green roof – which included promises of functionality. However, the result challenged the actors' perceptions of the green roof as a viable vegetation element: despite irrigation, green roofs were considered slow and “suffering” by the architect, the landscape architect, the landscaping contractor, and the representative of the maintenance company, and the drying up of vegetation was considered a problem.

The LEED certificate does not impose any specific requirements on the vegetation of a green roof, but any solution awards points. This did not encourage the actors in the construction process to consider different types of alternatives either in relation to other goals, such as landscape benefits. The consideration of the functionality of the selected green roof solution from different perspectives was beyond the scope of the discussion, because the finished product was thought to reach the aims in any case.

3. Opportunities and conditions for realizing green roofs - the operating space opens and limits

In this section, we will look at the dimensions of the green roofs in which the mechanisms and conditions of the operating space formation are made visible (cf. Peltola 2007, 16). In the first part, we discuss the factors that have opened the operating space, that is, enabled the realization of green roofs. Next, we will outline what factors limited and guided the possibilities of installing a green roof as the building process progressed and look at the roles of different actors. Thirdly, we present the key points for determining the operating space we have identified.

3.1 Green roof enabled: new goals for roof structure and interpretative benefits of green roofs

In the cases we examined, the installation of green roofs was enabled by project-specific needs, the specific requirements of the construction project and the consequent definition of non-standard targets for roof structures. A redefinition of goals (in our case, urban

landscaping and gathering of LEED points) provides justification for deviating from established solutions, which may create opportunities for novel actions (cf. Peltola 2007, 13; Harty 2010). Peltola refers to this as the opening of operating space, in which different factors create opportunities for certain modes of operation.

In the light of previous studies (see Introduction), the benefits associated with green roofs seem to be essential for making the realization of green roofs possible. For example, it is important that the decision makers value the benefits provided by green roofs, in order to make realizing them easier (Francis & Lorimer 2011). However, our cases suggest that the benefits are interpretative: different actors identified and defined the benefits differently at different stages of the process. Thus, the multifunctionality of the green roof, or the ability to simultaneously provide many benefits, is formed in a situation that, as such, can contribute to the realization of a green roof and assures, for example, the builder of the acceptability of the investment (cf. Pauleit et al. 2011, 273).

The benefits of green roofs were determined in our cases through the concrete and symbolic green quality of green roofs. Mell (2013) suggests that the word “green” in the term "green infrastructure" is construed in various contexts to refer to either green vegetation or communicating ecological sustainability. In our cases, the visual difference of the green roof from the customary aroused positive expectations. Green roofs were also connected to environmental friendliness, which was thought to produce image benefits. However, the green roof as a message of environmental responsibility is largely based on imagination, as there are little research results on the lifecycle impacts of green roofs, for example. If green roofing is used to achieve environmental responsibility, but green roofs are built using materials with a large environmental footprint, it is questionable whether responsibility is realized as desired (Bozorg-Chenani et al. 2014).

3.2 The operating space is limited: the new solution meets the traditions, routines and practices of construction

The key to adapting alternative ideas to be part of the operations is assessing the new ways against the old ones (Peltola 2007, 14). When transferring the idea of green roofs to practical design and decision-making, there were many conflicts in relation to the established principles, criteria, routines and habits of construction processes. At this stage, the realization of green roofs did not seem fully justified to all actors.

From the perspective of the actors, in the cases we examined, the realization of green roofs required different factors to be considered. It was essential for the developer to implement

a green roof so that it would be a profitable investment. This led to the consideration of the benefits of green roofs against costs and risks. According to our interpretation, however, the assessment of economy is a relative matter in the project: in both cases, the cost issues did not become an impediment to realization, but they were part of the construction project's standard economic analysis, which must be able to justify the economic viability of the choices. In these cases, the risks of green roofs were associated with images and interpretations of vegetation as part of buildings: based on what was previously adopted, vegetation was perceived as a sign and a cause of construction errors. In this case, the selection criteria for the choice were the criteria of affordability, economy and reliability, typical of the construction industry, as well as the simplicity and easy realization of the green roof. An effort was made to realize the green roof as simply as possible, without disturbing the basic functions of a construction project. These factors were reflected in the practical realization of the green roof and the success of the result. The main challenges were related to the technical functionality, structure and maintenance of the green roof.

According to Heikura and Lindman (2011), risk management is extremely important for construction companies, and new technologies and materials are not attractive alternatives due to warranty and liability periods. In our cases, the green roof was considered to threaten the primary purpose of the roof structure[33], which has been identified as a key concern of the builders in constructing green roofs (Hendricks & Calkins 2006). For this reason, the role of the structural designer[34] was highlighted in the design of the green roof, which in turn determined the scope for realization. In both cases, the builders felt that the green roof was a burden for maintenance, which reduced the scope to easy-to-manage and simple solutions. Thus, the determination of the rights to speak and act of actors in the construction process (see Peltola 2007, 16) may partly influence the choices.

Building industry practices form conditioning arrangements with the purpose of making the operations more predictable, consistent and therefore easier (cf. Barry 2001). In our cases, the realization of green roofs was based on the usual routines of construction through the implementation of shared, separate sub-projects and phases. This is generally seen as

[33] The technical purpose of the roof is to ensure the water and heat proofing of the entire roofing structure, whereby the technical functionality of the roof is the core function (Kattoliitto 2013).

[34] The duties of the structural engineer include various tasks of engineering design, such as structural solutions, dimensioning of structures and taking care of structural technology performance (see Table 1). In the case of various roof solutions, this means, among other things, the design of structural types.

enabling the implementation of complex processes (see, for example, Harty 2010; Barlow 2000). In our cases, however, green roofs did not smoothly settle into established sub-projects and phases. Instead, they were assigned to the actors involved in construction projects according to the customary task limits, and their realization as a whole was not anyone's responsibility. The different actors agreed on the green roof as part of their own practices and the actors were not necessarily aware of each other's goals, the meanings attached by them to the green roof or the problems they experienced. The actors had different perceptions of the actors, tasks and stages that are essential for the realization of green roofs. For example, in accordance with the division of tasks between the structural engineers and landscape designers, determining green roof load capacity is part of the tasks of the structural engineer, even though the load capacity is also related to the choice of the green roof vegetation. In particular, the role of the landscape designer was in some cases unclear, as they are not usually involved in the design of roof structures, and yet the planting design formed a new loop in the roof construction chain. Our perception is that in the cases the green roof was "added on top" of the tasks of different actors without thinking do they fit or not.

In addition to routines, efforts are made to manage construction processes through various legal and commonly agreed standards (Malvalehto et al. 2011) that simplify selection of solutions, make choices justifiable and ensure the reliability of choices (Heikura and Lindman 2011; Peltola 2007, 35). Because of the varying possibilities of realization, it may be difficult to define generic standards for green roofs (Henry & Frascaria-Lacoste 2012; Carter & Fowler 2008), but on the other hand, the lack of standards, sanctions and incentives, has slowed down the realization of green roofs (Williams et al. 2010; Ngan 2004). In our cases, the general design norms, standards, and classification methods of roof construction were the starting points for designing green roof solutions, and drastically limited the scope for realization of green roofs. Lightweight as a general principle of roof construction was self-evident, whereby heavier green roof solutions were perceived as problematic. For example, in Koukkuniemi, the head designer justified the requirement of lightness with technical constraints to the roof structure, such as the long spans of the lower roof structures and the snow load causing additional weight.

In our cases, the aim was to make green roofs more manageable and easier to understand by stabilizing the new idea in a recognizable form using different methods. From the point of view of the actor network theory, the manageability and stabilization of operations are based on the fact that some things can be taken for granted (Åkerman 2009) and therefore

need not be questioned. In both of our cases, different design guidelines were very important, such as the Building Information Foundation green roof cards and model solutions, and in Derby, also a ready-made green roof product that was chosen to gain validation and warranty for the realization. The information presented in the Building Information Foundation card, which complies with the general conditions of roof construction, was treated as solid factual information and an official standard, even though not legally binding.

The actors' assessments of the success of the outcome reflect the challenges that introducing a new idea, in this case integrating vegetation in buildings, with established practices produces in construction projects involving multiple actors. The green roofs were associated with images of green and vibrant nature, but its production could not be successfully combined with the various stages of the construction process. Although the operators responsible for the design, realization and maintenance of green roofs considered the functionality of the green roof and its prerequisites a vegetation element, the traditional criteria and principles such as the technical functionality of the roof structure and the requirement of lightness dominated the construction process and determined the realization of the green roof. In the end, the green roof did not become the expected visually appealing element. The term "green roof" may give rise to unrealistic expectations of the appearance of the roof (see Sadler et al. 2011, 296). The characteristics of problematic and not functional vegetation were described as brown coloring, unevenness of vegetation and stunted growth. The 'unreliability' of vegetation was also considered problematic: the green roof may grow slowly and dry out.

3.3 Key points for determining the operating space: flexible stages

Based on the cases we studied, the conditions determining the realization possibilities for green roofs form a multi-level and multi-phase path through which the green roof transforms from an idea to a concrete solution. Factors conditioning the realization are not uniformly preventing or promoting but are interpreted on a case by case basis (cf. Peltola 2007). Figure 1 shows, based on the cases, the key conditions for the realization of green roofs in the construction process.

Figure 1. Conditions determining the margin for realization of green roofs in the construction processes, based on our cases (division modified from Peltola 2007). The arrows describe the case-by-case nature of the operating space: different conditions can either narrow down or expand the margin.

4. Factors affecting the success from the perspective of the construction process

Based on our case study, we propose that the traditional goals of construction processes and the criteria for assessing choices can be flexible and redefined, and that therefore also unestablished solutions can be realized (cf. Peltola 2007, 45). However, current practices, principles and roles of building processes should be critically considered from the perspective of successful green roof realization. The realization of green roofs requires novel understanding of multidisciplinary and integrative design expertise. For example, from the very beginning of the project, the understanding of which factors affect the vitality of green roof vegetation is essential in order to plan appropriate structural solutions, including sufficient carrying capacity and other technical solutions (cf. e.g. Kallio et al. 2014).

Chopping operations into separate sub-projects is the basis for the organization of construction processes and is therefore not easy to change. However, the realization of green roofs shows that previous cooperation relationships and methods are inadequate and requires the actors to cooperate beyond the task limits (see also Ozorhon 2014). Cooperation between actors has been seen as an important aspect of the success of green roofs (see e.g. Hendricks & Calkins 2006). Snodgrass and Snodgrass (2006, 33–34) argue that at least the user of the property, the builder, the architect, structural engineers, land use planners, landscape architects, and vegetation experts should work together to achieve the goals of a green roof. Based on our cases, the landscaping contractor and the person responsible for the care and maintenance of the green roof should also be added to the list.

Parviainen (2006, 165–166), who has investigated the construction of knowledge and expertise in different organizations, suggests that routines and a well-established division of labour between different actors enable professionals to work together in different fields, but a change in actions may show the previous routines inadequate and require that old practices and knowledge are adapted to fit the new situation. Implementing new types of solutions, such as green roofs, that affect different tasks may create such change situation. For example, the pre-learned images of the possibility of damages caused by plants spontaneously sprouting on the surfaces of buildings may unnecessarily limit the margin of realization of green roofs, as modern green roof solutions keep the roots of plants separated from structures by root barriers.

By sharing the knowledge embedded in different phases and actors' practices and identifying new collaborative relationships, an understanding of the goals, expectations and

views of the various actors can be increased, and problematic areas clarified. From the point of view of developing cooperation, the identification of 'soft' topics is important in addition to technical issues (Shelbourn et al. 2007).

Based on this study, compatibility with customary practices can contribute to a non-standardized solution. For example, construction processes aim at the manageability and stability of operations, whereby model solutions and instructions that act as different types of classification make the realization of green roofs possible and, on the other hand, limit the scope for realization. Versatile standards and guidelines could help departing from traditional standards, tailor green roof solutions according to the situation, consider the goals of the different actors and match them. However, it should be noted that not everything needs to be standardized, but it must also be possible to adapt to the situation and project (Koskela 2000). Occasionally, adding new types of solutions that adapt to previous criteria and principles, such as various lightweight alternatives, could be the key to expanding the scope for green roofs. Such solutions could create new opportunities for roof construction without being too radical.

In both cases, the realization of the green roofs appeared as a test of a new idea, where the gathering of experience served as one of the reasons for the rationale of the choice. Positive experiences with new solutions may push the actors to question established standards of action. This is also about “learning by doing” (Ahern et al. 2014), which creates new connections and enhances understanding of the benefits of nature and the construction of green roofs. However, Heikura and Lindman (2011) state that the development of the construction industry in Finland is largely based on changing regulation and not on the industry's own research and development activities.

It should be noted that the green roof is part of the construction process, one solution among others (cf. Koebel et al. 2015), and the design processes in construction are often adjusted to be efficient (Zwikael, 2009). If processes are perceived to be working, operators may not have the motivation to change or develop their own operations, at least not radically, only for constructing green roofs.

5. Conclusion – balancing between urban structures and urban nature

The challenges and possibilities of realizing green roofs become clear, firstly, when considering their role as both roof structures and elements of urban nature, and secondly, when balancing between these two dimensions. The vegetation on the roof both expands and, especially through the experienced insecurities, restricts the possibilities for realizing

a green roof. A green roof will not be formed as a stable and predictable roofing option, for it is a living and, therefore, changing element. These factors are connected to the need for stabilizing that was prominent in our cases, and, more generally, to the understanding of urban nature as a manageable, predictable and cost-effective infrastructure (e.g. Montalto et al. 2013). Asikainen and Jokinen (2008) suggest that various classification systems stabilize the nature as an object of management and affect the type of urban nature that is produced. This "cultural base of nature management" may create practices that seem to be the only possible option. However, urban nature is dynamic: it is given meanings and it constantly re-organizes along with the process of urbanization. (ibid.) In this sense, the vegetation that is integrated with buildings is especially interesting. On the one hand, the aim of realizing a green roof may be to create a growing and vital natural element, and on the other hand, the power of growth of the nature is considered as a threat to the structures. This leads to the need to avoid risks and thus effectively manage the nature – even so effectively that the prerequisites to the thriving of vegetation are lost. Consequently, green roofs also push a reassessment of the role of vegetation as part of construction, which may produce new interpretations of the forms and acceptability of urban nature. The "waste lands" of the roofs may offer a basis for a special kind of symbolism that is based not only on traditional experiences on urban nature and various vegetational elements (Loder 2014).

This paper helps to understand the realization of not only green roofs, but possibly also other forms of new green infrastructure35. Green roofs represent the idea of a new kind of urban green structures and strategical development of urban nature36. A green roof lends meaning to a space that has not formerly been taken into consideration as part of urban construction or development, or individual construction initiatives. Green roofs may thus be seen to redefine the possibilities of constructing urban green. A corresponding connection may be seen in the paper of Peltola (2007), who suggests an operating space to the forest and energy sector, created by wood energy.

The development of novel green solutions should be considered as part of a wider discussion concerning planning and construction of urban spaces, for example from the point of view of the entire green network of the city: how new elements are created,

[35] For example, green walls, rooftop farming, bio art and water retention roofs.

[36] It is important to see that green roofs cannot replace the green spaces on the ground level. Instead, they support and enhance other green structures (cf. e.g. Williams et al. 2014, Mentens et al. 2005).

connected to the green network and attached to the process of urban planning and construction in a manner that enables exploiting the potential benefits they offer (Kallio et al. 2014, Laurila et al. 2014). The focus of further study might thus be the conditions in urban planning (for example, in the land use planning process) defining operating space for the realization of green roofs, and how the conditions in urban planning relate to the conditions recognized in construction processes. It would be important to find out how the various actors participating in the realization of a green roof view different conditions, and whether the operating space for realizing green roofs may be widened with the help of co-creation (cf. Nygren 2013, 27). In co-creation, the views and experiences of practical actors are of utmost importance: what possibilities for change and points of development are seen by, for example, urban planners, green planners or developers.

References

- Ahern, Jack & Cilliers, Sarel & Niemelä, Jari (2014). The concept of ecosystem services in adaptive urban planning and design: A framework for supporting innovation. Landscape and Urban Planning 125, 254–259.
- Alastalo, Marja & Åkerman Maria (2010). Asiantuntijahaastattelun analyysi: faktojen jäljillä. Teoksessa Ruusuvuori, J., Nikander, P. & Hyvärinen, M. (toim.) Haastattelun analyysi. Osuuskunta Vastapaino, Tampere, 372–392.
- Alexandri, Eleftheria & Jones, Phil (2008). Temperature decreases in an urban canyon due to green walls and green roofs in diverse climates. Building and Environment 43:4, 480–493.
- Asikainen, Eveliina & Jokinen, Ari (2008). Kaupunkiluonnon hallinnan utopia. Alue ja ympäristö 37:2, 49–62.
- Barlow, James (2000). Innovation and learning in complex offshore construction projects. Research Policy 29:7–8, 973–989.
- Barry, Andrew (2001). Political machines: governing a technological society. Athlone, New York.
- Benedict, Mark A. & McMahon, Edward D. (2012). Green Infrastructure: Linking landscapes and communities. The Conservation Fund. Island Press.
- Betonirakenteiset pientalot, rakennetyypit (2010). [viitattu 12.5.2015] www.betoni.com/Download/22478/Betonirakenteiset_pientalot.pdf
- Blayse, Aretha M. & Manley, Karen (2004). Key influences on construction innovation. Construction Innovation 4:3, 143–154.
- Bozorg Chenani Sanaz & Lehvävirta Susanna & Häkkinen Tarja (2015): Life cycle assessment of layers of green roofs. Journal of Cleaner Production 90, 153–162
- Brenneisen, Stephan (2006): Space for Urban Wildlife: Designing Green Roofs as Habitats in Switzerland. Urban Habitats 4:1, 27–36.
- Carter, Timothy & Fowler, Laurie (2008). Establishing Green Roof Infrastructure Through Environmental Policy Instruments. Environmental Management 42:1, 151–64.
- Castleton, Holly F. & Stovin, Virginia & Beck, Stephen B.M. & Davison, J. Buick (2010): Green roofs; building energy savings and the potential for retrofit. Energy and Buildings 42:10, 1582–1591.

- Colding, Johan (2011). The Role of ecosystem services in contemporary urban planning. Teoksessa Niemelä, J. (toim.): Urban ecology. Patterns, processes, and applications, 228–237. Oxford University Press, New York.
- Dunnett, Nigel & Kingsbury, Noël (2008). Planting green roofs and living walls. Timber Press, Portland.
- EU-komissio (2013). Green Infrastructure (GI) – Enhancing Europe's Natural Capital. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions. Bryssel 6.5.2013, COM(2013) 249 final. [viitattu 12.5.2015] http:// eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0249:FIN:EN:PDF
- Fernandez-Cañero, Rafael & Emilsson, Tobias & Fernandez-Barba, Carolina & Machuca, Miguel S. H. (2013). Green roof systems: A study of public attitudes and preferences in southern Spain. Journal of Environmental Management 128, 106–115.
- Francis, Robert. A. & Lorimer, Jamie (2011). Urban reconciliation ecology. The potential of living roofs and walls. Journal of Environmental Management 92:6, 1429–1437.
- Gabrych Malgorzata, Kotze, Johan & Lehvävirta, Susanna (2016). Substrate depth and roof age strongly affect plant abundances on sedum-moss and meadow green roofs in Helsinki, Finland. Ecological Engineering 86, 95–104.
- Getter, Kristin L. & Rowe, Bradley (2006). The role of extensive green roofs in sustainable development. HortScience 41:5, 1276–1285.
- Harty, Chris (2010). Implementing innovation: designers, users and actor-networks. Technology Analysis & Strategic Management 22:3, 297–315.
- Heikura, Tuija & Lindman, Juho (2011). Rakennettu ympäristö systeemisen innovaation haasteena. Teoksessa Valovirta, V., Nieminen, M., Pelkonen, A., Heikura, T., Lindman, J., Inkinen, S., Kaivo-oja, J.: Systeemisen muutoksen haasteet ja innovaatiotoiminnan mahdollisuudet –Tapaustutkimuksia ja politiikkanäkökulmia, 26–31. Tekesin katsaus 286/2011. Tekes, Helsinki.
- Helsingin kaupunki (2013). Helsingin kaupunginvaltuuston pöytäkirja 9/2013. § 154 Ryj / Valtuutettu Anni Sinnemäen aloite viherkattojen rakentamisesta 15.5.2013.
- Hendricks, Jennifer S. & Calkins, Meg (2006). The adoption of an innovation: barriers to use of green roofs experienced by Midwest architects and building owners. Journal of Green Building 3:1, 1–21.
- Henry, Alexandre & Frascaria-Lacoste, Nathalie (2012). The green roof dilemma. Discussion of Francis and Lorimer (2011). Journal of Environmental Management 104, 91–92.
- Hulevesiopas (2012). Suomen Kuntaliitto, Helsinki.
- Jungels, Jeremy & Rakow, Donald A. & Allred, Shorna B. & Skelly, Sonja M. (2013). Attitudes and aesthetic reactions toward green roofs in the Northeastern United States. Landscape and Urban Planning 117, 13–21.
- Kallio, Pasi & Mesimäki, Marja & Lehvävirta, Susanna (2014). Monitoiminnalliset viherkatot ja maankäyttö- ja rakennuslaki. Ympäristöjuridiikka 2, 98–138. Suomen ympäristöoikeustieteen seura.
- Kattoliitto (2013). Toimivat katot. Vammalan Kirjapaino Oy, Sastamala.
- Koebel, Theodore C. & McCoy, Andrew & Sanderford, Andrew R. & Franck, Christopher T. & Keefe, Matthew J. (2015). Diffusion of green building technologies in new housing construction. Energy and Buildings 97, 175–185.
- Koskela, Lauri (2000). An exploration towards a production theory and its application to construction. Technical Research Centre of Finland. VTT Publications 408. Otamedia Oy, Espoo.

- Kuper, Rob (2009). What's up? Examining the awareness of green roofs in suburbia. Journal of Water and Soil Conservation 64:5, 145A–149A.
- Latour, Bruno (2004). Politics of Nature. How to Bring the Sciences into Democracy. Mass. Harvard University Press, Cambridge Massachusetts, USA.
- Laurila, Sari & Jyrkänkallio-Mikkola, Jenni & Mesimäki, Marja & Kallio, Pasi & Kuoppamäki, Kirsi & Nieminen, Hanna & Lehvävirta, Susanna (2014). Normeja viherkatoille – perusteita kehittämiseen. Projektiraportti. Helsingin yliopisto. Koulutus- ja kehittämiskeskus Palmenia.
- Liu, Karen & Baskaran, Bas (2003). Thermal performance of green roofs through field evaluation. Report No. NRCC 46412 National Research Council Canada. Ottawa.
- Loder, Angela (2014). There's a meadow outside my workplace': A phenomenological exploration of aesthetics and green roofs in Chicago and Toronto. Landscape and urban planning 126, 94–106.
- Madre, Frédéric & Vergnes, Alan & Machon Nathalie & Clergeau Philippe (2014). Green roofs as habitats for wild plant species in urban landscapes: First insights from a large-scale sampling. Landscape and Urban Planning 122, 100–107.
- Malvalehto, Jukke & Siponen, Tuomas & Herrala, Maila & Haapasalo, Harri (2011). Infrastruktuurin arvoketjuanalyysi. Tuotantotalouden osaston tutkimusraportteja, 2/2011, Oulun Yliopisto. [viitattu 15.5.2015] http://herkules.oulu.fi/isbn9789514293740/isbn9789514293740.pdf.
- Mell, Ian C. (2013) Can you tell a green field from a cold steel rail? Examining the "green" of Green Infrastructure development, Local Environment: The International Journal of Justice and Sustainability 18:2, 152–166.
- Mentens, Jeroen & Raes, Dirk & Hermy, Martin (2006). Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? Landscape and Urban Planning 77, 217–236.
- Montalto, Franco A. & Bartrand, Timothy A. & Waldman, Alexander M. & Travaline, Katharine A. & Loomis Charles H. & McAfee, Chariss & Geldi, Juliet M. & Riggall, Gavin J. & Boles, Laureen M. (2013). Decentralized green infrastructure: the importance of stakeholder behavior in determining spatial and temporal outcomes. Structure and Infrastructure Engineering: Maintenance, Management, Life-Cycle Design and Performance 9:12, 1187–1205.
- The Multifunctionality of Green Infrastructure (2012). Science for Environment Policy. In-depth Reports. European Commission's Directorate-General Environment, edited by the Science Communication Unit. The University of the West of England (UWE), Bristol. [viitattu 27.4.2015] http://ec.europa.eu/environment/nature/ecosystems/docs/Green_Infrastructure.pdf
- Ngan, Goya (2004). Green roof policies: Tools for encouraging sustainable design. [viitattu 23.4.2015] http://www.gnla.ca/assets/Policy%20report.pdf.
- Nieminen, Hanna (2015). Viherkattojen toteutumisen liikkumavara osana rakentamisen prosesseja – tasapainoilua kaupunkirakenteen ja -luonnon rajapinnoilla. Pro gradu, Ympäristöpolitiikan ja aluetieteen koulutusohjelma, Tampereen yliopisto.
- Nurmi, Väinö & Votsis, Athanasios & Perrels, Adriaan & Lehvävirta, Susanna (2013). Cost-benefit analysis of green roofs in urban areas: case study in Helsinki. Ilmatieteen laitoksen raportteja 2/2013.
- Nygren, Nina V. (2013). Liito-oravan suojelun poliittinen prosessi ja suunnitteluvara Tampereen kaupunkiseudulla. Tampereen yliopisto. Johtamiskorkeakoulu. Ympäristöpolitiikka. Acta Universitatis Tamperensis 1859.
- Näyhä, Simo (2007). Heat mortality in Finland in the 2000s. International Journal of Circumpolar Health 66:5, 418–424.

- Oberndorfer, Erica & Lundholm, Jeremy & Bass, Brad & Coffman, Reid R & Doshi, Hitesh & (…) & Rowe, Bradley (2007). Green Roofs as Urban Ecosystems: Ecological Structures, Functions and Services. BioScience 57:10, 823–833.
- Ouldboukhitinea, Salah-Eddine & Belarbi, Rafik & Djedjig, Rabah (2012). Characterization of green roof components: Measurements of thermal and hydrological properties. Building and Environment 56, 78–85.
- Ouldboukhitinea, Salah-Eddine & Spolekb, Graig & Belarbi, Rafik (2014). Impact of plants transpiration, grey and clean water irrigation on the thermal resistance of green roofs. Ecological Engineering 67, 60–66.
- Ozorhon, Beliz & Abbott, Carl & Aouad, Ghassan (2014). Integration and leadership as enablers of innovation in construction: Case study. Journal of Management in Engineering 30:2, 256–263.
- Páll-Gergely, Barna & Kyrö, Kukka & Lehvävirta, Susanna & Vilisics, Ferenc (2014): Green roofs provide habitat for the rare snail (Mollusca, Gastropoda) species Pseudotrichia rubiginosa and Succinella oblonga in Finland. Memoranda Soc. Fauna Flora Fennica 90: 13–15.
- Parviainen, Jaana (2006). Kollektiivinen tiedonrakentaminen asiantuntijatyössä. Teoksessa Parviainen, J. (toim.) Kollektiivinen asiantuntijuus. 155–187. [Viitattu 3.3.2015] http://uta32-kk.lib.helsinki.fi/bitstream/handle/10024/65372/kollektiivinen_asiantuntijuus_2006.pdf?sequence=1.
- Pauleit, Stephan & Liu, Li & Ahern, Jack & Kaźmierczak, Aleksandra (2011). Multifunctional green infrastructure planning to promote ecological services in the city. Teoksessa Niemelä, J. (toim.) Urban ecology. Patterns, processes, and applications, 272–285. Oxford University Press, New York.
- Peltola, Taru (2007). Paikallisen energiahuollon ympäristöpoliittinen liikkumavara. Vaihtoehtoiset teknologiat, poliittiset käytännöt ja toimijuus. Tampereen yliopisto. Kauppa- ja hallintotieteiden tiedekunta. Yhdyskuntatieteiden laitos. Ympäristöpolitiikka. Acta Universitatis Tamperensis 1203.
- Rakennustietosäätiö (1999). Kansi- ja kattopuutarhat sekä viherkatot. RT 85–10709.
- Rakennustietosäätiö (1989). Talonrakennushankkeen kulku. RT 10–10387 (1989).
- Sadler, Jon & Bates, Adam & Donovan, Rossa & Bodnar, Stefan (2011). Building for biodiversity: accommodating people and wildlife in cities. Teoksessa Niemelä, J. (toim.) Urban ecology. Patterns, processes, and applications, 286–297. Oxford University Press, New York.
- Shelbourn, Mark & Bouchlaghem, N.M. & Anumba, Chimay & Carrillo, Patricia (2007). Planning and implementation of effective collaboration in construction projects. Construction Innovation 7:4, 357–377.
- Slaughter, Sarah E. (1998). Models of construction innovation. Journal of Construction Engineering and Management 124:3, 226–32.
- Suomen Ympäristökeskus (2013). Kaupunkiseutujen vihreän infrastruktuurin käsitteitä. Suomen ympäristökeskuksen raportteja 39. ViherKARA-verkosto, Helsinki. [viitattu 8.1.2015] https://helda.helsinki.fi/bitstream/handle/10138/42483/SYKEra_39_2013.pdf?sequence=1.
- Suomi, Juuso (2014). Characteristics of urban heat island (UHI) in a high latitude coastal city – a case study of Turku, SW Finland. [viitattu 22.5.2015] http://urn.fi/URN:ISBN:978-951-29-5912-9
- Tampereen tilakeskus, kiinteistökehitys (2012). Koukkuniemen Jukola ja Impivaara. Perusparannus ja uudisrakennus. Toteutussuunnitelma. Tampereen kaupunki. [viitattu

4.11.2015] http://www.satalaatta.fi/wp/wp-content/uploads/2013/01/Koukku_toteutussuunnitelma.pdf

- Tuomi, Jouni & Sarajärvi, Anneli (2009). Laadullinen tutkimus ja sisällönanalyysi. Tammi, Helsinki.
- Tzoulas, Konstantinos & Korpela, Kalevi & Venn, Stephen & Yli-Pelkonen, Vesa & Kaźmierczak, Aleksandra & Niemelä Jari & James, P. (2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. Landscape and Urban Planning 81, 167–178.
- U.S. Green Building Council. 2009. LEED 2009 for new construction and major renovations. [viitattu 3.11.2015] http://www.usgbc.org/Docs/Archive/General/Docs5546.pdf.
- Vantaan kaupunki (2014). Rakennettavien alueiden hulevedet ja kattokasvillisuus. Maankäytön, rakentamisen ja ympäristön toimiala. [viitattu 7.1.2015] http://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/96193_hulevesi_20012014.pdf.
- Veuro, Sini & Lehvävirta, Susanna & Mesimäki, Marja (2012). Viherkattojen elinkaarianalyysi ja kestävät rakenneratkaisut. Esiselvitys. Helsingin yliopisto. [viitattu 23.4.2015] http://www.luomus.fi/sites/default/files/files/esiselvitys_viherkattojen_lcapieni.pdf
- White, Emma V. & Gatersleben, Birgitta (2011). Greenery on residential buildings: Does it affect preferences and perceptions of beauty? Journal of Environmental Psychology 31:1, 89–98.
- Williams, Nicholas S. G. & Lundholm, Jeremy & Scott MacIvor, J. (2014). Do green roofs help urban biodiversity conservation? Journal of Applied Ecology 51:6, 1643–1649.
- Williams, Nicholas S. G. & Rayner, John P. & Raynor, Kirsten J. (2010). Green roofs for a wide brown land: Opportunities and barriers for rooftop greening in Australia. Urban Forestry and Urban Greening 9:3, 245–251.
- Zwikael, Ofer (2009). Critical planning processes in construction projects. Construction Innovation 9:4, 372–387.
- Åkerman, Maria 2009. Hybridit ja ympäristön politiikka. Teoksessa Massa, I. (toim.) Vihreä teoria. Ympäristö yhteiskuntateorioissa. Gaudeamus, Tampere, 238–261.

6.2 Case study II

Lessons from the implementation of nature-based solutions in the West of England

This summarises key learnings from the implementation of nature-based solutions (NBS) in the West of England region. Key challenges faced in implementation include financing, as there are no specific funding streams for such schemes (as this is an emerging area), and ongoing maintenance. A key driver is the recognition that well-designed NBS schemes can provide multi-functional benefits across varying ecological, hydrological, economic, landscaping, planning, health and wellbeing needs, that can prove more cost-effective and longer-lasting than traditional approaches. These examples emphasise the importance of both effective community engagement and partnership working in the ongoing success of NBS schemes.

FINANCING

Despite well-designed NBS schemes having multiple benefits to different stakeholder groups, this is an emerging design principle and there are no well-developed funding mechanisms for its implementation. Within UK planning frameworks, the key financing routes for NBS by local authorities are through Section 106 agreements and the Community Infrastructure Levy (drawn from developer contributions). However, these funds are limited and needed to fund all types of strategic infrastructure, often leading to conflicting priorities where, for example, a new school or other social infrastructure might be prioritised over an NBS scheme. As such, being able to communicate the multi-functional benefits of NBS, in particular its social benefits, is critical to being able to successfully draw down such funds.

Due to these limitations, there is a real need to unlock new types of financing for NBS schemes. In the West of England, many NBS schemes have been funded by a blend of large grants (including Heritage Lottery Fund and Big Lottery Fund), the abovementioned

Example 2: Bath Quays Waterside Park – Multifunctional NBS can aid funding

The project was originally conceived as a flood mitigation and defense project, however it became an opportunity to re-connect the city with its previously neglected riverside.

This led to the creation of a multifunctional riverside park, acting as a green open space for the public when river is low yet is designed to accommodate flood water when the river is high. In times of flood the park is closed to the public with bollard and chains with warning signs. An information campaign and cartoon played in Universities also explains that this is a park and a flood defense, so that at certain times of year it may be closed off. Flood tolerant wild flowers and ferns have been planted to withstand flood events. Ecological improvements included the planting of 150 trees including fruiting species to attract pollinators, reed rafts in the River Avon, sensitive riverside lighting for bats and other wildlife. The park will form part of a larger WaterSpace project which will see the development of a 3.7 mile linear park along the River Avon.

The total cost of the scheme was £7.22 million. The Council and Environment Agency are funding these works with a combination of Revolving Infrastructure funding made available by the West of England Local Enterprise Partnership (LEP): £6.1 million, and Local Levy: £0.510 million and Flood Defence Grant in Aid funding: £0.610 million.

Photo © B&NES. Find out more: http://oppla.eu/casestudy/19137

developer contributions and Government funding designed to catalyse economic growth (e.g. from Government through Local Enterprise Partnerships).

The Heritage Lottery Fund (HLF) uses money raised through National Lottery players and support a range of projects from historic parks, to urban river enhancement, to rare wildlife.

Example 3: Hanham Hall: Community Management Structure

This development achieved the 'Zero' carbon standard for its buildings, which were designed to reduce heat loss and rainwater is harvested for toilets and washing machines. The homes are fitted with mechanical ventilation with heat recovery systems, photovoltaics and solar shading systems. The development also incorporated a wide range of green infrastructure with over a third of the 9ha site dedicated to green space. This included allotments and orchards, a new park which leads to greenhouses, an apiary, a children's play area and meadow grass. Existing trees and hedgerows were retained and improved, and new native species were planted. There is also an extensive sustainable urban drainage system by which rainwater collects in a central bio-swale then flows into a retention pond where it is discharged.

During the design process an engagement programme was run with multiple stakeholders including the Parish Council, the Homes and Communities Agency, English Heritage, South Gloucester Council, Green Belt Society, Local residents and the supply chain. Two public consultation events were held for the wider community. The development has an innovative community management structure. It will be run by its residents who will have a share in a Community Interest Company set up to manage and maintain the buildings and grounds.

Photo © HTA Designs. Find out more: http://oppla.eu/casestudy/19153

Arnos Vale Cemetery in Bristol (https://oppla.eu/casestudy/19190) successfully secured funding from the HLF to regenerate the historic buildings and the habitats surrounding them. The BIG Lottery Fund is another opportunity for projects that improve education, health and the environment. The BIG Lottery fund local food project is supporting projects that enable local food to be more accessible to communities and this helped to fund the **Golden Hill Community Garden** in Bristol[37]

Linking NBS schemes to with economic opportunities is a good way to source different funding, for example from economic funding streams such as the Local Enterprise Partnerships (LEP). These are business led partnerships between local authorities and local private sector businesses. This was used for **Bath Quays Waterside Park** (https://oppla.eu/casestudy/19137) and for the **Filwood Park Green Business Centre** (https://oppla.eu/embedded-case-study/19194). Bath Quays Waterside Park was created as a flood defence to protect the new enterprise development which would see the potential provision of 2,500 new jobs, predicted to bring £100 million per year to Bath's economy.

The project successfully secured £6.1 million from the LEP and used this to create a multifunctional park acting as a flood defence and a public green space. The Filwood Park Green Business Centre was created to bring more green jobs into the area of Knowle West; funding from the LEP helped to create a sustainable urban drainage system (SuDS) and a wildlife area.

Funding linked to economic benefit is the most abundant, however it can be challenging to make a clear, evidence-based case for the economic benefits of NBS, although the above examples show where this has been successful. A more systematic uptake reflects a general lack of understanding about how our regional economies rely on natural capital.

There is further potential to unlock additional funding through green bonds and social impact bonds (although this is a nascent area).

[37] https://oppla.eu/casestudy/19195

PARTNERSHIPS

Due to the multi-functional nature of NBS, and the broad range of expertise needed in its successful design, implementation and ongoing management and maintenance, NBS schemes are generally most successful when developed in partnership. Effective partnership working also helps to unlock broader funding opportunities.

Nearby Gloucester Services (https://oppla.eu/embedded-case-study/19193) was funded through a unique partnership between a business (Westmorland Limited) and a charity (Gloucestershire Gateway Trust). A proportion of the profits from the service station go towards charitable projects which involve creating more green infrastructure on site such as

Example 4: Elderberry Walk: NBS in new developments

This development scheme has a unique partnership between HAB Housing, United Communities, Bristol and Bath Regional Capital (BBRC) and Cheyne Capital. Community involvement and consultation throughout the design and planning process has led to overall community support for the project with few objections to the application.

The scheme is also working to the Gloucester Wildlife Trust's Building with Nature benchmark, which sets the standard for Green Infrastructure in new developments. This has ensured that the development, consisting of 161 highly sustainable yet affordable homes, has green infrastructure at the heart of its design. The homes were designed around a central green corridor with existing trees and hedges used to define boundaries. The central green corridor links the development to an existing park, improving connectivity, as well as providing foraging opportunities for bats. The development also includes a communal wildlife garden and edible planting which will improve sense of place and sustainable food production.

Photo © HAB Housing. Find out more: http://oppla.eu/casestudy/19135

tree planting. The sustainable development **Elderberry Walk**[38], was funded as a collaboration between locally based Housing Association United Communities, Cheyne Social Property Impact Fund and Bristol and Bath Regional Capital.

Southmead Hospital (https://oppla.eu/casestudy/19175) have used a Private Finance Initiative (PFI) approach to fund the creation of the Brunel building and its surrounding green infrastructure. The PFI contractors, Carillion, funded most of the works and now fund its maintenance. This was a successful approach as the NHS Trust incorporated maintenance of the green infrastructure into the PFI contract, ensuring funding for the long-term maintenance and management of the site.

MANAGEMENT AND MAINTENANCE

In the design of NBS schemes, it is critical to think about long-term management and maintenance – both in terms of how they will be funded, but also the right design (e.g. plant selection) for minimal maintenance.

Funding

The maintenance of NBS schemes have typically been funded through council tax, however there is a need to move away from this as funds are limited.

A local resident fee or levy could be a good way to secure funding for NBS maintenance. This has been used for the **Hanham Hall**[39] development. However, this did not prove successful in a similar scheme in the West of England where residents felt that they had no transparency of what this levy was being used for, so the local Council stopped the levy. Therefore, if this method is used it is vital that the residents know what exactly this money is being used for if they are expected to pay. The Hanham Hall development has improved on this method with an innovative community management structure. It will be run by its residents who will have a share in a Community Interest Company set up to manage and maintain the buildings and grounds, including the maintenance of the SuDS. Residents pay a community Levy of £60 per year to help fund the maintenance, which is held in an account by the managing agents. Having a Community Interest Company can help increase the

[38] https://oppla.eu/casestudy/19135
[39] https://oppla.eu/casestudy/19153

transparency of where the community's money is going and gives the residents more control.

Another way to source additional funding for maintenance is to create a business out of the NBS, so that it becomes self-funding. Such opportunities could be using the area for educational events or conferences or growing and selling sustainable food. For example, Arnos Vale Cemetery is now a self-sustaining business gaining income through educational events and producing logs and charcoal. Gloucestershire Services have a farm shop and café within which they sell sustainable produce.

Example 5: Southmead Hospital – NBS for Health

The Brunel Building was designed to be highly sustainable, maximising natural daylight through orientation, as well as natural cooling and energy efficient heating. Sustainable urban drainage systems (SuDS) including 6 sedum green roofs and therapy gardens, were created to slow down rainwater runoff, which is collected from the roofs and used for ground maintenance and irrigation.

Health and well-being were also firmly in mind when designing the green infrastructure for this building. The herb garden on the roof of the building not only acts as a green space but also as a source of medicinal herbs that are used in cooking to benefit the patient's health. The 12 large therapy gardens and 6 garden courtyards are also used for physiotherapy and rehabilitation of patients

The site is maintained and managed to a high standard by the Private Finance Initiative (PFI) contractors Carillion and reviewed by the NBT who are creating a biodiversity management plan. The SuDS have reduced surface water runoff by almost 40% and water consumption by 25%, which has led to an annual saving of approximately £130,000.

Photo © Bristol NHS Trust. Find out more: http://oppla.eu/casestudy/19175

In order to ensure the long-term maintenance of NBS it is important to maintain partnerships after the development has been completed. It is also good to maintain relationships with local communities as they can be a willing resource for helping to maintain the NBS on their doorstep. A good way to ensure that the community looks after the NBS is to involve them in the design process from the start and give them some ownership of the project; if they have community allotments where they can plant and look after their own produce then they will maintain it themselves.

RIGHT DESIGN

It is very important to understand the local flora of an area when planting trees and shrubs and wildflowers. It is Important to plant native trees and plants and plants that are functional rather than just visually appealing. Southmead Hospital had problems with certain plant species on the green roofs, which survived well on the ground however did not survive well at higher altitudes. It is important to understand the biology and ecology of the plants that are being used so that they are planted in the appropriate environment. The Bath Quays Waterside Park planted specific plants that were known to survive flooding as the park also doubled up as a flood plain. In addition, NBS should source in sustainable materials e.g. using straw bricks or using old fishing nets to create tiles, and be mindful of the lifecycle impacts of its inputs. Materials should be re-used where possible from excavation.

6.3 Case study III

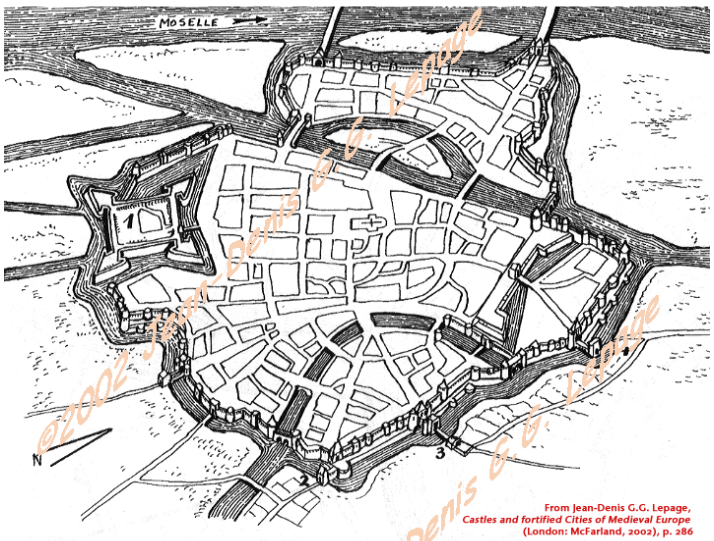
On the benefits of 'daylighting' rivers running through cities[40]

What preceded

Throughout history those human settlements that had the potential to grow into villages, towns and cities were situated on river banks, in estuaries or near the seacoast. Important prerequisites for growth were the availability of a reliable water supply and access to transport routes.

In a typical European town in the Middle Ages the streets would be very narrow, most people threw their rubbish out into the streets and an open sewer often ran down the middle of the street into a nearby river.

Fig. 1 Metz



From Jean-Denis G.G. Lepage, *Castles and fortified Cities of Medieval Europe* (London: McFarland, 2002), p. 286

Ground-plan, Metz (France). As early as 561 Metz was the capital of the Merovingian realm of Austrasia and an important bishopric. In the 12th century it became a free city within the German empire, and in the following centuries the municipality constructed a wall 6 km in perimeter with 38 towers, wet ditches and 18 gatehouses. In 1552, the king of France, Henri II, took Toul, Verdun and Metz from Charles V, emperor of Germany and king of Spain. The duke François de Guise reshaped the fortifications in 1552 and erected a bastioned citadel in 1560. The ground-plan shows the fortifications, the ducal citadel (1) and the main gates: the Mazelle gate (2), the Allemands gate (3) and the Sainte-Barbe gate (4).

[40] Prepared by the European Dredging Association (EuDA), Erik Mink, Rev.1 January 2019

When the population grew, and the town expanded, this situation became quickly untenable and hygiene needed to be improved. In many cases towns situated in lowlands would dig canals that cut through the city and provided a transport connection as well as an open sewer.

Fig 2. Lincoln, UK; the picture shows the current situation after clean-up of the water course.)

Fig 3. Amsterdam ca 1560.

The example of Amsterdam shows very clearly how the town grew and the number of canals grew as well.

Fig.4 Amsterdam ca 1760.

In the course of time many canals or smaller water courses that cut through towns or cities gradually became open sewers. The poor hygienic conditions started to be addressed some 200 years ago with the advent of the industrial revolution: as cities became more populated, the nearby rivers were also polluted with human and industrial waste, becoming sources of disease. At the same time the development of the railways meant that waterways were no longer the essential mode of transport they once were. The result was that all across Europe cities covered over their rivers, forcing them into culverts or tunnels below the metropolis. In the 19th century many water courses were thus out of sight and 'out of smell'.

With growing populations in cities there was a need for more drastic measures and in the late 19th century separate sewage culverts and conduits were constructed in many towns and cities.

In the 20th century the technology to treat sewage and waste water became available and was gradually introduced. This made it possible in principle to disconnect the stream of

sewerage from the open waters, culverts, canals etc. Nevertheless, in many cases sewage and rain water discharge was still combined and stormwater overflows containing sewage would occasionally discharge into covered streams or open water. Not surprisingly, the development of the necessary infrastructure put a heavy burden on public finances and it took many years to arrive at a more sustainable situation. Nevertheless, once such infrastructure works completed one should find the following situation: all sewage is separated from rain water and flows via the sewer system to treatment plants; from here the discharge water can be recirculated or discharged onto open water. Interconnections between sewer and water courses have been removed. The other water bodies: rivers, streams, canals, covered water courses, have all been returned to reasonable or good quality and do no longer spread bad smells and disagreeable odours.

Nevertheless, this new situation is not perfect either, because water flowing through culverts is of poorer quality.

Problems associated with existing culverting can include:

- "Increasing upstream flood risk due to blockages (of culverts or screens) by waterborne debris and/or constricted flood flows in the culvert itself.
- Increased downstream flood risk flows due to shortened response times and reduced flood retention in artificial channels, compared with natural watercourse floodplains.
- Reduced ecological value within concrete channels and with reduced light.
- Loss of and adverse effects on environmental features and wildlife habitat including disruption of the linear habitat of a watercourse, stopping species from spreading naturally.
- Increased concerns in relation to maintenance and health and safety both for drainage operatives and unauthorised trespassers due to poor access.
- Detrimental effects on passage for recreational users – whether on foot or waterborne. "

CIWEM 2007

What can be done?

Towards the end of the 20th century, further hygienic improvements are called for. It becomes often possible - and it is certainly advisable - to re-open the water courses that had been covered up/culverted inside cities and towns.

- The culverts running through towns and cities were built for practical reasons to deal with hygiene concerns. Once that problem has been resolved it becomes apparent that culverts have also significant disadvantages: Water that flows through culverts does not induce natural ecology; there are no water plants growing in the dark, fish or other aquatic life cannot sustain in this environment, oxygen content is poor.
- Culverts constrain the flow of water; in case of heavy rainfall or excess water, the water discharge capacity is insufficient, and the water will force a way out, either by flooding the streets or by destroying the infrastructure.

In view of these observations many initiatives have already been taken to open up covered waterways and existing culverts (ref. Wild et al 2011). The term commonly in use for this activity is “daylighting”. In urban design and urban planning, daylighting is the redirection of a stream into an above-ground channel. Typically, the goal is to return a stream of water to a more natural state. Daylighting is intended to improve the environment and ecology of a stream which had been previously diverted into a culvert, pipe, or a drainage system. In the UK, the practice is also known as de-culverting. The website www.daylighting.org.uk has collected a host of example projects and has as ambition to maintain a database that includes as many practical case histories as possible. In the section with examples we use some data provided by this website.

Creating, or re-creating where possible, open water courses in cities provides significant benefits; this is truly a nature-based solution:

- Water quality will be enhanced as aquatic life returns. There may be place for fish, crustaceans, water plants, amphibious life etc. (sustainable water management).
- On the berms and shores of the stream or canal, walking paths or parkland can be created that results in a pleasant environment to the population (aesthetic quality improved).
- Where space is available, a sort of flood plain can be created inside the city, which will serve to accommodate extreme water levels in case of heavy precipitation (flood protection). The open water can accommodate storm water surges if necessary.

- Open water courses in cities will have a beneficial effect on city climate and have the potential to lower the temperature of heat islands in cities by several degrees (sustainable city climate, anticipate climate change).

"Many culverted watercourses have been restored, encouraging access, improving the local quality of life and attracting opportunities for regeneration. Specific benefits include:

- Providing valuable wetland / aquatic habitat, aiding fish passage and significantly adding to the visual attractions of an area.
- Restoring historic canals for amenity or for navigation by powered and unpowered boats.
- Enhancing ecological quality of the water body.
- Complementing other urban regeneration initiatives and bringing commercial benefits such as enhanced image for properties and up to 20% increase in land values or rents.
- Reducing maintenance and construction costs by using natural bio-engineering techniques rather than concrete constructions.
- Reducing flood risk and creating balancing ponds to help reduce flooding downstream.

CIWEM 2007

Some examples

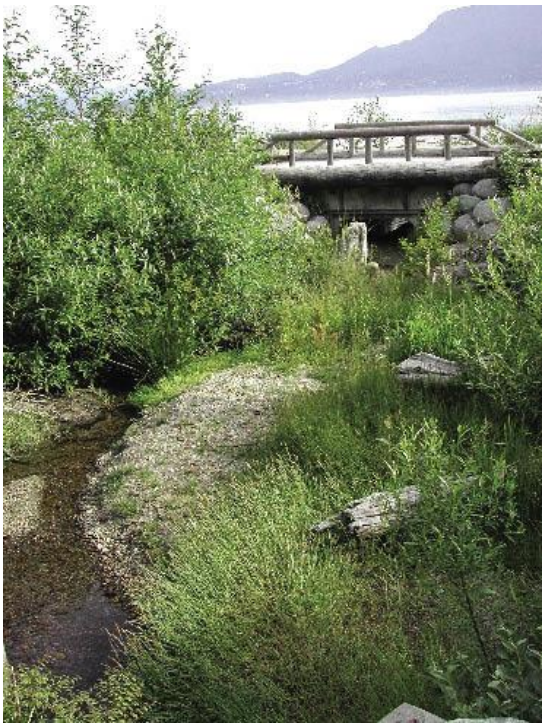
LONDON AREA

Several tributaries of the Thames river basin pass through the Greater London area. Some of these have been culverted since a long time and cannot be recovered (ex. Fleet Street is built over the Fleet river). In recent years a stretch of the Lea river, near the site where the Olympic games were held, has been daylighted over a distance of more than 500m. and provides again access for barges to and from the Thames.

Another example is the Quaggy river at Sutcliffe south of the Thames. A stretch of river had been covered for more than 50 years. Here as well 500 m of river have been daylighted and an urban park has been developed in 2003. The park serves at the same time as an area to alleviate flooding and now protects some 600 homes from being inundated.

VANCOUVER CA

Located upstream from Spanish Banks waterfront, one of the highest profile creeks in Vancouver Metro became open to salmon in 2000. In a collaborative project between Spanish Banks Streamkeepers Association and the Department of Fisheries and Oceans Canada, barriers to fish passage were removed and habitat structure was added. Spanish Banks Creek was previously diverted through a culvert underneath a parking lot, but the lower reaches of this creek have been revitalized. The culvert was removed in 1999. The banks were stabilized with riprap, large woody debris was added for habitat cover, and spawning gravels were added in appropriate areas.



Daylighted Stream at Spanish Banks, Vancouver, B.C.

SEATTLE

Pipers is among the largest streams in urban Seattle. Pipers Creek drains a 7 km2 watershed into Puget Sound. The headwaters begin in the north Greenwood neighbourhood.

Years of hard work by neighbours and volunteers have brought salmon back to Pipers Creek, Venema, and Mohlendorph creeks in the mid-2000s after there were none for 50 years. The project was completed in 2005 and included removing a stretch of culvert.

The creek waters are pretty in their impressively restored settings. Along with steeply higher flow volume during storm runoff and the resulting turbidity, water quality is still the remaining big issue in restoring salmon.

The north fork of Pipers Creek is the site for the 110th Cascades, an S.E.A. (Street Edge Alternatives) street demonstration project. The 110th Cascades are a creek-like cascade of stair-stepped natural, seasonal pools that intercept, infiltrate, slow and filter over 85,000 m2 of stormwater draining through the project. The cascades are a part of a Natural Drainage Systems project. The rehabilitation project united the community to support the effort and resulted in environmental and socially benefits.

YONKERS, NY STATE

In Yonkers, the ongoing efforts to daylight the Saw Mill River have already radically altered the city's physical landscape, and more change is still to come. The first major phase of this project was completed in 2012, opening up an airy new park in the heart of the city. A decades-old parking lot was destroyed and thus daylighted the river over a stretch of 250 m. Flocks of ducks and schoolchildren gather again along the banks of this swiftly flowing stream, where hundreds of different species now live.

SEOUL

One of the largest and most impressive examples of daylighting is the Cheonggyecheon in Seoul, South Korea. Some 6 kilometres of river were created through the city centre, with fountains and paddling areas in the artificial end, and open wildlife space in the more natural downstream end. Although the project was costly, it enhanced the economic, social and environmental conditions of the city and is highly appreciated.

Barriers and Benefits

From the above introduction and examples, it is apparent that daylighting of culverted streams or water bodies in cities is an interesting option to realize nature-based projects in an urban environment. There may be economic and other constraints. In summary:

Barriers/constraints to 'daylighting'

Ecological

- There is a prior need to separate sewage water and rain water.
- There is a need for adequate sewage treatment capacity.

Economic

- These infrastructure projects often entail high direct costs.
- They may also imply high indirect costs: property and real estate may have to be disowned.

Social/political

- Local authorities lack vision.
- Local authorities lack finances.
- May require public/private cooperation.
- May need support from civil society NGO's.

Benefits/drivers of 'daylighting'

Ecological

- Restoring quality of water body
- Enhancing ecological quality (biodiversity, fish, birds, plants,…)
- Reducing local temperature (combat city heat islands)
- Mitigate flooding risks

Economic

- Reduce costs of water treatment
- Increase value of near-by real estate property
- Stimulus for tourism

Social

- Create pleasant environment (aesthetic)
- Create pleasant local climate and space for recreation

And more indirectly:

- Authorities need to take measures to meet the goals of the EU Water Framework directive. For heavily modified water bodies (culverted streams) the goal of good ecological potential needs to be reached. Without de-culverting measures this may be difficult to achieve.
- Equally measures need to be taken to respond to the EU Flooding directive.
- Daylighting may provide an opportunity to provide some wetland space inside the urban environment.
- Both wetlands and healthy water bodies provide natural water 'treatment'.

References

T.C. Wild et al. – 'Deculverting: reviewing the evidence on the "daylighting" and restoration of culverted rivers.' – Water and Environment Journal vol. 25 (no.3) (2011).

The Chartered Institute of Water and Environmental Management (CIWEM) - Policy Statement on De-culverting (2007).

www.daylighting.org.uk

Annex 1

The methodological framework

NBS BARRIER LANDSCAPE ASSESSMENT

Methodological Framework

Authors: Adriana Bernardi (CNR-ISAC), Silvia Enzi (CNR-ISAC),, Marja Mesimäki (UoH), Susanna Lehvävirta (UoH), Frédéric Lemaitre (Oppla), Jonathan Porter (Oppla)

July 2017

1 Background

Barriers and solutions to the implementation of NBS: a summary from scientific literature

During recent years, it has been demonstrated that Nature-Based Solutions (NBS) can provide a significant role in decreasing the effects of climate change and improving resilience and wellbeing in cities and the rural environment. Despite this, NBS are still not as widespread as they could be. This propagation delay, more marked in some European regions, is due to different causes, revealed, e.g. by scientific literature concerning barriers for green infrastructure, or specific solutions, such as green roofs, not explicitly mentioning NBS but still falling under this concept. Only few studies exist concentrating explicitly on barriers for NBS.

Eggermont (2015) identifies the three different types of NBS, ranging from the less intrusive, i.e. focused on the simple maintenance of the existing ecosystems, to the most intrusive, i.e. creating new ecosystems. Eggermont's approach to the NBS is both ethical, defining them as essentially anthropocentric, and practical: they can present opportunities but also some risk (e.g. disrespect of biogeography). The challenge is to fuse the specific knowledge of the different experts and avoid considering NBS as "the one and the only", solution, embedding them in a "wider, coherent strategy at research and policy level" and linking to other ecosystem-based approaches such as green infrastructure and natural flood management.

The novelty of NBS is the main barrier. Under this umbrella, can be placed the "fear of unknown", emphasized by Kabisch et al. (2016) and consisting in the uncertainties, risks and possible negative changes of implementing NBS, and in the fear of new handling and protocols they require. This obstacle is linked with another barrier identified in literature, i.e. the lack of the assessment of their effectiveness according to the expected aims (Kabisch et al., 2016; Hendricks & Calkins, 2006). Even if several positive case studies exist as example, a sound methodology, common to the different actors engaged in evaluating the NBS's effectiveness, has still not been developed. Nature-based solutions are characterized by a multifaceted approach in their implementation, and a comprehensive set of indicators aimed at the global evaluation of their effects, especially in the longer run, is lacking. This lack of specific metrics furthermore hampers the mainstreaming of NBS (Xing, 2017). Although NBS definition expresses a positive concept, the possible challenges linked to their design processes in framing of nature and social impact are not still completely explored and leave some uncertainty, in different fields (Nesshöver, 2016).

In this direction, in the EU Framework Program 'Horizon 2020', the EKLIPSE project produced a report (Raymond et al. 2017) intended to be used to guide an assessment of the effectiveness of NBS projects. The report describes some success factors and limiting factors and elucidates them with case examples, and furthermore, establishes a common basis on NBS effectiveness indicators in the different fields involved (physical, economic, environmental, socio-cultural etc.)

Another strong barrier has been identified in policy. This aspect involves two main difficulties: the disconnection between short-term actions and long-term goals, and changes in administration. The requirements of NBS projects for funding, maintenance and monitoring work over longer timescales. The other difficulty concerns the so-called sectorial silos: administrative departments have their own sectorial language; the multifaceted implementation and benefits of NBS often do not fit into existing decision-making structures, and so the sectorial organization of public services is an obstacle to a cross-sectorial planning for NBS. Also, interactions set with "strong stakeholders" (e.g. housing associations, investors) can affect or impede the realisation of NBS. (Kabisch et al., 2016; Lindholm 2017).

The concept of "silos" can be applied also to the language, where a common terminology among the actors of NBS implementation is missing, leading to problems in a clear dialogue and communication. Communication is still quite lacking also in the field of dissemination of NBS examples and performances, both targeted to the directly involved actors (policy makers, urban planners, architects, market actors etc), and to wider society.

Linked to the policy barriers, another obstacle has been identified in the conflict between public and private management of the territory and with economic interests, and more generally, in the connection between NBS and the market economy (Lindholm, 2017).

Cities grow also during periods of population decline: it is the so-called market-guided growth, oriented to use the land for building offices, shops, and other activities creating jobs and attracting investments. For the market, built development is more attractive than urban green spaces, expensive especially in terms of maintenance costs and staff for it. EU funding instruments are complicated to apply (additional administrative staff and time), and requiring co-financing, that not all the cities can afford (Kabisch et al., 2016).

Lastly, there are barriers in the technological and scientific fields; they are represented by the lack of information on new construction products, of training on products, materials,

installation and maintenance techniques and by underdeveloped links between research and market actors (Hendricks & Calkins, 2006).

Some possible improvements and/or solutions to these obstacles have been identified. With regard to the novelty barriers, the solutions consist in highlighting as much as possible good practice case studies and improving existing projects (Kabisch et al., 2016); enhancing the potential adopters' access to information on the innovation; and creating "technology advocates", i.e. persons promoting the use of NBS, such as architects, construction managers or company owners. (Hendricks & Calkins, 2006). Xing (2017) suggests carrying out post-construction evaluation in order to maximise the benefits and to minimise repeated mistakes, developing standardized tests and procedures for in situ monitoring and circulating the results as widely as possible.

The barriers due to the present most common policy assessments could be overcome through a collaborative governance approach, linking government, policy officers, citizens, business, civil society, NGOs, to connect demands with actions and distribute responsibilities; provide economic incentives; remove administrative barriers among the actors, public and private (Kabisch et al., 2016); and use a participatory urban planning and design approaches, enhanced by a clear and transparent communication of potential actions. Following (Hendricks & Calkins, 2006), the green policy initiatives should be: regulatory legislation and incentives targeted at developers and building owners (e.g.: low-interest loans, design and installation grants, tax and fee rebates and expedited permit approval processes). Lindholm (2017) points out that motivation is more efficient than regulation.

To overcome the obstacles due to the economic aspects, a solution is indicated in creating conditions for a new business and finance model that disinvests in grey infrastructures and strengthens NBS (Kabisch et al., 2016).

Finally, regarding the technological/scientific barriers, an enhanced dialogue among the different actors is suggested, valorizing and exploiting existing tacit knowledge of different categories (policy makers, urban planners, citizens, material producers, researchers etc.) (Kabisch et al., 2016).

References

- Eggermont, H et al., 2015: Nature Based Solutions: new influence for environmental management and research in Europe. GAIA 24/4, 243-248.
- Hendricks, J.S. and Calkins, M., 2006: The adoption of an innovation: barriers to use of green roofs experienced by Midwest architects and building owners. Journal of Green Building, 1(3), 148-168.
- Kabisch, N. et al., 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, 21(2):39. https://www.ecologyandsociety.org/vol21/iss2/art39
- Lindholm, G., 2017: The implementation of Green Infrastructure: relating a general concept to context and site. Sustainability, 9(4), 610. http://www.mdpi.com/2071-1050/9/4/610
- Nesshöver, C. et al. 2016. The science, policy and practice of nature□based solutions: An interdisciplinary perspective. Sci. Total Environ. doi:10.1016/j.scitotenv.2016.11.106
- 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.
- Xing, Y. et al., 2017: Characterization of Nature-Based Solutions for the built environment. Sustainability, 9(1), 149. http://www.mdpi.com/2071-1050/9/1/149

2 Aims and scope of the framework

- To connect the work packages and tasks of WPs 3-6 to a coherent whole
- To connect the survey and interviews with
    - the actions concerning stakeholders, Think & Do Tanks, Local Representatives, and ThinkNature-events (WP4)
    - gathering cases for best practices, useful models and success stories (WPs 3 and 6)
    - gathering a database of influential, motivated people and organizations (’power-nodes’) working with NBS, to join TN-platform
- To form a logical, cumulative, solution-oriented process of
    - gathering relevant information from local level of barriers and drivers concerning NBS,
    - refining and processing the knowledge with relevant stakeholders/experts, and
    - producing a solid evidence-based toolbox to be used, e.g. in EU-and local-level decision-making for proliferating NBS
- To reveal tacit local knowledge to be further thematized using an analytical framework (instead of given categories of barriers etc. ready), i.e. conduct an inductive process moving from specific observations to broader generalizations (See Fig. 1).

3 Materials and methods

3.1 Survey

- Aim: to produce a semi-quantitative dataset of local (tacit) knowledge of
    - Drivers for using NBS in local level
    - Aims of the local NBS-projects
      → reveals targeted benefits (e.g. promote health & well-being, reduce pollution, achieve energy savings, enhance biodiversity, support stormwater management, mitigate urban heat island effect …)
    - Barriers for specific NBS
    - Tools to overcome the barriers -> solutions
    - 'Power-nodes' to be invited to the platform
    - Cases (for the platform & database)
- Participants and channels for contacting:
    - ThinkNature stakeholder-list (about 500 contacts)
    - Think & Do Tanks and Local Representatives (about 100 contacts)
    - ThinkNature and Oppla websites
    - NBS demonstration projects
    - Websites & other channels of stakeholder organizations
    - EU-channels, current and former EU-projects, officers
    - Targeted minimum amount of responses: 100
    - Criteria for representativeness: covering all regions, and the different stakeholder categories, e.g. in the ThinkNature stakeholder list.
- Methods for data gathering:
    - purposive sampling[41]

[41] a sampling technique in which researcher relies on his or her own judgment when choosing members of population to participate in the study, see e.g. http://research-methodology.net/sampling-in-primary-data-collection/purposive-sampling/

- semi-structured survey (in English): closed- and open-ended questions

- Research questions:
  - Why to use NBS? -> What are the motivations and drivers for NBS?
  - What is aimed by the NBS -> What are the expected benefits of NBS?
  - Why NBS are not realized? -> What are the barriers for implementing NBS?
  - How to realize successful NBS? -> What are the tools to overcome the barriers?
  - What are the components of successful NBS-projects -> What kinds of best practice -cases, success stories etc. there are?
  - Who is able to effect/who has the power? -> What are the 'power nodes' (influential persons, organizations etc.) who can have effect on realizing NBS and overcoming barriers?
- Methods for analysis
  - Consistent framework for the analysis for the whole dataset
  - Detailed categorization of the information gathered by the survey: data-driven analysis.
  - Reflect results to the pre-defined barrier-categories ('analytical framework': technical, political and legislative, financial and market, communication) + recognize other possible categories
  - Recognize and categorize also drivers etc. Other information, to maximize the impact of the survey

3.2 Expert interviews

- Aim: deepen the ‘big picture’ recognized by the survey, fill in remaining knowledge gaps
- Participants:
  - Think & Do Tanks and Local Representatives (about 100 contacts)
  - ‘Power nodes’ (i.e. influential persons identified by the survey)
- Methods:
  - semi-structured interviews (same structure for all regions): group- and individual -> group interviews can be arranged as meetings of local Think & Do Tanks (instructed by WP5 questionnaire team)
  - the results of the survey guide the structure of the interviews (i.e. form the basis for the questions to be asked)
  - also information from TN-cases (see E2ARC Case Study template: successes and limitations) should be gathered and analyzed together with the results
- Research questions:
  - Are there gaps (holes, black boxes) in the barrier landscape constructed by the survey?
  - Do local experts possess tacit knowledge that would be useful to deepen the picture?
- Methods for analysis
  - same framework/instructions for the analysis for each region
  - thematic (qualitative) categorization (broad themes of interest)

3.3 Workshops (event)

- aim: concretize gathered knowledge to solutions & produce evidence-based tools for decision-making (to be added in the TN-platform) – e.g. if a municipal strategy is identified as a strong tool to overcome barriers for building-integrated vegetation, models and principles for such strategies are designed in the workshops
- Participants:
    - TN-stakeholders and TN-platform-community

- methods:
    - various co-design and futures workshops methods may be utilized (allowing also on-line participation), e.g. producing (regional, local) scenarios for the future NBS proliferation → tools to overcome the barriers, solutions for successful NBS -> compiling the knowledge-base/toolbox for decision-making (with related cases, best practices etc. lessons learnt from the local actors)

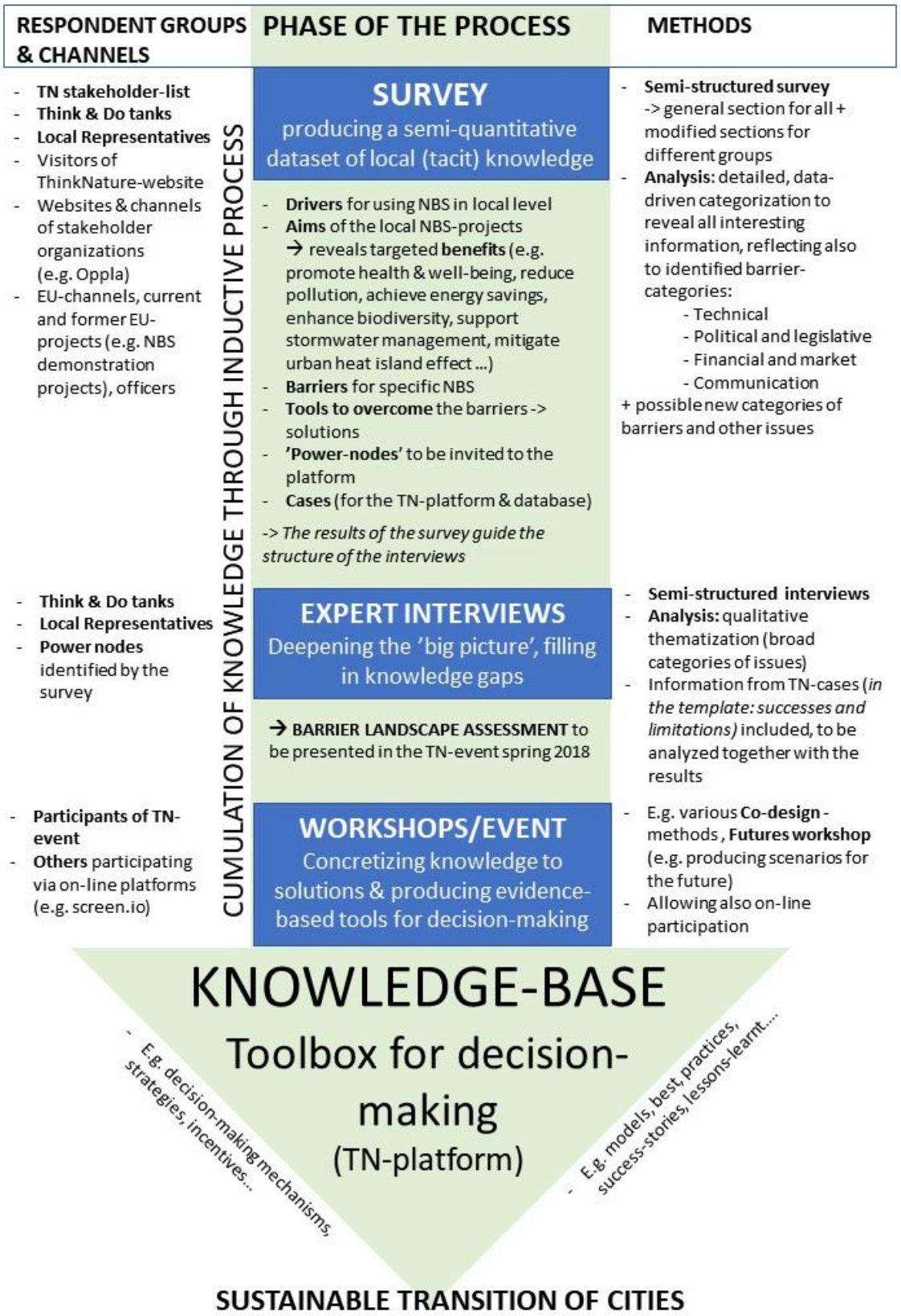
- Research questions:
    - How is the created barrier landscape understood at the local level?
    - What kinds of local solutions and tools are there for the identified barriers?

4 Limitations

- How do the practitioners identify NBS, compared to, e.g. green infrastructure in general, or green spaces and other 'common language' terms for NBS?
    - Use a list of examples, together with some comprehensive background information, e.g. EU-definition, shared typology from Eggermont et. al (2015) and EKLIPSE-report for the lists of potential actions for each identified challenge[42]
- There is already quite a lot of knowledge of barriers in general (even they are not called NBS) -> what is the crucial knowledge that is missing, to achieve a comprehensive understanding of NBS barriers?
- Barriers are contextual, i.e. a barrier can also be a driver in a certain context, and vice versa (e.g. standards, norms) -> how to produce general guidance from local cases – 'level of abstraction'? -> importance of getting contextual information (e.g. inquiring not only barriers but also drivers and motivation)
- Language: we can only reach people with a sufficient knowledge of English: conducting the survey in local languages (and translating the responses back to English) would be a major task -> not enough time.

[42] http://www.eklipse-mechanism.eu/apps/Eklipse_data/website/EKLIPSE_Report1-NBS_FINAL_Complete-08022017_LowRes_4Web.pdf

Figure 1. Process of the barrier landscape assessment



Annex 2

The questionnaire

BARRIERS AND DRIVERS FOR IMPLEMENTING NATURE-BASED SOLUTIONS IN CITIES

a survey for experts

INTRODUCTION

Nature-based solutions (NBS) use nature to create sustainability and resilience, adapt to climate change, and counteract the degradation of ecosystems. Such solutions should, bring more diverse nature and natural processes into cities, landscapes and seascapes. They are meant to support economic growth, create jobs, enhance human well-being, and be locally adapted and resource-efficient. Source: The EU Research and Innovation policy agenda on NBS.

This survey is part of the EU-funded project ThinkNature (https://www.think-nature.eu/), that aims to support the proliferation of sustainable NBS. This survey is important because it will help identify barriers that hinder the implementation of NBS, as well as possible solutions to overcome the barriers.

Participating in this survey is voluntary. The questionnaire should take approximately 20–30 minutes to answer. However, it may take even longer, depending on how detailed answers you choose to give. It includes multiple choice and free text questions. To be able to gain meaningful results, we kindly ask you to fill in the questionnaire as completely as possible. However, you can quit the questionnaire at any point, or fill in only parts of it. The decision to participate, decline or withdraw will have no effect on your relations with the ThinkNature project participants.

The outcome of the questionnaire will be published on the ThinkNature website but individual responses will remain anonymous. All responses will be treated with confidentiality and reported only in aggregate form. All the information that you provide will be used only for the purpose of developing knowledge and policies to support NBS, and for scientific studies.

By participating this survey, you will promote the development of cities towards sustainable use of NBS!

(This question is mandatory)

Have you worked with Nature-Based Solutions ⓘ, or closely followed planning or implementations of them?

Choose one of the following answers

- ○ Yes
- ○ No

YES SECTION

Please think of NBS-projects you have worked with, or closely followed the planning or implementation of them.
Please think of projects that were successfully implemented or that failed to reach their targets.

We are interested in all kinds of projects that exemplify problems, bottlenecks, as well as efficient ways to move forward in the implementations of different kinds of NBS.
Please select at least one answer

	Succesfully implemented	Failed to reach the targets	No answer
Green infrastructure, e.g.			
Green roofs or roof gardens	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Green walls or green facades	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Green corridors	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Street plants and trees	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Parks	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Rain gardens, vegetated ditches	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Urban farms, allotments or community gardens	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Private gardens	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Urban/peri-urban forests or woodlands	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Restoration of industrial sites	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Blue Infrastructure, e.g.			
Blue corridors	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Rivers or streams	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Use of balancing ponds and underground storage systems	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Sustainable Urban Drainage Systems	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Buffers, e.g.			
River bank restoration	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Floodplain restoration	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Coastal habitat restoration/maintenance	○ Succesfully implemented	○ Failed to reach the targets	● No answer

	Succesfully implemented	Failed to reach the targets	No answer
Wetlands	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Technical approaches and materials in support of NBS, e.g.			
Infiltration trenches	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Permeable pavements	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Bio-waste based growing materials	○ Succesfully implemented	○ Failed to reach the targets	● No answer
Waste effluent management through e.g. biodegradation and bioconversion	○ Succesfully implemented	○ Failed to reach the targets	● No answer

Other (please specify):

Below, you see the list of NBS you chose.

Please choose maximum two NBS-projects that, in your opinion, best exemplify the barriers and/or drivers for implementing these NBS.

Of these NBS, we will next ask you more detailed information.

Please select from 1 to 2 answers.

	Successfully implemented	Failed to reach the targets	No answer
Green roofs or roof gardens	○ Successfully implemented	○ Failed to reach the targets	◉ No answer
Green walls or green facades	○ Successfully implemented	○ Failed to reach the targets	◉ No answer

Next, we ask you about drivers ⓘ that could support the realization of this NBS and reaching the targets,and drivers that hindered the realization of this NBS.
Please answer those questions you think are relevant for

(Chosen example of NBS, failed or successful)

Please fill in at least one answer

Check all that apply
Please select at least one answer

- ☐ Technical drivers ⓘ
- ☐ Policy drivers ⓘ
- ☐ Market drivers ⓘ
- ☐ Communication drivers ⓘ
- ☐ Knowledge drivers ⓘ
- ☐ Process and tradition-based drivers ⓘ
- ☐ I do not know
- ☐ I think there are no drivers for this NBS
- ☐ Other:

Technical drivers ⓘ

- Please describe what drivers exactly could there be for this NBS. Please be concrete about the things and actors that may support the proliferation of this NBS.
- In what way exactly could these drivers support the implementation of this NBS? Please describe a concretely as possible.
- How could effective drivers be created? What exactly should be done to offer the drivers?
- Which key organisation(s) could push forward such drivers? Please provide contact details if available. ⓘ

Policy drivers ⓘ

Market drivers ⓘ

Communication drivers ⓘ

Knowledge drivers ⓘ

Process and tradition-based drivers ⓘ

Other, please specify:

In all these sections, the questions are the same as in the first one (Technical drivers)

Next, we ask about barriers that hindered the realization of this NBS, or hindered reaching the targets set for it, and possible ways to remove or alleviate the barriers.

Please answer those questions you think are relevant for

(Chosen example of NBS, failed or successful)

In your opinion, do the following categories of barriers affect the implementation of this NBS?
Check all that apply
Please select at least one answer

- ☐ Technical Barriers ⓘ
- ☐ Policy Barriers ⓘ
- ☐ Market Barriers ⓘ
- ☐ Communication Barriers ⓘ
- ☐ Knowledge Barriers ⓘ
- ☐ Process and tradition-based Barriers ⓘ
- ☐ I do not know
- ☐ I think there are no barriers for this NBS
- ☐ Other:

Technical Barriers ⓘ

- Please describe what barriers exactly could there be for this NBS. Please be concrete about the things and actors that may hamper the proliferation of this NBS.
- In what way exactly could these barriers hamper the implementation of this NBS? Please describe as concretely as possible.
- How could the barriers be removed? What exactly should be done to eliminate or alleviate the barriers?
- Which key organisation(s) could remove these barriers? Please provide contact details if available. ⓘ

Policy drivers ⓘ

Market drivers ⓘ

Communication drivers ⓘ

Knowledge drivers ⓘ

Process and tradition-based drivers ⓘ

Other, please specify:

In all these sections, the questions are the same as in the first one (Technical drivers)

In what size of a city/town did the planning or implementation of this NBS happen?

(Chosen example of NBS, failed or successful)

Size (approximate number of residents)

Choose one of the following answers

In what country did the planning or implementation of this NBS happen?

Choose one of the following answers

Other:

We are also interested in your views and opinions concerning future NBS, and your thoughts of how they could be promoted.

Please freely write down your thoughts with up to 500 words.

NO SECTION

What kinds of NBS do you consider important in cities, now or in the future?

Even if you have not worked with NBS, we are still interested in your opinion. Please think of NBS that could be related (even distantly) to your expertise.

Blue Infrastructure, e.g.
Check all that apply

- ☐ Blue corridors
- ☐ Rivers or streams
- ☐ Use of balancing ponds and underground storage systems
- ☐ Sustainable Urban Drainage Systems

Green infrastructure, e.g
Check all that apply

- ☐ Green roofs or roof gardens
- ☐ Green walls or green facades
- ☐ Green corridors
- ☐ Street plants and trees
- ☐ Parks
- ☐ Rain gardens, vegetated ditches
- ☐ Urban farms, allotments or community gardens
- ☐ Private gardens
- ☐ Urban/peri-urban forests or woodlands
- ☐ Restoration of industrial sites

Buffers, e.g.
Check all that apply

- ☐ River bank restoration
- ☐ Floodplain restoration
- ☐ Coastal habitat restoration/maintenance
- ☐ Wetlands

Technical approaches and materials in support of NBS, e.g.
Check all that apply

- ☐ Infiltration trenches
- ☐ Permeable pavements
- ☐ Bio-waste based growing materials
- ☐ Waste effluent management through e.g. biodegradation and bioconversion

Other (please specify)

Below, you see the list of NBS you chose.

Please choose *maximum two of them* that you consider most important for cities in the near future.

Of these NBS, we will next ask you more detailed information

Here, all the questions follow the same structure then in the "YES" section about drivers and barriers.

Annex 3

Selected literature for the scope of D5.1

Searches were conducted with search terms, such as ("nature based solution*" OR "nature-based solution*") AND (barrier* OR driver*) in Scopus Database and Web of Science in January 2019.

After evaluating the relevance, following papers were selected to highlight the state of art of scientific literature, and evidence-base concerning the scope of D5.1.

Ovando, P., Brouwer, R. 2019. **Review of economic approaches modeling the complex interactions between forest management and watershed services.** Forest Policy and Economics 100, 164-176. https://doi.org/10.1016/j.forpol.2018.12.007

Abstract

This paper provides a comprehensive review of two decades of published research that applies different economic approaches to address forested watershed management decisions. The review takes stock of the applied integrated economic and ecohydrological modeling approaches and assesses the way these approaches capture the complexities involved when linking ecohydrological and economic systems. The implications of integrating watershed services into forest management decisions are discussed, lessons are drawn from existing approaches and future research needs identified. Existing modeling approaches are categorized from independent modular models with a unidirectional flow of information to fully coupled holistic models, and are analyzed, among others, in terms of the efficiency improvement that forest-based investments achieve in watershed services provision. The review shows that the number of studies investigating the relationship between forest management and watershed services in economic decision-support models is very limited. Only 14 studies that were identified examine these relationships for water supply, while 9 studies were found to focus on the impact on water quality, 2 of which addressed water quality in combination with water supply. A shortcoming is that about half of the studies do not clearly specify baseline conditions to test the incremental value of the evaluated forest management actions in terms of watershed services provision, which undermines evaluating their cost-effectiveness or economic efficiency. A promising finding is nevertheless that in 8 of the 10 studies where these relationships were evaluated in terms of their costs and benefits compared to a specified baseline alternative, forest conservation or forest management is shown to be an economically efficient nature-based solution to supply the watershed services of interest. The limited availability of geo-referenced data and information, including the often complex and confidential nature of cost and price data,

and the high data demands of more advanced spatial econometric models are among the main barriers to address relevant forest and water economic interactions. Important future extensions of existing integrated approaches include the further coupling of more detailed ecohydrological models and multi-sectoral hydro-economic models that are able to account for the different risks (floods, droughts, wildfires) and uncertainties under climate change and their impact on watershed services and water security.

Albert C., Schröter, B., Hasse, D., Brillinger, M., Henze, J., Herrmann, S., Gottwald, S., Guerrero, P., Nicolas, C., Matzdorf, B. 2019. **Addressing societal challenges through nature-based solutions: How can landscape planning and governance research contribute?** Landscape and Urban Planning 182, 12–21; doi.org/10.1016/j.landurbplan.2018.10.003

Abstract

Nature-based solutions (NBS) in river landscapes, such as restoring floodplains, can not only decrease flood risks for downstream communities but also provide co-benefits in terms of habitat creation for numerous species and enhanced delivery of diverse ecosystem services. This paper aims to explore how landscape planning and governance research can contribute to the identification, design and implementation of NBS, using the example of water-related challenges in the landscape of the Lahn river in Germany. The objectives are (i) to introduce the NBS concept and to provide a concise definition for application in planning research, (ii) to explore how landscape planning and governance research might support a targeted use and implementation of NBS, and (iii) to propose an agenda for further research and practical experimentation. Our methods include a focused literature review and conceptual framework development. We define NBS as actions that alleviate a well-defined societal challenge (challenge-orientation), employ ecosystem processes of spatial, blue and green infrastructure networks (ecosystem processes utilization), and are embedded within viable governance or business models for implementation (practical viability). Our conceptual framework illustrates the functions of NBS in social-ecological landscape systems and highlights the complementary contributions of landscape planning and governance research in developing and implementing NBS. Finally, a research and experimentation agenda is proposed, focusing on knowledge gaps in the effectiveness of NBS, useful approaches for informed co-design of NBS, and options for implementation. Insights from this paper can guide further studies and support testing of the NBS concept in practice.

Artmann, M. and Katharina Sartison K., 2018. **The Role of Urban Agriculture as a Nature-Based Solution: A Review for Developing a Systemic Assessment Framework.** Sustainability 2018, 10, 1937; doi:10.3390/su10061937

Abstract

Urbanization and achieving sustainable agriculture are both major societal challenges. By reducing food miles and connecting people with nature, food cultivation in cities has several major advantages. However, due to further urban development (peri-) urban agriculture (UPA) is under threat. To strengthen UPA, we argue for considering UPA as a nature-based solution (NbS) supporting systemic approaches for societal challenges. However, academic knowledge on UPA's contribution to various societal challenges of urbanization is still fragmented. This study addresses the gap by conducting a systemic literature review, incorporating 166 academic articles focusing on the global north. The results of the review show that UPA contributes to ten key societal challenges of urbanization: climate change, food security, biodiversity and ecosystem services, agricultural intensification, resource efficiency, urban renewal and regeneration, land management, public health, social cohesion, and economic growth. The value of UPA is its multifunctionality in providing social, economic and environmental co-benefits and ecosystem services. When implementing UPA, social, institutional, economic, technical, geographical, and ecological drivers and constraints need to be considered. To upscale UPA successfully, the study develops an integrative assessment framework for evaluating the implementation and impact efficiency of UPA. This framework should be tested based on the example of edible cities.

Badiu, D.L., Onose D. A., Niță, M.R., Lafortezza, R. 2018. **From "red" to green? A look into the evolution of green spaces in a post socialist city.** Landscape and Urban Planning; doi.org/10.1016/j.landurbplan.2018.07.015

Abstract

Promoting green infrastructure and other nature-based solutions in urban environments is considered an effective approach to achieve resilience and meet sustainability goals. Countries with a post-Socialist History are still struggling to increase the amount of green spaces in cities. Bucharest is an example of a city that has undergone considerable transformation during the Socialist period (1948–1990) and after. Back then the drivers of urban transformation were mainly related to public land management, whereas after the fall of the Socialist regime private development prevailed. Our study aims to analyze the shift in the amount and distribution of green spaces in Bucharest as a consequence of the transition from a centralized planning system to a market-based system. We used historical maps and aerial images to determine spatial-temporal changes in the structure of Bucharest's urban parks and their surrounding areas. To determine the influence of planning approaches on green spaces, we analyzed the legislative framework from the Socialist period (labeled as "red") and post-Socialist period. Our results showed that the fall of the

Socialist regime are presented an important institutional change affecting urban greens paces. There was a major increase in the surface and number of green spaces during the Socialist period and a decrease afterwards as a consequence of a weak legislative framework, restitution of land sand owner ship conflicts. Our findings provide valuable knowledge on the evolutionary urban processes and sustainability approaches of the post-Socialist period in Romania and important insights for improving planning efforts and maximizing ecosystem services in cities.

Bellamy, C.C., van der Jagta, A.P.N., Barboura, S., Smith, M., Moseley, D. 2017**. A spatial framework for targeting urban planning for pollinators and people with local stakeholders: A route to healthy, blossoming communities?** Environmental Research 158, 255–268. http://dx.doi.org/10.1016/j.envres.2017.06.023

Abstract

Pollinators such as bees and hoverflies are essential components of an urban ecosystem, supporting and contributing to the biodiversity, functioning, resilience and visual amenity of green infrastructure. Their urban habitats also deliver health and well-being benefits to society, by providing important opportunities for accessing nature nearby to the homes of a growing majority of people living in towns and cities. However, many pollinator species are in decline, and the loss, degradation and fragmentation of natural habitats are some of the key drivers of this change. Urban planners and other practitioners need evidence to carefully prioritise where they focus their resources to provide and maintain a high quality, multifunctional green infrastructure network that supports pollinators and people. We provide a modelling framework to inform green infrastructure planning as a nature based solution with social and ecological benefits. We show how habitat suitability models (HSM) incorporating remote sensed vegetation data can provide important information on the influence of urban landcover composition and spatial configuration on species distributions across cities. Using Edinburgh, Scotland, as a case study city, we demonstrate this approach for bumble bees and hoverflies, providing high resolution predictive maps that identify pollinator habitat hotspots and pinch points across the city. By combining this spatial HSM output with health deprivation data, we highlight ‘win-win’ opportunity areas in most need of improved green infrastructure to support pollinator habitat quality and connectivity, as well as societal health and well-being. In addition, in collaboration with municipal planners, local stakeholders, and partners from a local greenspace learning alliance, we identified opportunities for citizen engagement activities to encourage interest in wildlife gardening as part of a ‘pollinator pledge’. We conclude that this quantitative, spatially explicit and transferable approach provides a useful decision-making tool for targeting nature-

based solutions to improve biodiversity and increase environmental stewardship, with the aim of providing a more attractive city to live, work and invest in.

Bonn, A., Allott, T., Evans, M., Joosten, H., Stoneman, R., 2016**. Peatland restoration and ecosystem services: Nature-based solutions for societal goals** (Book Chapter), Peatland Restoration and Ecosystem Services: Science, Policy and Practice 1, 402-417.

Abstract

'Peatland conservation is a prime example of a nature-based solution to climate change but we urgently need to switch from aspiration to action to secure the benefits that peatlands provide'. Julia Marton Lefèvre, former Director-General, IUCN Introduction The chapters of this book provide a compelling account of the crucial role of peatlands for human well-being and the role restoration can play in providing nature-based solutions to societal goals. Across the world, natural peatlands provide important ecosystem services, with a special role in climate regulation, water regulation, provision of cultural services, such as historical archives and recreation opportunities, and hosting important habitats for wildlife. In contrast, damaged peatlands on only 0.3% of the earth's land surface contribute disproportionally to global GHG emissions, producing probably up to 50% of the total global land bound and 5% of the total global annual anthropogenic CO2 emissions. Degraded peatlands therefore pose a high risk and, ultimately, a high cost to society. At the heart of peatland degradation is the unsustainable exploitation of peatland resources, mainly to maximise provisioning services for agricultural and forestry produce (Chapters 2 and 9-14). There are still perverse incentives and economic drivers in place fostering short-term profits (Chapters 2, 15 and 19), while neglecting consequences for global natural capital and sustainable livelihoods. The speed of degradation is alarming, especially in the tropics. Natural peatland habitats in Indonesia have shrunk to just 32% of the original peatland area, with most of those losses occurring in the last two decades as peatlands are drained and logged and converted to oil palm or pulpwood plantations. These plantations often cannot be sustained for more than one or a few production cycles, because subsidence eventually makes drainage of the low-lying peat soils impossible (Chapter 14). In temperate Europe, the majority of the peatlands has already been degraded by land use and land-use change over the past 150 years (Chapters 2, 10, 12). In Canada, recent technological advances and a desire for energy independence have meant that tar sand extraction will destroy peatlands to a significant extent. Also in Europe some of the remaining peatlands remain under current threat from the energy industry. © British Ecological Society 2016.

Calliari, E., Staccione, A., Mysiak, J. 2019. **An assessment framework for climate-proof nature-based solutions.** Science of The Total Environment 656, 691-700; doi.org/10.1016/j.scitotenv.2018.11.341

Abstract

Raising interest in 'nature-based solutions' (NBS) has inspired attempts to organise their principles and qualities within comprehensive and internally consistent evaluation frameworks, so as to demonstrate the superior performance of 'working with nature'. However, the proposed frameworks stop short of taking into account the changing conditions in which NBS are set to operate. Climate change, in particular, can alter ecosystems and their services, and may undermine the performance of green solutions that rely on them. We present here a 'dynamic' assessment framework that explicitly accounts for the impact of climate change on the effectiveness of the proposed NBS. The framework is based on an innovative approach that integrates system analysis and backcasting. Although it has not yet been applied to the NBS context, backcasting is well-suited to seize the transformational character of NBS, as it encourages 'breakthrough' leaps rather than incremental improvements. Our framework factors in the multifunctional character of NBS and is designed to capture associated direct benefits/costs and co-benefits/costs. It is meant to be applied ex ante to ideally support the choice between innovative NBS and traditional options, in an effort to respond to the societal challenges identified by the EU Research & Innovation agenda on the environment.

Davies, C., and Lafortezza, R. 2019. **Transitional path to the adoption of nature-based solutions.** Land Use Policy, 80, 406-409; doi.org/10.1016/j.landusepol.2018.09.020

Abstract

Spatial planning of green infrastructure has become well established since the turn of the millennium. However, as a planning and policy concept alone it lacks the focus and immediacy that decision makers may be looking for to solve current problems associated with urban and extra-urban sustainability and resilience. In nature-based solutions decision makers can find the focus and immediacy they are seeking. We posit that these nature-based solutions used in combination with spatial green infrastructure planning have the capacity to rival, replace or combine with existing grey infrastructure approaches. Nevertheless, there is a major inhibitor of change to be overcome. This is 'path dependence', a concept where active memory conditioned by past decisions has a controlling influence on decision making. This concept leads to self-reinforcement that is detrimental to the creation of climate-sensitive infrastructure. Unless path dependence is broken through a combination of reforms, the shift towards the full adoption of nature-based

solutions will not occur. A transition path covering four areas is proposed, which will help to overcome path dependence and lead to a greater use of nature-based solutions. We argue that the forum to debate these proposals is within the framework of UN Habitat. The Urban Thinkers Campus and World Urban Forum could be the fora for this exchange.

Fernandes, J.P., Guiomara, N., Gil, B. 2019**. Identifying key factors, actors and relevant scales in landscape and conservation planning, management and decision making: Promoting effective citizen involvement.** Journal for Nature Conservation, 47, 12–27; doi.org/10.1016/j.jnc.2018.11.001

Abstract

The paper analyses the current limitations of the constraints of decision and action processes in land-use, resource management and conservation policies and approaches, identifying their main factors, proposing alternative strategies to solve the present gaps and limitations. It identifies the need for a new paradigmatic approach based on innovative forms of involvement, commitment and individual and community rewarding systems. This approach is developed based on the characterization of the main drivers of land-use, resource management and conservation policies, namely α-perceptions (immediate and primary satisfaction) and k-perceptions (more mediate and complex consideration of satisfaction, implying long-term perceptions and collective benefits beyond the individual interests). It also analyses the effects of the introduction of new forms of income and incentives (such as trade-offs and payments for environmental services) or management approaches such as Ecological-Based Management or the use of Nature-Based Solutions. The main axioms and instruments necessary to build such a new paradigmatic approach (namely trade-offs, accountability and contractualization) are described. On this basis, it is possible to present a concept for an innovative institutional and social culture and a governance system aimed at an effective land-use, resource management and conservation policies. This governance concept is described and its sustaining individual, social and institutional drivers enunciated.

Frantzeskaki, N., 2018. **Seven lessons for planning nature-based solutions in cities.** Environmental Science & Policy, 93, 101-111; doi.org/10.1016/j.envsci.2018.12.033

Abstract

Nature-based solutions are proliferating in European cities over the past years as viable solutions to urban challenges such as climate change, urban degeneration and aging infrastructures. With evidence amounting about nature-based solutions, there is a need to translate knowledge about nature-based solutions to future policy and planning. In this

paper, we analysed fifteen cases of nature-based solutions' experiments across 11 European cities. What makes our case studies stand out is the balanced focus between ecosystem and social benefits in contrast to many published cases on nature-based solutions that have a weighted focus on the climate benefits. From a cross-case comparative analysis we draw seven overarching lessons related to all stages of proof-of-concept and implementation of nature-based solutions in cities: (a) nature-based solutions need to be aesthetically appealing to citizens, (b) nature-based solutions create new green urban commons, (c) experimenting with nature-based solutions requires trust in the local government and in experimentation process itself, (d) co-creation of nature-based solutions requires diversity and learning from social innovation, (e) nature-based solutions require collaborative governance, (f) an inclusive narrative of mission for nature-based solutions can enable integration to many urban agendas and (g) design nature-based solutions so as to learn and replicate them on the long-term. The lessons we draw show that nature-based solutions require multiple disciplines for their design, diversity (of settings) for co-creation and recognition of the place-based transformative potential of nature-based solutions as 'superior' to grey infrastructure. We further discern that urban planners need to have an open approach to collaborative governance of nature-based solutions that allows learning with and about new appealing designs, perceptions and images of nature from different urban actors, allows forming of new institutions for operating and maintaining nature-based solutions to ensure inclusivity, livability and resilience.

Georgiadis, T., Nardino, M., Cremonini, L., Carbone, C., Canini, G., Ciancarella, L., Piersanti, A., Villani, M., 2018. **URBESS - Nature based assessment tool for smart and sustainable urban planning** (Conference Paper), Acta Horticulturae 1215, 77-80.

Abstract

The focus of the URBESS Pathfinder Project is to investigate the feasibility of a service based on the integration of a suite of existing software tools that simulate the adoption of nature based solutions - specifically green infrastructure - in urban areas and estimate the multiple impacts and multidisciplinary interactions, with the aim at setting priorities for a more effective urban planning. The innovative aspect is the contemporaneous application of the three software packages to be integrated for a systemic approach with the aim at supporting and strengthening the confidence of urban planners and construction enterprises in making new sustainable interventions in the urban texture. The main goals of the project were: 1) to conduct a market scan to study and analyze in detail, opportunities, barriers, risks, competitors that the proposed approach/product can face on the market. Desk

research, 1-to-1 meeting and a survey will be arranged in order to engage potential clients and stakeholders (i.e., city decision makers, urban planners, architects, water engineers) and collect feedback and directions to take into account in the development of the service according to the market needs. The study will be focused on Italy but also European city decision makers and urban planners will be engaged exploiting the Climate-KIC connections of the Urban Transition Theme network; 2) to make a strategic analysis by adopting the PEST&SWOT tool for understanding and reviewing the perceptions and crucial aspects obtained as outputs from all the aforementioned activities and by, finally, drawing a preliminary business model prior to making further decisions about the development and implementation of the service. © ISHS.

Hernández-Morcilloa, M., Burgess, P., Mirck, J., Panterad, A., Plieningere, T. 2018. **Scanning agroforestry-based solutions for climate change mitigation and adaptation in Europe**. Environmental Science and Policy 80, 44–52; doi.org/10.1016/j.envsci.2017.11.013

Abstract

Agroforestry, the integration of trees and shrubs with livestock and/or crops, can make a substantial contribution to mitigating and enabling adaptation to climate change. However, its full potential will only be achieved if the challenges to agroforestry implementation are identified and the most efficient and sustainable solutions are made widely known. Therefore, the aim of this paper is to explore these challenges and to determine the most suitable set of solutions for each challenge that combines local effectiveness with European scale relevance. We performed a two-step “solution scanning” exercise. First, the main challenges to sustainable agroforestry in Europe were identified through 42 participatory workshops with 665 local stakeholders. The solutions to each challenge were scanned and classified into either direct solutions (28) to address climate change or indirect solutions (32) that improve the sustainability of agroforestry. In a second step, the direct solutions were prioritized through expert consultation in terms of their potential benefits for mitigation and adaptation. The most commonly reported barriers were a lack of knowledge and reliable financial support to which the most widely suggested indirect solutions were agroforestry training programmes and the development of safe economic routes. The direct solutions considered as holding the greatest mitigation and adaptation potential were the adoption of practices capable to increase soil organic carbon pools and the implementation of multifunctional hedgerows and windbreaks respectively. Our solution scanning approach can inform the implementation of the European climate strategy.

Kabisch, N., Frantzeskaki, S. Pauleit, S. Naumann, M. Davis, M. Artmann, D. Haase, S. Knapp, H. Korn, J. Stadler, K. Zaunberger, and A. Bonn. 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 21(2):39. http://dx.doi.org/10.5751/ ES-08373-210239

Abstract

Nature-based solutions promoting green and blue urban areas have significant potential to decrease the vulnerability and enhance the resilience of cities in light of climatic change. They can thereby help to mitigate climate change-induced impacts and serve as proactive adaptation options for municipalities. We explore the various contexts in which nature-based solutions are relevant for climate mitigation and adaptation in urban areas, identify indicators for assessing the effectiveness of nature-based solutions and related knowledge gaps. In addition, we explore existing barriers and potential opportunities for increasing the scale and effectiveness of nature-based solution implementation. The results were derived from an inter- and transdisciplinary workshop with experts from research, municipalities, policy, and society. As an outcome of the workshop discussions and building on existing evidence, we highlight three main needs for future science and policy agendas when dealing with nature-based solutions: (i) produce stronger evidence on nature-based solutions for climate change adaptation and mitigation and raise awareness by increasing implementation; (ii) adapt for governance challenges in implementing nature-based solutions by using reflexive approaches, which implies bringing together new networks of society, nature-based solution ambassadors, and practitioners; (iii) consider socio-environmental justice and social cohesion when implementing nature-based solutions by using integrated governance approaches that take into account an integrative and transdisciplinary participation of diverse actors. Taking these needs into account, nature-based solutions can serve as climate mitigation and adaptation tools that produce additional cobenefits for societal well-being, thereby serving as strong investment options for sustainable urban planning.

Lafortezza, R., Chenb, J., Konijnendijk van den Boschc, C., Randrupd, T.B. 2018. **Nature-based solutions for resilient landscapes and cities.** Environmental Research 165, 431–441; doi.org/10.1016/j.envres.2017.11.038.

Abstract

Nature-based solutions (NBS) are increasingly applied to guide the design of resilient landscapes and cities to enable them to reach economic development goals with beneficial outcomes for the environment and society. The NBS concept is closely related to other concepts including sustainability, resilience, ecosystem services, coupled human and

environment, and green (blue) infrastructure; however, NBS represent a more efficient and cost-effective approach to development than traditional approaches. The European Commission is actively engaged in investing in NBS as a driver in developing ecosystem services-based approaches throughout Europe and the world. The pool of knowledge and expertise presented in this Special Issue of Environmental Research highlights the applications of NBS as 'living' and adaptable tools to boost the capacity of landscapes and cities to face today's critical environmental, economic and societal challenges. Based on the literature and papers of this Special Issue, we propose five specific challenges for the future of NBS.

Sandra Lavorel, S., Colloff M.J., Locatelli B., Gorddard, R., Prober, S.M., Gabillet, M., Devaux, C., Laforgue, D., Peyrache-Gadeau, V. 2019**. Mustering the power of ecosystems for adaptation to climate change.** Environmental Science and Policy 92, 87–97; doi.org/10.1016/j.envsci.2018.11.010.

Abstract

Mountain social-ecological systems (SES) supply important ecosystem services that are threatened by climate change. In mountain SES there is a paradox between high community capacity to cope with extremes, and governance structures and processes that constrain that capacity from being realised. Climate adaptation that maintains livelihoods and supply of ecosystem services can catalyse this innate adaptive capacity if new adaptive governance arrangements can be created. Using the French Alps as a case study, we outline a participative framework for transformative adaptation that links adaptive capacity and governance to provide social innovation and ecosystem-based adaptation solutions for mountain SES. Grassland management was the main entry point for adaptation: bundles of adaptation services supplied by the landscape mosaic of biodiverse grassland types can maintain agricultural production and tourism and facilitate income diversification. Deliberate management for core adaptation services like resilient fodder production, erosion control, shade or aesthetic value generates co-benefits for future transformation ability. People activate bundles of adaptation services along adaptation pathways and realise benefits via co-production with other forms of capital including traditional knowledge or social networks. Common and distinctive adaptation services in each pathway create options for transformation if barriers from interactions between values and rules across scales can be overcome. For example conserving mown terraces which is a critical adaptation nexus reflects a complex interplay of values, markets and governance instruments from local to

European scales. We conclude that increasing stakeholders capacity to mobilise adaptation services is critical for empowering them to implement adaptation to global change.

Lin, Z., J Qi. J 2017. **Hydro-dam – A nature-based solution or an ecological problem: The fate of the Tonlé Sap Lake.** Environmental Research 158, 24–32; doi.org/10.1016/j.envres.2017.05.016.

Abstract

Recent proliferation of hydro-dams was one of the nature-based solutions to meet the increasing demand for energy and food in the Lower Mekong River Basin (LMRB). While construction of these hydro-dams generated some hydropower and facilitated expansion of irrigated lands, it also significantly altered the basin-wide hydrology and subsequently impacted wetland ecosystems. Unintended adverse consequences of ecosystem services from lakes and wetlands offset the intended gains in hydroelectricity and irrigated agriculture. The trade-offs between gains in energy and food production and losses in aquatic ecosystem services were perceived to be significant but knowledge of the magnitude, spatial extent, and type of ecosystem services change is lacking and, therefore, the question whether the hydro-dam is an optimized solution or a potential ecological problem remains unanswered. In this study, as the first step to answer this question and using the Tonlé Sap Lake as an example, we quantified one of the impacts of hydro-dams on lake ecosystem's phenology in terms of open water area, a critical ecological characteristic that affects lake systems' fish production, biodiversity, and livelihoods of the local communities. We used the MODIS-NDVI time series, forecast function and the Mann-Kendall trend test method to first quantify the open water area, analyzed its changes over time, and then performed correlation analysis with climate variables to disentangle dam impacts. The results showed reduced hydro-periods, diminishing lake seasonality and a declining trend in Tonlé Sap Lake open water area over the past 15 years. These changes were insignificantly related to climatic influence during the same period. It is concluded that basin-wide hydro-dam construction and associated agricultural irrigation were deemed to be the primary cause of these ecological changes. Further analyses of changes in the lake's ecosystem services, including provision and cultural services, need to be carried out in order to have a holistic understanding of the trade-offs brought by the hydro-dam proliferation as a solution to the emerging energy and food demand in the LMRB.

Liu, L., Jensen, M.B., 2017. **Climate resilience strategies of Beijing and Copenhagen and their links to sustainability.** Water Policy 19, 6, 997-1013; doi: 10.2166/wp.2017.165

Abstract

Like numerous other cities, Beijing and Copenhagen are experiencing more frequent urban flooding due to increased impervious cover and climate change. Consequently, huge investments are foreseen to maintain resilience. Analyses of planning documents and interviews with key stakeholders reveal that in their climate resilience strategies both cities do employ alternative approaches based on on-site retention-detention of stormwater runoff. However, when there is an emergency situation with heavy downpours, both cities rely heavily on conventional concepts involving deep tunnels for rapid discharge. The applied alternative solutions tend to be more engineering-based, like underground tanks in Beijing and detention-discharge plazas in Copenhagen. More nature-based solutions lag behind. Both cities are simultaneously targeting specific additional sustainability goals. Nevertheless, other potential goals seem to be neglected, like livability improvements in Beijing and biodiversity support and water footprint reduction in Copenhagen. The main barriers for implementing more nature-based solutions with greater sustainability potentials were a combination of time constraints caused by external political pressures for rapid problem solving, lack of routines for the innovation and documentation of solutions for dense urban areas, and insufficient multi-sectorial collaboration. These factors limit the propagation of alternative solutions and tip the balance of current investments towards a conventional approach. © IWA Publishing 2017.

Marchant, R., et al. 2018. **Drivers and trajectories of land cover change in East Africa: Human and environmental interactions from 6000 years ago to present.** Earth-Science Reviews 178, 322–378; doi.org/10.1016/j.earscirev.2017.12.010.

Abstract

East African landscapes today are the result of the cumulative effects of climate and land-use change over millennial timescales. In this review, we compile archaeological and palaeoenvironmental data from East Africa to document land-cover change, and environmental, subsistence and land-use transitions, over the past 6000 years. Throughout East Africa there have been a series of relatively rapid and high-magnitude environmental shifts characterised by changing hydrological budgets during the mid- to late Holocene. For example, pronounced environmental shifts that manifested as a marked change in the rainfall amount or seasonality and subsequent hydrological budget throughout East Africa occurred around 4000, 800 and 300 radiocarbon years before present (yr BP). The past 6000 years have also seen numerous shifts in human interactions with East African ecologies. From the mid-Holocene, land use has both diversified and increased

exponentially, this has been associated with the arrival of new subsistence systems, crops, migrants and technologies, all giving rise to a sequence of significant phases of land-cover change. The first large-scale human influences began to occur around 4000 yr BP, associated with the introduction of domesticated livestock and the expansion of pastoral communities. The first widespread and intensive forest clearances were associated with the arrival of iron-using early farming communities around 2500 yr BP, particularly in productive and easily-cleared mid-altitudinal areas. Extensive and pervasive land-cover change has been associated with population growth, immigration and movement of people. The expansion of trading routes between the interior and the coast, starting around 1300 years ago and intensifying in the eighteenth and nineteenth centuries CE, was one such process. These caravan routes possibly acted as conduits for spreading New World crops such as maize (Zea mays), tobacco (Nicotiana spp.) and tomatoes (Solanum lycopersicum), although the processes and timings of their introductions remains poorly documented. The introduction of southeast Asian domesticates, especially banana (Musa spp.), rice (Oryza spp.), taro (Colocasia esculenta), and chicken (Gallus gallus), via transoceanic biological transfers around and across the Indian Ocean, from at least around 1300 yr BP, and potentially significantly earlier, also had profound social and ecological consequences across parts of the region.

Through an interdisciplinary synthesis of information and metadatasets, we explore the different drivers and directions of changes in land-cover, and the associated environmental histories and interactions with various cultures, technologies, and subsistence strategies through time and across space in East Africa. This review suggests topics for targeted future research that focus on areas and/or time periods where our understanding of the interactions between people, the environment and land-cover change are most contentious and/or poorly resolved. The review also offers a perspective on how knowledge of regional land-use change can be used to inform and provide perspectives on contemporary issues such as climate and ecosystem change models, conservation strategies, and the achievement of nature-based solutions for development purposes.

McVittie, A., Cole, L., Wreford, A., Sgobbi, A., Yordi, B. 2018. **Ecosystem-based solutions for disaster risk reduction: Lessons from European applications of ecosystem-based adaptation measure**. International Journal of Disaster Risk Reduction 32, 42–54; doi.org/10.1016/j.ijdrr.2017.12.014

Abstract

Disaster risk reduction (DRR) and climate change adaptation are connected through a common goal: reducing the impacts of extreme events and increasing resilience to

disasters, particularly among vulnerable populations. By coordinating adaptation and disaster risk management policies, multiple benefits can be achieved. Ecosystem-based adaptation (EbA) offers a cost-effective adaptation and DRR at different scales and under multiple scenarios. EbA uses natural or managed ecosystem processes to increase resilience and adaptation to climate change. EbA delivers other benefits, including mitigating greenhouse gases, and improving biodiversity, water and air quality. These co-benefits can be the primary driver for implementation and reflect related policy objectives. EbA are also associated with different land use or habitat types (e.g. agriculture, forestry, coastal, urban, or freshwater ecosystems).

This paper considers the lessons learnt from implementing EbA across a range of land uses. However, implementation frequently applies multiple measures across land uses and at varying scales. The evidence indicates that adaptation and DRR are achievable cost-effectively whilst providing important co-benefits. Demonstrating these co-benefits ensures both stakeholder support and funding opportunities. Further, the mainstreaming of nature-based solutions across policy areas linked to different co-benefits both increases the acceptability of EbA and also opens up multiple funding sources. Key to the success of EbA is the involvement of stakeholders throughout the implementation process; this can include demonstrating private benefits and utilising trusted intermediaries. However, gaps often remain in our knowledge of the biophysical and economic benefits, or negative impacts, of EbA indicating that research and monitoring remain a priority.

Ovando, P., Brouwer, R. 2019. **Review of economic approaches modeling the complex interactions between forest management and watershed services**. Forest Policy and Economics 100, 164-176; doi.org/10.1016/j.forpol.2018.12.007

Abstract

This paper provides a comprehensive review of two decades of published research that applies different economic approaches to address forested watershed management decisions. The review takes stock of the applied integrated economic and ecohydrological modeling approaches and assesses the way these approaches capture the complexities involved when linking ecohydrological and economic systems. The implications of integrating watershed services into forest management decisions are discussed, lessons are drawn from existing approaches and future research needs identified. Existing modeling approaches are categorized from independent modular models with a unidirectional flow of information to fully coupled holistic models, and are analyzed, among others, in terms of the efficiency improvement that forest-based investments achieve in watershed services provision. The review shows that the number of studies investigating the relationship

between forest management and watershed services in economic decision-support models is very limited. Only 14 studies that were identified examine these relationships for water supply, while 9 studies were found to focus on the impact on water quality, 2 of which addressed water quality in combination with water supply. A shortcoming is that about half of the studies do not clearly specify baseline conditions to test the incremental value of the evaluated forest management actions in terms of watershed services provision, which undermines evaluating their cost-effectiveness or economic efficiency. A promising finding is nevertheless that in 8 of the 10 studies where these relationships were evaluated in terms of their costs and benefits compared to a specified baseline alternative, forest conservation or forest management is shown to be an economically efficient nature-based solution to supply the watershed services of interest. The limited availability of geo-referenced data and information, including the often complex and confidential nature of cost and price data, and the high data demands of more advanced spatial econometric models are among the main barriers to address relevant forest and water economic interactions. Important future extensions of existing integrated approaches include the further coupling of more detailed ecohydrological models and multi-sectoral hydro-economic models that are able to account for the different risks (floods, droughts, wildfires) and uncertainties under climate change and their impact on watershed services and water security.

Peter B.G., Mungai, L. M., Messina, J.P., Snapp S.S. 2017. **Nature-based agricultural solutions: Scaling perennial grains across Africa**. Environmental Research 159, 283–290; doi.org/10.1016/j.envres.2017.08.011

Abstract

Modern plant breeding tends to focus on maximizing yield, with one of the most ubiquitous implementations being shorter-duration crop varieties. It is indisputable that these breeding efforts have resulted in greater yields in ideal circumstances; however, many farmed locations across Africa suffer from one or more conditions that limit the efficacy of modern short-duration hybrids. In view of global change and increased necessity for intensification, perennial grains and long-duration varieties offer a nature-based solution for improving farm productivity and smallholder livelihoods in suboptimal agricultural areas. Specific conditions where perennial grains should be considered include locations where biophysical and social constraints reduce agricultural system efficiency, and where conditions are optimal for crop growth. Using a time-series of remotely-sensed data, we locate the marginal agricultural lands of Africa, identifying suboptimal temperature and precipitation conditions for the dominant crop, i.e., maize, as well as optimal climate conditions for two perennial grains, pigeonpea and sorghum. We propose that perennial grains offer a lower impact, sustainable

nature-based solution to this subset of climatic drivers of marginality. Using spatial analytic methods and satellite-derived climate information, we demonstrate the scalability of perennial pigeonpea and sorghum across Africa. As a nature-based solution, we argue that perennial grains offer smallholder farmers of marginal lands a sustainable solution for enhancing resilience and minimizing risk in confronting global change, while mitigating social and edaphic drivers of low and variable production.

Annex 4

Template for recognizing and evaluating drivers, actions and stakeholders for NBS-implementation

Based on the results of D5.1, we suggest a table template to be used for recognizing drivers and coming up with practical examples of actions and stakeholders to overcome barriers for NBS at various levels. The levels of actions can be, e.g. regional or organizational.

The table template can be used, e.g. as an interactive task in workshops, seminars and educational contexts, and as a tool for authorities and decision-makers, to support mapping suitable, locally adjustable actions for NBS adoption and implementation. The table can be used for various situations, such as recognizing actions for single NBS or larger systems of various NBS, organizational development (e.g. urban planning system) and NBS product development.

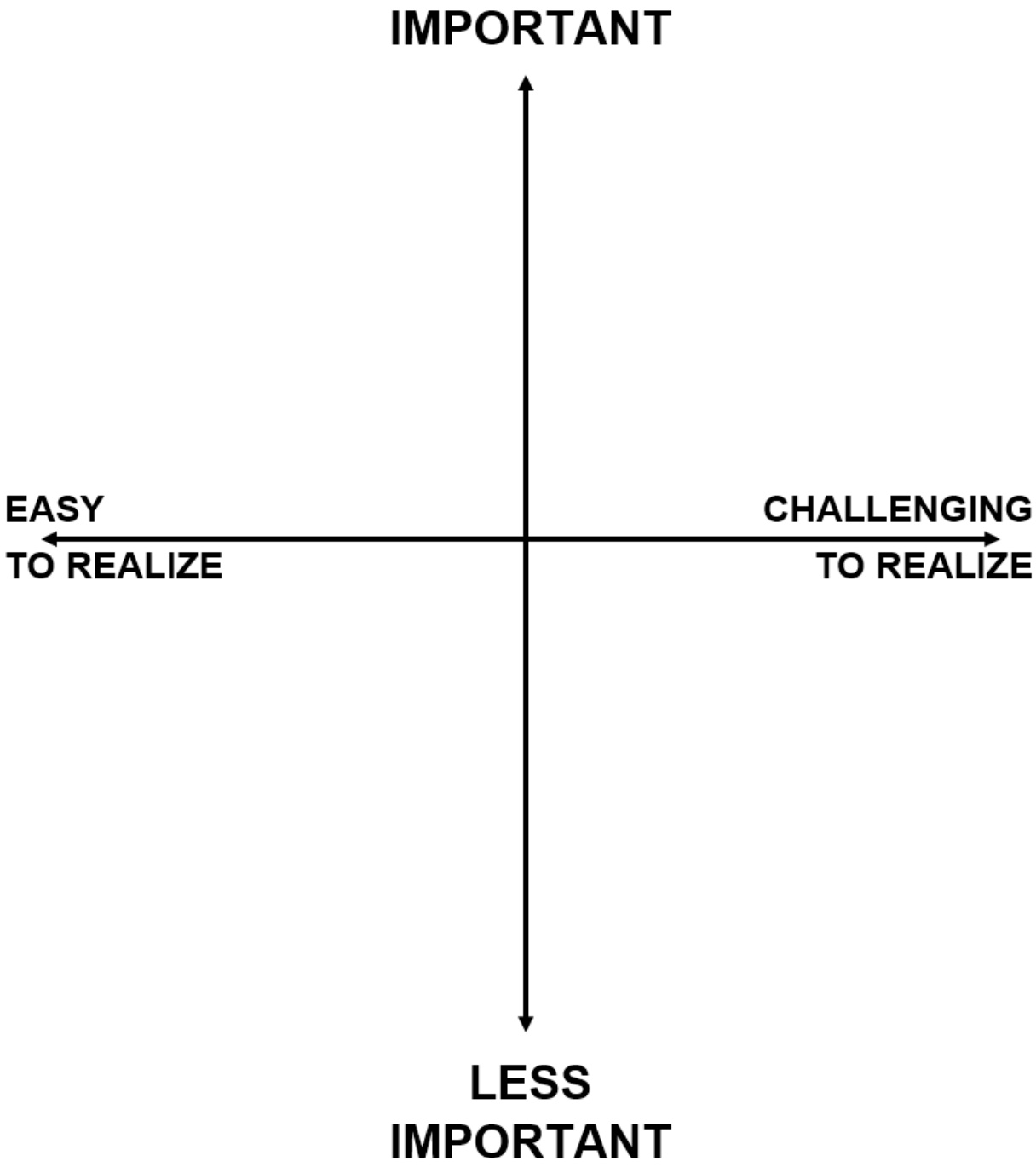
First, drivers (= enabling factors) for NBS in the given context are discussed and added in the table. Various workshop/group-working methods can be used to recognize drivers. The process may begin with first recognizing the barriers, and then thinking of how to remove or overcome these barriers. Next, the actions to create and push the drivers are discussed and added in the table, according to the sector of actors being responsible for creating and/or implementing each action. If feasible, the stakeholders in each sector are specified. The regional levels can be defined depending on the context and needs. ‘Actor sector’ can be, e.g. public, private, and third sector, or companies of different size groups etc., and divided in smaller groups if needed.

In order to evaluate the importance and realizability of actions, a grid can be used (see the template). For example, if an action is recognized to be important and easy to realize, it can be implemented soon, and if an action is important, but challenging to realize, efforts should be aimed at developing the action, or circumstances of implementation.

TABLE TEMPLATE

Drivers for NBS/ actions	(e.g regional/ organizational) **Level 1**	(e.g regional/ organizational) **Level 2**	(e.g regional/ organizational) **Level 3**
Driver 1			
Actor sector 1 • actor group 1 • actor group 2 • ….	- action 1 - action 2 - …	- action 1 - action 2 - ….	- action 1 - action 2 - …
Actor sector 2 • actor group 1 • actor group 2 • ….	- action 1 - action 2 - …	- action 1 - action 2 - ….	- action 1 - action 2 - …
Actor sector 3 • actor group 1 • actor group 2 • ….	- action 1 - action 2 - …	- action 1 - action 2 - ….	- action 1 - action 2 - …
Driver 2	-	-	-
Actor sector 1 • actor group 1 • actor group 2 • ….	- action 1 - action 2 - …	- action 1 - action 2 - ….	- action 1 - action 2 - …
Actor sector 2 actor group 1 actor group 2 ….	- action 1 - action 2 - …	- action 1 - action 2 - ….	- action 1 - action 2 - …
Actor sector 3 • actor group 1 • actor group 2 • ….	- action 1 - action 2 - …	- action 1 - action 2 - ….	- action 1 - action 2 - …
Driver 3			
• Etc.			

GRID TEMPLATE FOR ASSESSING THE IMPORTANCE OF ACTIONS AND REQUIRED EFFORTS FOR REALIZING THE ACTION.


IMPORTANT
EASY
TO REALIZE
CHALLENGING
TO REALIZE
LESS
IMPORTANT

Accelerate adoption of innovations

→ support creativity and visionary thinking

THINK NATURE – THINK FUTURE!