ARCADIA

Transformative climate resilience by nature-based solutions in the continental bio-geographical region

Work Package 8
‘Design & performance’

D8.1– A guidance for choosing NbS and designing high performing green infrastructures

Co-funded by the European Union

The transformative climate resilience by nature-based solutions in the continental bio-geographical region project has received funding from the European Union under the HORIZON-MISS-2022-CLIMA-01 call with Grant Agreement n. 101112737.

Work Package 8 'Design & performance'
DELIVERABLE 8.1

Operational Guidance for regions for choosing NbS and designing high performing green infrastructures

Task 8.1 Design of nature-based solutions and green infrastructures

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ARCADIA
Transformative climate resilience by nature-based solutions in the continental bio-geographical region

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TABLE OF CHANGES

Version	Date	Description

GLOSSARY

Entry	Definition
Nature-based Solutions	Nature-based Solutions (NbS) are defined by the International Union for Conservation of Nature (IUCN) as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al., 2016)
Blue Green Infrastructure	Blue-green infrastructure (BGI) networks - defined in ARCADIA as "an interconnected network of waterways, wetlands, wildlife habitats, and other natural areas; greenways, parks, and other conservation lands; working farms, ranches, and forests; and wilderness and other open spaces that support species, maintain natural ecological processes, sustain air and water resources, and contribute to the health and quality of life"- play an important role in addressing ecosystem fragmentation and environmental changes.

ACRONYMS

Abbreviated	Extended
NbS	Nature based Solution
BGI	Blue Green Infrastructure

List of figures

Figure 1 ARCADIA project structure
Figure 2 The ARCADIA Models and Fellows regions
Figure 3 The proposed objective of the guideline and ToR, as presented to the regions
Figure 4 Overview of the needs of the ARCADIA regions
Figure 5 The project phases that can be distinguished
Figure 6 Similarity of guidelines matched with climate hazards visualized with MDS in a 2D format
Figure 7 Similarity of guidelines matched with needs from the regions visualized with MDS in a 2D format
Figure 8 An example of the quick reference guide for the how-to topic 'conduct monitoring, evaluation and impact assessments'

List of tables

TABLE OF CONTENT

TABLE OF CHANGES 3
GLOSSARY 4
ACRONYMS 4
List of figures 5
List of tables 5
1. Introduction 7
1.1. Background of the project 7
1.2. Objectives of the deliverable 8
1.3. Scope of the deliverable 9
1.4. Reading guide 10
2. Methodology 10
2.1. Inventory of needs 10
2.2. Inventory of existing guidelines 14
2.3. Comparing needs and guidelines 16
3. Similarity analysis of the guidelines 18
3.1 Introduction to Multidimensional scaling 18
3.2 Guidelines similarity on climate hazards 18
3.3 Guidelines similarity on regional needs 20
3.4 Reflection on the similarity analysis 21
4. Guide to the guidelines 21
4.1. Background and scope 21
4.2. Reflection on the needs 22
4.3. Products for operational guidance 22
5. Next steps 25
References 29
Annex 30
Annex 1. Questionnaire for the regions 31
Annex 2. The needs explained 32
Annex 3. The number of guidelines found for each hazard, project phase and need 34

1. Introduction

1.1. Background of the project

The main goal of the ARCADIA project is to mobilise European regions and communities to accelerate the adoption of Nature-based Solutions and assist them in:

- Accessing up-to-date, evidence-based actionable knowledge
- Guidance, knowledge-intense tools and services
- Mutual learning and networking opportunities.

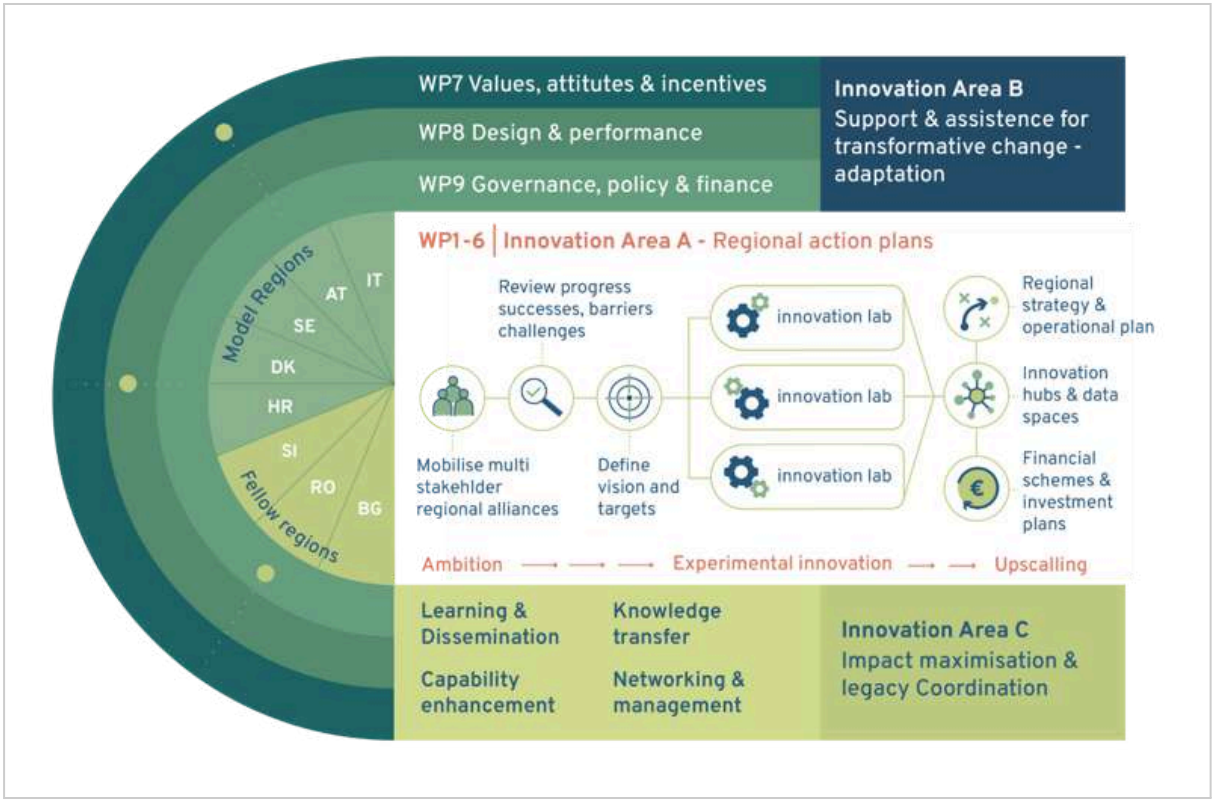


Figure 1. ARCADIA project structure.

Within the ARCADIA project, work package 8 'Design & Performance' (WP8) aims to guide the implementation and/ or upscaling of Nature-based Solutions (NbS) and Blue Green Infrastructures (BGI). It is important that NbS are adapted locally and be coherently chosen to help assure sustainability and to prevent undesired side effects. WP8 will support both the Model regions and Fellows Regions (see Figure 2), by facilitating access to important aspects like climate risk data, methods and models.

The main objectives of WP8 are to:

1 **Guide the selection and design of nature-based solutions and blue-green infrastructure networks that are locally appropriate.**

Develop tailored strategies for implementing nature-based solutions and blue-green infrastructure that align with the specific environmental, social, and economic contexts of each region.

2 **Support model regions in evaluating the performance and potential unintended consequences of nature-based interventions.**

Provide tools and methodologies to assess how well nature-based solutions perform in reducing climate risks and identify any unexpected negative impacts, ensuring interventions are both effective and sustainable.

3 **Create data spaces and continuous monitoring systems to track progress and aid in large-scale design.**

Establish integrated data platforms and ongoing monitoring frameworks to collect, analyze, and share information on the effectiveness of nature-based solutions, facilitating informed decision-making and scalable implementation.

1.2. Objectives of the deliverable

The specific goal of Task 8.1 is to develop a guidance to design NbS and high-performing BGI networks that maximise response to local climate risks and societal needs, are well adapted to local circumstances and meet the visions of the Model and Fellows regions (depicted in figure 2). The Model Regions will serve as examples of best practices, driving innovation and sustainable development, while Fellows Regions are actively learning and adapting these practices to enhance their own growth (ARCADIA, 2024). The needs of the regions are described in chapter 2.1.

The following objectives for the current document, Deliverable 8.1, were stated in the grant agreement:

a. Describe relevant (EU) projects, initiatives, and good practices examples.
b. Describe insights, experiences and lessons learned regarding the design and implementation of NbS and Green infrastructures.
c. Offer an overview of typologies and taxonomies of NbS.
d. Describe NbS and BGI design and selection support services for the Model regions.
e. Describe the operational guidance from WP8 to the Model regions.

These initial objectives remain the current objective as no need for additional objectives came to the fore during the work on this deliverable.

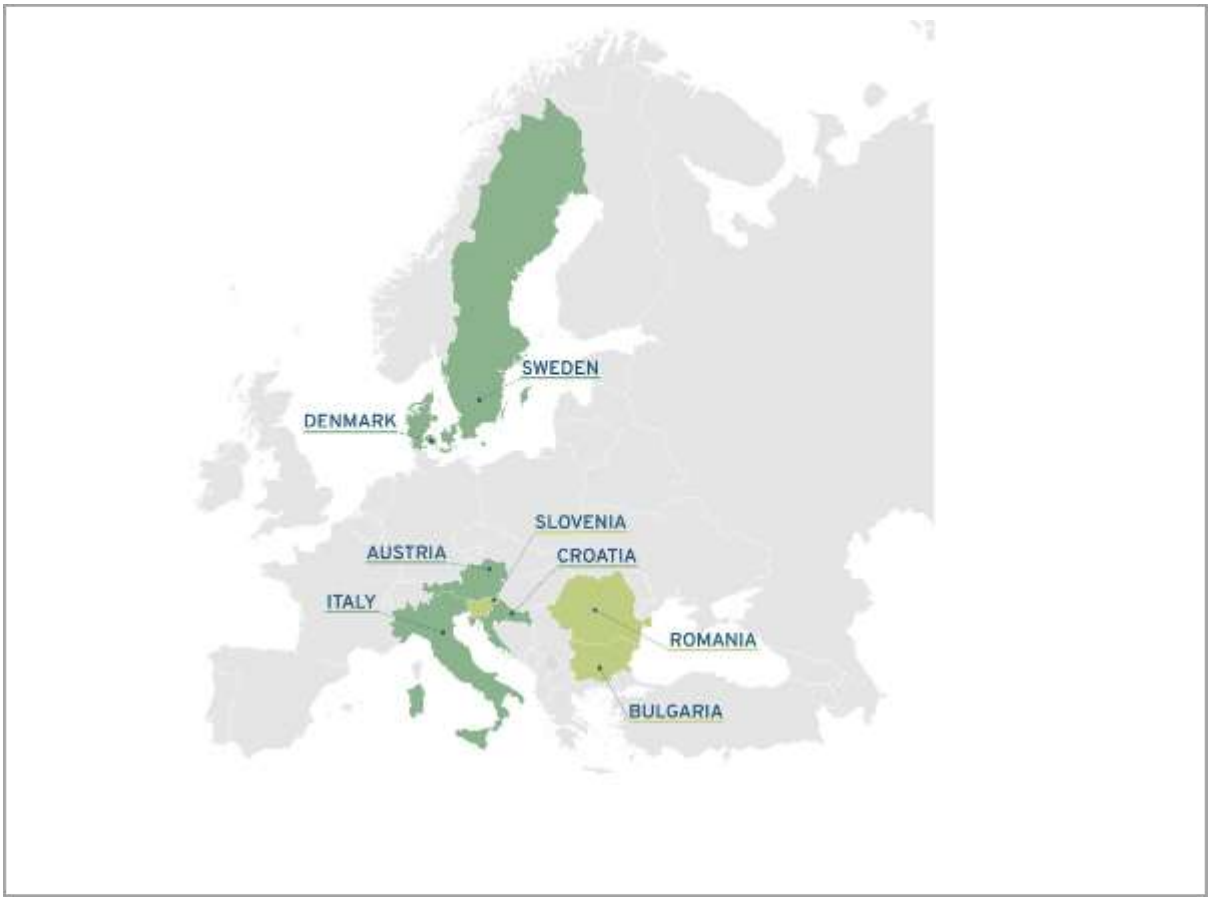


Figure 2. The ARCADIA Model regions are depicted as dark green areas, the Fellows regions as green areas (ARCADIA, 2024).

1.3. Scope of the deliverable

In the Milestone document preceding Deliverable 8.1, the proposed NbS and BGI initiatives of the ARCADIA regions were classified into suggested categories of NbS solutions. It was found that the most significant categories were BGI, dynamic nature management, natural water purification and water storage. Rather than continuing from a solutions-oriented perspective, a more user-based approach for operational guidance is chosen now. That is, scientific research shows that certain challenges have to be faced in order to implement NbS effectively.

Known challenges are (personal communication, Kajfež Bogataj, 2024):

- Scale and impact
- Competing land uses
- Funding and investment
- Lack of knowledge and expertise
- Vulnerability to climate change
- Social and equity challenges
- Monitoring and maintenance
- Integration with other solutions
- Perceived effectiveness and public perception
- Policy and regulatory barriers

These challenges justify a closer examination of how to meet the needs of the regions, in order to overcome the perceived barriers. In addition, as NbS must be adapted locally, a different way of working is proposed: based less on descriptive outputs and more on facilitating the identification and access to relevant guidelines. This way, the regions are provided with guidance that can be tailor made to their local situation. Therefore, the scope of Deliverable 8.1 is to provide a 'guide to the guidelines'.

1.4. Reading guide

This report starts with a description of the methodology used for Deliverable 8.1 in Chapter 2. The first section will go into the inventory of the needs of the regions. The second section addresses the inventory of existing guidelines, after which the needs and guidelines are jointly assessed in chapter 2.3. The preliminary findings are shared with and reflected on by the ARCADIA regions, as described in the final section. A similarity analysis of the guidelines is carried out in chapter 3. Chapter 4 will elaborate on the 'guide to the guidelines' approach and products for operational guidance. Suggestions for subsequent steps are considered in chapter 5.

2. Methodology

The methodology for Deliverable 8.1 includes several steps, which are described in this chapter. Assessments are carried out to establish the extent to which a new guidance could be of added value and what topics it should address. It starts with an inventory of the needs of ARCADIA Model and Fellows regions, followed by an inventory of existing guidelines. This results in an extensive database, in which the guidelines are assessed against the needs that the regions expressed.

2.1. Inventory of needs

To determine how the ARCADIA regions could be assisted best, an inventory of needs is carried out. It starts with a questionnaire sent to the Model and Fellows regions at the start of the ARCADA project, followed by one-on-one meetings with the regions during the Summer of 2024.

2.1.1 Questionnaire for the regions

The replies to the questionnaire (see annex 1) show that each region has its own reasons for implementing or upscaling NbS/BGI within ARCADIA. The following reasons were indicated:

- **Austria:** Focusing on climate change adaptation strategies, particularly for floods. extreme rainfalls, droughts and heatwaves.
- **Croatia** (Zagreb): Mitigating climate risks related to heatwaves and flash floods
- **Croatia** (Krapina-Zagorje County): Addressing climate hazards related to landslides and biodiversity.
- **Denmark:** A need for multifunctional solutions prioritizing natural systems and enhancing conditions for biodiversity and aquatic environments facing problems such as floods and water availability, sea level rise
- **Italy:** Promoting active and sustainable forest management to reduce climate change risks (such as floods, extreme rainfalls and landslides) and enhance the forest value chain and ecosystem services supply
- **Romania**: Support GPs exchange on NbS and BGI in order to create a cleaner and a greener region facing e.g. heatwaves and water quality issues.
- **Bulgaria:** support politicians and policy makers facing hazards such as extreme rainfall and heatwaves, droughts and wildfires
- **Slovenia:** Striving to improve quality of life, enable greening efforts, and combat climate change particularly on water management issues (like flood and drought)
- **Sweden:** Uniting decision makers to emphasize nature-based climate adaptation and long-term strategic planning on climate change related topics such as floods, drought and heat waves.

A need expressed by most of the regions is to set up a holistic approach that actively involves local stakeholders in developing comprehensive strategies addressing societal issues and biodiversity challenges, providing multiple benefits. Additionally, these will need to consider long-term perspectives and the challenges posed by climate change.

2.1.2 Meetings with the regions

The 1-on-1 meetings were held by the WP 8.1 team including Wageningen Research (WR) and the University of Southern Denmark (SDU), with both the Model and the Fellow regions[1] (in some cases also including the local organisations involved in the living labs). The meetings were hosted by WP8 leadership and organised by WP6.

These meetings started with an overview of the objectives of this task, an introduction of the purpose of the meeting, a description of the process and the current phase in the process at the time. The purpose of these meetings was to improve understanding of the needs for a guideline of the regions, by inventorying and discussing who are the intended future users of the guideline. For what purposes would they be using a guideline? What should the guideline look like in terms of content, scope and form? By discussing the findings of the questionnaire, the regions articulated their own needs more elaborately and reflected on the needs of the other regions.

[1] Only Slovenia was not consulted, due to practical reasons regarding the Summer period.

Also, some preliminary findings, based on the analysis of the questionnaire results by the ARCADIA WP8.1 team, were discussed and validated with the regions such as the proposed objective of the guideline and the Proposed Terms of Reference (ToR), as shown in figure 3.

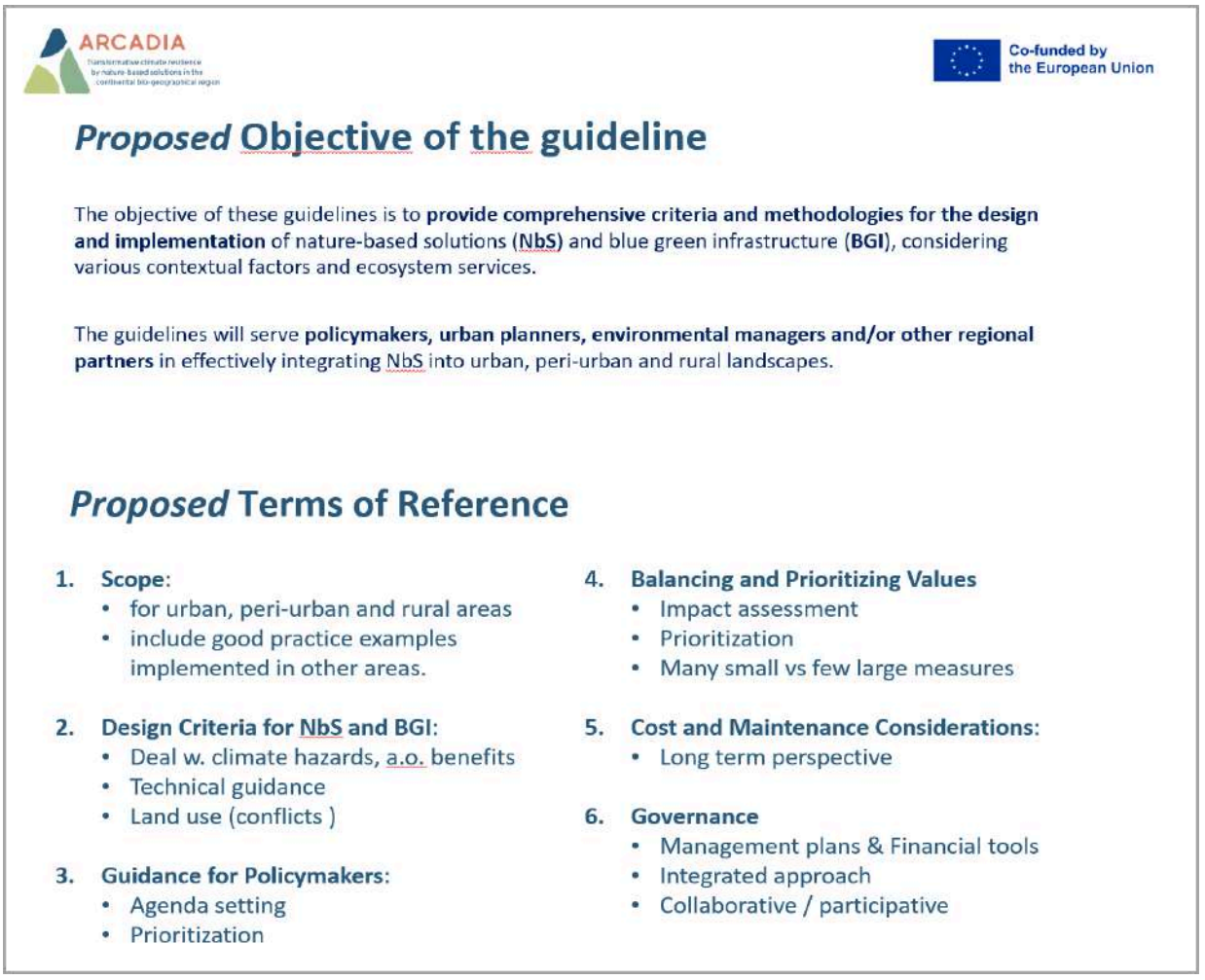


Figure 3. The proposed objective of the guideline and ToR, as presented to the regions.

Importantly, the observation was discussed that the needs of the regions, including the nature and characteristics of the intended target groups, vary widely, both between and within the regions. This led to the idea to develop an approach or tool to assist the regions to find the guidelines relevant for their situation rather than creating a new guideline: a 'guide to the guidelines'. This guide will be about connecting demand and supply by providing regions with the guidelines which are usable within their regional context.

The 1-on-1 meetings concluded by presenting the intended next steps and timeline for preparing and finalizing the milestone document and the current document, and checking the region's availability.

2.1.3. Analysing the needs

The insights from the questionnaire and the 1-on-1 meetings were further supplemented by a round of additional questions to some of the regions for further clarifications. These inputs provided the basis for a preliminary assessment of the needs and after further discussions and structuring the final set of needs was agreed upon between within the WP8.1 team. The needs are summarised in figure 4. They are further explained in Annex 2.



Figure 4. Overview of the needs of the ARCADIA regions.

2.2. Inventory of existing guidelines

As NbS solutions increasingly emerge as promising pathways, a growing number of guidelines arises. To increase the potential of Deliverable 8.1, an extensive inventory of existing guidelines was conducted. Its objective was to identify possible gaps and to organise resources that align with the challenges and goals of each region. It resulted in a spreadsheet with an overview of guidelines. The spreadsheet is structured using a two-way approach:

1 **Project-based insights**

Collecting guidelines from relevant EU-funded projects and other established initiatives.

2 **Challenge-based categorisation**

Organising guidelines according to regional needs, climate hazards, and project phases (e.g., exploration, preparation, implementation, post-implementation). See also section 2.3.

2.2.1. Relevant EU projects

In a wide variety of projects, a lot of new insights, tools and guidelines are created related to NbS and BGI. Among these, already 76 EU-funded NbS research projects are focusing on climate and biodiversity related topics (European Research Executive Agency, 2003). The 11 EU-funded projects that have similarities in focus and scope with ARCADIA, have been summarised in the ARCADIA Milestone 8.1 document. The following six criteria were used (ARCADIA WP8, 2024, P.27):

1. The project is focused on transformational change to strengthen resilience.
2. The project is on a regional/community scale.
3. The project is focused on adapting to climate change.
4. The project has a systemic approach by including the environmental system, social system and governance system.
5. The project has a multi-hazard perspective.
6. The project is focused on Nature-based Solutions or/and Blue Green Infrastructure.

2.2.2. Gathering guidelines

In order to meet the objectives of this deliverable, an extended inventory of existing guidelines was conducted. This was done in relation to the challenges and/or focus of the different ARCADIA regions involved. First, guidelines were inventoried by borrowing knowledge from two related projects in which Wageningen Research (WR) is involved. Second, an additional online search was carried out.

The following projects were considered:

1 Adaptive Cities Through integrated Nature Based Solutions (ACTonNBS)

This database is an overview of what has been developed in terms of NbS and climate resilience tools in cities. The catalogue compiled 70 tools (till August, 2020) from existing inventories from EU granted projects in NBS, other international projects, internet searches (desktop research), interviews with different EU cities, workshops organised by ACTonNBS and professional networks (Voskamp et al., 2021).

2 Growth Fund project: NL2120

In this knowledge programme, governments, nature organisations, engineering firms, dredging companies, and knowledge and professional institutions work together on NbS for major challenges in the areas of climate, nature-inclusive agriculture, biodiversity and housing. This ongoing project provides a curated internal inventory of NbS guidelines.

The additional search for guidelines was based on:

- English language only
- Open source and free of use
- Keywords such as:
  - Nature-based solutions guidance/guide/guidelines
  - EU-funded NbS project
  - Nature-based solutions implementation
  - Blue and/or Green infrastructure guidance/guide/guidelines
  - Ecosystem-based adaptation strategies
  - Climate adaptation tools and resources
  - NbS for urban resilience
  - Regional NbS case studies
  - NbS monitoring and management
  - NbS spatial planning
  - NbS atlas
  - NbS cost and benefits
  - NbS impacts (assessment)
  - NbS co-creation/participation

2.3. Comparing needs and guidelines

After finding the guidelines and adding them to the spreadsheet, the next step was to review the guidelines and to indicate the relevance of each guideline to the following categories: climate hazards, the project phases and the needs expressed by the regions. The team consisting of people from both Wageningen Research and the University of Southern Denmark went through each guideline by scanning the guideline content. More than 120 guidelines were considered that way.

2.3.1. Categories used

In this section the climate hazards, projects phases and needs of the regions are specified, as a starting point for the identification of relevant guidelines for the ARCADIA regions.

Hazards

The relevant natural and climate hazards indicated are:

- Heavy rainfall
- Flooding
- Drought
- Heat waves
- Landslides
- Wildfires
- Sea level rise

These were chosen because of the relevance to the ARCADIA regions.

Project phases

The project phases indicated for each guideline are:

- Exploration (financing, site selection, fact finding and analysis)
- Preparation (planning and design approaches, stakeholder engagement and co-creation)
- Implementation (construction and installation of measures)
- Post-implementation (monitoring evaluation and learning, replication)

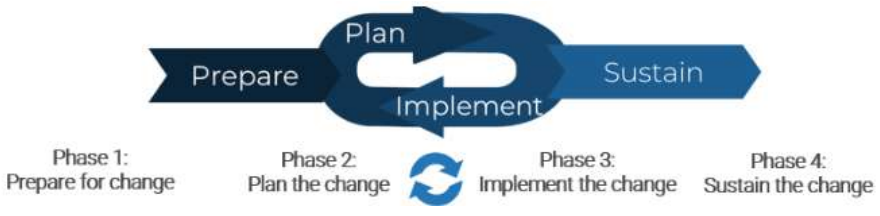


Figure 5. The project phases that can be distinguished (Info-Tech Research Group, n.d.)

Needs

The regional needs identified per guideline are the needs as presented in 2.1.3.

2.3.2. The review of existing guidelines

The overview of existing guidelines contains a unique identification number per guideline, the name of the guideline, a short description, an indication of which case studies are mentioned in the guideline, the URL of the guideline and columns for the purpose of keeping track of the review process (such as name of the reviewer and remarks).

Each guideline was reviewed against the categories as mentioned in section 2.3.1, and was assigned to the relevant ones. While reading through the guidelines, the team was also able to comment whether the guideline was especially interesting or if it was not relevant for this collection and should therefore be removed from the list. The reviewing of the regional needs, then served as criteria for assessing the guidelines, helping to evaluate how well each guideline addresses one or more of these needs.

For quality control, a second round of reviews was conducted by a different member of the team. If there were differences of opinion, a third reviewer would check and the final decision was made after a discussion with the team.

2.3.3. Observations

It was found that many relevant guidelines already exist. Over 120 guidelines were reviewed. The team discovered applicable guidelines for all categories: climate hazards, the project phases and the needs expressed by the regions. Annex 3 shows the number of guidelines found for each category. Most guidelines were found for:

Hazards	Flooding (42), heavy rainfall (40), heatwaves (33) and drought (29)
Project phases	Exploration phase (81) and/ or preparation phase (74)
Needs	Selection of fitting NBS/BGI (56), practical examples (53), assessment of impacts / benefits (46) and assessment of site specific characteristics and demands (41)

These observations suggest that all needs of the regions are potentially met by existing guidelines, but there can still be numerous guidelines to choose from (depending on the topic). In addition, most guidelines seem generic and lack practical guidance. For operational guidance, additional direction is required. Ultimately, the aim within ARCADIA is to select the most relevant guidelines, that not only propose actions, but also offer guidance on how to proceed, thus coming to a selection that covers the regional needs and climate hazards as much and as broadly as possible.

2.3.4. Validating preliminary findings with the ARCADIA regions

In October, a WP8 meeting with the regions was organised to discuss the process and findings regarding the inventory of needs and guidelines. It involved a final check on the

needs of the regions (2.1.3), a presentation of the number of guidelines per category (2.3.3) and a summary of the similarity analysis (chapter 3). Based on the findings, a 'guide to the guidelines' approach was proposed. The purpose of the meeting was to come to a joint decision about the approach to follow ('go/ no go' moment). It was decided to proceed with a 'guide to the guidelines' approach. This approach is discussed in chapter 4.

3. Similarity analysis of the guidelines

To gain an overview of the similarities among the guidelines, a similarity analysis using Multidimensional Scaling (MDS) was conducted to visually represent the relationship between them. Upon reviewing the guidelines, it was observed that many of the guidelines appeared similar in terms of the climate hazards they address and the needs they meet.

3.1 Introduction to Multidimensional scaling

Multidimensional scaling (MDS) is a technique used to represent objects in a space based on their similarities or dissimilarities. Essentially, MDS is a dimension-reduction algorithm that shows the underlying structure of a dataset by calculating distance measures between objects (Mueller, 2023). The goal is to position the objects in a dimensional space based on similarity or dissimilarity scores, rather than relying on their individual features.

For this analysis, we used the Bray-Curtis similarity to analyse the guidelines. This method gives a range between 0 and 1, indicating how similar two samples are across various parameters – in this case how similar two guidelines are on the parameters; climate hazards and needs (Clarke & Warwick, 1994). The Bray-Curtis similarity is better at handling the large proportion of zeroes, which is the case for this dataset and this measure will not consider shared absences as being similar, which makes sense here (Latten, 2022).

3.2 Guidelines similarity on climate hazards

Figure 6 presents a MDS graph in two dimensions, illustrating the similarities between which climate hazards the guidelines address. The numbers on the graph correspond to the identifying number for each guideline in the datasheet. The 2D stress is very low (0,04) which means that the space between the guidelines closely reflects their actual multivariate distance when reduced to two dimensions.

The two larger bubbles on the left side of the graph represent the guidelines addressing "all" climate hazards or have been marked as "not found" (those guidelines where NBS were not described related to climate hazard category). These contain a large amount of the similarities in the graph. If we disregard these clusters, the remaining guidelines are primarily clustered together in the centre of the graph. This cluster is centred around a large bubble in the middle representing guidelines addressing "heavy rainfall", "flooding", "drought" and "heat waves". The smaller bubbles near the central cluster are very similar in their relation to climate hazards with only minor differences, such as one additional or one

fewer climate hazard compared to the central cluster bubble. The further away from the centre the greater its dissimilarity the guideline is.

Apart from the main cluster surrounding the central bubble, there are only a few outliers. For example, guidelines 13 and 79 that are only addressing the climate hazard "sea level rise". Similarly, guidelines 48 and 94 that are only addressing the climate hazard "heavy rainfall" and guidelines 57 and 120 are only addressing "flooding". These outliers appear to be more specific to a single climate hazard, whereas the majority of the guidelines near the centre of the cluster are more general. This observation is further supported by the large clusters that represent guidelines addressing either all or none of the climate hazards.

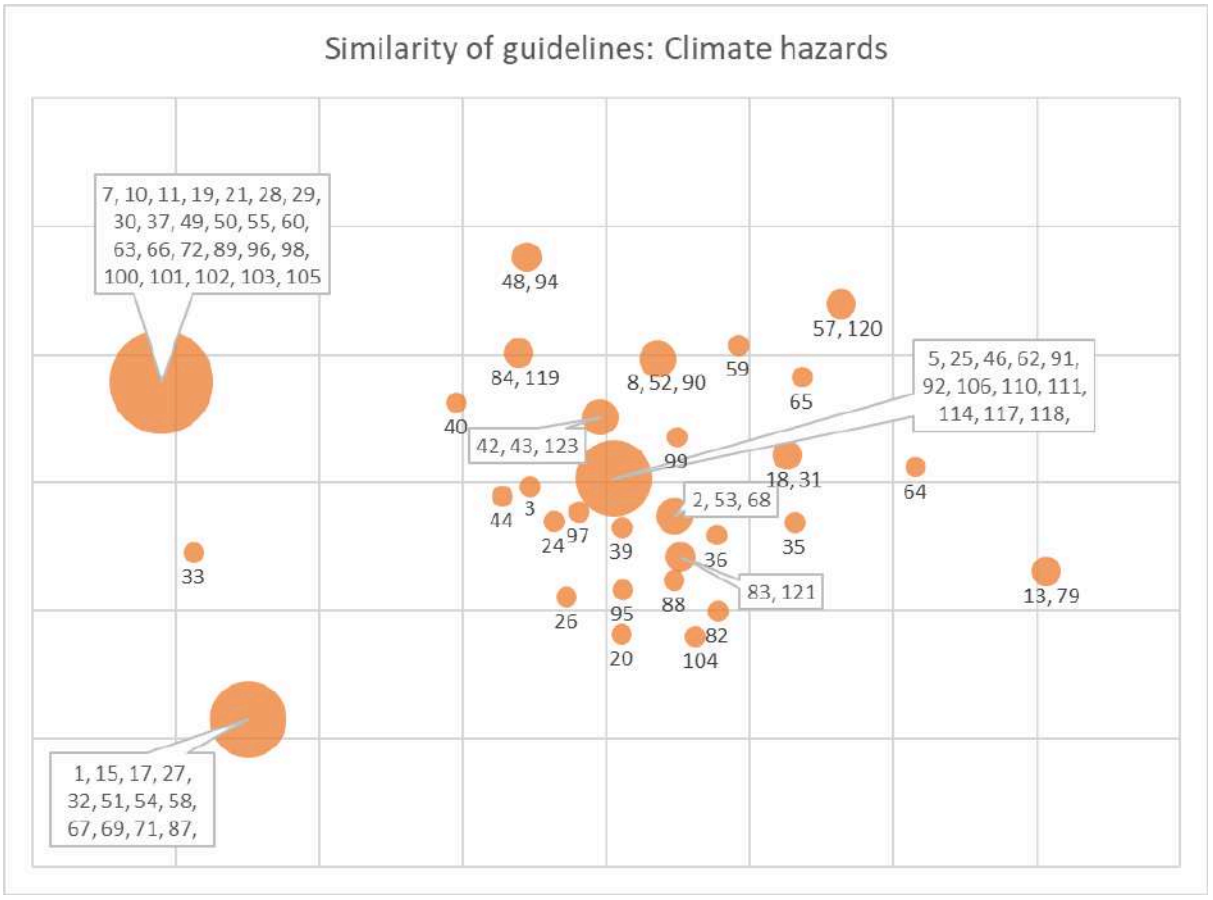


Figure 6. Similarity of guidelines matched with climate hazards visualized with MDS in a 2D format. Bray-Curtis similarity. 2D stress: 0,04

3.3 Guidelines similarity on regional needs

Figure 7 presents a MDS graph in two dimensions, showing the similarities between which needs the guidelines potentially meet. The numbers on the graph correspond to the identifying number for each guideline in the datasheet.

Unlike the graph for climate hazards, this graph does not have the same obvious patterns. In this graph the bubbles are more scattered, likely because there are more parameters within

needs. The stress level for figure 2 is also higher in this analysis than in figure 1 with 2D stress of 0,18. This is however still within the acceptable stress level (Latten, 2022).

On the right side of the graph, there are some clusters with larger bubbles. These represents guidelines addressing either "Selection of fitting NBS/BGI" (20, 24, 53, 54, 72, 88), both "Selection of fitting NBS/BGI" and "Assess site specific characteristics and demands" (46, 62, 71, 118) or "Selection of fitting NBS/BGI" and "Design criteria for implementation of NBS" (29, 30, 87).

The large central cluster with many smaller bubbles (mostly containing only one guideline each), is characterized by guidelines addressing several of the needs.

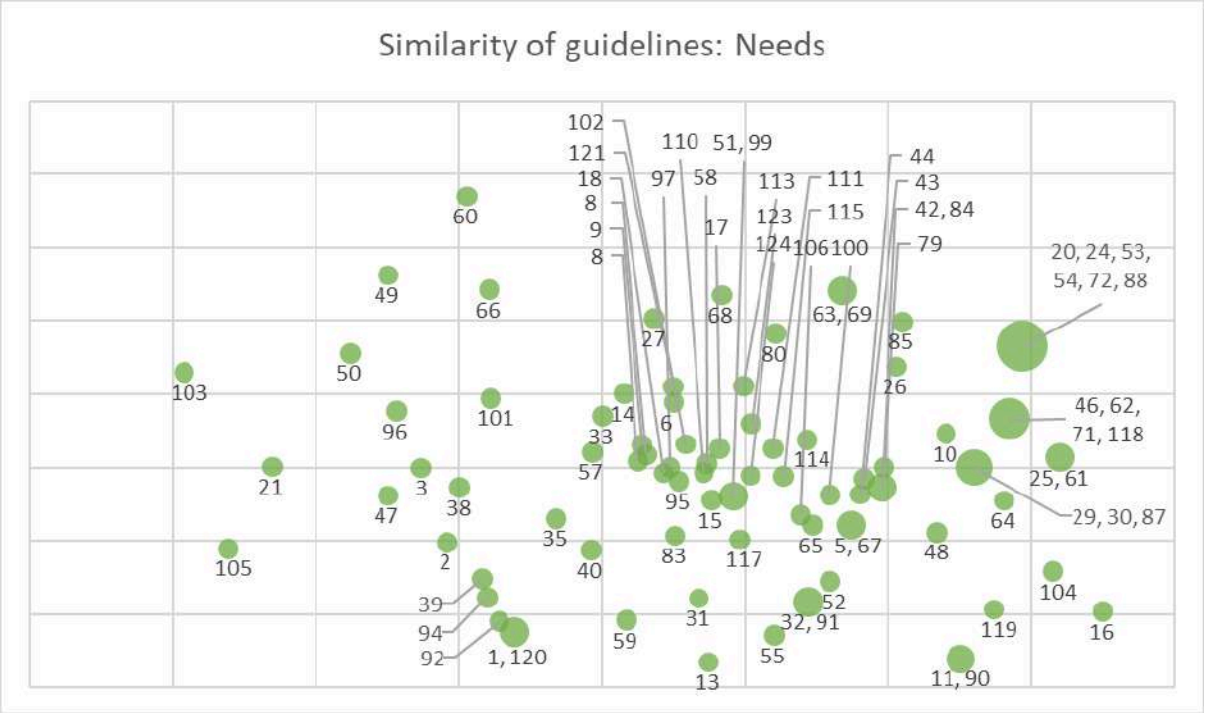


Figure 7: Similarity of guidelines matched with needs from the regions visualized with MDS in a 2D format. Bray-Curtis similarity. 2D stress: 0,18

3.4 Reflection on the similarity analysis

The similarity analysis and the two MDS graphs indicate that the majority of the guidelines are closely clustered, with a high degree of similarity, leaving only a few outliers. Especially concerning climate hazards. While in figure 7 addressing the needs the guidelines are somewhat more scattered but generally many of the guidelines address several of the needs. This supports the observation made upon reviewing the guidelines and further supports the argument that providing a guide to finding the recommended guideline among the many existing is a more effective approach than creating a new guideline.

4. Guide to the guidelines

The Task 8.1 team worked on a 'guide to the guidelines', in which the team assists the regions to find (the applicable parts of) the guidelines where they can find information to suit their needs. This offers tailored access to the wealth of information that is available, but takes each individual region a lot of time to inventory, explore, digest and translate into actionable knowledge for their specific context. This way, a process is developed that could be applied by and outscaled to other regions as well.

4.1. Background and scope

Until recent years, there were not any known overviews to indicate the suitability of existing tools and guidelines for addressing the various challenges related to the implementation and upscaling of NbS and BGI. Voskamp et al. (2021) were the first to start a database in relation to NBSs in cities. Their research shows that end-users find it challenging to find and navigate all available tools and resources. It is also questioned whether developing a new tool is always the best option, or whether the modification of an existing tool could be more (cost) effective. As an example, they mention that translating tools into multiple languages could make them accessible to a larger group of end-users. This could also apply to the ARCADIA regions.

Nevertheless, new guidelines keep emerging. Recent examples are the Nordic Guidance for Nature-based Solutions (Norwegian Institute for Nature Research et al., 2024) and Compilation of existing guidance on ecosystem restoration (Kupilas et al., 2024). To help the ARCADIA regions find the guidelines that suit their needs, a database of all known relevant guidelines is compiled. Within ARCADIA, this 'guide to the guidelines' approach is taken a step further than updating and extending a database for NbS/ BGI. In addition, a 'quick reference guide' is developed, containing recommended reads per topic. It is meant as a working document that is tested and improved during the ARCADIA project.

4.2. Reflection on the needs

The regions expressed a very wide range of needs, from impact assessments (necessitating a quantitative analysis of the specific hazard to be addressed by a certain NbS/ BGI measure), to guidance for policy makers (such as raising political awareness) and consideration related to governance and maintenance (ARCADIA WP8, 2024, p.22).

Four of the regions mentioned a need for design criteria: the formulation of the Emilia-Romagna region covers the generally identified need most comprehensively, as: "A set of criteria to design NbS and BGI, in consideration of climate hazards, territorial context and related provision of ecosystem services."

Good practices and learning from others are mentioned by several regions. This makes clear a need for practical examples – showing that the concepts of NbS and BGI are not just ideas, but can be implemented effectively in the real world. This is probably seen as required to create the awareness needed to generate political momentum and to prevent having to invent the wheel over and over again. Maybe surprisingly, none of the regions expressed the need for scientific evidence or key figures.

A final check on the needs and a discussion about the 'guide to the guidelines' approach with the regions (see section 2.5), resulted in the following, additional inquiries:

- Take into account the length of the guidelines.
- Try to generalize the needs that are addressed, as the guide to the guidelines must also be made available for other continental regions.
- There are different end-users with their own specific needs, for example policy officers, financial experts (legal), technical implementation. Tailor products to target groups if possible.
- Consider translating descriptions into the languages spoken in the regions, since not everyone involved in the living labs masters the English language.

4.3. Products for operational guidance

End-users can only benefit from guidelines and tools when they are aware of their existence. As it is important to adapt NbS to specific needs and local contexts, it is also essential that end-users can make an informed selection of the guidelines available. The 'guide to the guidelines' consists of two related products: a 'quick reference guide' (iPDF) and an extensive guideline database. In this section, both products are explained.

4.3.1. A quick reference guide (iPDF)

An interactive PDF (iPDF) is designed as a 'guide to the guidelines' for Nature-Based Solutions (NBS) and Blue-Green Infrastructure (BGI). The document offers a curated selection of practical guidelines, serving as a quick reference guide to help regions navigate extensive information on project needs or climate hazards by highlighting the most practical and relevant resources. Additionally, the iPDF functions as a working document for partner regions to test in local innovation labs. By exploring the recommended guidelines, regions can identify the most promising approaches and determine any additional steps needed for

their local contexts. While this guide does not aim to be exhaustive, it strives to provide valuable insights derived from existing resources, facilitating practical application and further adaptation efforts.

What is an iPDF?

An iPDF is a PDF file to use digitally. It contains text and images, but can also include interactive elements like buttons, hyperlinks and graphic material. An iPDF uses handy navigation, making it easy for the user to find spot-on information. It can also be used on mobile devices.

Navigation
Jump to other pages and back

Hyperlinks
One click away from entering online websites and documents

Design of the guide

The iPDF is designed to match the ARCADIA style. On the first page a short introduction and instruction for use can be found. The guide starts with two clickable entries on the second page, climate hazards and how-to topics, as mentioned below:

Climate hazards
- Heavy rainfall
- Flooding
- Drought
- Heat waves
- Landslides
- Wildfires
- Sea level rise

How-to
- Select and design NbS/ BGI
- Assess and value benefits
- Determine costs of measures
- Approach spatial planning
- Execute management and maintenance
- Conduct monitoring, evaluation and impact assessments
- Engage the public
- Learn from practical examples

Each item navigates to a page dedicated to the chosen topic. On this page recommended reads can be found, with per guideline:
- A hyperlink to the particular guideline
- Publication date
- Tailor made description, including a reference to relevant parts of the guideline
- Clickable symbols indicating:
  - Which hazards are addressed within guidelines for each how-to topic
  - Which how-to topics are addressed within the guidelines for each hazard

Each page contains an interactive button ‘overview’ to lead users back to the entries page. An example of the design is shown in figure 8.

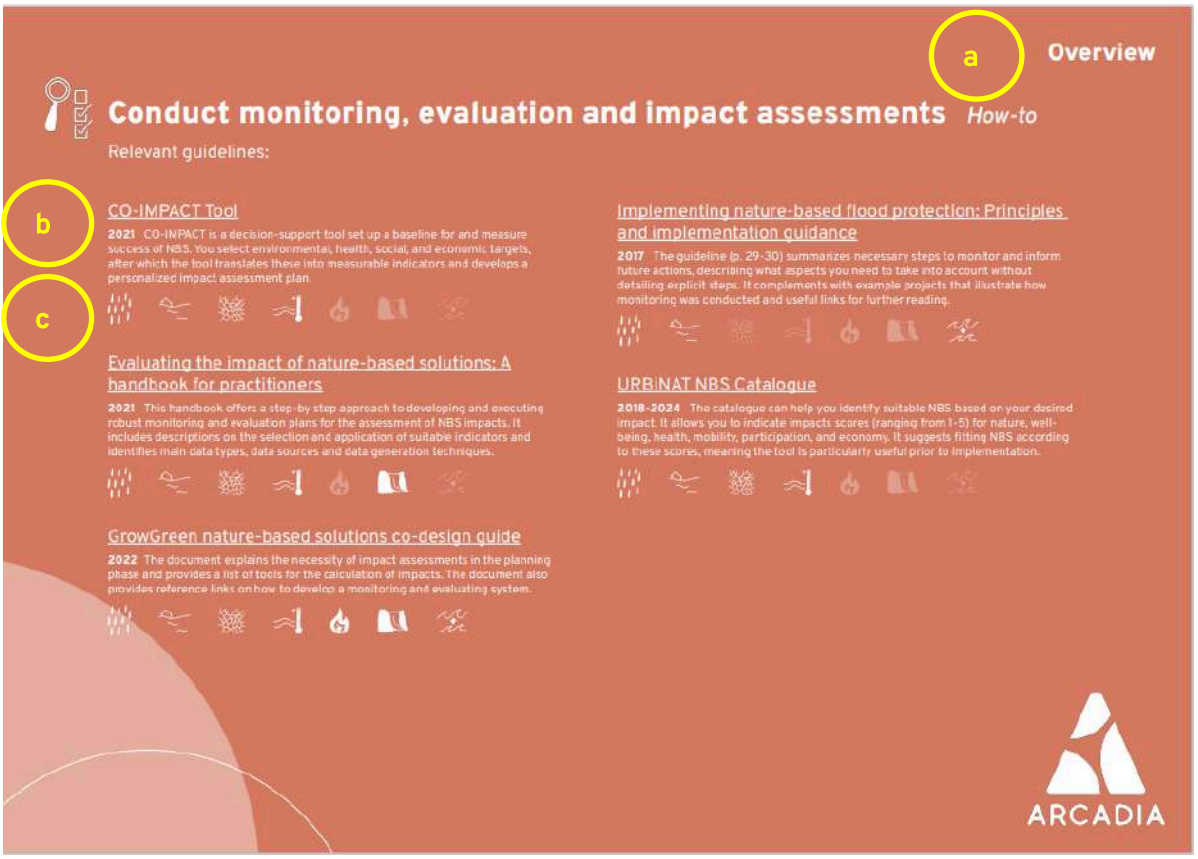


Figure 8. An example of the quick reference guide for the how-to topic 'conduct monitoring, evaluation and impact assessments'. The page contains an interactive button 'overview' to lead users back to the entries page (a) and per guideline a description (b) and clickable symbols (c) indicating if any specific hazards are being addressed within the guideline.

Reflection on the entries

The entries and items in the iPDF are the result of the inventories conducted (as described in chapter 2) as well as practical findings during the selection of recommended reads. Even though guidelines have been found for all categories - climate hazards, the project phases and needs expressed by the regions -, only five guidelines are found for wildfires and only two for cold waves. Because they lack concrete guidance for implementing NbS/BGI, these were not selected as recommended reads. As none of the regions expressed a specific interest in cold waves, cold waves were not incorporated in the iPDF. Wildfires are included as an item, in spite of the gap found. A gap for guidelines addressing wildfires was also previously stated by Voskamp et al. (2021). A consultation of experts in wildfire management among scientists at WR led to confirmation of this gap.

4.3.2. Database

All the guidelines regarding NbS/BGI are included in an extensive guideline database. End-users can consult this overview for a deep-dive on existing guidelines and use filter options to select relevant guidelines themselves.

5. Next steps

A large number of relevant guidelines exists already and many of these guidelines cover similar topics, as we saw in the similarity analysis (chapter 3). Rather than creating yet another guideline, the conclusion is clear that the ARCADIA regions would benefit more from assistance in accessing and finding the existing ones and translating these, both in terms of language as well as in terms of making the information more fitting to their context.

The ARCADIA Task 8.1 team will therefore support the ARCADIA regions with finding the appropriate guidelines and tools within the regional Innovation Labs. This will be a demand driven process, in which the WP8.1 team engages with the regions in their work to design and implement NbS / BGI measures and discusses needs for guidance more in depth, specifically focussed on the needs of that region, in relation to which actions should be developed to improve, build on or complement existing guidance.

Starting with the guideline database, and more specifically the recommended reads, this will steer a more tailored discussion of the needs of each regional co-Innovation Lab implemented within ARCADIA and the guidance that would be instrumental in taking steps forward. In this way, we improve understanding of the need for any additional guidance or whether existing guidance could be tailored best by adding additional information, for instance by adding additional tools and techniques, by describing how data that is available for that particular Innovation Lab be utilised best, or by translating existing guidance in the language most widely understood in the Living Lab if that is what is needed most.

During this process there will also be room for sharing new insights from ongoing projects and any new guidelines that become available during this process. Creating overview of the additional desired actions, helps to identify possible synergies between the different regions. Also, this provides a basis for prioritising actions to make sure that at least the most important and most needed actions will be performed and needed results are delivered.

Thus, the next steps proposed are:

- Identify a contact person per region
- Match up with other ARCADIA activities
- Explore which guidelines from the database/recommended reads are most promising for each region and what additional steps are needed
- Perform a quick scan of newly published guidance
- Create an overview of the additional guidance, and inventory actions
- Prioritise actions
- Implement actions
- Update guideline database

Region contact person

This process will start by validating whether the regional coordinator or someone else would be positioned best to represent the region. This could be the regional coordinator, the regional knowledge partner or for instance the project leader of one or more of the co-Innovation Labs in that region.

Match up with other ARCADIA activities

Connecting to ongoing ARCADIA activities, such as the task related to the development and operationalisation of ARCADIA Climate Toolbox, is the preferred way to organise this, as it minimizes demand on resources for both the regions and the WP8 team. This will be explored by identifying the activities that fit best in terms of content, timeline and target group. Meetings with representatives of both the WP8.1 team and the regions will be planned accordingly.

Explore 'recommend read' guidelines

The 'recommended read' guidelines from the database will be the starting point for more in-depth discussions with the regions to discuss the guidance that they need. Do the recommended reads contain the guidance needed, what else is needed, why, in what form and how. What are actions that will need to be put in place to take this a step further? This will be discussed and noted in a brief, informal and practical summary per region.

Quick scan of new guidelines

As several relevant guidelines were published during the months between the writing of the milestone document and this deliverable, it is clear that the number of the guidelines continues to expand. Keeping track of any new guidelines and tools is needed to make sure that all the most recent guidelines are taken into consideration. The newly acquired in-depth insight from the analysis of the region needs and identified actions for further guidance, will steer a quick scan of newly published guidance. This will be done via an online search and interaction with ongoing projects such as NBRACER, DESIRMED and other projects that the Task 8.1 team and other ARCADIA partners are involved in.

Overview of additional actions needed

After a first round of discussions with the regions, the next step will be to create an overview of which guidelines will be further elaborated on and how. Actions could include work sessions focussed on a specific topic, adding information to a guideline, translation, finding and citing good practices examples, etc. Any overlap between, and potential for synergies of the actions needed, will be identified and communicated with the applicable regions. This helps avoid double work and improves insight into the knowledge and expertise that the regions have, that might benefit the other regions.

Prioritise actions

The overview of actions will help to identify actions that serve the needs for several regions or guidelines that are relevant for several needs of one region might be more relevant to be selected for translation. The prioritisation will be done in discussion with the regions and the WP8 ARCADIA team.

Implement actions

The actual implementation of actions will take shape depending on the actions that are identified during the process outlined here. As mentioned above, some examples include the organisation of work sessions focussed on a specific topic, adding specific information on technological know-how or expertise to an existing guideline, translating (parts of) a guideline, etc.

Update guideline database

The last step will consist of updating the guideline database by adding the newly found guidelines and by adding the additional outputs created in the process outlined here.

References

ARCADIA. (2024). *Objectives and Results.* https://www.arcadia-adaptation.eu/index.php/the-project/

ARCADIA WP8. (2024, 7 11). Review of nature-based solutions implemented in the regions, and models & data used. *ARCADIA (internal document).*

Clarke, K. T., & Warwick, R. M. (1994). *Change in Marine Communities: An Approach to Statistical Analysis and Interpretation.* Plymouth Marine Laboratory.

European Research Executive Agency. (2003). Nature-based solutions. In *EU-funded NBS R&I projects tackle the climate and biodiversity crises* (ISBN: 978-92-95234-17-8). Nature-based solutions. Retrieved 11 28, 2024, from https://rea.ec.europa.eu/funding-and-grants/horizon-europe-cluster-6-food-bioeconomy-natural-resources-agriculture-and-environment/nature-based-solutions_en

Kajfež Bogataj, L. (2024, 11 7). *Climate change challenges in region Podravje, Slovenia* [webinar].

Kupilas (et al.), B. (2024, March 1). *Compilation of existing guidance on ecosystem restoration* [Reference document for Member States to inform nature restoration planning]. Ecologic Institute, Berlin.

Latten, A. (2022, 2). *Multidimensional Scaling.* Environmental Computing. https://environmentalcomputing.net/graphics/multivariate-vis/mds/

Mueller, S. T. (2023). *Distance, Similarity, and Multidimensional Scaling, Self-Organizing Maps.* MTU. https://pages.mtu.edu/~shanem/psy5220/daily/Day16/MDS.html

Norwegian Institute for Nature Research, NIRAS/Aarhus University, Norwegian Institute for Water Research, Lund University, Natural Resources Institute Finland, Faroe Islands National Museum, & Agricultural University of Iceland. (2024, December). *Nature-based Solutions for societal challenges.* NBS guide. Retrieved December 17, 2024, from https://nbsguide.org/About

Voskamp, I.M., Luca, C. d., Polo-Ballinas, M.B., H., H., & Brolsma, R. (2021). Nature-Based Solutions Tools for Planning Urban Climate Adaptation: State of the Art. *Sustainability, 13(11), 6381.* https://doi.org/10.3390/su13116381

Annex

Annex 1. Questionnaire for the regions

LINK to the online form:
https://forms.office.com/pages/responsepage.aspx?id=5TfRJx92wU2viNJkMKuxjxRxYYVxKrlGjmRPLRtKVBNUREJTNE5EUlJKMlNDOVdKWEw4M1E2V0FBSi4u&route=shorturl

Annex 2. The needs explained

Needs	Explanation; Tools and guidance on: …
Assess site specific characteristics and demands	providing insight into the characteristics of an area, including both biophysical (such as soil, water, slope, climate) and socio-cultural aspects (demography, land-use, water use (in relation to agriculture and citizens, quality and quantity). - demands include for example biodiversity conservation and restoration, soil protection, soil stabilization, flood mitigation, C sequestration, ecosystem services and other environmental aspects.
Selection of fitting NBS/BGI	Selecting appropriate NbS/BGI measures considering e.g. climate hazards, territorial context, and ecosystem services and compare/weigh different NbS/BGI options.
Design criteria for implementation of NBS	designing NbS/BGI, both for technical aspects (designing the works, dimensioning), and on process/ governance aspects: participation, finance.
Assessment of impacts / benefits	physical (soil, water, slope, climate) as well as socioeconomic (related to other types of agriculture, health benefits, recreation)
Valuation of benefits	assigning monetary value to benefits accrued from the NbS/BGI
Costs of measures	determining costs for NbS/BGI measures; from implementation to long term maintenance.
Mainstreaming NbS/BGI in (spatial) policy	engaging politicians and policy makers. Building governance structures for integration of NbS/BGI in land use, engage stakeholders and promote scaling of NbS/BGI

Spatial planning tools	integrating NbS/ BGI with other types of land use and manage potential conflicts (shaping stakeholder participation / co-creation, choosing the appropriate scale)
Management and maintenance	development of long-term plans, including ongoing maintenance works
Raising public awareness	communicating NbS/ BGI options, make people enthusiastic about NbS, show best practices, show C/B's, etc.
Public participation (co-creation)	working on NbS with stakeholders and general public
Monitoring, evaluation and learning	monitoring, evaluation (ex-post) and learning of NbS/BGI initiatives
Practical examples	The regions indicated interest in relevant practical examples for all of these topics.

Annex 3. The number of guidelines found for each hazard, project phase and need

Natural and Climate hazards									
Heavy rainfall	Flooding	Drought	Heat waves	Cold waves	Land-slides	Wild fires	Sea level rise	All	Not found
40	42	29	33	2	9	5	14	17	23

Project phase			
Exploration phase	Preparation phase	Implementation phase	Sustainment phase
81	74	48	36

Assess site specific characterics and demands	Selection of fitting NBS/BGI	Design criteria for implementation of NBS	Assessment of impacts / benefits	Valuation of benefits	Costs of measures	Mainstreaming NbS/BGI in (spatial) policy	Spatial planning tools	Management and maintenance	Raising public awareness	Public participation (co-creation)	Monitoring, evaluation and learning	practical examples
providing insight into the characteristics of an area, including both biophysical (such as soil, water, slope, climate) and socio-cultural aspects (demography,	Selecting appropriate NbS/BGI measures considering e.g. climate hazards, territorial context,	designing NbS/BGI, both for technical aspects (designing the works, dimensoining), and on process/	physical (soil, water, slope, climate) as well as socioeconomic (related to other types of landbouw,	assigning monetary value to benefits accrued from the NbS/BGI	determining costs for NbS/BGI measures; from implementation to long term maintanance.	engaging politicians and policy makers. Building govermance structures for	integrating NbS/ BGI with other types of landuse and manage potential conflicts (shaping	development of long-term plans, including ongoing maintenance works	communicating NbS/ BGI options, make people enthusiastic about NbS, show best practices, show	working on NbS with stakeholders and general public	montoring, evalutation (ex-post) and learning of NbS/BGI initiatives	please indicate whether the document elaborates any pracitcal examples
41	56	31	46	17	18	15	20	18	17	25	20	53

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Co-funded by
the European Union

Quick reference guide

Curated Resources for Implementing Blue-Green Infrastructure and Nature-based Solutions.

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Colophon

Disclamer
Views and opinions expressed in this report reflect only the author's view and do not necessarily reflect those of the European Union or The European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

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Introduction

This deliverable is part of Work Package 8 of ARCADIA (Arcadia adaptation) and presents an interactive PDF (iPDF) designed as a ‘guide to the guidelines’ for Nature-Based Solutions (NBS) and Blue-Green Infrastructure (BGI).

The document offers a curated selection of practical guidelines, serving as a quick reference guide to help regions navigate extensive information on project needs or climate hazards by highlighting the most practical and relevant resources.

Additionally, this iPDF functions as a working document for partner regions to test in local living labs. By exploring the recommended guidelines, regions can identify the most promising approaches and determine any additional steps needed for their local contexts.

Instruction for Use

On the following page, you can click on a specific need or climate hazard to access the corresponding guidelines directly. While this guide does not aim to be exhaustive, it strives to provide valuable insights derived from existing resources, facilitating practical application and further adaptation efforts.

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Climate hazards

- Heavy rainfal
- Flooding
- Drought
- Heat waves
- Landslides
- Sea level rise

How-to

- Select and design NbS/BG
- Asses and value benefits
- Determine costs of measures
- Approach spatial planning
- Execute management and maintenance
- Conduct monitoring, evaluation and impact assements
- Engage the public
- Learn from practical examples

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Heavy rainfall *Climate hazard*

Relevant guidelines:

CO-IMPACT

2021 Rather than addressing hazards directly, the tool asks you to select desired environmental (and social, economic and health) benefits and then offers suitable indicators and methodologies to plan monitoring and evaluation processes. Pertaining heavy rainfall, it provides suggestions on rainfall storage, rainfall infiltration, and water management.

Evaluating the impact of NbS: A handbook for practitioners

2021 This handbook offers a step-by step approach to developing and executing robust monitoring and evaluation plans for the assessment of NbS impacts. Case study 2 highlights a potential solution to address extreme rainfall, describing co-benefits and suggesting environmental, social, and economic indicators to monitor such NbS

Green Stormwater Infrastructure Planning & Design Manual

2021 The manual addresses heavy rainfall hazards by guiding the implementation of Green Stormwater Infrastructure (GSI) from a technical perspective. Section 2.3.3 outlines methods for drainage area delineation, optimizing stormwater capture and runoff management. Section 3.3 provides technical requirements for designing GSI systems to manage rainfall effectively, emphasizing infiltration, storage, and controlled discharge.

Sustainable drainage systems (Susdrain)

1993-2024 This portal, developed by CIRIA, offers a comprehensive collection of guidance documents addressing heavy rainfall hazard from general principles to specific SuDS components. Notable resources include the CIRIA C753 SuDS Manual, which provides detailed advice on designing systems for surface water management, infiltration enhancement, and flood risk mitigation. Note: Registration is required to access most documents.

Urban Nature Labs: Nature-based Solutions - Technical Handbook Factsheets

2019 This handbook addresses rainfall by showcasing various NbS solutions. Each solution is introduced with an explanation of its role in nature, its technical and design parameters, and the conditions required for its implementation.Tailored to urban resilience, these solutions can manage stormwater effectively, reduce runoff, and enhance infiltration.

Urban Green-Blue Grids

Living portal An interactive online portal helps users tackle heavy rainfall hazards by exploring water management challenges through a comprehensive story map. With 169 measures and 75 projects, users can identify effective strategies for reducing runoff and mitigating flood risks. Filters such as goal, scale, cost, and soil type streamline the search for specific solutions.

The Nature-based Solutions Opportunity Scan (NBSOS)

2024 The document addresses rainfall hazards by leveraging geospatial data to identify opportunities for pluvial flood reduction. It maps flood-prone areas, models benefits of NbS like bioretention and green spaces, and provides tailored recommendations for urban resilience. This tool aids strategic planning to mitigate flood risks effectively.

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Back to home

Flooding *Climate hazard*

Relevant guidelines:

Building with Nature & Beyond: Principles for Designing Nature Based Engineering Solutions

2021 This book explains how engineering, ecological and social design principles can support the realization of effective and sustainable hydraulic infrastructure designs. Section 4.3 and cases ‘Climate-proof Noordwaard’, ‘City with Nature’, ‘Coastal Protection’ and ‘Flood-proof Indonesia’ are especially interesting in terms of flood-related measures.

Engineering with Nature: An Atlas

2018 The atlas provides an overview of projects that integrate natural processes into engineering strategies that support flood risk mitigation and ecosystem restoration. Descriptions detail the use of natural and nature-based features (for instance, floodplains, riverine systems, wetlands, etc.) and highlight additional social, economic and engineering benefits.

Evaluating the impact of NbS: A handbook for practitioners

2021 This handbook offers a step-by step approach to developing and executing robust monitoring and evaluation plans for the assessment of NbS impacts. Section 5.2.2 and case studies 1, 2, and 4 highlight potential NbS to reduce flooding risks, describing co-benefits and suggesting environmental, social and economic indicators to monitor such solutions.

Implementing nature-based flood protection: Principles and implementation guidance

2017 The document presents five principles and implementation guidance for the planning, assessment, design, implementation, monitoring, management, and evaluation of NbS for flood risk management. Example projects illustrate how these steps work in real life cases and direct you to additional resources.

Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide

2019 This guide is designed to enhance understanding on how and where nature-based and hybrid solutions can improve the resilience of coastal roads and bridges, summarizing potential flood-reduction benefits as well as additional advantages. It also includes site characterization tools, decision support for selecting NbS, and suggested performance metrics.

Urban Green-Blue Grids

Living portal An interactive online portal helps users address flooding by exploring water management challenges through a comprehensive story map. Offering 169 measures and 75 projects, users can identify effective strategies including enhancing water retention, managing excess runoff, etc,. Filters such as goal, scale, cost, and soil type simplify the search for flood-specific solutions.

The Nature-based Solutions Opportunity Scan (NBSOS)

2024 The document addresses flooding hazards by leveraging geospatial data to identify opportunities for pluvial flood reduction. It maps flood-prone areas, models benefits of NbS like bioretention and green spaces, and provides tailored recommendations for urban resilience. This tool aids strategic planning to mitigate flood risks effectively.

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Drought *Climate hazard*

Relevant guidelines:

CO-IMPACT

2021 Rather than addressing hazards directly, the tool asks you to select desired environmental (and social, economic and health) benefits and then offers suitable indicators and methodologies to plan monitoring and evaluation processes. As it relates to drought, it provides suggestions on water security, rainfall storage and water management.



Urban GreenUP: NbS Catalogue

2018 The catalogue begins with 46 NbS organized into 14 categories, including Horizontal GI, water treatment, Sustainable Urban Drainage systems (SUDs), etc,. It details NbS with technical specifications, ecosystem benefits, and maintenance needs. For instance, rain gardens (Section 3.2) and green filter areas (Section 4.3) focus on water retention, reuse, and conservation, addressing drought hazards.



Urban Nature Labs: Nature-Based Solutions Implementation Handbook

2022 The handbook provides a comprehensive guide for implementing NbS in urban areas, offering technical specifications and monitoring frameworks. Chapter 4.6 specifically details NbS technical specifications, including strategies like constructed wetlands and retention ponds for water storage and reuse. Appendix I also provides updated indicators to evaluate water availability and drought resilience.



Sustainable drainage systems (Susdrain)

2019-2024 This portal, developed by CIRIA, offers a range of guidance documents that address drought resilience through sustainable water management strategies. Notable resources include guidance on rainwater harvesting and SuDS design, which emphasize water retention and reuse to reduce reliance on traditional water sources. Registration is required to access most documents.



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Heat waves *Climate hazard*

Relevant guidelines:

CO-IMPACT

2021 Rather than addressing hazards directly, the tool asks you to select desired environmental (and social, economic and health) benefits and then offers suitable indicators and methodologies to plan monitoring and evaluation processes. Regarding heatwaves, it provides suggestions on reducing urban heat island effects, heat stress and air temperatures, and realizing thermal comfort zones.

Evaluating the impact of NbS: A handbook for practitioners

2021 This handbook offers a step-by step approach to developing and executing robust monitoring and evaluation plans for the assessment of NbS impacts. Section 5.2.1 describes a case on urban heat island incidence; tables 4.1 and 4.3 suggest indicators to measure effects of NbS on heat-related hazard and disaster risks.

Urban Nature Labs: Nature-based Solutions - Technical Handbook Factsheets

2019 The UNaLab NbS Technical Handbook provides insights into mitigating heat waves through NbS. Specifically, chapter 2.1 details the role of single-line street trees in reducing urban heat islands, emphasizing their shading and cooling effects. Additionally, Chapter 4.1 outlines the use of green roofs as a strategy to lower ambient temperatures and enhance urban microclimates.

Urban Green-Blue Grids

Living portal An interactive online portal helps users tackle heat challenges by providing strategies to mitigate urban heat islands and improve cooling. Users can explore various solutions like shading, green infrastructure, and cooling systems, using filters such as goal, scale, cost, and soil type.

The Nature-based Solutions Opportunity Scan (NBSOS)

2024 The document addresses heat waves by identifying urban heat islands and modeling cooling benefits of solutions like tree canopies and green roofs. It provides tailored recommendations to reduce surface temperatures, enhance shading, and improve urban microclimates, promoting heat resilience in regional planning and development.

ARCADIA

Back to home

Landslides *Climate hazard*

Relevant guidelines:

Evaluating the impact of NBS: A handbook for practitioners

2021 This handbook offers a step-by step approach to developing and executing robust monitoring and evaluation plans for the assessment of NbS impacts. Case study 3 describes an NbS practice on landslides and debris flows; table 4.3 provides some indicators to measure effects of NbS on risks of landslides.

Back to home

Sea level rise *Climate hazard*

Relevant guidelines:

Building with Nature & Beyond: Principles for Designing Nature Based Engineering Solutions

2021 This book explains how engineering, ecological and social design principles can support the realization of effective and sustainable hydraulic infrastructure designs. Videos on ‘storm surge barriers’ and ‘ designing dikes’, the Sand Engine Delfland case study and cases 4 (Coastal Protection) and 6 (Flood-proof Indonesia) are particularly relevant.

Engineering With Nature: An Atlas

2018 The atlas provides an overview of projects that integrate natural processes into engineering strategies that support flood risk mitigation and ecosystem restoration. Descriptions detail the use of natural and nature-based features (for instance, floodplains, riverine systems, wetlands, etc.) and highlight additional social, economic and engineering benefits.

Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide

2019 This guide is designed to enhance understanding on how NbS can be implemented to improve resilience of coastal roads and bridges under conditions of sea level rise and extreme weather events. It also includes site characterization tools, decision support for selecting NbS, and suggested performance metrics.

Select and design NbS/BGI *How-to*

Relevant guidelines:

Building with Nature & Beyond: Principles for Designing Nature Based Engineering Solutions

2021 The handbook offers a comprehensive engineering approach that focuses on the use of natural materials and ecological processes to achieve sustainable hydraulic infrastructural designs. It explains the BwN concept, supplementing with cases and Chapter 3 offers guidelines to implement the ecological design.

Catalogue of NBS for urban resilience

2021 This catalogue describes five important principles for the integration of NBS in cities. It categorizes various NbS 'families', indicating types of city the NbS can be applied to, suitability of the location, spatial and technical characteristics, and environmental qualities.

Green Stormwater Infrastructure Planning & Design Manual

2021 This manual provides guidance for planners and designers on creating green stormwater infrastructure (GSI) in the city. It uses Philadelphia as the case city to introduce the step-by-step planning and design strategy, technical requirements, and workflows for GSI projects.

Implementing nature-based flood protection: Principles and implementation guidance

2017 The guideline offers key principles to consider when planning NbS, summarizes the steps needed for planning, assessment and design, and what outputs facilitate the process. Example projects illustrate how these steps work in practice and direct you to additional resources.

ProGIreg: Methodology on spatial analysis in front-runner and follower cities

2018 This document supports users in selecting and designing NbS and BGI by offering practical methodologies, tools, and criteria to tailor solutions to local social, ecological, and spatial contexts.

URBiNAT NBS Catalogue

2018-2024 The catalogue allows you to select NbS according to your needs, aspirations, and local environmental conditions. The selection tool offers options to search for key words, choose types of NbS, indicate selected impacts and highlights best practices and useful references

ARCADIA

Asses and value benefits *How-to*

Relevant guidelines:

EU Guidance on Integrating Ecosystems and their Services into Decision-Making

2019 The EU Guidance on Integrating Ecosystems and their Services into Decision-Making provides a framework for policymakers and industry leaders. Step 3 focuses on mapping, asesseing, and valuing ecosystem services. It offers methodologies and apporaches to incorporate these values into decison-making processes.

Implementing nature-based flood protection: Principles and implementation guidance

2017 Chapter 2 step 5 provides neccessary steps to assesses and values the benefits of nature-based flood protection (as well as cost and impacts). The focus is on evaluating the economic, environmental, and social outcomes. It uses methodologies such as cost-benefit analysis, ecosystem service valuation, and stakeholder-driven assessments to quantify advantages like flood risk reduction, habitat restoration, and community resilience.

Assessing the Benefits and Costs of Nature-Based Solutions for Climate Resilience: A Guideline for Project Developers

2023 Chapter 2 of this guideline delves into the methodologies for valuing the benefits and costs of NbS. It provides a decision framework and practical tools to help project developers quantify the economic, social, and environmental impacts of NbS projects.

URBiNAT NBS Catalogue

2023 The catalogue can help you identify suitable NBS based on your desired impact. It allows you to indicate impacts scores (ranging from 1-5) for nature, well-being, health, mobility, participation, and economy. It suggests fitting NbS according to these scores, meaning the tool is particularly useful prior to implementation.

ARCADIA

Determine costs of measures *How-to*

Relevant guidelines:

Catalogue of NBS for urban resilience

2021 For each urban NbS type, the catalogue outlines key cost considerations for the investment and implementation stage as well as longer-term maintenance costs. It also provides indicative examples of unit costs (which can vary significantly and are highly site- and project-specific).

Cost-Benefit Analysis and the Environment

2006 The book provides an in-depth assessment of conceptual and methodological developments in cost-benefit analysis and the environment. It does not tell you how to conduct a cost-benefit analysis, but chapter 2 does describe the relevant stages of such a practical analysis.

Implementing nature-based flood protection: Principles and implementation guidance

2017 The guideline summarizes (p. 24-25) necessary steps to estimate the costs (as well as benefits and effectiveness), describing what aspects you need to measure without explicitly detailing how to perform this analysis. It does, however, reference example projects that describe how calculation methods are applied in practice.

A Guide to Assessing Green Infrastructure Costs and Benefits for Flood Reduction

2015 The guide helps users estimate costs of GI for flood reduction through a six-step process: defining flooding problems, modeling scenarios, setting targets, evaluating GI effectiveness, calculating costs/benefits, and communicating strategies. It balances costs with long-term benefits, highlighting GI's economic, environmental, and social advantages for informed decision-making.

World Bank. Assessing the Benefits and Costs of Nature-Based Solutions for Climate Resilience: A Guideline for Project Developers

2023 This publication offers an overview of valuation methods for estimating costs (and benefits) associated with NbS, along with a decision framework to guide the design of such assessments. Case study examples demonstrate how valuation methods are applied during different phases of the project cycle.

UNALAB: NBS Value Model

2019 The document provides a comprehensive approach to assessing costs of implementing NbS. Chapter 2.3 links specific NBS clusters with financial options, outlining investment and operational costs. Tables 3 and 4 further categorize costs for diverse interventions, offering tailored insights for urban planners to determine funding requirements.

ARCADIA

Approach spatial planning *How-to*

Relevant guidelines:

EU Guidance on Integrating Ecosystems and their Services into Decision-Making

2023 Part 2 chapter 5 of this document provides practical guidance for integrating ecosystem services into spatial planning, offering tools, methodologies, and examples to enhance sustainability and address trade-offs in land-use and development decisions.

ProGIreg: Methodology on spatial analysis in front-runner and follower cities

2018 This document provides a comprehensive methodology for spatial analysis in urban planning, guiding users to integrate NbS into sustainable spatial strategies while addressing social, ecological, and economic challenges effectively.

Green Stormwater Infrastructure Planning & Design Manual

2021 The manual guides users in spatial planning by providing a set of standards, strategies and tools for integrating Green Stormwater Infrastructure into urban landscapes, optimising sustainabilities and water management practices.

ARCADIA

Execute management and maintenance *How-to*

Relevant guidelines:

Catalogue of NBS for urban resilience

2021 "For each NbS typology, the catalogue provides basic guidance on maintenance requirements such as intensity of labor, frequency, or special care in the initial stages of development.

Guidelines for design, construction and maintenance of large scale NBS

2024 This guideline provides insights for managing and maintaining NbS projects, drawing from three European case studies. Chapter 4 outlines detailed strategies on monitoring and evaluating the performance of NbS, including key indicators and metrics for success.

NBS for coastal highway

2019 Chapter 8 focuses on monitoring, maintenance, and adaptive management for NbS supporting coastal highway resilience. However, its principles, like routine inspections, addressing erosion, debris removal, and adaptive adjustments, can apply broadly to NbS management in other contexts, ensuring long-term performance and climate change adaptability.

Planning Management for Ecosystem Services: An Operations Manual

2017 This manual provides in chapter 3 a structured six step approach to integrating ecosystem management, which can be helpful for creating a management plan for NbS projects. The six outlined steps include: identifying and engaging stakeholders, addssing ecosystem services, setting objectives, developing management actions, implementing management actions, monitoring and adapting.

ARCADIA

Conduct monitoring, evaluation and impact assessments *How-to*

Relevant guidelines:

CO-IMPACT Tool

2021 CO-IMPACT is a decision-support tool set up a baseline for and measure success of NbS. You select environmental, health, social, and economic targets, after which the tool translates these into measurable indicators and develops a personalized impact assessment plan.



Evaluating the impact of nature-based solutions: A handbook for practitioners

2021 This handbook offers a step-by step approach to developing and executing robust monitoring and evaluation plans for the assessment of NbS impacts. It includes descriptions on the selection and application of suitable indicators and identifies main data types, data sources and data generation techniques.



GrowGreen nature-based solutions co-design guide

2022 The document explains the necessity of impact assessments in the planning phase and provides a list of tools for the calculation of impacts. The document also provides reference links on how to develop a monitoring and evaluating system.



Implementing nature-based flood protection: Principles and implementation guidance

2017 The guideline (p. 29-30) summarizes necessary steps to monitor and inform future actions, describing what aspects you need to take into account without detailing explicit steps. It complements with example projects that illustrate how monitoring was conducted and useful links for further reading.



URBiNAT NBS Catalogue

2018-2024 The catalogue can help you identify suitable NbS based on your desired impact. It allows you to indicate impacts scores (ranging from 1-5) for nature, well-being, health, mobility, participation, and economy. It suggests fitting NbS according to these scores, meaning the tool is particularly useful prior to implementation.



ARCADIA

Engage the public *How-to*

Relevant guidelines:

Building with Nature & Beyond: Principles for Designing Nature Based Engineering Solutions

2021 Part II of this handbook (chapter 6-10) offers information on how to build a coalition of stakeholders to support the design and implementation of ecosystem-based hydraulic infrastructures. It describes stakeholder mapping and game theory techniques and provides stakeholder-inclusive social design principles.

GrowGreen nature-based solutions co-design guide

2022 The guide is a comprehensive guidance tool that explains what a collaborative design process for NbS entails. It provides reading materials, concrete tools and case studies that illustrate how co-design processes – including planning, mobilization and evaluation stages – have been implemented in other NbS projects.

Guidelines for co-creation and co-governance of nature-based solutions: Insights from EU-funded projects

2021 This publication delves into co-creation and co-governance approaches, presenting various ways of co-designing, co-developing, co-implementing and co-monitoring NbS. Drawing upon real life cases in Europe, It illustrates best practices regarding the co-creation of NBS at its different stages, phases and scales. .

LIFE MEDACC - After LIFE MEDACC Communication Plan

2013-2018 This communication plan highlights the importance of implementing communication and dissemination efforts after the project has finished. It offers practical examples to inform and enthuse the public about NbS and inspire other watersheds.

ProGIreg - Guidelines for co-designing and co-implementing green infrastructure in urban regeneration processes

This document offers practical guidance on how to initiate, steer and organize collaborative design processes for the planning and implementation of NbS with stakeholders and the wider public. It provides 6 co-design principles with practical illustrations of their application through ‘stories’ and detailed instructions and templates for tools and instruments.

URBiNAT NBS Catalogue

2023 The catalogue allows governmental authorities and citizens to co-select and co-create NbS according to their specific needs, ambitions and realities on the ground. It offers suggestions on ways and methods to ensure a participatory approach throughout, from co-diagnostic to co-monitoring stages.

ARCADIA

Learn from practical examples *How-to*

Relevant guidelines:

Catalogue of NBS for urban resilience

2021 The Catalogue by the World Bank emphasizes practical examples by categorizing solutions into fourteen urban NbS families. Each family includes multiple examples showcasing successful implementations in urban settings.

GrowGreen nature-based solutions co-design guide

2022 The guide is intended for practitioners responsible for the design and implementation of NbS projects. The guide elaborates on three phases: Planning, Mobilising, and Evaluating. In each phase, guiding questions are formulated, and for each question, different case study examples are provided.

Urban Nature Atlas

2024 In this atlas, you can find practical examples of urban NbS, featuring over 1,000 case studies worldwide. It offers detailed insights into various urban projects. The website provides a filter options to refine searches by criteria such as challenges addressed, NbS, and environmental impact.

NBS Best Practice Guidelines

unknown The Nature-Based Solutions Initiative's case study platform offers a collection of best-practice examples from around the globe. You can explore cases by filtering criteria such as country, ecosystem type, and climate impact addressed, providing valuable insights into effective NbS implementations.

ProGIreg - Nature-based solutions and green infrastructure

2023 This website provides practical examples of 8 types of NbS; each example includes an explanation, links, and/or clip. Types of NbS include leisure activities and clean energy, regenerated soil, community-based urban farms and gardens, aquaponics, green walls and roofs, accessible green corridors, local environmental compensation processes, and pollinator biodiversity.

Guidelines for co-creation and co-governance of nature-based solutions: Insights from EU-funded projects

2023 This document is based on four EU projects: CLEVER Cities, URBiNAT, ProGIreg, and Connecting Nature. Each section includes a box with a practical example of how co-creation and co-governance were implemented in one of these projects.

Implementing nature-based flood protection: Principles and implementation guidance

2017 This World Bank document focuses on principles and implementation guidance for nature-based flood protection. It includes best practice examples for each of the eight defined process steps in the document.

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