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RECUPERANDO ECOSISTEMAS URBANOS

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Categorized database of good practice tools for the design, implementation, monitoring and maintenance of restorative NBS

Document Information

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Contents

Executive Summary

The lack of access to resources, tools and innovative solutions hinders cities' ability to lead the solution of environmental problems and the development of green economies. This is particularly true for medium-sized cities. Aiming to empower these cities through Nature-based Solutions (NBS), this deliverable provides a categorized compilation of 130 tools (e.g. criteria, models, decision-support systems, methodologies, strategies, guidelines, and standards) relevant to the different stages of ecosystem restoration and rehabilitation through NBS to respond to challenges identified by the INTERLACE cities (D1.3). The database seeks to integrate multiple objectives and indicators, and to foster participatory engagement. The tools identified will support the development of the NBS assessment systems in T3.2 and provide guidance for integrated and ecologically coherent urban planning processes in T3.3 and T3.4. Unlike existing online resources, this database intends to provide tools specifically targeted to common challenges of medium-sized cities and considering the stages in the full cycle of design, implementation, and long-term maintenance of NBS. The database also aims to have a stronger representation of tools useful for CELAC cities that are frequently lacking. This report describes the process of building the categorized database of good practice tools for the planning, implementation, monitoring and maintenance of restorative NBS, explains the database structure, and summarizes its content.

Introduction

Technology and innovative solutions decrease the drawbacks of urbanization through efficient urban planning, maintenance of streets and properties, and environmental protection. When cities' rapid growth in size and density is asynchronous with the implementation of innovative solutions and technology, the result is a highly unplanned urban development that leaves cities facing new or more complex and interdependent environmental challenges. Due to differences in regional contexts and associated inefficiencies of national mandates at smaller scales, cities are now leading the charge on environmental action. However, most cities are struggling to live up to their ambitions due to a lack of access to adequate tools and innovative solutions to design, assess and implement environmental solutions to their challenges. This is particularly true for medium-sized cities of less than 300,000 people, whose administrations often lack resources and tools to address the strain they place on socio-ecological systems and their peripheries through natural ecosystem destruction, degradation, and fragmentation.

With the aim of empowering medium-sized cities to tackle their environmental challenges through Nature-based Solutions (NBS), Task 3.1 compiled and categorized 130 tools (i.e. available criteria, models, decision-support systems, methodologies, strategies, guidelines, and standards). These tools are relevant for the different stages of ecosystem restoration and rehabilitation through NBS and aim to tackle the environmental challenges not only INTERLACE cities are facing (D1.3), but also other medium-sized cities throughout the world. This document describes the approach used for creating this compilation and categorization and for the selection of ten of those tools to be showcased in the INTERLACE Innovation Hub. The tools identified will be integrated into the pilot assessment framework (M3.2) and will contribute to the Urban NBS Governance Altas (D2.3). A selection of tools will be tested in each city and integrated into key inspiration tools to invite the use of NBS by non-experts (D3.3). They will also serve as input to develop a guideline to equip cities globally with tools needed to create a tailored assessment system for restorative NBS (D3.4).

Existing NBS-related online databases include illustrative examples (Urban Nature Atlas) or specific tools centered in one single stage (planning, implementation, monitoring and maintenance) of the NBS development (e.g. Naturvation and Clearing House). Others, help cities navigate the phases of development of NBS, but do not provide specific tools useful for a city-led implementation. Our database of tools intends to build on existing online resources to provide targeted solutions for common challenges for medium-sized cities covering all the stages of development and implementation of NBS. It also aims to complement existing online resources providing a stronger representation of tools useful for CELAC cities.

Building the database

Humboldt Institute (HI), supported by Universitat Autònoma de Barcelona (UAB), Fundaciòn Tecnalia Research and Innovation (TEC) and Yepezsalmon Yepez Salmon Asociados S.A. (YES), collected and

categorized available tools (e.g. criteria, models, tools, decision-support systems, methodologies, strategies, guidelines, and standards) relevant for the different stages of ecosystem restoration and rehabilitation through NBS (planning, implementation, monitoring and maintenance). This recollection was focused on tools that could be useful to respond to the needs identified in the Joint City Forum (T1.3) and consisted of the following six steps:

Step 1. Identification of city challenges. During the Joint City Forum held online during the 4th and 5th of November of 2020, the INTERLACE cities identified the challenges that they are currently facing. The information discussed during the meeting was collected in an online Miro board and was later summarized in a list of 15 challenges by the Humboldt Institute. Later, and following an agile approach for product development, Ecologic Institute carried out a first iteration where the cities contributed their feedback on the relevance of the 15 challenges to each city. Ecologic Institute compiled this feedback for D1.3, and as shown in Table 1, green space management, ecologic connectivity, flood risk/soil permeability and reconnection to the biosphere/environmental education were the most commonly identified challenges.

Table 1: Table from D1.3 representing the overview of the 15 challenges defined during the City Forum, sorted from most to least relevant for the six INTERLACE cities/city regions.

Table 1: Overview of challenges per city

(15 challenges were pre-defined by the research partners, here from top to bottom sorted according to the amount chosen most often)

	CBIMA	Chemnitz	Envigado	Granollers	Metropolia Krakowska	Portoviejo	Total
Green space management (i.e. accessibility)							6
Ecologic connectivity							4
Flood risk: pluvial and fluvial / Soil permeability							4
Reconnection to the biosphere / environmental education							4
Drought and fire risk							3
Heat stress and heat island effect							3
Watershed restoration/water quality							2
Air quality/noise							2
Social cohesion							2
Social equity							2
Human health, comfort and well-being							2
Water management (i.e. reuse)							1
Landslide risk							1
Nature appropriation / Stewardship							1
Soil quality							0
Other							
Total	3	7	6	7	7	8	

Results from collecting the specific challenges from each INTERLACE city.

Step 2. Literature review and web search. Each of the participating institutions, HI, UAB, TEC and YES, was assigned 4 - 5 city challenges (derived from step1/D1.3) to carry out a literature review and web search of tools that could be helpful for the different stages of restoration and rehabilitation through NBS. Later, the 4 - 5 sets of challenges were reassigned to a different institution to ensure wide expertise coverage as well as a balanced representation of tools from different parts of the world.

Step 3. City feedback. Following the Agile Approach, a first iteration was carried out to compile feedback from the cities on the product development during the City Focal Point meeting on March 2nd, 2021. A poll was distributed during the meeting with four questions regarding the types of tools in which the cities are mostly interested, the types of users that will be consulting the database, the scale of the intervention and the factors that will allow the cities to know the NBS interventions are being successful (Fig. 1). The cities were mostly interested in tools for planning and design, evaluation and monitoring, both technicians and citizens will be the final users, the interventions will be at the city and local scales and the implementation of the NBS will be successful when both indicators start being reported and the NBS are integrated among sectors.

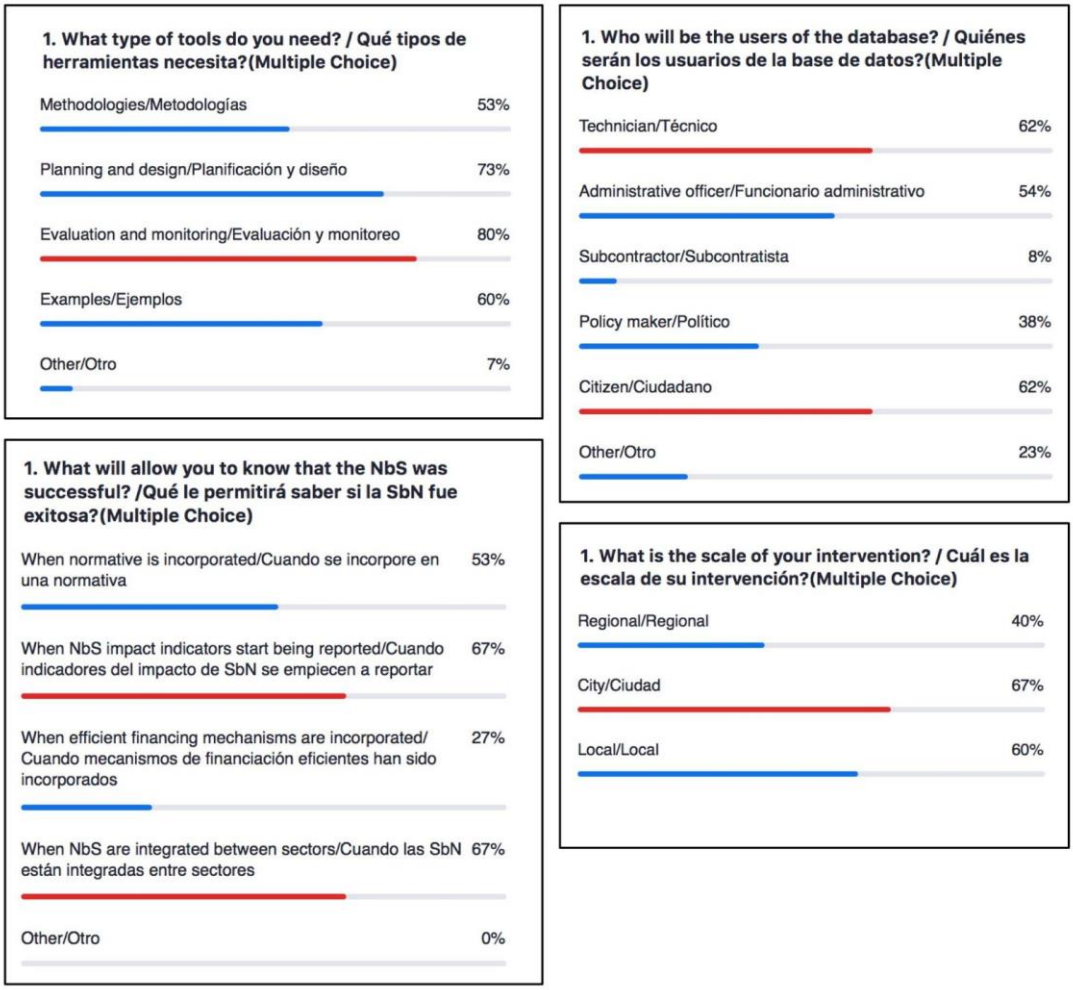

Figure 1: Results of the poll distributed to the INTERLACE cities during the City Focal Point meeting.

Step 4. Consortium and expert feedback. In order to get feedback from the INTERLACE consortium, HI distributed both a survey with some examples of tools and a document with all the gathered tools. Three responses, which included both tools and feedback observations, were incorporated into the database. In addition, a survey (both, in English and Spanish) was distributed to 61 experts on NBS identified based on a search in Google Scholar or directly by HI, UAB, TEC and YES. The Advisory Board of the INTERLACE project and the NBS Task Forces implemented by the European Commission for cooperation between H2020 NBS-related projects, were also contacted. The survey asked to identify tools in the respondent's field of expertise that could aid the planning, implementation, monitoring and/or maintenance of NBS. In addition, experts were asked to identify the best tool in their field of expertise and to explain their preference. In total, 31 responses were obtained from scientists, practitioners or decision-makers (Fig. 2), which suggested a total of 73 tools. Their opinion on their preferred tool was also considered in the ten tool selection.

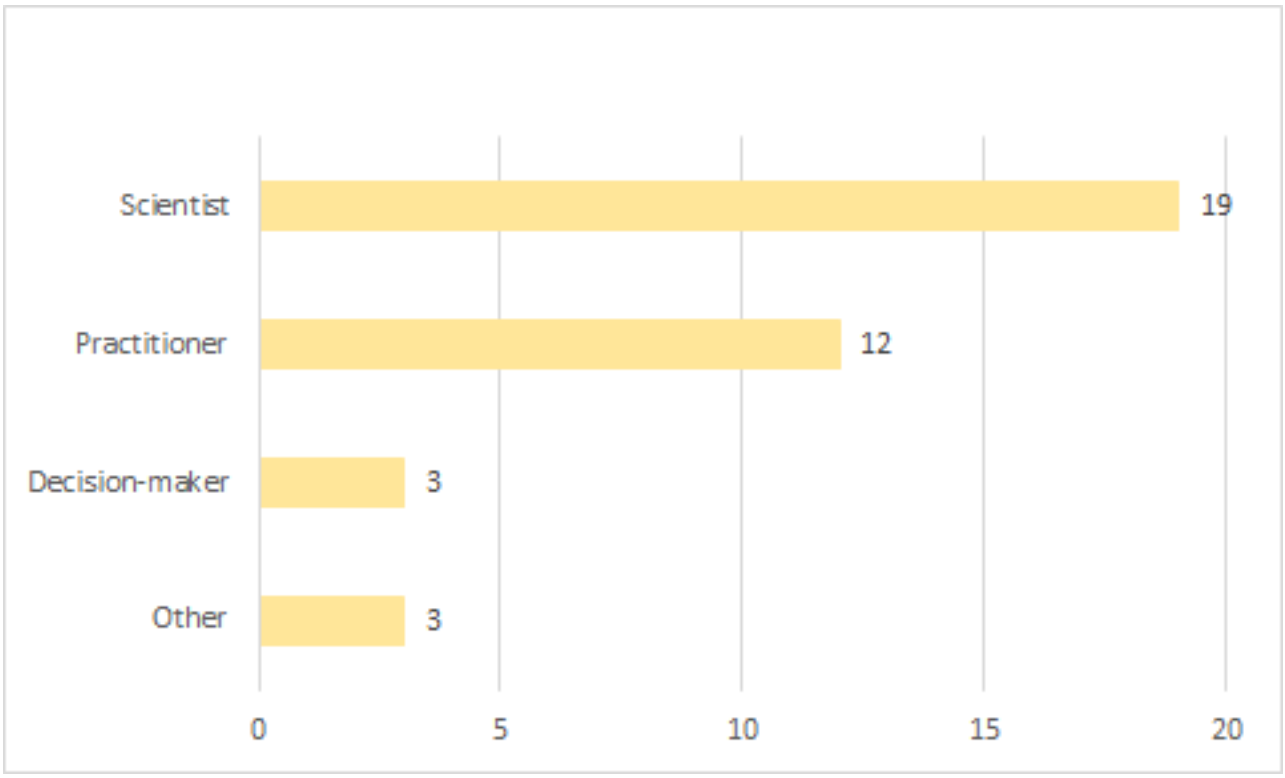

Figure 2: Expert's background indicated by the respondents of the survey. The category "other" included consultant, moderator, or "working to empower, nurture and strengthen youth-led climate/nature solutions at local and regional level". The number of answers exceeded the number of respondents since it was possible to select more than one option

Step 5. Categorization of the database. The database was organized in ten categories to describe each tool: description, format and type of tool, relevant challenges for the INTERLACE cities, multifunctionality, stage, module of the Assessment Framework, scope, location, scale or resolution, paid or free, and additional information (see Table 2 for definition of all categories and subcategories). "Relevant challenges for INTERLACE cities" were those identified in D1.3 and "Multifunctionality" refers to the number of challenges that can be assessed by the tool. "Stage" refers to the phase (planning,

implementation, monitoring and maintenance) of ecosystem restoration and rehabilitation through NBS. The information in the database was presented in a disaggregated format (only one value per cell) in order to enable the filtering function. Likewise, the selected subcategories were indicated by the number 1 to facilitate further calculations (e.g. total number of guidelines).

The "Module of the Assessment Framework" refers to the Pilot Assessment framework under development in T3.2, which is composed of a modular design where the final user can choose in-between and as many of the nine modules as useful for their NBS implementation: Context Analysis (Identification of Challenges), Spatial Screening and Prioritization, Type and Design of NBS, Impact Assessment and Comparison of NBS, Monitoring, Integration of Stakeholders, Governance and Strategies, Financial Mechanisms and Data Visualization (Fig. 3). Following the Agile Approach, a first iteration was carried out under T3.2 to obtain feedback from the cities on the product development during the City Focal Point meeting on April 6th, 2021. The INTERLACE cities gave feedback on which of the modules would be the most useful for their respective interventions. The modules with highest relevance to cities were Monitoring, Financial Mechanisms and Integration of Stakeholders (Fig. 3).

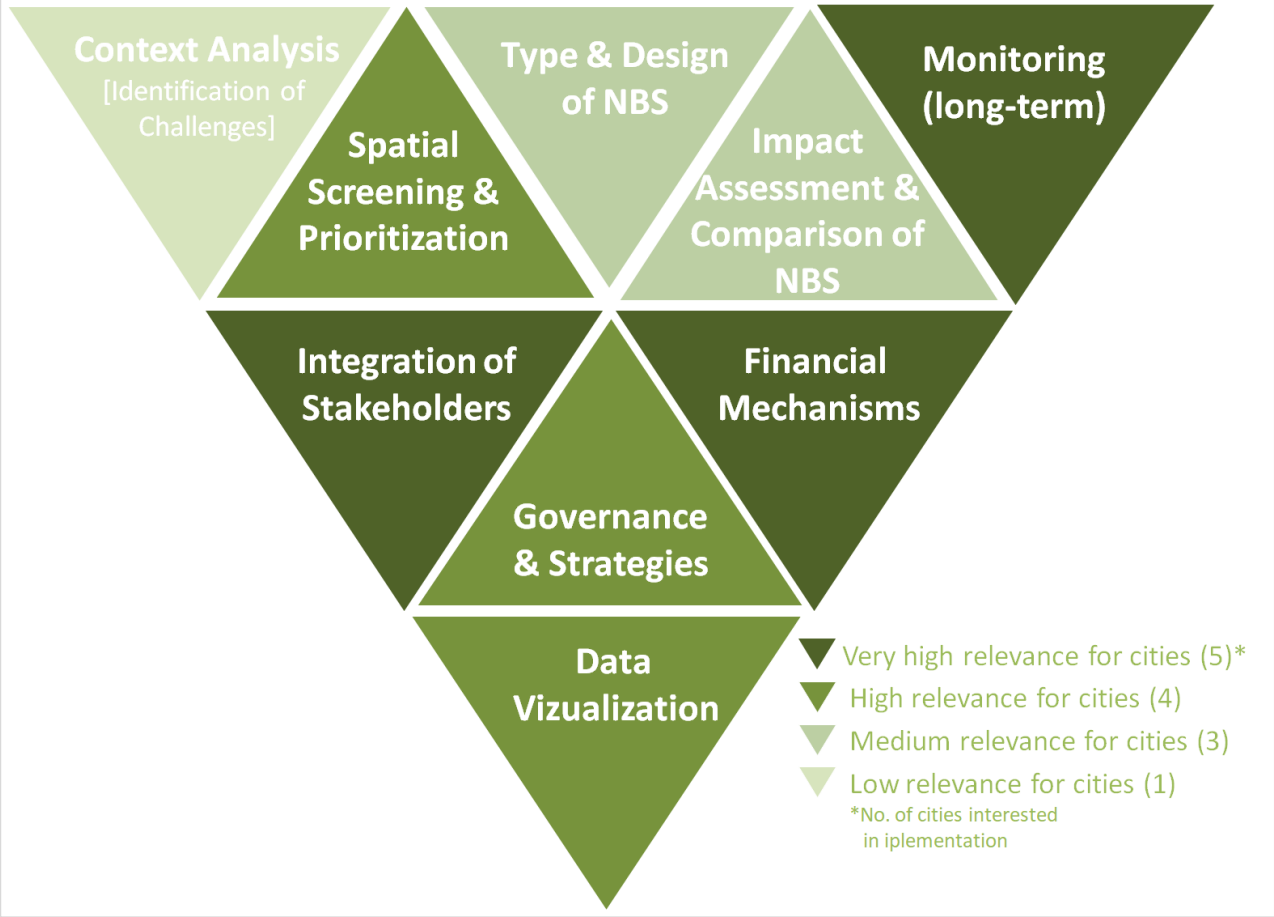

Figure 3: INTERLACE Pilot Assessment Framework developed under T3.2 (draft 2, 15/05/2021). The shade of green represents the interest the cities showed in each module during the City Focal Point meeting

Step 6. Selection of ten tools. The tools were selected to be showcased in the INTERLACE Innovation Hub. The criteria of selection included freely available tools, and tools that represented multiple challenges or a balanced representativeness of all challenges among tools. The scale, scope and the needs that the cities identified during the City Focal Point meeting were also taken into account. In addition, a balance was aimed between European and CELAC tools and the opinion by experts on the best tools was also considered. Each tool was described in a summarized format to be directly incorporated into the INTERLACE Innovation Hub (Boxes 1 - 10) and the extended version is presented in the database ("10 tool selection" sheet). The knowledge brokers and the six INTERLACE cities were contacted for feedback on the factsheet's informativeness and conciseness. Three answers were obtained and incorporated.

Categorized database of good practice tools for restoration through NBS

As a result of the literature review and web search, 99 tools were gathered. From the surveys sent to the Consortium, Advisory Board and experts, 31 responses were obtained and 73 tools were recommended. After reviewing them, 31 new tools were incorporated for a total of 130 tools in the final database. The 130 gathered tools were mainly reports (40 tools), websites (38), and software (36; either online or to be downloaded and installed); the rest of them were scientific papers (9); books (4) and 'other' (one Excel file, one EU Directive, and one QGIS Plugin). Regarding the tool multifunctionality, 67% of the tools were classified as 'low', addressing 1 - 3 challenges; 19% as 'medium', addressing 4 - 9 challenges; 10% as 'high', addressing 10 - 15 challenges; and finally, 4% were classified as 'not applicable' or NA, for compilations of tools or when the challenge was not specified. Figure 4 illustrates the number of tools that addressed each of the challenges. Regarding the stage of the NBS development, in general, tools served for more than one stage, with considerable overlapping among them. 121 tools were identified for designing, 89 for implementing, 71 for monitoring and 55 for maintenance. There was also overlap among the modules of the Assessment Framework; most tools were classified within either the 'context analysis', 'monitoring', or 'design solutions' modules (Fig. 5). Regarding the geographic location where the tool can be used, 'worldwide' included tools that can be used in different places of the world, without excluding Europe and CELAC cities (Fig. 6). 42% of the gathered tools were of exclusive applicability for Europe and 7% for CELAC cities.

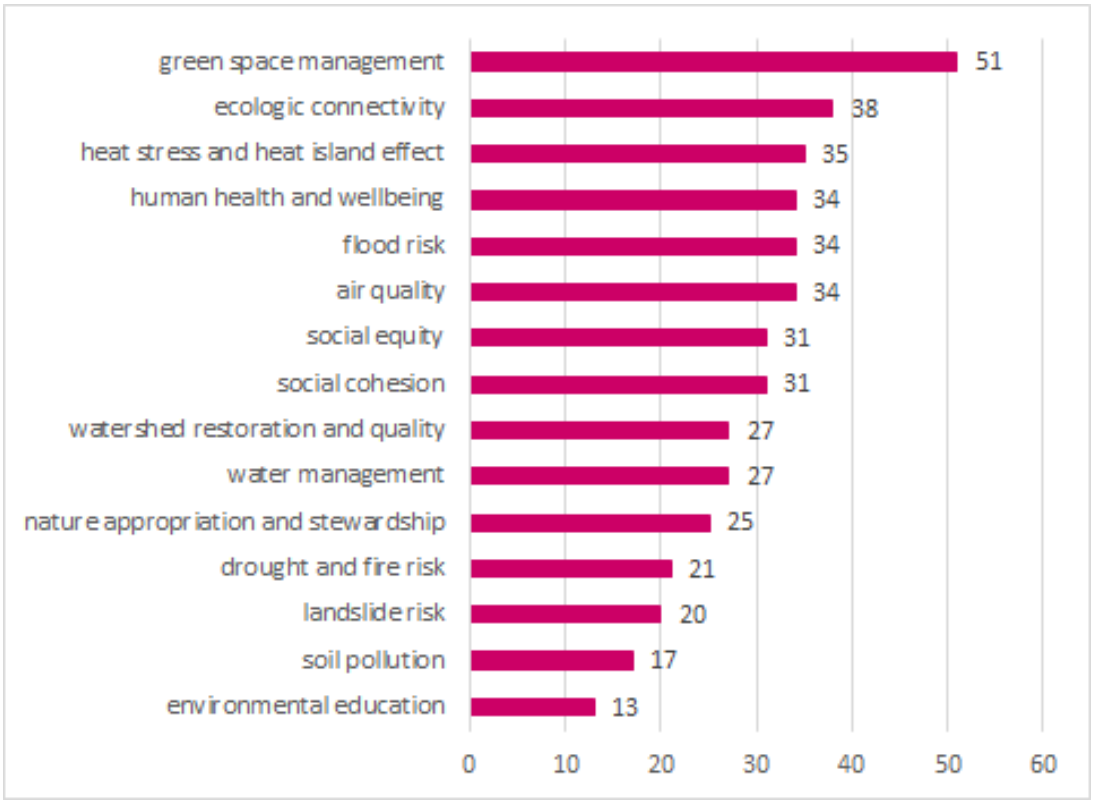

Figure 4: Number of tools per relevant Challenge for the INTERLACE cities

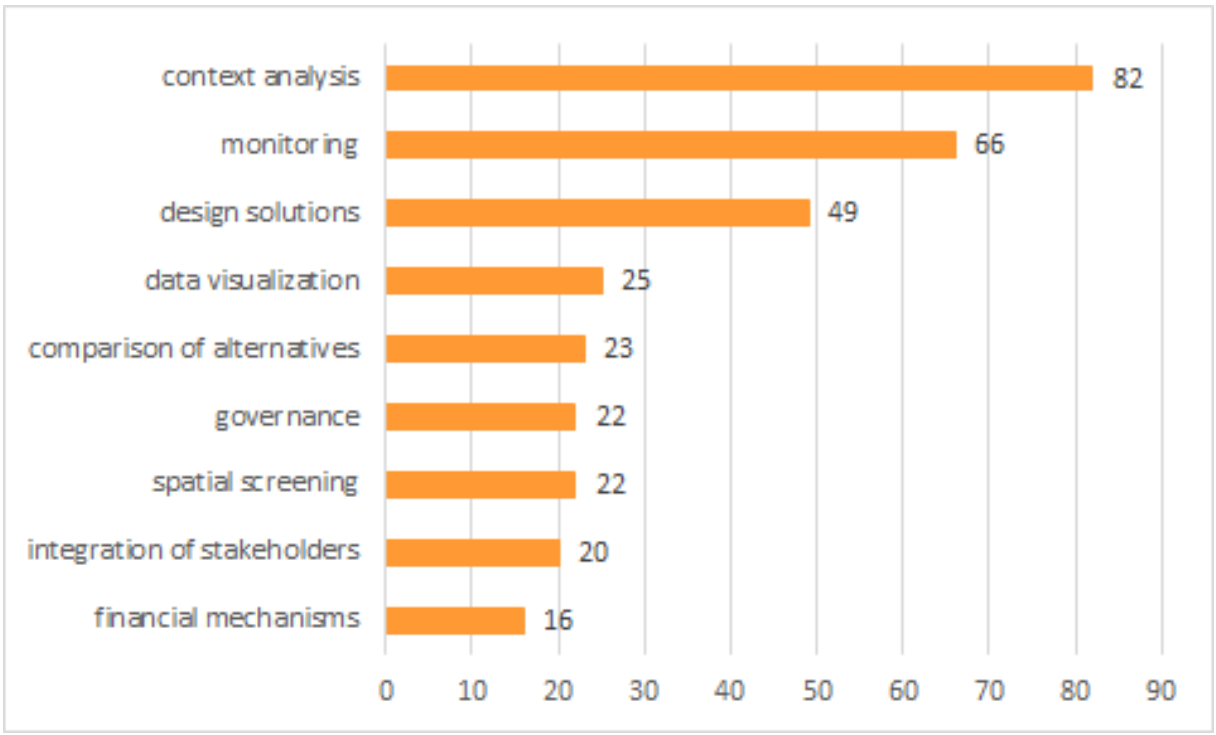

Figure 5: Number of tools per module of the Pilot Assessment Framework.

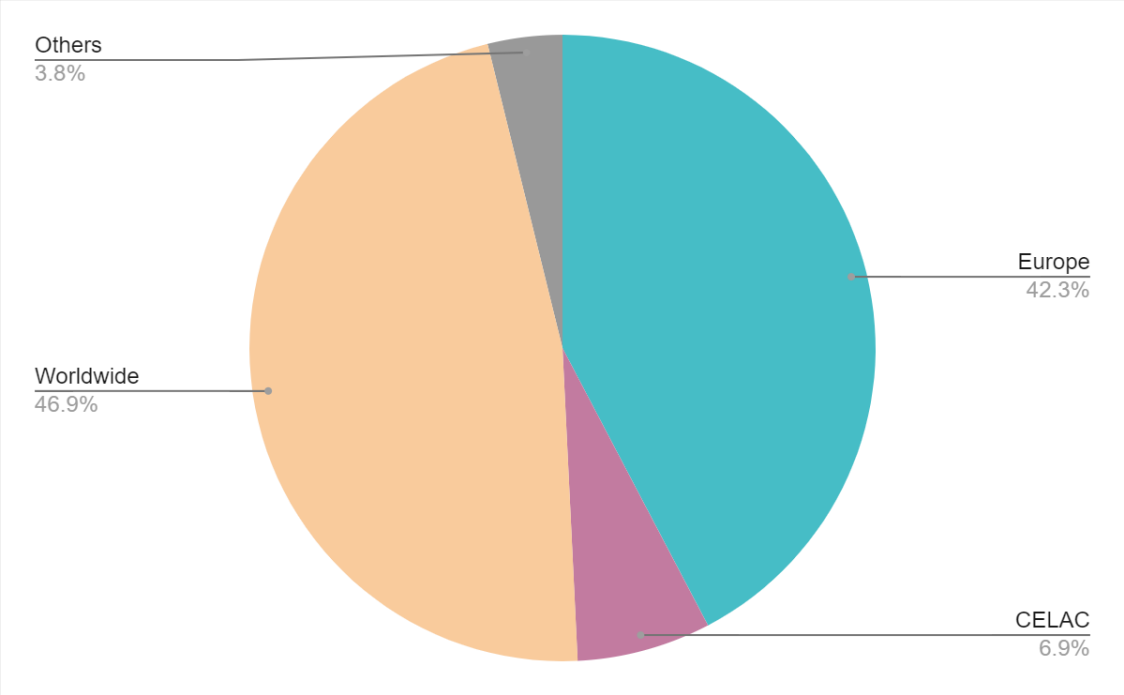

Figure 6: Location where the tools can be applied.

The database was organized in a Google Sheet file with five sheets:

- The first sheet contains basic information about the product.
- The second sheet is a glossary that defines the categories used to describe each tool (Table 2).
- The third sheet consists of the gathered tools (rows) described by ten categories and 44 subcategories (columns, Table 2).
- The fourth sheet includes the ten selected tools, with a link for each factsheet PDF.
- The fifth sheet has a list of the contributing experts.

Table 2: Glossary of the categories and subcategories used to define each tool of the database.

Category / subcategory	Content
1. Description: this category is divided into the five following fields that provide basic information about the tool.	
Tool name	provides the tool's name.
Link	link of the tool or webpage where the tool can be found. For scientific papers or books the DOI is given and a recommended citation is written on the 'additional notes' column.
Created by	tool's author, or the organization that created it.

Summary description	a brief description of the tool is provided.
Level of expertise	the level of expertise is classified as ‘low’ when the tool guides the user throughout the whole process and the tool is intuitive and user friendly; ‘medium’, when the tool gives the user enough instructions to run or use it but it is necessary to have knowledge on the topic; and ‘high’, when it is necessary to have specific knowledge in the topic, or to be able to run models, implement surveys, or follow advanced methodologies.
2. Format and type of tool: informs the format and selects the type of tool.	
Format	shows whether the tool is a report, website, software (online or to be downloaded and installed), scientific paper, book, or ‘other’.
Evaluation	tools in which the outcomes are assessments in a given NBS-related topic.
Model	tools corresponding to models that represent current conditions or possible scenarios related to NBS.
Data	tools that provide useful data or datasets to be incorporated in any of the planning, implementation, monitoring or maintenance stages of restoration through NBS (such as repositories of climate information, biodiversity, coverage maps, among others).
Index or indicator	tools that provide values (or a way of calculating them) representing variables to qualify some parameter. Some examples of indicators in the context of NBS are: annual amount of pollutants captured by vegetation, net carbon sequestered by the urban forest, ecological connectivity index, among others.
Criteria or standards	tools that consist of instruments describing specific conditions as a reference point to achieve optimal status in relation to NBS (standards), or the variables or parameters to be measured in order to evaluate the NBS (criteria).
Decision-support tool	tools that are systems that present and analyze different alternatives to support decision-making.
Methods, strategies, or guidelines	tools that describe or guide through a set of procedures necessary to achieve a goal or objective related to the NBS.
Map visualization	tools corresponding to maps or aids to build spatial visualizations related to NBS planning, implementation, or monitoring.
Case studies	consists of illustrative experiences related to NBS implementation

3. Relevant challenges for INTERLACE cities: shows the challenges that each tool addresses**.**	
Heat stress/heat island effect	selected when the tool addresses the urban Heat Island effect (UHI). UHI refers to higher temperatures in urban areas compared to their surrounding rural areas, which can be conducive to heat stress
Air quality	selected when the tool addresses air quality or air pollution issues.
Soil pollution	selected when the tool addresses soil quality or soil pollution issues
Water management	selected when the tool deals with aspects related to water resource management (i.e. optimal use of water resources)
Watershed restoration and quality	selected when the tool addresses actions to improve the quality or to restore watersheds.
Ecologic connectivity	selected when the tool deals with improvement or management of ecological connectivity and biodiversity conservation or restoration.
Green space management	selected when the tool deals with the management or improvement of urban green spaces of the conversion of traditional grey into green areas.
Drought and fire risk	selected when the tool addresses or helps to identify and manage the risk of drought or fire.
Flood risk	selected when the tool addresses or helps to identify and manage flood risks.
Landslide risk	selected when the tool addresses or helps to identify and manage landslide risks.
Social cohesion	selected when the tool aids in identifying societal resilience through collaborative and positive community engagement and trusting attitude among actors in the context of environmental multi-benefit actions or NBS.
Social equity	selected when a tool evaluates social equity in the context of NBS, such as improving the equitative access to green areas, or overcoming social, economic, cultural and political forms of exclusion and inequality.
Nature appropriation and stewardship	selected when the tool provides instruments to implement environmental education or actions to promote sustainable and responsible enjoyment/use of nature.
Environmental education	tools that aid in environmental education.

Human health and wellbeing	selected when a tool deals with aspects of human health and wellbeing.
Multifunctionality	indicator of the number of relevant challenges addressed by a tool; 'low' is for tools addressing 1 - 3, 'medium' is for tools addressing 4 - 9, and 'high' is for tools addressing 10 - 15 challenges.
4. Stage: indicates in which stage(s) of NBS development the tool can be used.	
Designing	tools that help the user to design an NBS.
Implementation	tools that help the user to put the NBS plan/design into effect.
Monitoring	tools to measure indicators during the implementation and/or maintenance of the NBS.
Maintenance	tools used once the implementation is finished to preserve and manage the NBS.
5. Module of the Assessment Framework: module in which each tool is categorized.	
Context analysis	includes tools that help to generate the baseline and risk analysis for the city as part of an initial stage of NBS planning.
Spatial screening	includes geographic analysis tools to aid in the selection of the NBS location.
Comparison of alternatives	includes tools that help to compare different implementations of NBS.
Monitoring	includes tools to measure the social and environmental effectiveness of a NBS implementation (ex post).
Design solutions (types of NBS)	includes tools that help the user in the design of a given NBS.
Integration of stakeholders	includes tools or instruments that aid in stakeholder integration.
Financial mechanisms	includes tools or instruments related to financial funding of NBS.
Governance	includes tools of governance-related aspects of NBS (including government, civil society, and the private sector).

Data visualization	includes tools to increase the accessibility of a NBS project to reach wider audiences.
6. Scope: defines whether the tool can be used in rural, urban or both contexts.	
7. Location: names the geographic area where the tool is applicable.	
8. Scale or resolution: defines the scale at which the tool is applicable. For example, neighborhood, city, watershed, mesoscale-levels.	
9. Paid or free: indicates whether it is a free or paid tool.	
10. Additional notes: provides additional relevant information.	

Ten selected tools

The 10 tools to be showcased in the Innovation Hub include models, guidelines, indicators, case studies, data repositories, map visualization, evaluation tools, and decision-support tools. Two tools are highly multifunctional, addressing 11 and 14 challenges respectively (The Urban Nature Navigator - Box 1, and Nature4Cities Platform - Box 2). The remaining eight tools are applicable to 2 - 6 challenges (iTree - Box 3, Urban Adaptation Support Tool - Box 4, SWAT - Box 5, ARIES - Box 6, Urban Multi-scale Environmental Predictor - Box 7, Guía para la Integracion de las Soluciones Basadas en la Naturaleza en la planificación urbana - Box 8, and Nature-based solutions for cities in Latin America and the Caribbean - Box 9). The 15 challenges identified by the INTERLACE cities during the Joint City Forum (D1.3) are represented in the ten tools selected (Fig. 7). Green space management, which was prioritized by the six cities (Table 1), is addressed by six of the tools selected for the Hub. Ecological connectivity was prioritized by four cities and is addressed by six tools as well. Flood risk was also prioritized by four cities and three selected tools address this challenge. Environmental education, identified by four of the cities, is addressed by three of the selected tools. In addition, due to the high relevance that the INTERLACE cities gave to the financial mechanisms module of the Pilot Assessment Framework (Fig. 3), one relevant tool was selected (Biofin - Box 10). Also, all the other Pilot Assessment Framework modules were covered by the selected tools except for ‘Data visualization’. Regarding the geographic applicability of the selected tools, six tools can be applied worldwide, two are specific for Europe, and two are specific for CELAC cities. The provided examples of applications for each tool include five examples in European cities and six in CELAC cities.

Figure 7: Number of selected tools addressing specific challenges.

Box 1. The Urban Navigator Factsheet

The Urban Nature Navigator

NATURVATION
cities – nature – innovation

Created by: Naturvation research project
Link: https://naturvation-navigator.com/
Language: English
Low level of expertise required

This assessment tool is based on the use of indicators that capture ecological, social and cultural benefits that nature-based solutions can make towards urban sustainability goals. It also provides methods to enable the decision processes for implementing nature-based solutions in cities.

Challenges addressed

- Heat stress and heat island effect
- Water management
- Watershed restoration and quality
- Ecological connectivity
- Green space management
- Flood risk
- Social cohesion
- Social equity
- Nature appropriation and environmental education
- Human health and wellbeing

Outcomes

The Bronze Level provides a snapshot of how different nature-based solutions can contribute to addressing urban sustainability challenges. The Silver level enables the identification of the benefits and the trade-offs of different nature-based solutions together with a set of decision processes. The Golden level delivers a set of tools that can be used in local contexts to generate values of nature-based solutions in high resolution or across cities.

Examples of application

Mexico City: Water Fund

The challenges addressed in this project were: flooding, water scarcity, and improving water management. A Water Fund (The Nature Conservancy) was implemented and improved, offering solutions to conserve, restore and manage ecosystem to improve rainwater absorption and filtering, and aquifers' quality and governance. The fund was implemented as "a mechanism to channel investment from associated organizations toward projects that meet collectively agreed priorities", in which local communities became stewards and often collective owners of natural assets

Scope

Urban.

Type of tool

- Decision-support tool
- Index or indicators

Uses

Assessing the contributions that different nature-based solutions can make to meet the urban sustainability challenges and identifying nature-based solutions that fit the needs of the user.

Scale

- Subnational
- Local

Location

Worldwide.

Advantages

Intuitive platform accessible to wide audiences engaged in applications of nature-based solutions. It allows to assess the multifunctionality of nature-based solutions.

Constrains

It does not include documentation on the calculation of the scores which limits its applicability.

Box 2. Nature 4 Cities factsheet

NATURE 4 CITIES

Created by: Nature4Cities
https://nature4cities-platform.eu/#/
Language: English, French, German, Hungarian, Italian, Spanish and Turkish
Low level of expertise required

Comprehensive reference Platform for Nature Based Solutions (NBS), offering technical solutions, methods and tools to empower urban planning decision making. This will help addressing the contemporary environmental, social and economic challenges faced by European Cities. Nature4cities brings Nature back into innovation, planning and implementation driven thinking. This new technical and governance approach implies collaborative models driven by citizens, researchers, policy makers, and industry leaders, relying on participative processes and sharing of Best Practice.

Challenges addressed

- Heat stress and heat island effect
- Air quality
- Soil pollution
- Water management
- Watershed restoration and quality
- Ecological connectivity
- Green space management
- Flood risk
- Landslide risk
- Social cohesion
- Social equity
- Nature appropriation and stewardship
- Environmental education
- Human health and wellbeing

Outcomes

Guidance throughout different stages of the project development.

Examples of application

The Impact of Façade Orientation and Woody Vegetation on Summertime Heat Stress Patterns in a Central European Square: Comparison of Radiation Measurements and Simulations

This paper was produced in the context of the Nature4Cities project. The addressed challenge was urban heat island. The impact of woody vegetation and façade orientation on the radiation heat load was assessed. Results showed that mature shade trees can reduce temperature form 65–75°C to 30–35°C and shading from buildings adjacent to sidewalks play also an important role in mitigating pedestrian heat stress.

Type of tool

- Decision-support tool
- Case studies

Uses

- Create an NBS project
- Assess an NBS project
- Implement an NBS project

Scale

Local.

Location

European Cities.

Scope

Urban.

Advantages

User-friendly platform that covers a wide range of NBS challenges. It is a comprehensive tool that guides the user in the planning, evaluation and implementation of NBS and also suggests specific tools.

Constrains

The level of expertise required varies according to the specific tool selected.

Box 3. iTREE factsheet

iTREE - Tools for assessing and managing forests and community trees

Created by: USDA Forest Service
https://www.itreetools.org/
Language: English
Medium level of expertise required

i-Tree is a set of free, science-based tools that quantify the benefits and values of trees around the world, aid in tree and forest management and advocacy, and show potential risks to tree and forest health. The tools include i-Tree Canopy, i-Tree Landscape, i-Tree Eco, i-Tree Design, and i-Tree Hydro.

Challenges addressed

- Heat stress and heat island effect
- Ecological connectivity
- Green space management

Type of tool

- Decision-support tool
- Map visualization

Outcomes

- Report with summary
- An open-source map equivalent to Google Maps

Uses

- Assess forest conditions, ecosystem services, and values.
- Determine risks to the forest and human health.
- Calculate how changes in forest structure will lead to changes in ecosystem services and values.
- Develop best local management strategies to sustain and enhance desired ecosystem services, forest and human health.
- Determine the best tree species, locations and planting rates to optimize ecosystem services and values through time.

Examples of application

Contribution of Ecosystem Services to Air Quality and Climate Change Mitigation Policies: The Case of Urban Forests in Barcelona, Spain

iTree was used to assess the contribution of ecosystem services provided by urban forests to quality of life in the city (i.e., air purification, global climate regulation, and air pollution). The research concluded that green infrastructure-based efforts to offset urban pollution at the municipal level have to be coordinated with territorial policies at broader spatial scales.

Simulating the Hydrological Impact of Green Roof Use and an Increase in Green Areas in an Urban Catchment with i-Tree: A Case Study with the Town of Fontibón in Bogotá, Colombia

Using iTree Hydro model, the study simulated the different scenarios to the hydrological benefits of trees, green areas, and permeable zones in an area of Bogotá D.C. As a result, the implementation of green roofs as a way to increasing permeable zones corresponding to plants was proposed.

Scale

- Global
- National
- Local

Location

Global.

Scope

Urban and rural.

Advantages

- Provides easily understood, science-based metrics.
- The tool can quantify the ecosystem services of a single tree, which is very useful for high-resolution city assessments.

Constrains

Local data may not be available or complete for all locations and may not represent current condition.

Box 4. Urban Adaptation Support factsheet

The Urban Adaptation Support Tool

Climate ADAPT
SHARING ADAPTATION INFORMATION ACROSS EUROPE

Created by: European Environment Agency
https://climate-adapt.eea.europa.eu/knowledge/tools/urban-adaptation
Language: English
Low level of expertise required

The Urban Adaptation Support Tool guides European adaptation decision-makers and practitioners in cities through the main steps of the climate adaptation process. The tool is based on the adaptation policy cycle, and highlights the key issues to be considered when planning and implementing adaptation. The six steps of the Tool help to prepare ground for adaptation, understand the risks and vulnerabilities to current and future climate hazards, identify and assess adaptation options, develop and implement a climate change adaptation strategy and/or action plan and monitor the results of the adaptation action.

Challenges addressed

- Heat stress and heat island effect
- Drought and fire risk
- Flood risk

Type of tool

- Data
- Map visualization
- Case studies

Outcomes

A comprehensive overview of the current and projected climate impacts in European cities.

Uses

Decision-support and context analysis tool.

Examples of application

Isar-Plan – Water management plan and restoration of the Isar river, Munich (Germany)

Flood risk and restoration in the Isar river in the city of Munich. The objective was to improve flood control, biodiversity and recreational quality. They implemented the following solutions: Rehabilitation and restoration of river and floodplains improving functional connectivity of ecological networks and green space and corridors in urban areas.

Scale

- National
- Local

Location

European cities.

Scope

Urban and rural.

Advantages

Comprehensive and clear guidelines that guide the user through different steps of planning, implementing and assessing climate adaptation plans.

Constrains

It is a general guideline for climate change adaptation that does not expand on NBS. However, the risk and vulnerability assessment and monitoring guidance can be adapted to the planning, implementing, and assessment of NBS.

Box 5. SWAT model factsheet

SWAT
Soil & Water Assessment Tool

Created by: Texas A& M University
https://swat.tamu.edu/
Language: English
High level of expertise required

Environmental Context Soil and Water assessment tool. The Soil & Water Assessment Tool is a small watershed to river basin-scale model used to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. SWAT is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds.

Challenges addressed

- Soil pollution
- Watershed restoration and quality
- Landslide risk

Type of tool

Model.

Outcomes

- Database
- Hydrology tab - average annual values over all the years of simulation

Uses

Watershed-scale simulation tool.

Examples of application

The Effects of Land Use and Climate Change on the Water Yield of a Watershed in Colombia

Based on SWAT modelling, this study estimates the effects of land use and climate change on water yield. It was located in the Tona watershed, an important source of water for a metropolitan population. Results identified strategic areas in which the protection and conservation activities of water managers can be focused.

Scale

- Global
- National
- Subnational
- Local

Location

Global.

Advantages

Computationally efficient; uses readily available inputs; well documented, with several user's manuals and a theoretical manual; open source.

Constrains

Novice users may feel overwhelmed by the variety and number of inputs when they first begin to use the model. Expertise in hydrology is recommended, limiting the number of potential users.

Scope

Urban and rural.

Box 6. ARIES factsheet

ARIES (ARtificial Intelligence for Ecosystem Services)

ARIES
ARtificial Intelligence for Environment & Sustainability

Created by: Ikerbasque Research and BC3
https://aries.integratedmodelling.org/
Language: English
Medium level of expertise required

ARIES (ARtificial Intelligence for Ecosystem Services) is a networked collaborative software technology designed for rapid ecosystem service assessment and valuation. It gives equal emphasis to ecosystem service supply, demand, and flow in order to quantify actual service provision and use by society (as opposed to quantifying potential service benefits). It aims to provide a suite of models that support science-based decision-making.

Challenges addressed

Green space management.

Type of tool

- Model
- Data
- Map visualization

Outcomes

Maps and quantitative data on ecosystem services.

Uses

Provides scientific evidence of ecosystem services for policy making and nature management.

Examples of application

Cost-effective restoration and conservation planning in Green and Blue Infrastructure designs. A case study on the Intercontinental Biosphere Reserve of the Mediterranean: Andalusia (Spain) – Morocco

The study proposed a novel approach for systematically selecting cost-effective areas for restoration based on biodiversity, ecosystem services, and ecosystem condition. The result was an optimal spatial design of Green and Blue Infrastructure, in a setting encompassing the Intercontinental Biosphere Reserve of the Mediterranean in Andalusia and Morocco.

Scale

- Global
- National
- Subnational
- Local

Location

Worldwide.

Scope

Urban and rural.

Advantages

Compared to other existing models, it requires less data and expertise (accessible to policy makers and other non-technical users). The spatial scale depends on data availability; the typical cell size for areas with detailed data is 30 m.

Constrains

The artificial intelligence framework is not intuitive and the complexity of the code may limit the accessibility.

Box 7. Urban Multi-scale Environmental Predictor factsheet

Urban Multi-scale Environmental Predictor

Created by: UMEP
Link: https://umep-docs.readthedocs.io/en/latest/Introduction.html
Language: English
High level of expertise required

UMEP is climate service plugin for QGIS (free and open-source desktop geographic information system) that can be used for a variety of applications related to outdoor thermal comfort and climate change mitigation.

Challenges addressed

- Heat stress and heat island effect
- Air quality
- Ecological connectivity

Type of tool

- Evaluation
- Model
- Decision-support tool

Outcomes

Outputs can be used to characterize the urban environment, to prepare meteorological data for use in cities, to undertake simulations and consider alternative scenarios, and to compare and visualize different combinations of climate indicators.

Uses

Identify heat and cold waves; assess the impact of green infrastructure on runoff; evaluate the effects of built infrastructure on human thermal stress and the impact of human activities on heat emissions

Examples of application

The effect of urban geometry on mean radiant temperature under future climate change: a study of three European cities

The study examines the effect of urban geometry on daytime heat stress in three European cities. The study finds that dense urban structure can reduce daytime heat stress in the summer and does not cause substantial changes in the winter. Also, it concludes that in dense urban settings, a more diverse urban thermal environment is preferred to compensate for reduced solar access in the winter.

Scale

Local.

Location

Worldwide.

Constrains

Requires expertise with the QGIS software.

Advantages

Open source

Scope

Urban.

Box 8. Guía para la Integración de las Soluciones Basadas en la Naturaleza en la planificación urbana factsheet

Guía para la Integración de las Soluciones Basadas en la Naturaleza en la planificación urbana

Created by: Ecologic Institute/Humboldt Institute
https://www.ecologic.eu/sites/default/files/publication/2020/figueroa-20guia-planificacion-urbana-b33_s_c5-1final_en-baja.pdf
Language: Spanish and English
Low level of expertise required

Provides steps and tools to support planners to identify and spatially prioritize strategic zones to strengthen or create new NBS, and design and maximize the benefits of NBS interventions for climatic resilience, inhabitant wellbeing, and ecosystem health. It also provides financing strategies and NBS monitoring options, as well as case studies and application examples.

Challenges addressed

- Watershed restoration and quality
- Ecological connectivity
- Green space management
- Social cohesion
- Nature appropriation and stewardship
- Human health and wellbeing

Type of tool

- Methodologies, strategies, guidelines
- Case studies

Uses

The guideline is useful for the design, implementation, and selection of monitoring methods and financing opportunities for urban NBS.

Outcomes

- NBS project or monitoring strategy formulated.
- Improved NBS implementation.

Scale

- Subnational
- Local

Examples of application

Análisis de los beneficios de La Reserva Forestal Protectora Bosque Oriental de Bogotá

As part of the development of the Guideline, a workshop was carried out in order to get to know the perception of different stakeholders about the benefits of one key urban protected area. To this end, they used the Protected Areas Benefit Assessment Tool (Ivanic et al. 2020) to assess the cultural, health and wellbeing, educational, and sacred importance. They also identified coherence issues with regards to the planning policy instruments of the area.

Location

Colombia.

Scope

Urban.

Advantages

- Provides a comprehensive step-by-step guidance with tools and case studies.
- Although designed for Colombia, can be applied to other CELAC contexts.

Constrains

Focused mainly on small and medium-sized cities, not very useful for consolidated cities.

Box 9. Nature-based solutions for cities in Latin America and the Caribbean factsheet

Nature-based solutions for cities in Latin America and the Caribbean

City Adapt

RECONECTANDO CIUDADES CON LA NATURALEZA

LATINOAMÉRICA Y EL CARIBE

Created by: CityAdapt Project
https://cityadapt.com/guiassbn/
Language: Spanish, English
Low level of expertise required

This guideline provides practical methods for identifying, designing, implementing and monitoring NBS in CELAC urban contexts. It seeks to empower different stakeholders in the decision-making process, providing tools and examples to effectively apply NBS, build capacities, and facilitate resilient urban planning and development.

Challenges addressed

The guideline focuses on challenges associated with risk and vulnerability to climate change

Type of tool

- Methodologies, strategies, guidelines
- Case studies

Outcomes

NBS project or specific stage formulated or strengthened in its implementation or monitoring stage. Including risks and vulnerability assessments and guidelines for participatory workshops.

Uses

The guideline is useful por designing, implementation, and monitoring urban NBS in CELAC cities

Examples of application

Climate vulnerability risk assessment in Xalapa Mexico

The landslide and flood risks were identified and weighted, resulting in an identification of high-risk rural localities. In Xalapa's urban areas, the Community Management Centers were identified as well as the most vulnerable neighbourhoods. After the risk identification stage meetings with communities were done, in order to inform communities and include their inputs. As a result, a hotspots analysis was co-produced for the area.

Scale

- Subnational
- Local

Location

CELAC

Scope

Urban and rural

Advantages

Provides a very comprehensive and complete guidance with examples, tools, resources and case studies.

Constrains

The guide is specifically designed for CELAC cities.

Box 10. BIOFIN factsheet

BIOFIN

The Biodiversity Finance Initiative

Created by: United Nations Development Programme
https://www.biofin.org/sites/default/files/content/publications/workbook_2018/
Language: English
Low level of expertise required

BIOFIN is an initiative to help countries raise and manage capital and use financial incentives to support sustainable biodiversity management. It includes private and public financial resources, investments in commercial activities that produce positive biodiversity outcomes and the value of the transactions in biodiversity-related markets such as habitat banking.

Challenges addressed

- Ecological connectivity
- Green space management
- Nature appropriation and environmental education

Type of tool

Methodologies, strategies and guidelines.

Outcomes

Finance solutions provide impact that contribute to the national biodiversity targets via: generating revenue, realigning current expenditures, avoiding future expenditures, delivering financial resources more effectively and efficiently.

Uses

The online catalogue is a comprehensive list of instruments, tools and strategies that are applicable to the field of biodiversity finance.

Examples of application

BIOFIN experts are currently creating Biodiversity Finance Plans in 40 countries, including those of the INTERLACE CELAC cities and thus this tool is particularly relevant for such cities. In Costa Rica, for example, eight biodiversity finance solutions were prioritized: issuance of a green bond for the acquisition of lands for protected areas, establishment of a green lending facility for corporate sustainability, development of a concessions platform for non-essential services in protected areas, implementation of the Sustainable Tourism Impact Fund, Establishment of the Costa Rica ABS Challenge Fund, implementation of a crowdfunding initiative in order to provide financing for ecological monitoring and research, Restructuring of the Payment for Environmental Services System, and establishment of a Fishing program.

Scale

- Global
- National
- Local

Location

Global.

Scope

Urban and rural.

Advantages

- The finance solutions catalogue is open source and available for anyone to use.
- Offers a clear, step-by-step guidance

Constrains

Not specific to urban contexts. It requires specific information on the institutional and political context.

INTERLACE
RESTORING URBAN ECOSYSTEMS
RECUPERANDO ECOSISTEMAS URBANOS

INTERLACE is a four year project that will empower and equip European and Latin American cities to restore urban ecosystems, resulting in more liveable, resilient and inclusive cities that benefit people and nature.

interlace-project.eu

INTERLACE es un proyecto de cuatro años que busca empoderar y soportar ciudades de Europa y América Latina en la restauración de ecosistemas urbanos, resultando en ciudades más vivibles, inclusivas y resilientes para el beneficio de la gente y la naturaleza.

Project Partners

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