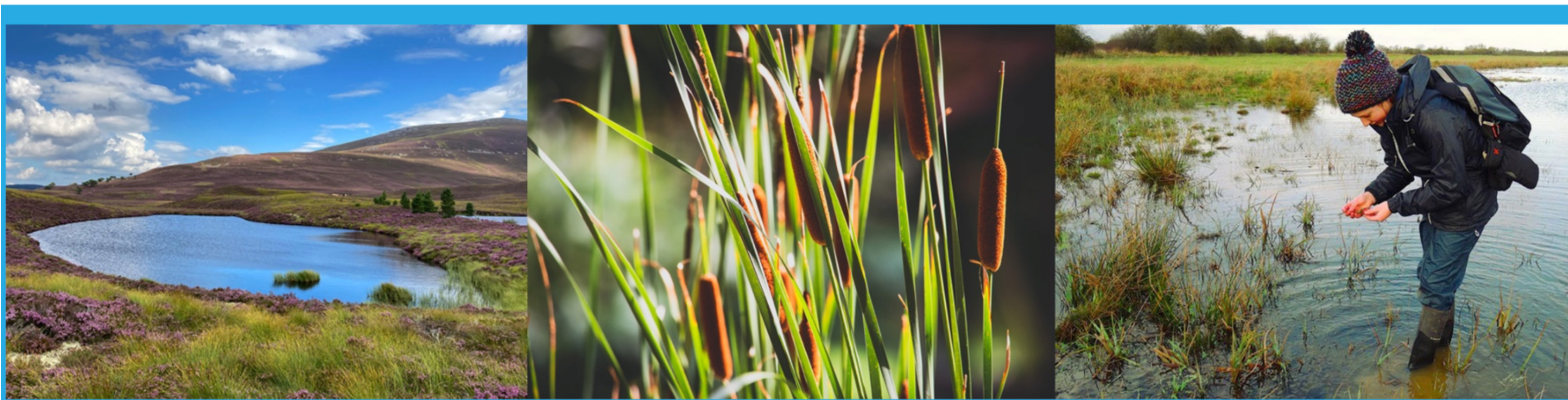
Ponderful

PONDS FOR CLIMATE



A decision support tool supporting the Policy Guidance Document

D4.8

Pond Ecosystems for Resilient Future Landscapes in a Changing Climate

European Commission

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Ponderful Partners:

University of Vic – Central University of Catalonia (Spain) – Prof. Sandra Brucet (Project coordinator), Dr. Diana van Gent (Project Manager)

IGB im Forschungsverbund Berlin (Germany) – Dr. Thomas Mehner (WP2 co-coordinator)

Katholieke Universiteit Leuven (Belgium) – Prof. Luc De Meester (WP2 coordinator)

Haute Ecole Spécialisée de Súisse occidentale (Switzerland) – Prof. Beat Oertli (WP4 coordinator)

Universitat de Girona (Spain) – Dr. Dani Boix

Ecologic Institut gemeinnützige GmbH (Germany) – Dr. Manuel Lago

University College London (UK) – Dr. Carl Sayer

Middle East Technical University (Turkey) – Prof. Meryem Beklioğlu

CIIMAR - Interdisciplinary Centre of Marine and Environmental Research (Portugal) – Dr. José Teixeira (WP5 co-coordinator)

Aarhus University (Denmark) – Dr. Thomas A. Davidson

Uppsala University (Sweden) – Dr. Malgorzata Blicharska (WP1 coordinator)

Bangor University (UK) – Dr. Sopan Patil (WP3 coordinator)

Technical University of Munich (Germany) – Prof. Johannes Sauer

I.S.A.R.A. – Institut Supérieur d'Agriculture Rhône-Alpes (France) – Dr. Joël Robin

Freshwater Habitats Trust (UK) – Dr. Jeremy Biggs (WP5 co-coordinator)

Universidad de la República (Uruguay) – Dr. Mariana Meerhoff

Randbee Consultants SL (Spain) – Juan Arevalo Torres

Amphi International APS (Denmark) – Lars Briggs

Authors:
Maryam Lotfian (HES-SO University of Applied Sciences and Arts Western Switzerland), Florent Joerin (HES-SO University of Applied Sciences and Arts Western Switzerland)

Contributors:
Beat Oertli (HES-SO), Aurélie Boissezon (HES-SO), Tuba Bucak Onay (AU), Parinaz Rashidi (BU)

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Executive summary

This decision support tool uses the scientific outcomes of the Ponderful project by incorporating them into a multicriteria decision analysis (MCDA) framework aimed at guiding pond and pondscape management strategies to tackle critical societal challenges, including climate change. It promotes the implementation of nature-based solutions (NBS) and evaluates their impacts using Nature's Contribution to People (NCP) indicators, enabling a comprehensive assessment of the ecological and climatic benefits provided by ponds and pondscapes. The tool facilitates evidence-based decision-making by comparing various NBS approaches, such as the creation of clean water ponds or the management of pond water quality, across a range of NCP indicators like aquatic biodiversity (amphibians, plants, macroinvertebrates), emissions of GHG, water quality, and water storage, and under diverse land use and climate change scenarios. This decision support tool was developed using the knowledge presented in the PONDERFUL technical handbook and it supports the policy guidance document.

This document outlines the tool's development process, including iterative enhancements, stakeholder collaboration, and integration of the MCDA approach. It discusses the tool's structure, the data and models used in the process, and future directions for its enhancement and scalability.

The tool is available here. To use the tool, you must first create an account.

1. Introduction

The aim of this decision support tool is to use and disseminate the scientific findings from the Ponderful project by integrating them into a multicriteria decision analysis (MCDA) framework. This tool is specifically designed to assist decision makers defining their pond management strategies to address major societal challenges such as climate change. These strategies are based on promoting the implementation of nature-based solutions (NBS) and are assessed by the indicators of Nature's Contribution to People (NCP). The tool enables a comprehensive assessment of the ecological and climatic benefits provided by ponds, supporting evidence-based decision-making.

The tool provides a platform to compare various NBS implementations, such as the creation of clean water ponds or the management of pond water quality, over a range of NCP indicators such as biodiversity or GHG emissions, and across diverse land use and climate change scenarios. Its output and functionality is linked to the outputs generated by integrated models developed in Work Package 3 (WP3) and the datasets of NCPs gathered through the stratified sampling of 210 ponds across Europe and Turkey in Work Package 2 (WP2).

This deliverable document provides a comprehensive overview of the tool's development journey. It details the iterative phases of development, the collaborative dialogues held with stakeholders, and the incorporation of the MCDA approach into the tool's design. Additionally, it delves into the structural composition of the tool, the challenges encountered during its development, and the envisioned future steps for refinement and scalability.

2. Multicriteria decision structuring

Multicriteria Decision Analysis (MCDA) is a concept that can range from simple everyday decisions, such as choosing which restaurant to have lunch at, to more complex ones, like deciding which house to buy (Tsoukiàs, 2008). It can also involve highly intricate decisions, such as determining the best location to construct a building (Joerin et al., 2001) or selecting a construction plan that minimizes impacts on soil quality and biodiversity (Adem Esmail & Geneletti, 2018). While the concept itself is ancient, the term "MCDA" was popularized in 1979 by Stanley Zionts through his article "MCDM – If Not a Roman Numeral, Then What?"(Zionts, 1979)

As its name suggests, multiple criteria influence the choice among various alternative decisions, commonly referred to as alternatives or variants. For example, when deciding between three housing options, the criteria might include price, the number of bedrooms, access to public transportation, and proximity to shopping centers, among others. Each of these criteria carries its own priority and weight for the person making the decision. For one individual, price might be the most important factor, while for another, the number of bedrooms might take precedence. Thus, the decision depends on how each alternative performs against the criteria that matter most to the decision makers. Accurately identifying and prioritizing these criteria is crucial for enabling well-informed and effective decisions.

Before initiating an MCDA, it is necessary to establish a clear structure for the decision problem. This involves defining the key elements of the decision-making process, which include the decision maker, relevant data, the chosen method, and the approach.

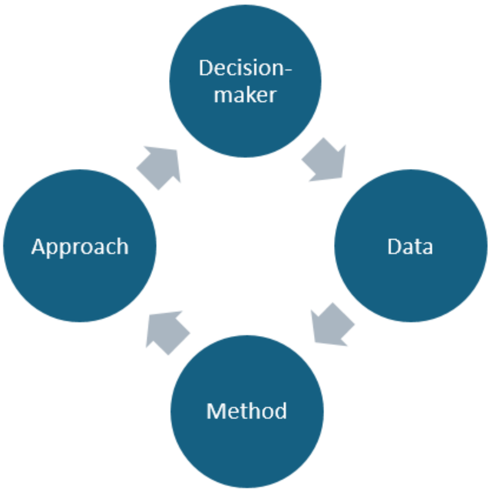


Figure 1: Main elements of decision structuring

Decision-Maker

The decision maker varies depending on the decision problem. It could range from a single individual to a group of people, or from a private, governmental, or non-governmental organization. Understanding who the decision makers are and in which context the decision is made, is crucial for designing an effective decision-making process. For the Ponderful project, this question was discussed with partners and stakeholders, resulting in the following definitions of potential decision makers:

- An administrative official, such as a manager of a region or park.
- A landowner.
- Someone seeking to influence an authority.

Additionally, it was discussed that decision makers could contribute to actions such as fund allocation, developing a communication campaign aimed at policy change, or creating ponds on their own land. Notably, the decision maker does not need to be a biologist or an expert in the management area but can receive support from experts to make informed decisions.

Data

An essential component of the decision-making process is the data used to assess the impact of each alternative on various criteria. For the Ponderful project, data comes from two primary sources:

- Data provided by **WP2** and **WP3** models.
- Data contributed by decision makers while using the decision support tool. These data allow the decision makers to define their own preferences, as the importance given to the different criteria taken into account.

Details about the various input data will be explained in the section dedicated to the tool.

Method

There are several methods for conducting MCDA, with some of the most well-known including:

- AHP (Analytic Hierarchy Process) (Saaty, 1980)
- SAW (Simple Additive Weighting) (Afshari et al., 2010)
- TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) (Uzun et al., 2021)

Although these methods differ in techniques and offer distinct advantages and disadvantages, they all use the concept of criteria importance or weights to compare various alternatives. For the Ponderful decision-making process, we adopted an approach similar to the SAW method. However, we also incorporated the decision maker's management objectives into the process, creating what we call the **Prudent Weighted Average** (Bana e Costa et al., 2016). This method is inspired by the M-Macbeth method. It ensures careful consideration of not only the importance of criteria but also the management objectives of the decision maker.

In this method:

- The decision maker selects and ranks the criteria, which are then used to calculate the weights.
- The decision maker provides their management objectives for each criterion.
- We calculate the level of satisfaction of the management objectives for each criterion and finally an overall level of satisfaction for each alternative (nature-based solution).

The formula below illustrates how the satisfaction score for each criterion is calculated:

Given:

- S_j: Level of objective reached for criterion j.
- N_j: The value for criterion j
- O_{min}: Minimum objective for criterion j.
- O_{max}: Maximum objective for criterion j.

Then:

- If $N_j \leq O_{min}$: $S_j = 0$ **means that objective not achieved**
- If $O_{min} < N_j < O_{max}$: $S_j = (N_j - O_{min}) / (O_{max} - O_{min})$
- If $O_{max} \leq N_j$: $S_j = 1$ **means that objective completely achieved**

Goal and Approach

The decision support tool has been designed to fit in with a constructivist interactionist approach to decision-making. This means that the decision support process is approached as a learning process that enables the decision maker to define or consolidate his preferences. By using the tool, the decision maker gains insights into the decision-making process through iterative analysis, testing different parameters, and evaluating their impact on the final outcome. For example, they can adjust:

- The weights of the criteria.

- The alternatives (NBS).
- The management objectives.

This iterative process helps the decision maker better understand the influence of each parameter on the results. The learning process or decision support process ends when the decision maker feels ready to make a decision.
In the next section, we explain how this MCDA method is applied within the Ponderful project. This includes details on tool development, the integration of data and models from WP2 and WP3, the alternatives considered, and more.

3. The design process of the decision support tool

The tool aims at forecasting the impact of NBS implementation types on NCP indicators under a range of climate change and land use scenarios. As mentioned earlier, the tool is dependent on the modeling outcome from WP3 in order to evaluate the impact of an NBS on an NCP indicator. The choice of the NBS implementation types, NCP indicators to include have been done over iterative discussions over the various phases of the decision support tool development.

3.1. Definition of NBS implementation types and NCP indicators

NCP indicators: The selection process for the NCP indicators used in the tool has been a collaborative effort, discussed at annual PONDERFUL meetings in Porto (2022) and Uppsala (2023), during internal WP4 meetings, and notably at the third Ponderful workshops with stakeholders (WP1-WP3-WP4). The third workshops were conducted in eight countries with overall 180 stakeholders, from October to December 2023, where stakeholders proposed potential indicators for inclusion in the tool. These suggestions were then evaluated based on:

- The availability and applicability of data from WP2;
- The compatibility with existing or potential models from WP3;
- Expert knowledge in pond management from WP4 leaders.

As a result of the discussion with partners and stakeholders, the final selected list of NCP indicators included in the tool are: Aquatic biodiversity (amphibians, plants, macroinvertebrates), emissions of GHG (CO_2, CH_4), water quantity, and water quality (trophic status).

NBS implementation types: The discussion on implementation of different types of NBS has also been a key focus. The current list includes creation of clean water ponds, management of water quality , as well as no human action. The choice of these selected actions are as well dependent on the capabilities of models produced by WP3, as well as the discussions with stakeholders on the actions that are most important for them.

3.2. Development phases

The tool was evolved over three main development phases: **mockup, prototype, and the final tool.** Figure2 illustrates the detailed process of the decision support tool development.

Mockup preparation (April 2022 – June 2023): This initial phase involves extensive collaboration, especially with WP3 and WP4, as well as interactions with other WPs during the last two annual meetings. These discussions led to the creation of a tool mockup, which outlines the tool's structure and functionalities. The mockup served as a foundational guide for the development of version 0 and facilitated the clarification of input parameters required from other WPs. It is important to note that the mockup is a non-functional prototype that does not conduct any analysis or incorporate real data. The various stages involved in creating the mockup were discussed with other WP members, notably WP3 and WP4. The final version was subsequently refined and adapted based on insights gained from these discussions.

Development of version 0 (June 2023 – March 2024): Following the review of the mockup in consortium meetings and its presentation during Ponderful workshop 3, the development of version 0 started. This version was simplified in response to the challenges and feedback received from stakeholders during workshop 3. A pilot case study was conducted in collaboration with Park Jorat in Switzerland (pondscape managers and municipalities) to test version 0, with further details on this collaboration provided in *section 3.3*. The tool is built using the Django framework and runs within a Docker container, using a PostgreSQL/PostGIS database for data modeling and storage. It is open source, and its code is freely accessible on GitHub.

Development of the final version (March 2024 – November 2024): The final version represents an enhancement of version 0, focusing on improved structure, styling, and user experience, while incorporating input data from all partner countries. Multiple interactive links to the handbook have been added in order to bring to the user an access to an overview of the Ponderful project. This version is designed to support decision makers across Europe. It is crucial to highlight that the tool's final outcomes are fundamentally dependent on the provided input data and the results of the integrated models.

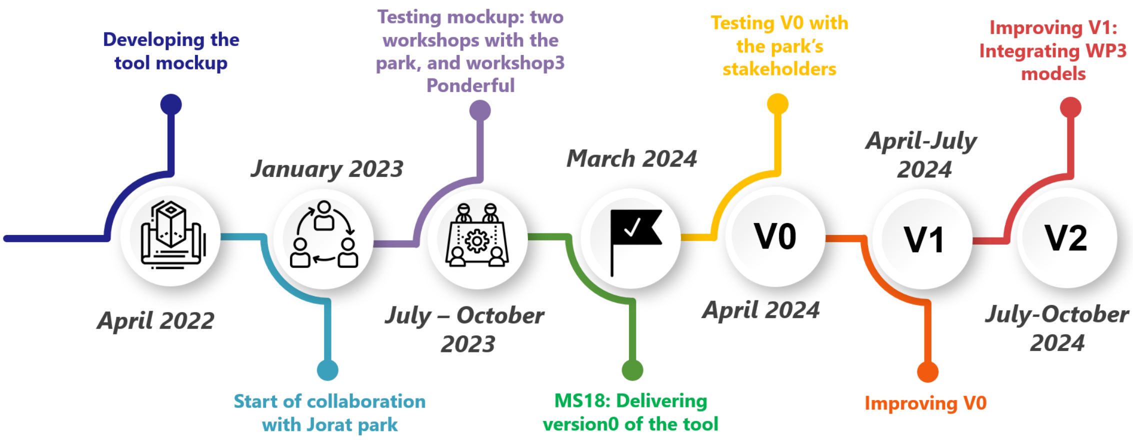


Figure 2: The development phases of Ponderful Decision Support Tool

3.3. Pilot experiment

The Jorat Nature Park, a suburban park, situated in the northern part of Lausanne, Switzerland, is dedicated to enhancing biodiversity, facilitating visitor engagement, and promoting sustainable resource management. The park encompasses two zones: a protected (central) zone and a transition zone (See Figure 3), including 33 ponds distributed across both zones. It was selected as the pilot area to evaluate the initial version of the decision support tool.

Figure 3: Nature Park Jorat: the pilot management area

The selection of the Jorat Nature Park as the pilot area had several reasons. Firstly, it provided an opportunity to evaluate the tool's applicability beyond the project's sites, testing its generalizability to other regions. Secondly, it allowed us to engage with stakeholders and decision makers not directly involved with the Ponderful project, evaluating the responses of individuals less familiar with the project to the tool and its objectives. Additionally, the park's proximity to our campus facilitated the organization of meetings and workshops.

Since January 2023, we have engaged in monthly meetings with a biology expert from the park, with a total of 12 meetings and 3 workshops with local decision makers (municipalities). The workshops took place in July and September 2023 for discussion of the mockup, choice of NBS implementations and NCP indicators, and a final workshop took place in April 2024 focused on testing the version 0 of the tool. The initial workshop aimed to introduce the Ponderful project to stakeholders and decision makers, discussing both the opportunities and challenges of pond creation (as NBS) in their area. The second workshop focused on presenting the decision support tool's mockup and conducting exercises to assess user engagement with the tool's questions and the ease of providing responses. The final workshop was to test the initial version of the tool (V0), gathering feedback for potential enhancements and recommendations to further improve the tool.

Figure 4: Workshops with Jorat Park stakeholders (left: first workshop, right: final workshop testing the V0)

4. Decision Support Tool's main components

The decision support tool has three main components: the models provided by WP3, the input parameters by the decision maker, and the MCDA results. Each are explained below:

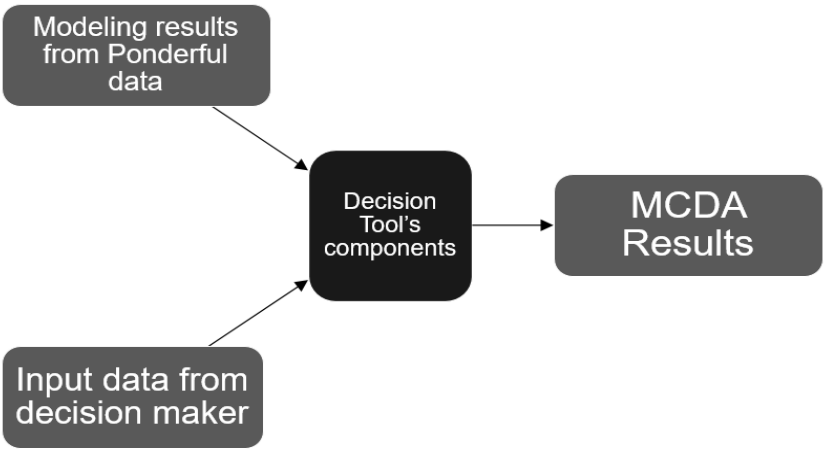


Figure 5: Decision tool's main components

4.1. Input data from Ponderful models

As previously mentioned, one of the key objectives of the decision makers is to facilitate the dissemination of Ponderful's results. The tool is designed to serve as a bridge between decision makers and the models, simplifying their application. Instead of requiring direct use of the models, the tool provides a more accessible interface through a multicriteria analysis framework. This approach makes the models more understandable and usable by the general public without requiring specialized expertise.

As a result, certain models developed by WP3 have been integrated into the tool. These models are used in the application server side and are not directly accessible by the users. The models include:

Species accumulation curves: This model illustrates the relationship between the number of ponds and species richness. A species accumulation curve is a graphical representation used to estimate the number of species in an area based on the sampling effort, such as the number of ponds surveyed. In this project, species accumulation curves are used to estimate the richness metrics based on the number of ponds for all PONDERFUL data for country-level. These curves eventually reach an equilibrium point where adding more ponds no longer increases the species richness in the region. In its current version, the model indicates equilibrium for different species at different equilibrium points. This model is applied to three NCP indicators: amphibians (species level), aquatic plant species (genus level), and macroinvertebrates (family level for the orders: Coleoptera, Ephemeroptera, Plecoptera, Trichoptera, Odonata, Gastropoda).

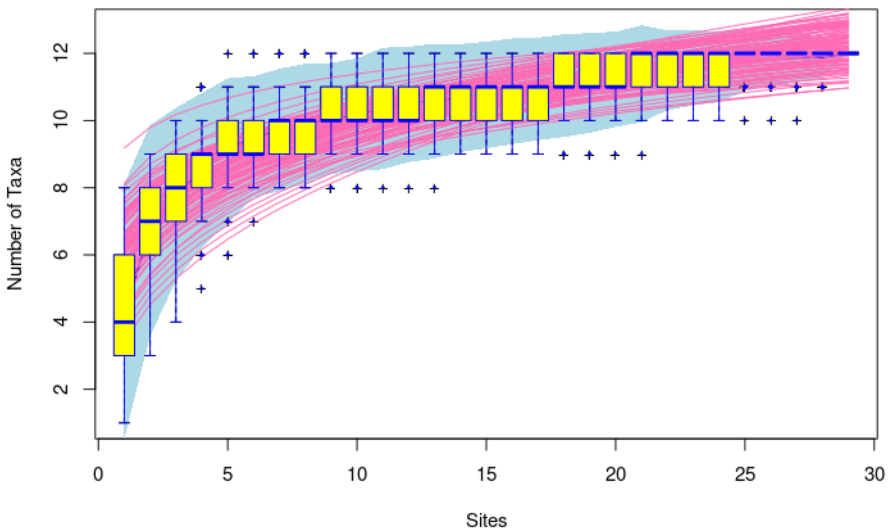


Figure 6: Example of accumulation curve for amphibians for ponds from the Canton of Geneva in Switzerland

Trophic states data: Trophic status of the ponds were classified based on Total Nitrogen (TN) values considering all three seasons (Summer, Autumn, Spring) using the thresholds defined by Rosset et al. (2014). Oligotrophic and mesotrophic ponds are combined and used as oligo-mesotrophic ponds representing ponds with low productivity. Table1 illustrates the different categorization of trophic states.

Table 1: Limits of the concentrations of total nitrogen and total phosphorus used to determine the trophic status (table obtained from Rosset et al. (2014))

Trophic status	Abbreviation	Limits N [mg/l]		Limits P [mg/l]	
Oligotrophic	O	≤ 0.3	(0.035)	≤ 0.01	(0.001)
Mesotrophic	M	≤ 0.65	(0.035)	≤ 0.035	(0.0025)
Eutrophic	E	≤ 1.5	(0.085)	≤ 0.1	(0.0065)
Hypertrophic	H	≤ 3.75	(0.225)	≤ 0.25	(0.015)
Highly hypertrophic	HH	> 3.75	(0.225)	> 0.25	(0.04)

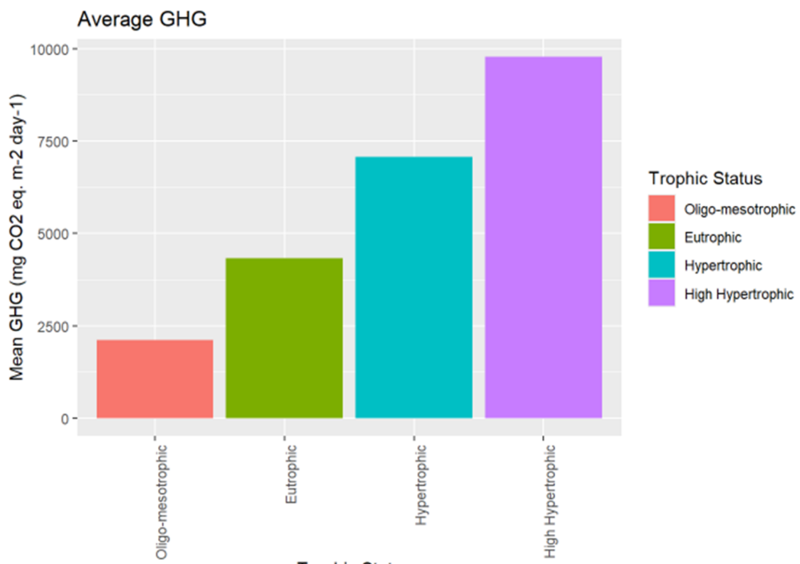


Figure 7: Example of relations used in the tool: emission of GHG in function of the trophic status of the ponds

Scenario maps: To generate future scenario maps, the Boosted Regression Tree (BRT) model was used to train predictions for each biodiversity and ecosystem service indicator for PONDERFUL ponds. The trained model was then extrapolated to the entire European region using current land use data (Rashidi et al., 2023) and climate maps from WorldClim (www.worldclim.org), both resampled to a 5 km resolution. These maps represented the baseline conditions.

These trained models were also applied to predict future states for the 2040–2060 period under three different SSP scenarios (SSP1, SSP3, and SSP5) using future land use projection maps at a 5 km resolution (Parinaz et al., 2013) and future climate maps.

These scenarios are categorised into three distinct themes: Sustainability (SSP1xRCP2.6), Regional Rivalry (SSP3xRCP6.0), and Fossil-fueled Development (SSP5xRCP8.5). This land use data is available for access in the PONDERFUL database. In the decision support tool we have simplified these themes as the following:

Sustainability (SSP1xRCP2.6):

- **Slight land use and climate change**: A sustainable future with minimal land use changes and strong climate action keeps environmental impacts low and ecosystems relatively stable.

Regional Rivalry (SSP3xRCP6.0):

- **Moderate land use and climate change:** A fragmented world with moderate land use pressures and insufficient climate action leads to localized environmental degradation and moderate global warming.

Fossil-fueled Development (SSP5xRCP8.5):

- **Strong land use and climate change:** Intensive land use changes driven by high economic growth and unchecked fossil fuel emissions result in severe climate impacts and widespread environmental damage.

4.2. Input data by decision maker

Another key component of the Ponderful decision support tool is the input data provided directly by decision makers during its use. This data is crucial for the multicriteria analysis. The tool gathers information mainly about the decision makers' preferences and objectives. More specifically, decision makers provide input across six distinct steps:

Defining the management area: In this step, the decision maker, who can be supported by a manager of the pondscape, defines the area for which they wish to evaluate the impact of NBS implementation. This can be done by either manually digitizing the area or importing a shapefile (.shp) of the region. After defining the area, the decision maker is required to provide additional information, such as:

- The approximate current number of ponds in the area.
- The current average trophic state of the ponds, if known (with the option to select "I do not know" if this information is unavailable).

Once the management area is defined and the necessary information is provided, the user can submit the data and proceed to the next step: defining the types of NBS implementations they wish to explore.

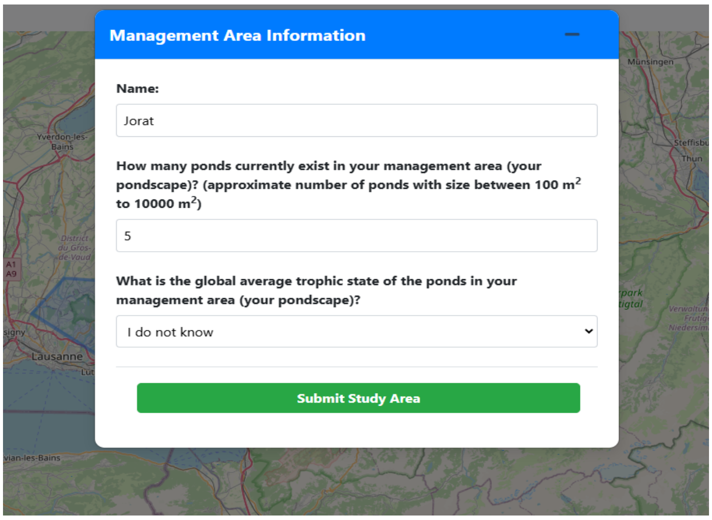


Figure 8: Defining the management area

Selection of NBS types: In this step, decision makers select the types of NBS they wish to evaluate within their management area. As outlined in the section on the design process, the selection of NBS options was carefully considered throughout the tool's development phases. The final list includes the following options:

- Creation of clean water ponds
- Management of water quality
- No human action (allowing nature to take its course)

If the decision maker selects the creation of clean water ponds, they must specify a range for the minimum and maximum number of ponds they intend to create. Based on this input, the tool generates three possible pond creation scenarios: minimum, maximum, and the average of the two.

To assist users in making informed decisions, the tool provides additional details for the actions of pond creation as well as managing and restoring, referencing specific sections of the Ponderful Technical Handbook.

Once the NBS types have been selected, the next step involves choosing the relevant NCP indicators.

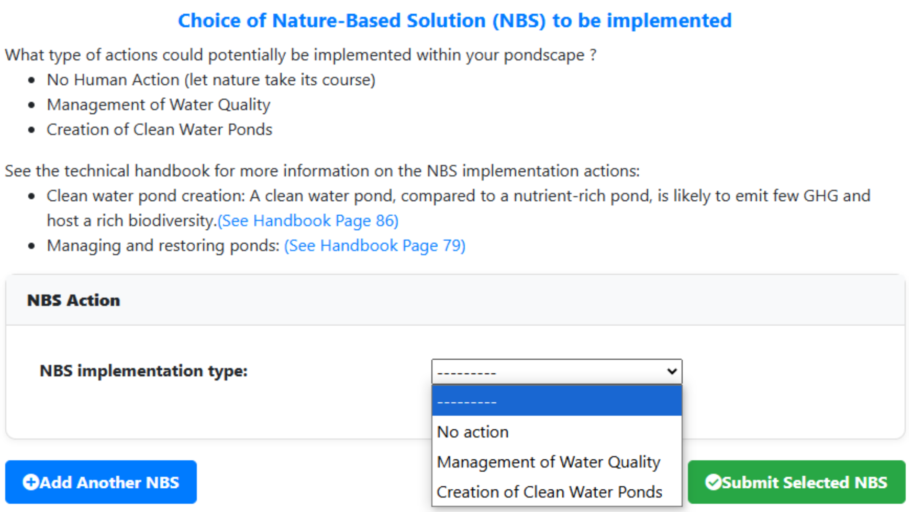


Figure 9: Selection of NBS implementation types

Selection of NCP indicators: In this section, the decision maker selects the NCP indicators they wish to evaluate for the impact of NBS implementations selected in the previous step. Similar to the selection of NBS types, the choice of NCP indicators was thoroughly discussed during the tool's development phases. Figure 10 illustrates the final list of selected indicators.

To support informed decision-making, the tool provides users with links to the relevant sections of the Ponderful Technical Handbook for each NCP indicator, offering detailed explanations and additional context.

Once the NCP indicators are chosen, the user proceeds to the next step: ranking the selected NCP indicators.

Choice of NCP indicators (Nature's Contribution to People)

Which NCP indicators do you want to take into account in your analysis?

Select All	NCP Indicator	Unit of Measure (expressed per pondscape)	Objective	Reference to Handbook
☑	Amphibian species	Number of species	To maintain or to increase	Check technical handbook
☑	Aquatic plant genus	Number of genus	To maintain or to increase	Check technical handbook
☑	Macroinvertebrates	Number of families (Coleoptera, Ephemeroptera, Plecoptera, Trichoptera, Odonata, Gastropoda)	To maintain or to increase	Check technical handbook
☑	GHG emission (CH_4, CO_2)	Average mg of CO_2 equivalents/m^2 /day	To decrease	Check technical handbook
☑	Water storage	Total water volume (m^3)	To increase	Check technical handbook
☑	Water quality	mg of Total Nitrogen (TN) / L	To decrease	Check technical handbook

Submit Selection and Rank the Selected Indicators

Figure 10: Selection of NCP indicators

Ranking of the NCP indicators: In this step, the decision maker ranks the selected NCP indicators based on their importance. This prioritization reflects the specific context and goals of the management area being evaluated. The ranking is essential for the multicriteria analysis, as it calculates a weight for each NCP indicator, which is then used to generate a global weighted average in the final results.

After completing this step, the user proceeds to define their management objectives for each selected and ranked NCP indicator.

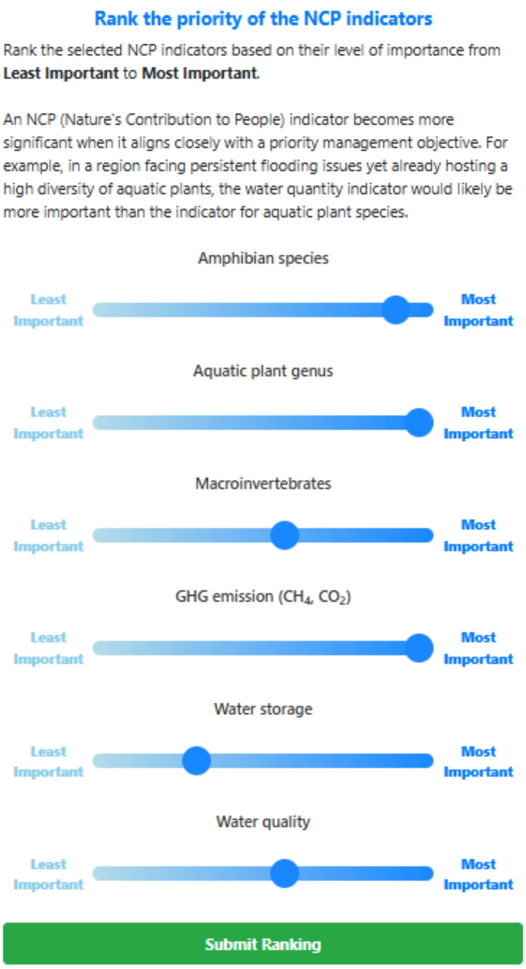
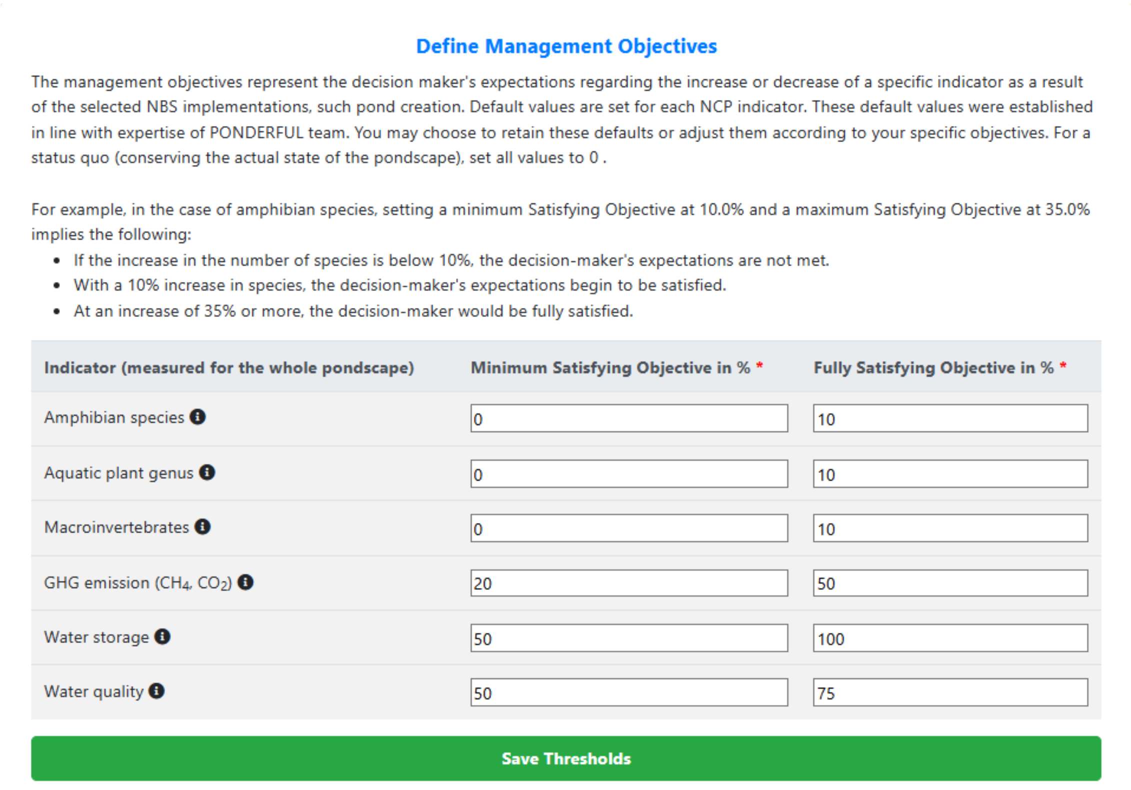


Figure 11: Ranking the selected NCP indicators

Defining management objectives: In this step, decision makers define their management objectives for each selected and ranked NCP indicator. The tool provides default values for each indicator, which users can choose to retain or adjust based on the specific context of their management area and objectives. These objectives guide the multicriteria analysis in computing a final evaluation, determining the extent to which each objective is achieved.

For example, if a management objective is to increase amphibian richness by 10–30%, any increase below 10% would be considered unsatisfactory, while an increase above 30% would fully satisfy the objective for that indicator.

At this stage, the decision maker has provided all the necessary information related to the NCP indicators and can proceed to the final step: defining land-use and climate change scenarios.


Define Management Objectives

The management objectives represent the decision maker's expectations regarding the increase or decrease of a specific indicator as a result of the selected NBS implementations, such pond creation. Default values are set for each NCP indicator. These default values were established in line with expertise of PONDERFUL team. You may choose to retain these defaults or adjust them according to your specific objectives. For a status quo (conserving the actual state of the pondscape), set all values to 0 .

For example, in the case of amphibian species, setting a minimum Satisfying Objective at 10.0% and a maximum Satisfying Objective at 35.0% implies the following:

- If the increase in the number of species is below 10%, the decision-maker's expectations are not met.
- With a 10% increase in species, the decision-maker's expectations begin to be satisfied.
- At an increase of 35% or more, the decision-maker would be fully satisfied.

Indicator (measured for the whole pondscape)	Minimum Satisfying Objective in % *	Fully Satisfying Objective in % *
Amphibian species	0	10
Aquatic plant genus	0	10
Macroinvertebrates	0	10
GHG emission (CH_4, CO_2)	20	50
Water storage	50	100
Water quality	50	75

Save Thresholds

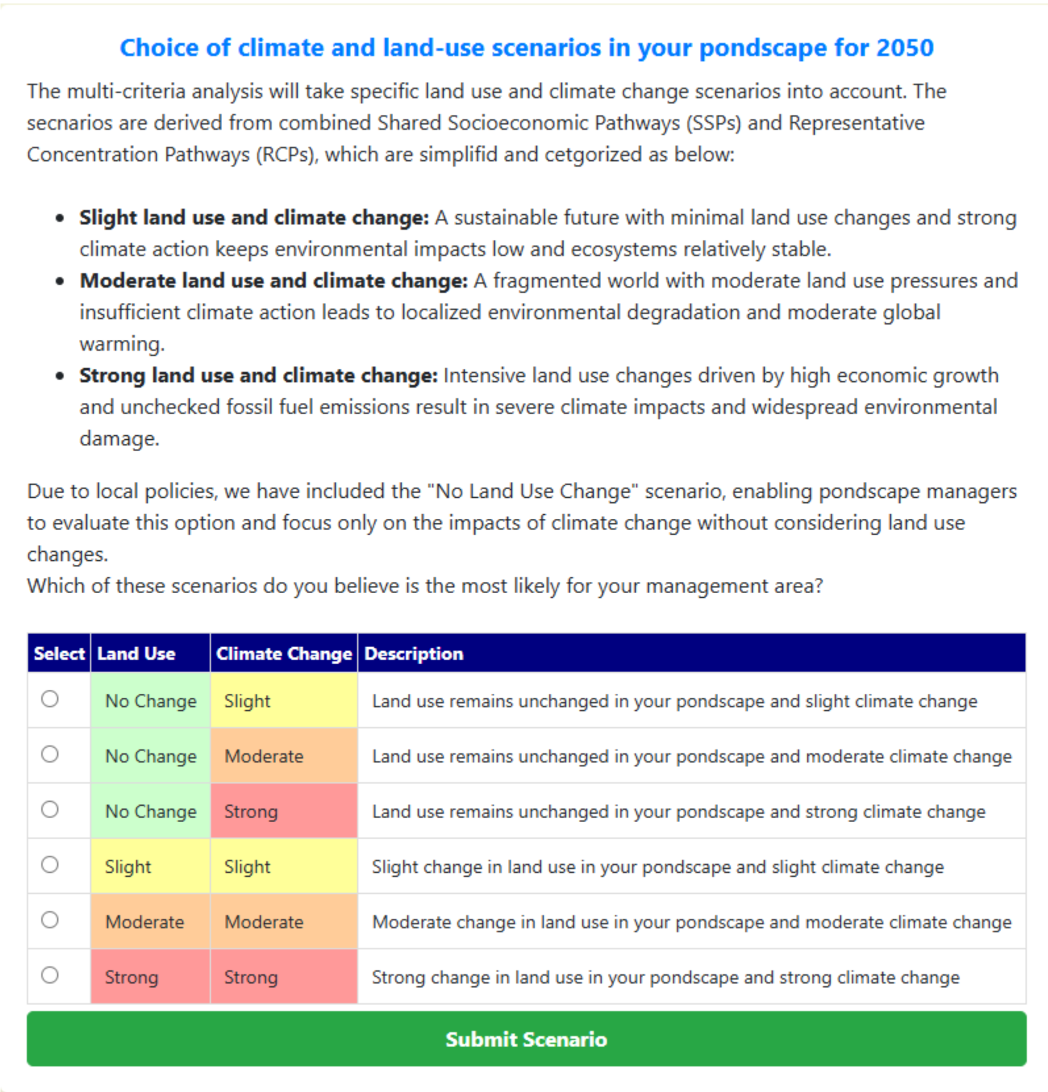
Figure 12: Defining management objectives for the selected NCP indicators

Selection of land use and climate change scenario: The final input required from the decision maker is to select the land-use and climate change scenario under which they wish to evaluate the impact for the year 2050. Scenario maps, as explained in the Ponderful model section, are used to assess the potential impacts within the management area.

During the initial step of defining the management area, the tool calculates the average values of scenario maps for all scenarios and indicators within that area. Based on the scenario selected at this stage, the corresponding values are retrieved from these pre-calculated average raster values.

Recognizing that land-use changes are highly influenced by local policies and challenging to model at a European scale, the tool provides an option to assume no land-use change within the decision maker's management area. In such cases, only climate change scenarios are considered in the analysis.

At this point, the decision maker has provided all the necessary inputs, and the analysis is ready to run. The next section presents and interprets the results of the evaluation.



Choice of climate and land-use scenarios in your pondscape for 2050

The multi-criteria analysis will take specific land use and climate change scenarios into account. The secnarios are derived from combined Shared Socioeconomic Pathways (SSPs) and Representative Concentration Pathways (RCPs), which are simplifid and cetgorized as below:

- **Slight land use and climate change:** A sustainable future with minimal land use changes and strong climate action keeps environmental impacts low and ecosystems relatively stable.
- **Moderate land use and climate change:** A fragmented world with moderate land use pressures and insufficient climate action leads to localized environmental degradation and moderate global warming.
- **Strong land use and climate change:** Intensive land use changes driven by high economic growth and unchecked fossil fuel emissions result in severe climate impacts and widespread environmental damage.

Due to local policies, we have included the "No Land Use Change" scenario, enabling pondscape managers to evaluate this option and focus only on the impacts of climate change without considering land use changes.
Which of these scenarios do you believe is the most likely for your management area?

Select	Land Use	Climate Change	Description
○	No Change	Slight	Land use remains unchanged in your pondscape and slight climate change
○	No Change	Moderate	Land use remains unchanged in your pondscape and moderate climate change
○	No Change	Strong	Land use remains unchanged in your pondscape and strong climate change
○	Slight	Slight	Slight change in land use in your pondscape and slight climate change
○	Moderate	Moderate	Moderate change in land use in your pondscape and moderate climate change
○	Strong	Strong	Strong change in land use in your pondscape and strong climate change

Submit Scenario

Figure 13: Selection of land use and climate change scenarios

5. Results interpretation

The results illustrate how well the management objectives are achieved for each NBS implementation and each selected NCP indicator. These results are derived using the models developed by Ponderful, combined with scenario maps and the decision maker's defined management objectives. The final scores, which indicate the level of achievement, are calculated using the formula described in the section on multi-criteria decision structuring.

The percentage of achievement is categorized into six levels:

- 0%: Not achieved
- 0–20%: Barely achieved
- 20–40%: Minimally achieved
- 40–60%: Partially achieved
- 60–80%: Mostly achieved
- 80–100%: Fully achieved

It is important to note that the calculated score for objective achievement may vary significantly if the management objectives change. If an NBS implementation does not meet a given NCP indicator's objective, this does not necessarily mean the NBS has no positive impact. Rather, it indicates that the modeled outcomes fall short of the decision maker's minimum objective. For example, if the minimum objective for reducing GHG emissions is set at a 20% decrease, but the model predicts a 15% decrease for a specific NBS, the objective is not achieved. However, the NBS still contributes to reducing GHG emissions.

To enhance decision-making, it is recommended to test the tool with different runs using varied management objective values. This approach can help identify which NBS implementation is best suited for a given management area and which management objectives could be reached with these NBS implementations.

Additionally, the tool emphasizes that the creation of clean water ponds, even if not guaranteed to increase taxonomic richness, contributes to supporting populations of many species. Moreover, clean water ponds generate fewer GHG emissions compared to nutrient-rich ponds.

The selected scenario: Slight change in land use in your pondscape and slight climate change

NBS Implementation	Amphibian species	Aquatic plant genus	Macroinvertebrates	GHG emission (CH_4, CO_2)	Water storage	Water quality	Weighted Average
No action	Minimally Achieved	Barely Achieved	Not Achieved	Not Achieved	Unknown	Not Achieved	Barely Achieved
Management of Water Quality	Minimally Achieved	Minimally Achieved	Achieved	Minimally Achieved	Unknown	Minimally Achieved	Minimally Achieved
Creation of 10 Clean Water Ponds	Achieved	Achieved	Achieved	Unknown	Achieved	Not Achieved	Mostly Achieved
Creation of 20 Clean Water Ponds	Achieved	Achieved	Achieved	Unknown	Achieved	Partially Achieved	Mostly Achieved
Creation of 30 Clean Water Ponds	Achieved	Achieved	Achieved	Unknown	Achieved	Mostly Achieved	Mostly Achieved

Figure 14: An example of decision support output, evaluating the impact of different NBS implementations types over a range of selected NCP indicators, for the scenario strong land use and climate change

6. Limitations and future improvements

The tool provides a valuable resource for raising awareness about the impacts of ponds and pondscapes on biodiversity and climate. It also supports decision makers in comparing and testing different NBS implementations. However, it has certain limitations and areas for improvement that could be addressed in a potential second phase of the project.

Current limitations

1) Scale of models: The tool currently relies on models developed at a European scale. While this is useful for broader applications, using the tool at a local scale requires additional context-specific inputs, such as local policies and finer-scale data (e.g., localized weather patterns) to improve model accuracy.

2) Dependence on Ponderful data: The tool is dependent on the data and models produced as part of the Ponderful project. Consequently, any limitations of these models (e.g., data being concentrated in specific regions within each country, leading to uneven spatial representation) also affect the tool's accuracy and usability.

3) Lack of location-specific recommendations: The current version does not provide recommendations tailored to specific locations, such as identifying optimal areas for creating ponds or implementing other NBS actions.

Potential future improvements

1) Enhanced local adaptation: Future iterations of the tool could be adapted to better support local-scale applications. This could include integrating finer-resolution environmental and geographical data to enhance accuracy and relevance for specific management areas. Biodiversity data should also be enriched by more local scale data, also at a finer taxonomic resolution (species level, when possible).

2) Location-specific recommendations: The tool could be improved by generating suitability maps, which identify optimal areas for NBS actions based on local environmental and geographical conditions. This would provide more actionable insights for decision makers.

3) Dynamic integration with models: Another improvement would be to link the tool directly to the models. This would allow updates to the models to be automatically reflected in the tool, eliminating the need for manual updates and ensuring the tool remains current with the latest updates in modeling.

By addressing these limitations, the tool could become a more robust and practical resource for decision-making at both local and regional levels.

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Ponderful

Coordinator: Prof. Sandra Brucet, University of Vic – Central University of Catalonia & ICREA

Project Manager: Dr. Diana van Gent, University of Vic – Central University of Catalonia

Contact: diana.vangent@uvic.cat

Duration: 1 December 2020 to 30 November 2024

Website: www.ponderful.eu

Facebook: /Ponderful-331847228188664

Twitter: @ponds4climate

Instagram: @ponds4climate

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