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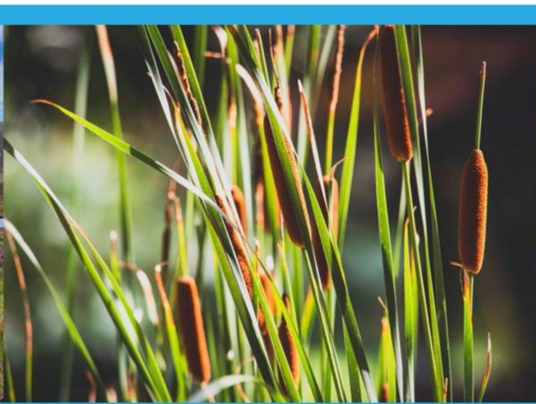
PONDS FOR CLIMATE



Deliverable D1.5

Report on the socio-economic analysis of ponds and pondscapes

Pond Ecosystems for Resilient Future Landscapes in a Changing Climate

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Executive Summary

Pondscapes are important Nature-Based Solutions (NBS) for climate mitigation and adaptation, as well as in biodiversity conservation, but they are neglected in water- and nature-related national and EU policies and strategies. There is also limited knowledge on the relationships between pondscapes' biodiversity and Ecosystem Services (ES)/ Nature's Contributions to People (NCPs) delivery. The mission of the PONDERFUL project is to increase the understanding of the role of pondscapes in providing NCPs/ES and to promote greater implementation of pondscapes as NBS in order to mitigate or adapt to the current trends of environmental deterioration. PONDERFUL quantifies the relations among biodiversity, ecosystem state, ES/NCP and climate change (CC) by developing scenarios for climate mitigation and adaptation using pondscapes, and testing the implemented pondscape-based solutions using DEMOnstration sites (DEMO sites) co-developed with stakeholders. Ultimately, PONDERFUL is developing practical tools for creating and managing pondscape Nature-Based Solutions.

The aim of Deliverable 1.5 is to describe the methods of the socio-economic analysis that was conducted within Task 1.6 of the project, as well as its outcomes. We successfully explored how pondscapes' benefit delivery capacity could be quantified through available indicators, which were collected by project partners. Then, the Benefit of the Doubt method allowed us to aggregate such indicators at criteria and sub-criteria levels, to further compare heterogeneous pondscapes. With the Analytic Hierarchy Process, we investigated stakeholder preferences for such criteria in a straightforward, bottom-up assessment. Next, such preferences became weights for a Multi-criteria Decision Analysis, comparing pondscapes on their benefit delivery effectiveness. Data Envelopment Analysis was then used to provide insights on pondscapes' efficiency. Finally, integrating knowledge from the available literature and our data, we discussed how pondscapes perform as NBS in comparison to other such measures.

We found that stakeholder preferences for ES and NCP change considerably between demo-sites. More in general, for all the PONDEFUL demo-sites environmental benefits are ranked higher by stakeholders, except for the Uruguayan one where provisioning benefits are favored instead. This is in line with the intended use of such ponds, since Uruguayan pondscapes are mostly privately owned, and maintained in support of agricultural activities. Once these preferences have been extended at the national level, Osona (ESP), Ayas Yolu (TU), Imrendi (TU), Avernako (DK), Altos del Chorro (UY), Albera (ESP), and Sorgun (TU) pondscapes consistently held the highest scores for benefit delivery effectiveness. Indeed, they all provide mostly those benefits that are preferred by their respective stakeholders. Under the efficiency assessment, Ayas Yolu (TU) proved to be the best performing pondscape. This is not only the best in term of input-output performance (technical efficiency), but also at the appropriate scale to optimize such ratio overall (scale efficiency). Finally, comparing the literature with our newly acquired knowledge, we found initial evidence that could support pondscapes' potential as cost-efficient and scalable NBS.

1. Introduction

Small water bodies, like ponds and pondscapes, can be implemented as Nature Based Solutions for adaptation to, and mitigation of, Climate Change's impacts. They provide various ecosystem services and Nature's Contributions to People, such as regulating climate, storing carbon, mitigating food risk and alleviating pollution. The benefits also include improving physical and mental life of local inhabitants by encouraging recreational activities and tourism in some areas. With such a multidimensional contribution, it can be complex to quantify the performance of pondscapes as NBS, as well as to compare them based on such performances.

Furthermore, these benefits are not perceived equivalently among the different stakeholders within the same pondscape, or stakeholders among different pondscapes. Therefore, there might be mismatches between the designed functions of a pondscape and the function that the stakeholders appreciate. To assess this issue, the assessment of pondscape benefit delivery performances should be conditional on stakeholders' preferences for ES and NCP. This translates into pondscapes' benefit delivery effectiveness.

Finally, every benefit comes with a cost. In the specific case of an NBS like pondscapes, there are costs, such as infrastructure, capital, and maintenance costs. Thus, it is questionable whether the benefits of pondscapes can be achieved by covering the associated costs. Or, in other words, it has to be determined whether pondscapes are efficient NBS. This comparison is not only used to compare pondscapes among themselves, but also to compare them with other NBS.

To assess these points from a holistic perspective, Task 1.6 from WP1 explores the socio-economic perceptions of net benefits provided by pondscapes, understanding the priorities in ecosystem services and identifying best practices that can ensure economic feasibility and biodiversity conservation based on local stakeholder perspective. This task aims to answer the following questions:

1. How can the socio-economic benefits of ponds and pondscapes be quantified?
2. Pondscapes' effectiveness:
    a. How do stakeholders perceive the relative importance of environmental, social, and economic characteristics of ponds as NBS?
    b. Based on these perceptions, how can pondscapes be ranked?
3. Pondscapes' efficiency:
    a. How efficient can a pondscape be, not only in comparison with each other (b) but also with other NBS?

2. Method

2.1. Data

Indicators on pondscapes' benefit performances have been collected by WP2. However, these data were collected at the pond level. Therefore, we modified WP2 data to obtain a complete dataset of relevant indicators at the pondscape scale. We considered the sampled ponds as a representative subset of the pondscapes they belonged to, and compared these subsets as independent entities. From now on, with the term "pondscape", we refer to one of these subsets, which will be our observation unit. Table 1 shows the variables of our final dataset, which includes 40 pondscapes.

Table 1. Variables included in pondscape level dataset.

Variable	**Meaning**	**udm**	**Used for**
ID	ID	-	Reference
Pondscape	Name of the pondscape	-	Reference
Country	Country where the pondscape is located	-	Reference
NearRoads	% of ponds within 100m of paved or unpaved roads in the pondscape	%	Input – Sensitivity analysis
PA	% of protected pondscape area out of the total	%	Input – Sensitivity analysis
Agri100m	% of agricultural land area within 100m of ponds (arable + grassland)	%	Input – Sensitivity analysis
Wild100m	% of wild land area within 100m of ponds (woodland + marshland + rank land)	%	Input – Sensitivity analysis
Urban100m	% of urban land area within 100m of ponds	%	Input – Sensitivity analysis
Other100m	% of other land area within 100m of ponds	%	Input – Sensitivity analysis
NumPonds	Number of ponds assessed for the included variables	-	Input
AvgDist	Average distance between ponds assessed for the included variables	Km	Input
TotPondArea	Sum of ponds' median surface areas	m2	Input
MedianPondDepth	Median of ponds' median depths	m	Input
Managed	% of managed pondscape out of the total	%	Input
AvgPondGrazed	Average grazed ponds' area in the pondscape	%	Social output
AvgPondPerGrazed	Average grazed ponds' perimeters in the pondscape	%	Social output
AvgGrazing_int	Average grazing intensity in the pondscape	-	Social output
AvgFreq_ppVis	Average frequency of people visiting ponds in the pondscape	-	Social output
Business_op	% of ponds near business-related structures (campsites, water treatment plants, farms, industrial plants, golf courses) in the pondscape	%	Social output
UrbDist	Average distance between pondscape coordinates (see variables above) and nearest 3 settlements > 1000 ppl	Km	Social output
TotGHGbub	Sum of median ponds GHG emissions (CO2e, bubbling method)	CO2E (mg m^{-2} d^{-1})	Environmental output
TotGHGconc	Sum of median ponds GHG emissions (CO2e, diffusion method)	CO2E (µ g L^{-1})	Environmental output
Machropytes	Max number of machropyte species recorded in a pondscape's pond	-	Environmental output
Zooplankton	Max number of zooplankton species recorded in a pondscape's pond	-	Environmental output
InvComplete	Tot number of Machropyte and Zooplankton invasive species recorded in a pondscape's pond	-	Environmental output

In Annex A, we report figures from the exploratory analysis we conducted. It is visible that some indicators have more variability than others, and there are also a few outliers[1] among the pondscapes for certain indicators. We decided not to remove these outliers to avoid reducing the variability of our dataset further, because the assessment of pondscapes' heterogeneity is a fundamental focus of PONDERFUL, and because it represents a crucial characteristic of these complex systems. In the next steps, we adopted "robust" analytical methods, to control the bias that outliers can introduce in a sample.

We assessed the research questions in order, by organizing three sub-tasks that have been carried out in chronological harmony with other tasks of the project. The three sub-tasks are:

T 1.6.1 – *Multi-criteria Decision Analysis (MCDA) and Benefit-of-the-Doubt (BoD)* to rank pondscapes based on their effectiveness in delivering ES and NCP benefits.

T 1.6.2(a) – *Data Envelopment Analysis (DEA)* to compare pondscapes in their input-output performances, and thus their efficiency.

T 1.6.2(b) – a comparison of pondscapes and other NBS measures from the literature

Let's look at these sub-tasks more in detail.

2.2. Sub-task 1.6.1 – Multi-criteria Decision Analysis and Benefit-of-the-Doubt

In this sub-task, we explored how to quantify ES and NCP contributions, how stakeholders perceive them, and how pondscapes can be ranked accordingly. To do this, we followed the same methodological framework as in RPA (2004), which consists of four steps:

i. *Screening*: selection of primary and secondary criteria (indicators) for assessment

ii. *Scoring*: get the relative importance of indicators based on pairwise comparison, using a 1-to-9 scale

iii. *Weighting*: relative weights within the groups of primary and secondary criteria (indicators) for each stakeholder are derived

iv. *Ranking*: rank the ponds and pondscapes according to the stakeholders' perceptions identified previously (i.e. on their effectiveness)

A pondscape's effectiveness, in this study, is the capacity to deliver those ES and NCP that its stakeholders prioritize. This subtask covers research questions 1 and 2.

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[1] Defined as values below the 25th percentile and above the 75th percentile.

Step 1 – Screening: choice of criteria

The quantification of pondscapes' benefit delivery requires choosing relevant criteria to classify such benefits. To do so, we conducted a literature review on the most common frameworks used within the topic of NBS, as well as beyond such niche. Furthermore, the constant collaboration with our project partners allowed us to monitor which indicators were being collected in every WP. These two sources of information have been put together to select commonly accepted criteria that are contextual to the PONDERFUL project and relevant to its case studies.

The literature does not agree on a unique classification framework for the ES and NCP provided by NBS. The Millennium Ecosystem Assessment (MEA) classifies ES into four big groups: provisioning, regulating, cultural and supporting services. Meanwhile, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) provides a more human-oriented classification, consisting of 18 "Nature's Contributions to People" (NCP). To integrate these frameworks, Haines-Young & Potschin (2018) established CICES, a clearly defined 5-level classification of ES. Even though CICES is a good framework, it is quite unbalanced, with only 17 classes of cultural ES compared to 31 regulation and maintenance ES or 42 provisioning ES.

Since PONDERFUL wishes to comprehensively consider all kinds of benefits, given the available data from other WPs, we combined CICES classification, which has clear structures and definitions of provisioning and regulating services, with the classification provided by the handbook to evaluate NBS by the European Commission (2021), which elaborates the indicators and definitions in socio-economic aspects. The relationship between the MEA, the IPBES assessment framework, CICES and the EU Handbook is illustrated in Figure 1.

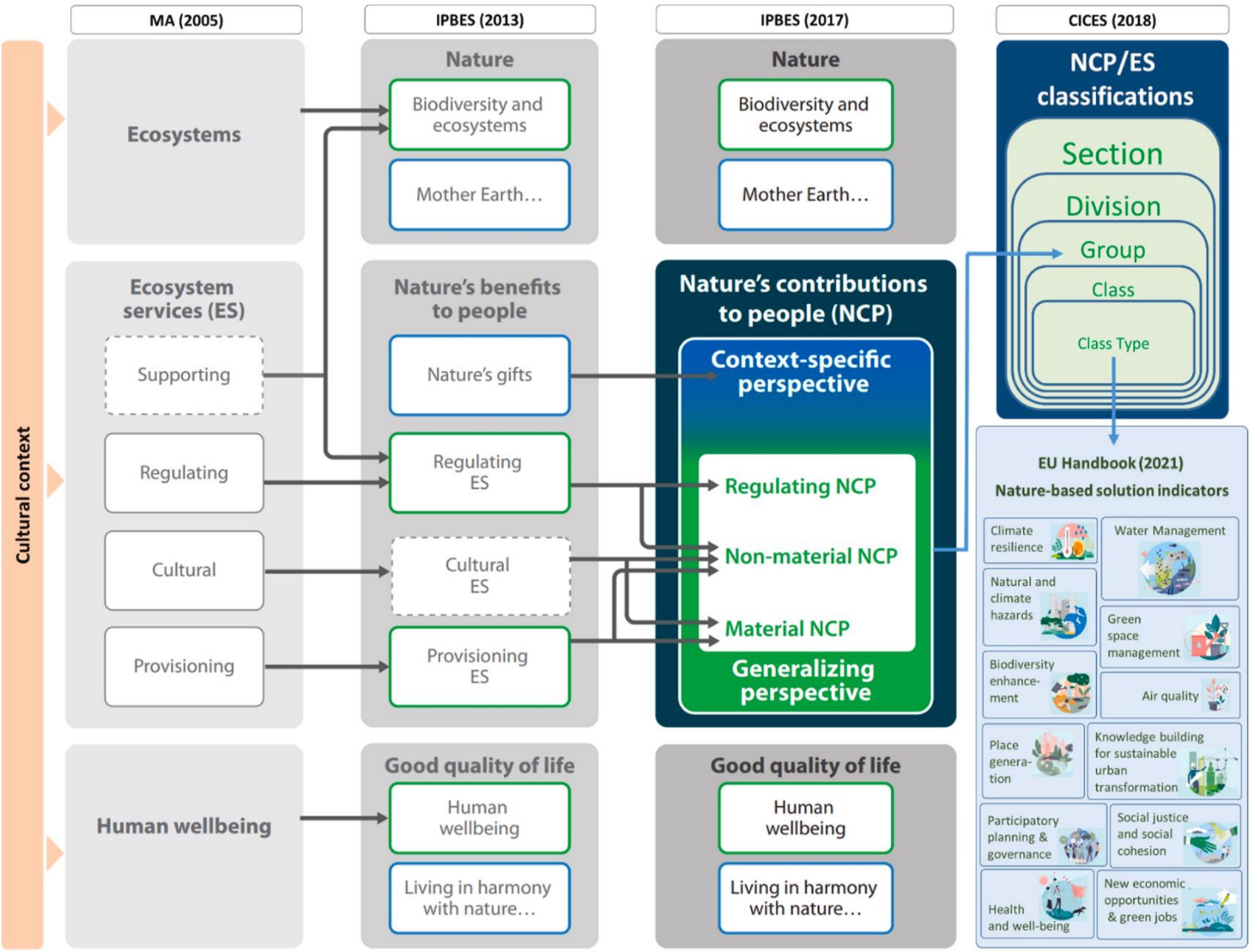


Figure 1. Relationship between MEA and IPBES assessment framework. MA (2005), IPBES (2013, 2017) adopted from Díaz et al. (2018). Photos of EU Handbook adopted from European Commission (2021). Source: Vo et al. (2023)

In our hierarchy, "socio-economic benefits" and "environmental/biodiversity benefits" criteria are further separated into six sub-criteria each. A third level of sub-criteria further specifies some of the second-level-sub-criteria, but it is not complete with respect to all of them. The hierarchy is presented in Figure 2.

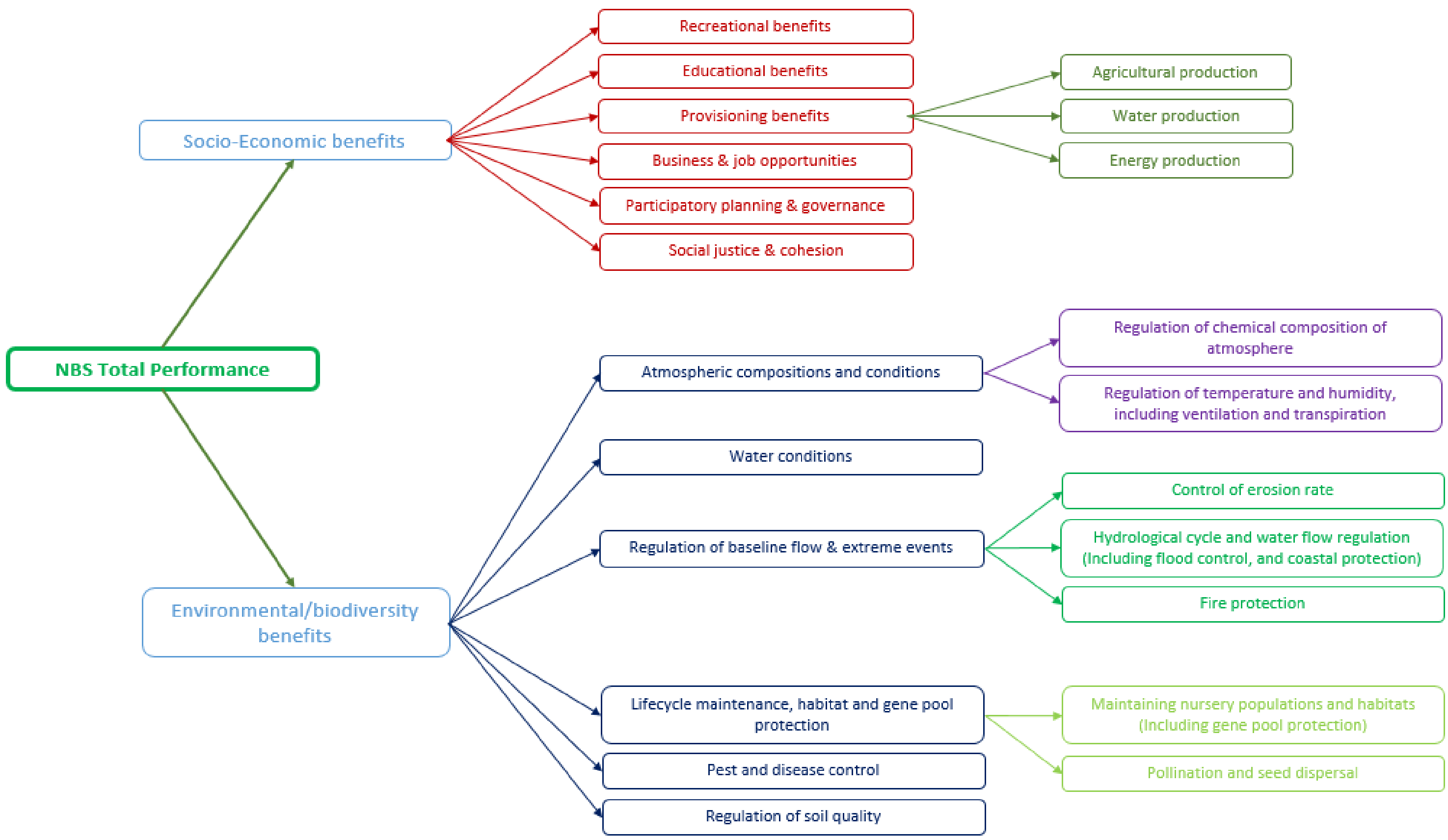


Figure 2. Classification model/hierarchy of this study. Source: Vo et al. (2023)

The chosen criteria were used to operationalise the generic concept of "benefits", and served as backbone to coherently structure all our further analyses.[2]

Step 2 – Scoring: stakeholder preferences

During the first workshops of the project, we administered a survey to several stakeholders in eight countries (Belgium, The Netherlands, The United Kingdom, Denmark, Spain, Germany, Turkey, and Uruguay) assessing their preferences for several benefit criteria. Overall, 242 stakeholders were identified in the PONDERFUL pondscapes and collaboration with 123 of them was established. The other 119 stakeholders were not contacted, due to their influence on decisions about the pondscapes. Among the 123 approached stakeholders, 101 stakeholders agreed to take part in the workshops.

To collect data, stakeholders' workshops were organized on-site from October 2021 to March 2022. The idea of the project is to cover ponds representing three bioclimatic regions, and the Uruguayan demo-site serves as a test of the PONDERFUL idea in the

[2] To simplify the next paragraphs, sub-criteria and criteria have been renamed as follows: "Recreational benefits" = Recreation, "Provisioning benefits" = Provision, "Business & Job opportunities" = Business, "Atmospheric composition and conditions" = Atmosphere, "Lifecycle maintenance, habitat..." = Lifecycle, "Pest and diseases" = Pest, "Socio-economic benefits" = SocioEconomic, "Environmental & Biodiversity benefits" = Environmental; and they will be referred with these names from now on.

contrast of southern hemisphere. Most of the workshop participants were stakeholders who were actively involved in the management decisions regarding the pondscapes, i.e., whether and, if yes, what type of ponds will be created, and how to manage the ponds. For example, the stakeholders might be, but not limited to, landowners of the ponds, authorities, scientists working with those ponds, or representatives of non-governmental organizations.

The workshops lasted approximately 4–6 hours each depending on the local conditions and COVID-restrictions of the organizers. The organizers first presented an introduction to the PONDERFUL project, the definition of NCPs, and interviewed the stakeholders regarding their opinions about the most important NCPs that the pondscapes provide, how they perceive the role of pondscapes, and how they want them to develop in the future. Then, the stakeholders took part in a mapping exercise, in which they received a map of the area and tried to plan the future of the pondscapes as they wish, with the support of visualized objects. Finally, when the participants already got the basic knowledge about NBS, NCPs, ES, and had their own vision toward what they wanted for the pondscapes, they filled in the Analytic Hierarchy Process (AHP – more on this in the next paragraph) questionnaire. By conducting the questionnaire at the end of the workshops, we ensured that the stakeholders had received the necessary information from the former sessions, so that a high load of information in the questionnaire would not overwhelm the participants.

The template of the questionnaire can be found in Annex B.

Step 3 – Weighting: turn preferences into weights

The AHP method was used to study stakeholder preferences. AHP is simple enough to reach stakeholders at all professional levels, but still capable of understanding stakeholders' preferences thoroughly. It consists of a pairwise comparison approach using a predefined scale, from 1 to 9, to derive the relative importance of one criterion (or sub-criterion) to another, when the decision weights or utility functions are not known in advance (Ishizaka and Nemery, 2013). AHP can serve as the main research method to derive weights for ES and to rank environmental alternatives. AHP's weights can subsequently be fed into further analyses or models (Bozali, 2020; Haile and Suryabhagavan, 2019; Bryan et al., 2011; Macedo et al., 2018).

After collecting the importance scores assigned to each criteria (and sub-criteria), these are transformed into an appropriate scale for comparison. In our investigation we explored several options for scale transformation, namely, normal, inverse linear, logarithmic, and asymptotic scales. Then, we checked the transformed data for consistency (e.g. if "option a" scores 9 relative to "option b", and "option b" scores 9 relative to "option c", then "option a" should score 18 relative to "option c', which could prove problematic depending on the scale transformation, since it exceeds the original 1-9 score), and we kept only those data observations that yielded an appropriate number of consistent observations. Harker's algorithm was then applied to transform inconsistent data instead of eliminating them. The preference of each stakeholder was derived by the geometric mean method to avoid the rank reversal problems, and then aggregated across scales by the arithmetic mean.

Although the weights calculated with the AHP method are specific to the pondscapes that have been surveyed during the first workshops, we lacked specific data on stakeholder preferences for all other pondscapes in our sample. Therefore, we decided to generalise these preferences, and assume them consistent at the national level. These national stakeholder preferences enter the ranking step as multipliers for pondscapes' benefit performance data, in a weighted-sum MCDA.

Step 4 – Ranking: compare pondscapes

Next, we had to aggregate indicators at the criteria or sub-criteria level, for which we had AHP weights. Table 2 shows which indicators pertained to which sub-criteria. It is possible to see that only some sub-criteria were represented in our data. Criteria and sub-criteria for which we did not have relevant indicators have been excluded from our analysis. Therefore, the AHP results have also been updated after this step.

Table 2. Hierarchy of criteria, sub-criteria, and indicators available in our data.

Criteria	Sub-criteria	Indicators
Socio-economic benefits	Recreational benefits	AvgFreq_ppVis
		UrbDist
	Educational benefits	-
	Provisioning benefits	AvgPondGrazed
		AvgPondPerGrazed
		AvgGrazing_int
	Business & job opportunities	Business_op
	Participatory planning & governance	-
	Social justice & cohesion	-
Environmental & Biodiversity benefits	Atmospheric compositions and conditions	TotGHGbub
		TotGHGconc
	Water conditions	-
	Regulation of baseline flow & extreme events	-
	Lifecycle maintenance, habitat and gene pool protection	Machropytes
		FishAmph
		Macroinv
		Zooplankton
	Pest and disease control	InvComplete

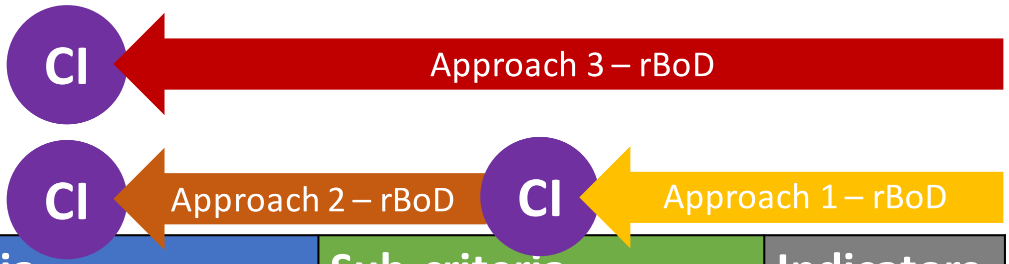
For a couple of sub-criteria only one indicator was selected, thus the transformation consisted of an equivalence. However, some sub-criteria were described by multiple indicators and we could not make informed assumptions on the relative relevance (i.e., compositional weight) that each indicator should have relatively to its specific sub-criteria. We adopted the Benefit of the Doubt (BoD) aggregation method to combine these indicators. This approach consists in an output-oriented Data Envelopment Analysis (DEA) method to combine multidimensional indicators into an aggregated indicator (or Composite Indicator (CI)), when no prior knowledge on the contributing weights is available. The fundamental assumption is that different units prioritize different aspects (indicators) of the overall performance. Since a unique set of weights could be biased towards the characteristics of a specific unit, BoD endogenously estimates the indicators' weights for each observation unit. This is the set of multipliers that maximises the overall performance of such unit with respect to all others in such criteria. Consequently, for each unit, higher weights are coupled with their best performing indicators, and lower ones with the least performing indicators.

The presence of outliers in our data could influence the indicator weights endogenously determined for other units, and thus their CI scores. In our analysis, we adopted a "robust" BoD method to minimize the impact of such outliers. The method bootstraps the basic BoD algorithm across b (b = 500 in our analysis) randomly generated sub-samples of size m (m = 20 in our analysis). Doing so, multiple intermediate criteria and sub-criteria CIs are calculated for every pondscape, based on different sub-samples, limiting the bias caused by single outliers. The final criteria and sub-criteria CIs are the average of these intermediate CI for a same pondscape.

We applied this method with three alternative approaches:

- *Approach 1* - We aggregated indicators at the sub-criteria level, obtaining 6 Composite Indicators ("Business", "Recreation", "Provisional", "Atmosphere", "Pest", "Lifecycle");
- *Approach 2* - We aggregated the previously obtained sub-criteria (from Approach 1) at the criteria level, obtaining 2 composite indicators ("SocioEconomic", "Environmental");
- *Approach 3* - Finally, we aggregated indicators at the criteria level directly, obtaining 2 composite indicators ("SocioEconomic", "Environmental").

These three aggregation approaches are graphically represented in Figure 3 below, and have been compared in the steps that followed.



Criteria	Sub-criteria	Indicators
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		AvgGrazing_int
	Business & job opportunities	Business_op
	Participatory planning & governance	-
	Social justice & cohesion	-
Environmental & Biodiversity benefits	Atmospheric compositions and conditions	TotGHGbub
		TotGHGconc
	Water conditions	-
	Regulation of baseline flow & extreme events	-
	Lifecycle maintenance, habitat and gene pool protection	Machropytes
		FishAmph
		Macroinv
		Zooplankton
	Pest and disease control	InvComplete

Figure 3. Representation of the three aggregation approaches at different levels.

At this stage, we had CI for pondscapes' benefit delivery performances at sub-criteria and criteria levels (depending on the approach considered), as well as stakeholder preferences for such benefit criteria and sub-criteria. Next, such preferences became weights of our Multi-criteria Decision Analysis (MCDA), and have been multiplied by the CI vlaues to provide overall effectiveness scores for each pondscape. Finally, we compared the pondscapes and ranked them based on these scores.

2.3. Sub-task 1.6.2(a) - Data Envelopment Analysis

Efficiency is the ability to accomplish something with the least amount of resources. In the case of pondscapes, the inputs that go into their creation, restoration, and management are the resources to optimize. The evaluation of pondscapes' efficiency is carried out with Data Envelopment Analysis (DEA). This is a non-parametric method to compare input-output production efficiency, even without prior knowledge on the transformation processes involved. As such, DEA offers the opportunity for an objective evaluation of pondscapes' benefit delivery efficiency. In our case, the Decision Making Units (DMU) under assessment are the social planners that coordinate the pondscapes' implementation and management. Specifically, given the fact that decision makers can only control the inputs to a pondscape project (they cannot directly decide on the outputs delivered), input-oriented DEA is applied. For the basic DEA model in our investigation, we considered "variable returns to scale", as this is the most general assumption we can make on the relationships that link input usage and output delivery for the case of pondscapes.

Inputs & Outputs

From the work of WP4 we realized that a monetary evaluation of pondscapes' inputs and outputs would have been very difficult, due to their heterogeneity, among other issues[3]. Therefore, we selected a set of variables collected in WP2 that could be considered as proxies of fixed and ongoing costs of realising, restoring, and managing pondscape NBS. These became our inputs and can be seen in Table 1.

Outputs on the other hand are the benefits delivered by pondscapes, aggregated either at the criteria or sub-criteria level, to avoid the burden of dimensionality. In Cooper et al. (2007), the rule of thumb for setting the number of DMUs is given as $\#\mathrm{DMU} = \max(\mathrm{m} * \mathrm{s};\ (\mathrm{m} + \mathrm{s}) * 3)$, where m and s are respectively the number of inputs and outputs considered. In our study, we are constrained by the number of available pondscapes for which we have input and output data (40). Consequently, when assessing pondscapes at the sub-criteria level (6 outputs), we can consider a maximum of 6 inputs, while there can be as much as 11 inputs when outputs are at the criteria level (2).

Model Specification

Following Charnes et al. (1978) definition of efficiency, Johnes (2004) formulates it as:

$$TE_K = \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \qquad (1)$$

Where:

TE_k : technical efficiency of firm *k* using *m* inputs to produce *s* outputs;

y_{rk} : quantity of output *r* produced by firm *k*;

x_{ik} : quantity of input *i* consumed by firm *k*;

u_r : weight of output *r*;

v_i : weight of input *i*.

n : number of firms to be evaluated

s : number of outputs

m : number of inputs

[3] E.g. confidentiality of some costs in the case of private pondscapes

In our model, such technical efficiency is maximized by minimizing the weighted sum of inputs, while outputs are held constant (input-oriented DEA). Below, we provide the dual linear programming equations of such input-oriented DEA, with variable r.t.s.

$$Minimize\ \theta_k \tag{2}$$

Subject to

$$y_{rk} - \sum_{j=1}^{n} \lambda_j y_{rj} \leq 0 \qquad r = 1, \dots, s \tag{3}$$

$$\theta_k x_{ik} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0 \qquad i = 1, \dots, m \tag{4}$$

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{5}$$

$$\lambda_j \geq 0 \qquad \forall j = 1, \dots, n \tag{6}$$

Were θ_k represents the technical efficiency of firm *k*, and λ_j is the associated weighting of outputs and inputs for firm *j.*

After performing the DEA on the three alternative aggregative approaches, we compared results, and ran a sensitivity analysis on them. This sub-task allowed us to answer research question 3.a.

2.4. Sub-task 1.6.2(b) - Comparing pondscapes and other NBS

This final sub-task was introduced to cover research question 3.b, since the heterogeneity of data available for other NBS did not allow us to directly compare them in a normal DEA. Given this issue, we searched the literature on the most common evaluation criteria used for NBS. After collecting data on these, we compared this knowledge with the insights on pondscapes performances provided by the literature as well as the PONDERFUL project in a discussion.

3. Results

3.1. Sub-task 1.6.1: Multi-criteria Decision Analysis

Analytic Hierarchy Process

Initially, the AHP analysis was run on all 12 hypothesized sub-criteria. However, after selecting only those for which we had representative indicators, we re-ran the analysis to adapt the results. Since the outcomes from the first version of the analysis are mostly still valid with the reduced set of sub-criteria, we report them here first and then adjust where necessary.

The AHP results provide a clear description of stakeholders' preferences. Particularly, we can see that environmental benefits are ranked higher by stakeholders in all assessed pondscapes (Figure 4 and Table 3). The only exceptions are Uruguayan pondscapes, where provisioning benefits are favoured instead (Figure 4 and Table 3). These preferences closely reflect the purpose and characteristics of the pondscapes and the occupation of stakeholders involved. In Uruguay, all the assessed ponds are used for agricultural purposes (e.g., watering cattle) and are located entirely on private properties. Therefore, stakeholders of these ponds include farmers who own the land, and technical public servants or policy makers, thus provisioning benefits are not surprisingly favoured, as highlighted in Figure 4. This happened even if some other benefits (such as habitat creation and biodiversity) could also occur under certain local management practices of the studied ponds.

These results indicate that other potential benefits are currently not sought nor promoted, under the prevailing paradigm of these pondscapes (Uruguayan) being solely useful to boost agricultural production. On the contrary, these results suggest that different management paradigms should actively be established, and different management practices should actively be promoted by the relevant public institutions to increase the conservation and climate mitigation value of these and other similar pondscapes in Uruguay. In contrast, the European and Turkish pondscapes have been dedicated for conservation purposes or connected to various environmental programs, so the environmental services play a more important role in the perception of stakeholders.

The 1-sample Wilcoxon test of the isometric log-ratio gives significantly different results for all pondscapes. As depicted in Figure 4, the red lines are the border between economic (lower) and environmental (upper) benefits. A large difference between economic and environmental benefits in the German assessed pondscape is only significant at the 10% level, due to the low number of stakeholders. Only Uruguayan stakeholders significantly prefer economic benefits to environmental benefits. All other participants in the European and Turkish assessed pondscapes significantly emphasise environmental benefits more than economic ones.

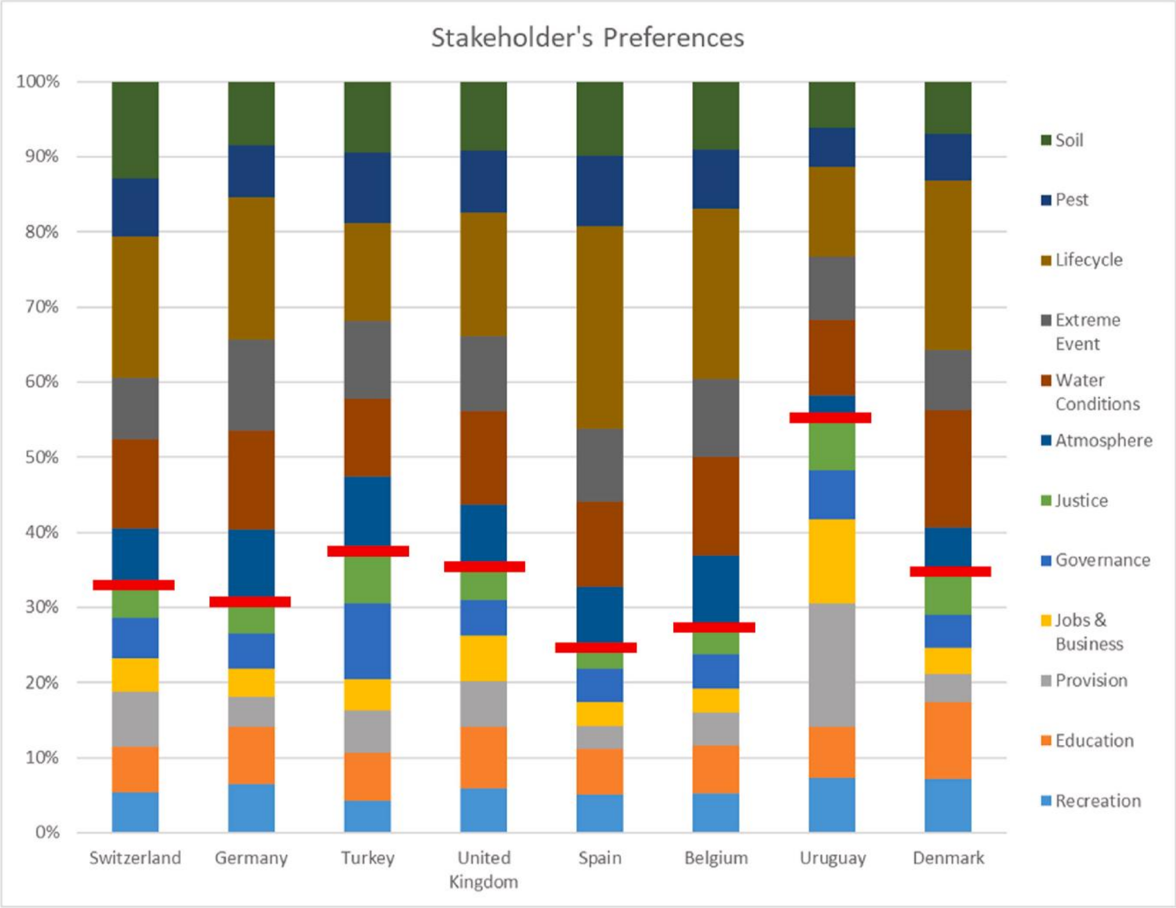

Figure 4. Stakeholder group aggregation by assessed pondscape. Source: Vo et al. (2023).

Male and female stakeholders' opinions mostly do not differ significantly at the 5% level (Figure 5). Both male and female stakeholders emphasise the environmental benefits significantly more than economic benefits, and so do non-doctorate stakeholders. However, there are many statistically significant differences between stakeholders with doctorate degree and those without. For stakeholders with a doctorate degree, no significant result is observed, but the p-value is close to the threshold of 10% of preferring environmental benefits to economic benefits (Figure 6).

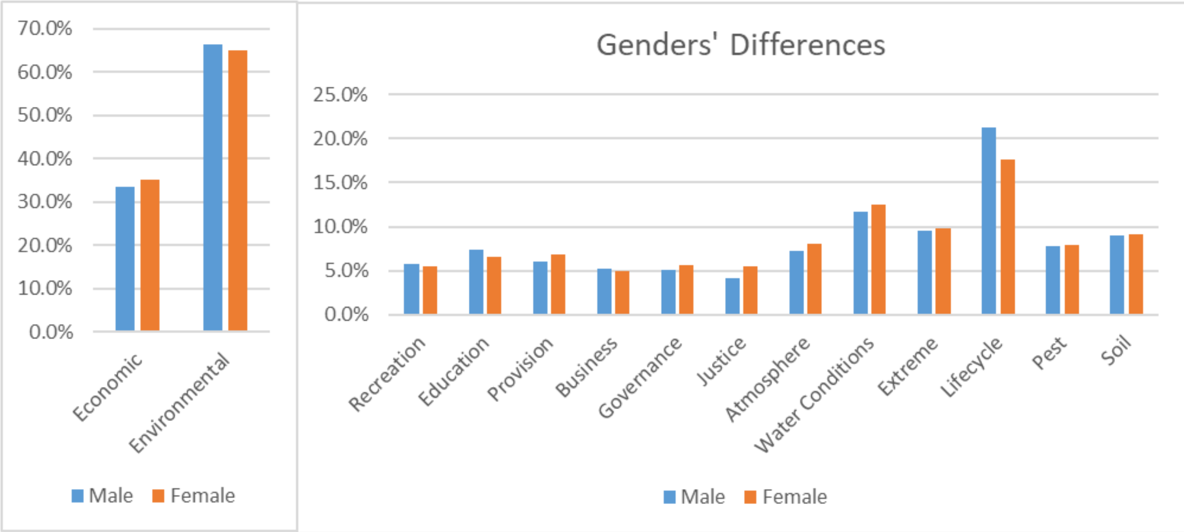

Figure 5. Differences from gender's perspective. Source: Vo et al. (2023).

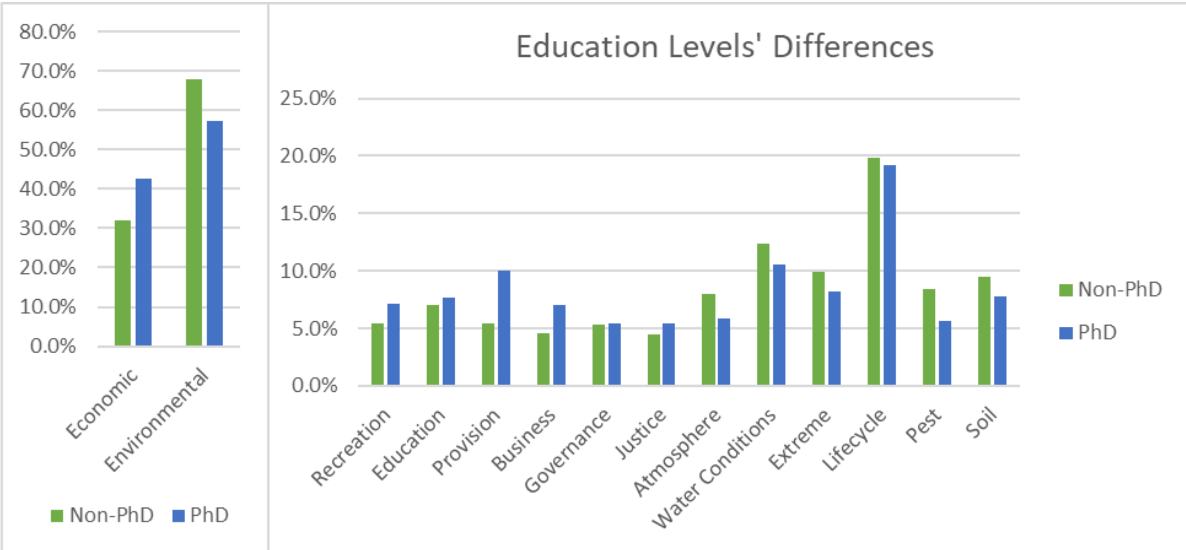

Figure 6. Differences from education's perspective. Source: Vo et al. (2023).

Table 3. AHP weights for full set of sub-criteria.

	Recreation	Education	Provision				Jobs & Business	Governance	Justice	Atmosphere			Water Condition	Extreme Event				Lifecycle			Pest	Soil
				Agriculture	Water	Energy					Chemical	Physical			Erosion	Flood	Fire		Nursery	Pollination		
CH	5.4%	6.1%	7.4%	2.2%	3.4%	1.8%	4.3%	5.5%	4.2%	7.6%	3.7%	3.9%	12.0%	8.1%	2.8%	3.0%	2.3%	18.8%	13.5%	5.3%	7.8%	12.9%
DE	6.5%	7.6%	4.0%	1.3%	1.9%	0.8%	3.7%	4.7%	4.5%	9.3%	3.0%	6.3%	13.2%	12.1%	2.7%	5.6%	3.8%	19.0%	12.5%	6.5%	6.9%	8.5%
TU	4.3%	6.3%	5.8%	2.0%	2.1%	1.6%	4.1%	10.2%	7.2%	9.5%	4.7%	4.8%	10.4%	10.4%	3.3%	4.7%	2.4%	13.0%	7.0%	5.9%	9.3%	9.5%
UK	5.9%	8.2%	6.1%	2.2%	2.4%	1.5%	6.1%	4.6%	4.4%	8.3%	4.1%	4.2%	12.4%	10.0%	2.9%	5.0%	2.2%	16.5%	10.4%	6.1%	8.2%	9.2%
ES	5.1%	6.0%	3.1%	1.1%	1.3%	0.6%	3.2%	4.5%	3.1%	7.8%	3.3%	4.5%	11.2%	9.8%	2.6%	4.2%	3.0%	27.0%	18.8%	8.2%	9.3%	9.9%
BE	5.2%	6.5%	4.4%	1.4%	1.9%	1.1%	3.1%	4.5%	3.7%	9.4%	3.9%	5.5%	13.1%	10.4%	3.0%	5.2%	2.3%	22.6%	16.5%	6.1%	8.0%	9.0%
UY	7.3%	6.9%	16.4%	8.1%	5.8%	2.5%	11.2%	6.4%	6.7%	3.3%	1.2%	2.1%	10.1%	8.3%	1.9%	4.1%	2.3%	11.9%	7.4%	4.5%	5.3%	6.2%
DK	7.2%	10.1%	3.7%	1.0%	1.7%	1.0%	3.5%	4.4%	5.5%	6.1%	2.6%	3.5%	15.7%	8.0%	2.4%	3.6%	1.9%	22.4%	15.7%	6.7%	6.2%	7.0%

Note: Stakeholders' group of assessed pondscape in CH: Switzerland, DE: Germany, TU: Turkey, UK: United Kingdom, ES: Spain, BE: Belgium, UY: Uruguay, DK: Denmark.

We ran sensitivity analyses of our results by changing the aggregation rule of survey data from arithmetic average to centering, as well as testing the potential rank-reversal in the case of both AHP scoring and normalised-scoring (run by simulations). Overall, rankings of the preferred ES are consistent among the two aggregating rules. Only in the Turkish assessed pondscape, ecosystem services change two ranks at high ranked (2nd to 7th ranked) services. Furthermore, the results of the simulation show that there are no more than 1.6% cases of rank reversal for both AHP scoring and normalised-scoring. Hence, the simulation proved that the results are quite robust under the change of aggregation rules.

Since the AHP methods ranks alternatives based on pairwise comparisons, when some of these options are eliminated the relative preferences for the remaining ones change as well. Once the data on ES and NCP delivery performances became available, we realised that we could not count on indicators for each of the 12 sub-criteria previously hypothesized. Consequently, we re-run the AHP analysis with the reduced set of 6 assessable sub-criteria. After updating the AHP results, the stakeholders' preferences at sub-criteria and criteria levels changed as shown in Table 4 and Table 5, respectively.

Table 4. Updated criteria AHP weights.

Countries	SocioEconomic	Environmental
CH	32.86%	67.14%
DE	31.04%	68.96%
TU	37.84%	62.16%
UK	35.34%	64.66%
ESP	24.98%	75.02%
BE	27.45%	72.55%
UY	54.94%	45.06%
DK	34.55%	65.45%

Table 5. Updated sub-criteria AHP weights.

Countries	Recreation	Provision	Business	Atmosphere	Lifecycle	Pest
CH	10.31%	14.06%	8.48%	13.65%	38.81%	14.68%
DE	15.87%	7.46%	7.71%	18.09%	36.44%	14.43%
TU	11.88%	15.54%	10.43%	17.26%	25.49%	19.41%
UK	11.39%	11.52%	12.43%	16.47%	31.25%	16.93%
ESP	11.40%	6.73%	6.86%	12.99%	44.59%	17.43%
BE	10.67%	9.74%	7.03%	17.13%	39.42%	16.00%
UY	10.12%	27.32%	17.50%	7.14%	24.95%	12.96%
DK	16.09%	8.69%	9.77%	11.64%	40.86%	12.94%

Benefit of the Doubt

The BoD aggregation method provided CI at the sub-criteria and criteria levels. A higher value in a specific CI is indicative of an overall stronger performance across indicators under such benefit sub-criteria, or criteria, even when favourable BoD-weighting is applied. We recall that with the BoD method, compositional weights are determined endogenously for each pondscape, as those that maximise its performance with respect to all other observations. With Approach 1, we combined the available indicators across Pest, Lifecycle, Atmosphere, Recreation, Provision, and Business sub-criteria. These describe the multidimensional benefits that pondscapes can provide as detailed in Table 2. An example for German pondscapes is reported in Figure 7. In Annex C, the reader can see the plots of how individual pondscapes scored in each sub-criterion after the BoD aggregation.

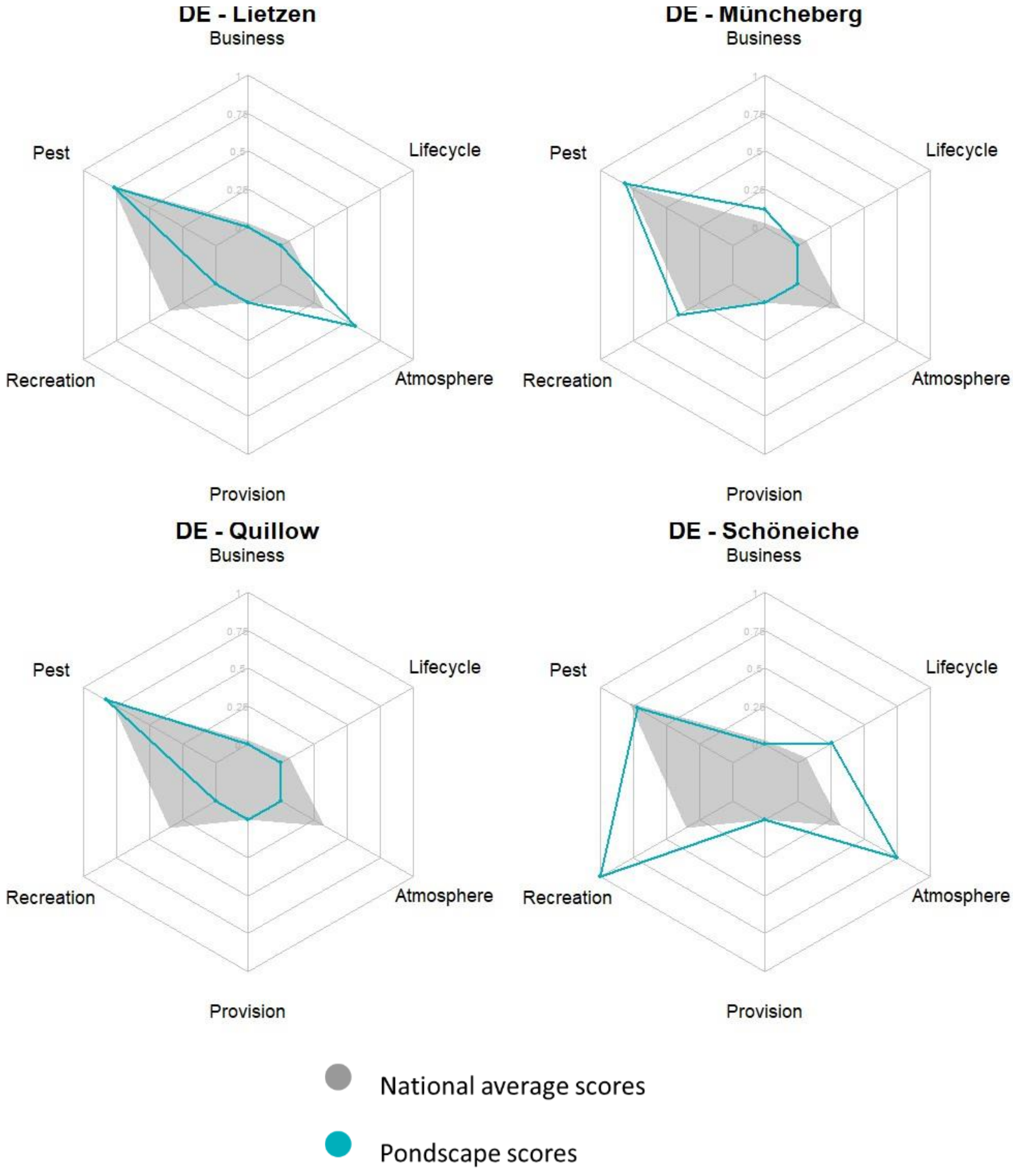

Figure 7. Pondscapes CI for all six sub-criteria (Approach 1), in Germany (normalised).

In general, most pondscapes scored well in the Pest subcriteria, which relate to the absence of invasive species (limited to Machropytes and Zooplankton due to the available data) in the pondscape. Only a few observations did not obtain a high CI for such sub-criteria, such as the "Albera" pondscape in Spain. Belgian pondscapes provide a good amount of recreational benefits, while score the lowest for almost all other sub-criteria. The Swiss pondscapes mostly focus on Pest and Recreation benefits, as well as on Atmosphere contributions. Additionally, some individual Swiss pondscapes provide Lifecycle, Provision, and Business benefits. In Germany, on top of Pest benefits, the Lietzen and Schöneiche pondscapes provide Atmosphere ES. The latter also scores well in the Recreation sub-criteria, and moderately well for Lifecycle benefits. In Müncheberg, Recreation is slightly relevant aspect too. In Denmark, benefits provided by pondscapes usually cover at least one more sub-criteria, on top of Pest and Atmosphere. The pondscape in Avernako performs well across all sub-criteria. Except for Garrotxa, all Spanish pondscapes provide Recreation benefits together with Lifecycle benefits, while Business contributions are the least present overall. Turkish pondscapes are particularly heterogeneous. They all provide Pest benefits, on top of which each individual pondscape provides additional ES and NCP. Ayas Yolu has a maximum CI value for Pest, Atmosphere, and Provision benefits. In the UK, most ponds provide Pest and Recreation benefits, except for Norfolk Horningtoft-Brisley, which lacks the latter. The other three pondscapes individually provide also variable Lifecycle and Atmosphere ES and NCP. Finally, Uruguayan pondscapes are the most skewed towards Provision benefits (except for Altos del Chorro), and generally also contribute with Atmosphere and Pest benefits.

The complete datasets of CI obtained at the sub-criteria and criteria levels with our three approaches can be found in Annex D. At the end of Annex D, the reader can also find a correlation table of such CIs. From such table, we see that at the sub-criteria level Recreation and Provision scores are negatively correlated, as pondscapes that provide the most Provision benefits are private and not accessible to the public, and vice-versa. In addition, Pest and Lifecycle are negatively correlated, and this could be because the former CI has been inverted in polarity to better represent the non-desirability of an increase in invasive species recorded. This adjustment inverted the existing positive correlation between the total amount of recorded species and the number of invasive ones among them. Additionally, at the criteria level, the corresponding CI calculated with approaches 2 and 3 have a positive correlation > 0.8. Finally, CIs calculated with both approaches 2 and 3 have some correlations with sub-criteria level CIs. Particularly, both Atmosphere and Lifecycle CIs are positively correlated with their corresponding criteria-level CIs. Instead, Pest CI is not significantly correlated to them in neither approach 2 or 3. Environmental CI from approach 2 is also significantly correlated with Provision CI from approach 1, which is strange since this sub-criteria was combined into the SocioEconomic criteria instead. Regarding SocioEconomic CIs from approaches 2 and 3, these are positively correlated only with Recreation CI from approach 1. In general, approach 3 generated CIs that are more strongly correlated with sub-criteria-level CIs from approach 1, compared to approach 2’s CIs.

Multi-criteria Decision Analysis

Our analysis allowed us to identify which pondscapes are more effective in delivering the benefits that their stakeholders prefer. In such sense, highly effective pondscapes are those that provide the most ES and NCP and they are relevant for their social context. Since the CI has been generated with three separate approaches, the MCDA results varied depending on which set of CI has been considered. The analysis on sub-criteria level CI produced scores without ex aequo ranking, while both the other methods produced rankings with at least two pondscapes in the same position.

In Annex Table E.2 the reader can see that Belgian pondscapes consistently scored (and ranked) among the worse 75% of pondscapes, as did the German ones, with the exception of Schöneiche, which consistently ranked among the best 11 pondscapes. Also Osona (ESP), Ayas Yolu (TU), Imrendi (TU), Avernako (DK), Altos del Chorro (UY), Albera (ESP), and Sorgun (TU) consistently ranked among the best 11 pondscapes, independently of the approach used to generate CI. All other pondscapes were ranked less homogeneously - between the 10th and 30th position - by the three approaches. Those pondscapes consistently ranking at the top of the list have the highest CI in those criteria and sub-criteria most relevant to local stakeholders. For example, the three Turkish pondscapes mentioned above provide relevant benefits for Provision, Atmosphere, and Pest sub-criteria, which together account for > 52% of stakeholders' preferences. Albera and Osona instead excel respectively in Lifecycle and Recreation the first, and in all but Business the second, significantly contributing to benefits that are heavily prioritized in Spain (recreation and Lifecycle alone account for > 55% of cumulative preference). On the other hand, the pondscapes performing worse in term of effectiveness either provide only moderate contributions for ES and NCPs that are not priorities to local stakeholders, they score low in those benefits that are necessary to them, or a combination of both. For example, Belgian and German pondscapes provide ES and NCP pertaining to categories that are not prioritised by their stakeholders, Pest and Recreation the firsts, mostly Pest the second.

The result of the MCDA for the three approaches can be found in Annex E.

3.2. Sub-task 1.6.2(a): Data Envelopment Analysis

Data Envelopment Analysis

The Data Envelopment Analysis was our method of choice to compare pondscapes in terms of efficiency. Under the three CI approaches used, some efficiency scores are very close to 1 – which translates to fully efficient - even when the pondscape is not exactly on the efficiency frontier. Therefore, once the efficiencies have been rounded and normalised as ranks, many DMUs end up in the first positions ex-aequo. The plots of reference sets are in this case more informative than the actual lists of rankings based on efficiency scores. These plots represent a pondscape's relative efficiency, as the frequency with which it appears in the reference sets of the other pondscapes. A reference set in DEA is the group of closest efficient observations to which an inefficient DMU should look at for optimal improvement.

The DEAs at both criteria-level CI (approaches 2 and 3) consider the same five pondscapes as efficient, in comparison to the remaining 35. These are: Ayas Yolu (TU), Alpagut (TU), Sorgun (TU), Avernako (DK), and Lietzen (DE). Of these, Ayas Yolu is the pondscape that is most often the target reference to other pondscapes in the analysis (Figure 8 and Figure 9). Or in other words, it is most often present in the reference sets of inefficient pondscapes.

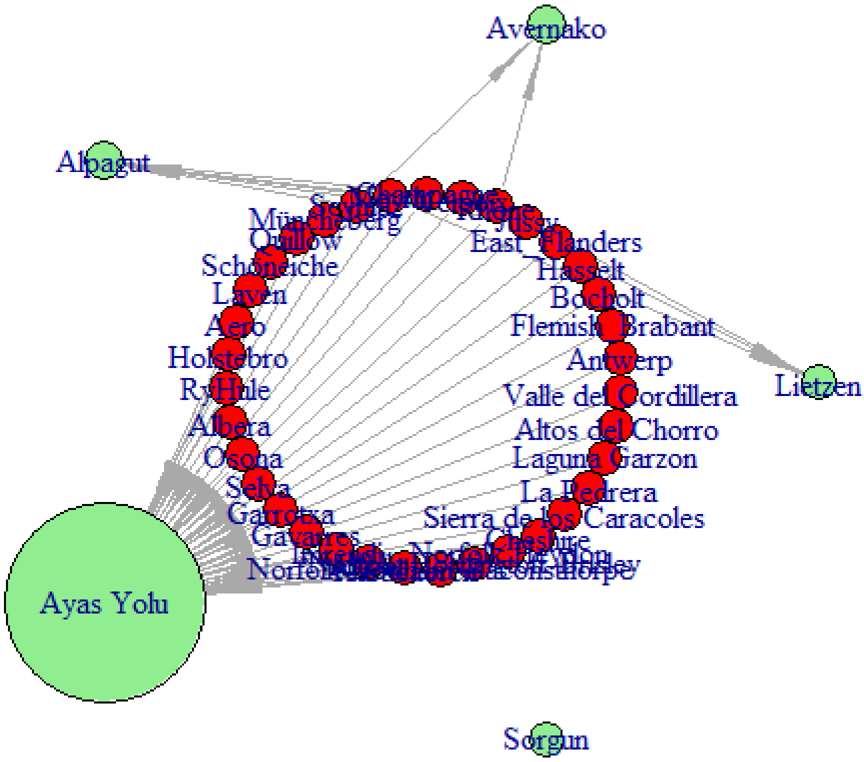

Figure 8. DEA result for Approach 3 CI.

Note: green pondscapes are considered efficient, red ones are not. Size of the dot represents pondscape relevance within other pondscapes' reference sets; each arrow is a reference link.

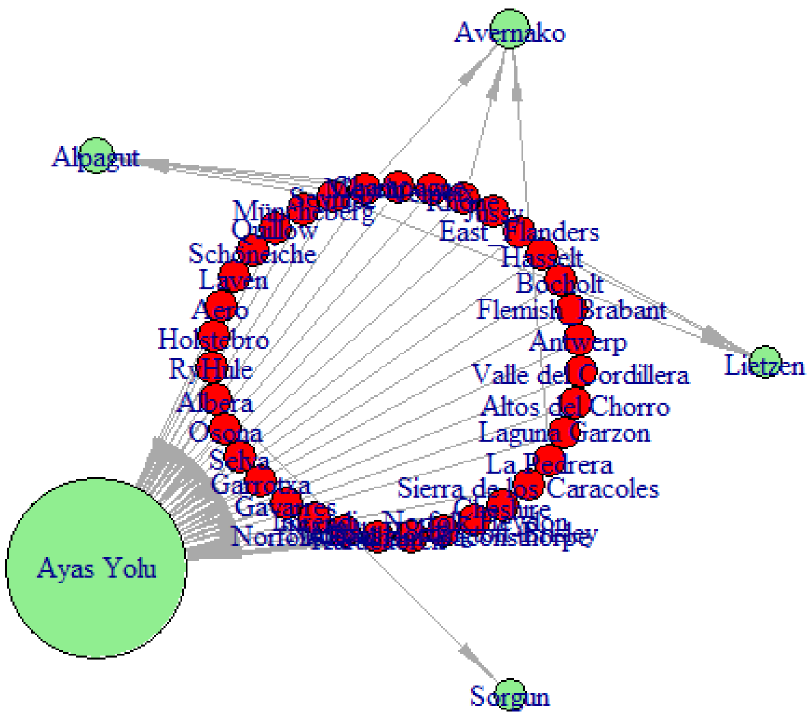

Figure 9. DEA result for Approach 2 CI.

Note: green pondscapes are considered efficient, red ones are not. Size of the dot represents pondscape relevance within other pondscapes' reference sets; each arrow is a reference link.

The sub-criteria approach instead was less able to discriminate between efficient and inefficient units (Figure 10). The reason could be that the increased number of inputs flaws the analysis through the burden of dimensionality, introducing an inadequate number of degrees of freedom (Cooper et al., 2007). With every input or output added to the analysis, the number of observations regarded as efficient increases due to the computational setup of DEA. As it can be seen below, this approach yields only 16 non-efficient pondscapes. Also in this case, Ayas Yolu (TU) seems to be the most efficient one, as it is present in most reference sets.

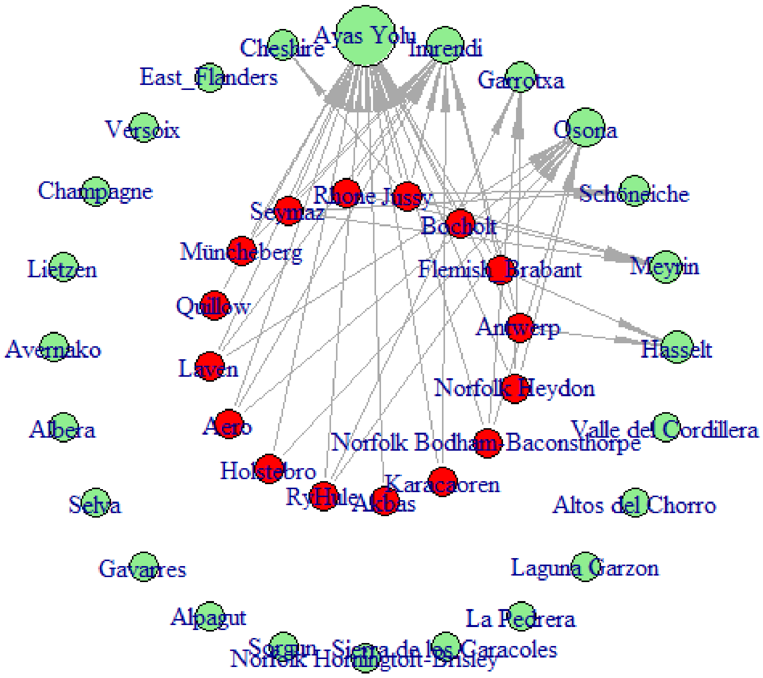

Figure 10. DEA result of sub-criteria level CI.

Note: green pondscapes are considered efficient, red ones are not. Size of the dot represents pondscape relevance within other pondscapes' reference sets, each arrow is a reference link.

Sensitivity analysis

In the literature, sensitivity analysis for DEA is usually conducted by testing how efficiently DMUs react when input and output indicators are modified, added, or subtracted (Cooper et al., 2007). In our study, we already saw that from the three approaches investigated for the generation of CI at sub-criteria and criteria levels. Both approaches 2 and 3 result in the same 5 pondscapes being considered efficient, even when their CI output values differ. Therefore, we consider these results to be robust. While the third approach also consider the same 5 pondscapes efficient (Figure 10), the cumulative amount of input and output variables (5 + 6 = 11 variables) is close to the limit of 12 calculated with Cooper's formula (Cooper et al., 2007), given the available DMUs. This limits the DEA capacity to distinguish between efficient and inefficient observations, resulting in a higher number of efficient pondscapes and a less indicative analysis. As an additional check, we also tried adding input variables that we initially left out of our basic DEA model (see Table 1), but as with Approach 1, the increased number of variables flawed the analyses and most DMUs were considered efficient.

In an additional step, we tried performing our basic DEA with a “constant return to scale” assumption, in order to compare DMUs under technical efficiency and scale efficiency. This resulted in a reduced set of pondscapes being considered efficient overall, since the new assumptions is more restrictive. For approach 1, efficient DMUs become 21 instead of 26, but the analysis is still not capable of effectively discriminate efficient and inefficient units. Instead, for approaches 2 and 3, only 3 DMUs are efficient, these are Ayas Yolu (TU), still the most present in all reference sets, Avernako (DK), and Sorgun (TU). These three pondscapes are both technically and scale efficient, since they lie on the efficiency frontier of both variable r.t.s. (return to scale) and constant r.t.s. DEAs. Instead, Alpagut (TU) and Lietzen (DE) pondscapes should increase their scale to reach the efficiency frontier under the constant r.t.s. assumption.

3.3. Sub-task 1.6.2(b): comparing pondscapes and other NBS

Even if the potential of pond as NBS has already been studied, the PONDERFUL project is the first to look at the concept of “pondsape”. Therefore, the literature currently lacks detailed information and data on the ES and NCP provided by this measure. The few data that are present at the pond level are often qualitative, or the result of experts’ consultations, and very heterogeneous in the indicators they cover. These aspects made it impossible to find reliable information that could be statistically analysed and compared to PONDERFUL data. Since the goal of this sub-task was to develop a first benchmark for future discussions on pondscapes as NBS, we carried it out as a discussion comparing the available data on ponds as NBS retrieved from the literature, those on other NBS, and PONDERFUL data.

After our review, we found one main source of coherent data on NBS benefits, which also included ponds. These are the Natural Water Retention Measures (NWRM) website[4]. The platform collects evidences in support of NWRM at the EU level. Here, we were able to find information that was comparable with the indicators from the PONDERFUL project. We will discuss these in the following paragraphs.

Ecosystem services

The NWRM project evaluated three kinds of pond-related measures: Retention ponds, Basins and ponds, and Sediment capture ponds. All these measures scored among the top 18 out of 53 considered measures in terms of the ES provided. Specifically, retention ponds place 11th, being particularly effective in providing Biodiversity Preservation, Recreational Opportunities, and Aesthetic/Cultural Value contributions. The other two kinds of ponds instead are effective in delivering Water Storage, Fish Stocks and Recruiting, Flood Risk Reduction, Erosion/Sediment Control, and Filtration of Pollutants

[4] http://nwrm.eu/

services. Annex G presents the original dataset from the NWRM website ranked by each ES contribution.

Costs

On top of being effective measures for delivering ES, ponds are also cost-efficient, as can be seen in the measure-specific data collected by the NWRM project[5]. Indeed, if we exclude land acquisition costs (which are high for every measure, depending on its scale and context of implementation), the fixed and ongoing managing costs of ponds are relatively lower than other measures that outperform them in benefit delivery, such as “Floodplain restoration and management” or “Re-meandering”. Additionally, the fact that costs for pond implementation have been clearly identified, while those for certain measures (e.g. in the case of “Land use conversion” and “Afforestation of reservoir catchments”) cannot be reliably estimated before a specific assessment, is indicative of higher ease of implementation. This is a fundamental aspect to inform the preferences of those having to decide which measure to implement.

Scale

A downside of ponds as NWRM is that they are characterised as small-scale interventions, in contrast to more extended measures such as “Land use conversion” and “Floodplain restoration and management”. However, when ponds are considered as part of a pondscape, they overcome this limitation, and become adapt to larger scale interventions as well.

[5] see individual measures’ descriptions at http://nwrm.eu/measures-catalogue

4. Conclusions

Pondscapes' socio-economic and environmental benefits can be quantified and described through appropriate indicators. These must be selected among several that are commonly studied in the literature, based on their relevance for the context under assessment. The heterogeneity resulting from diverse settings can be reduced at higher criteria and sub-criteria levels for comparison, with the generation of composite indicators. In our case, the BoD method proved useful at this stage, to endogenously determine single indicators' weight for the aggregation, providing unbiased results.

The perspective of stakeholders for individual benefits can then be assessed by inquiring to rank benefit criteria and sub-criteria. The Analytic Hierarchy Process is a method to conduct such comparison in a coherent and straightforward manner. With it, we were able to determine which benefits were mostly prioritized by stakeholders in different countries. Once these preferences were calculated, they became multipliers for a simple weighted-sum Multi-criteria Decision Analysis. Such analysis allowed us to rank pondscapes on their effectiveness, or their capacity to deliver the benefits their stakeholder most expected. This kind of comparison improves simpler considerations on output quantity, characterizing the output delivery performance according to the context, with fundamental implications for policy making at various levels.

Finally, to compare efficiency among pondscapes, the DEA approach was used. We saw that focusing on the amount of different inputs used on pondscapes' performances provided additional insights for the evaluation of their potential. Even if the heterogeneity in available data still makes it impossible to statistically compare pondscapes' efficiencies with other NBS, the literature provides general information which seems in support of our hypothesis: pondscapes have a large potential as NBS. These insights, once again, can be particularly informative for policymakers having to decide on a measure to put in place for climate change mitigation and adaptation purposes.

Comparing our two analyses, we can say that MCDA was most informative in the presence of more disaggregated data, when benefits were considered at the sub-criteria level. DEA instead yielded more informative results when the outputs were aggregated at the criteria level, since too many inputs and outputs flawed its capacity to discriminate on efficiency. We think that policy makers should consider both approaches in a complementary way. As suggested in Cooper et al. (2007), DEA can be particularly informative *ex-post,* as a retrospective evaluation for monitoring purposes. While MCDA is a powerful tool for the *ex-ante* assessment, to justify the choice of a specific measure over many available.

Future analysis should focus on improving our approach by providing more and better data on benefit delivery, more detailed data on stakeholder preferences, and generate new knowledge on alternative NBS for a robust statistical comparison. Also, considering larger and more diverse pondscapes could further improve the robustness of results, supporting their adoption as NBS for mitigation of, and adaptation to Climate Change impacts.

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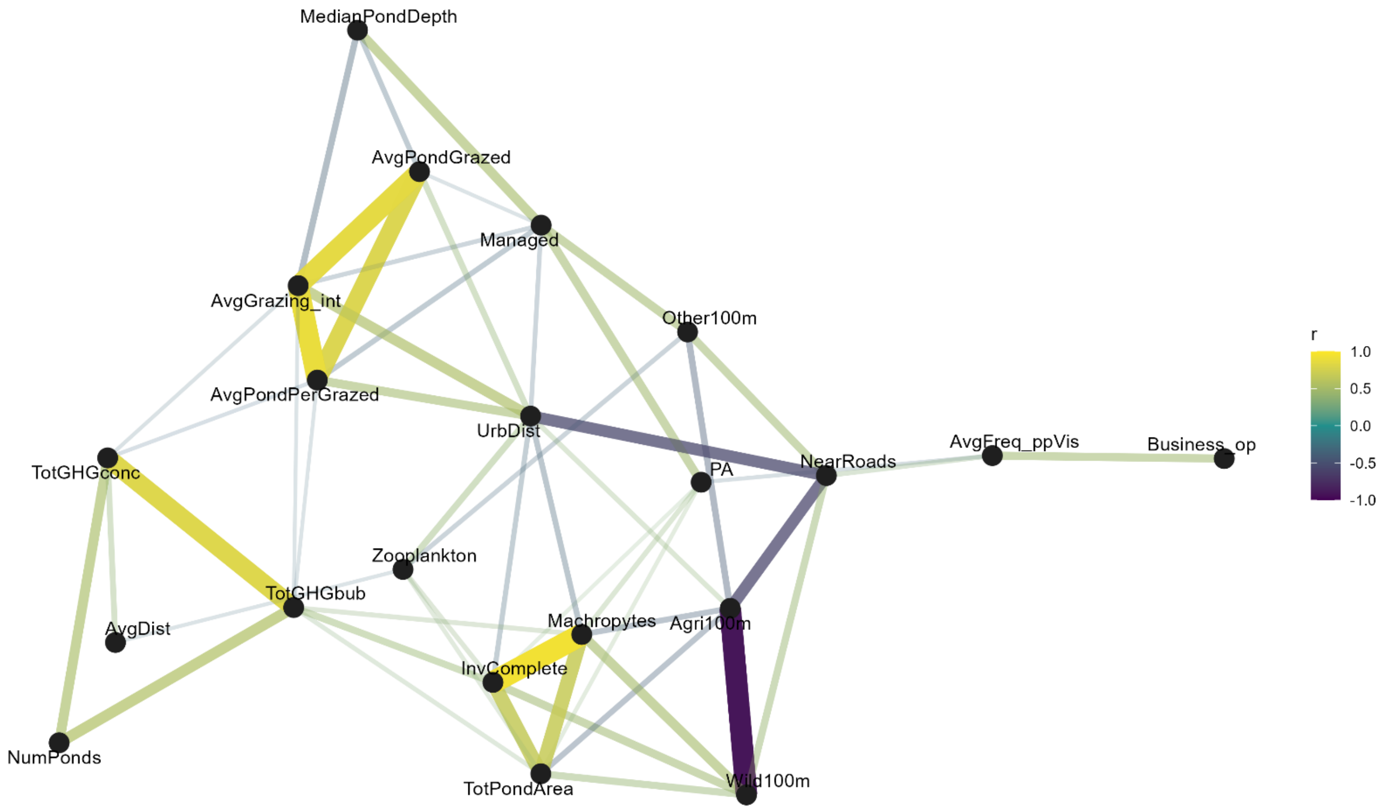
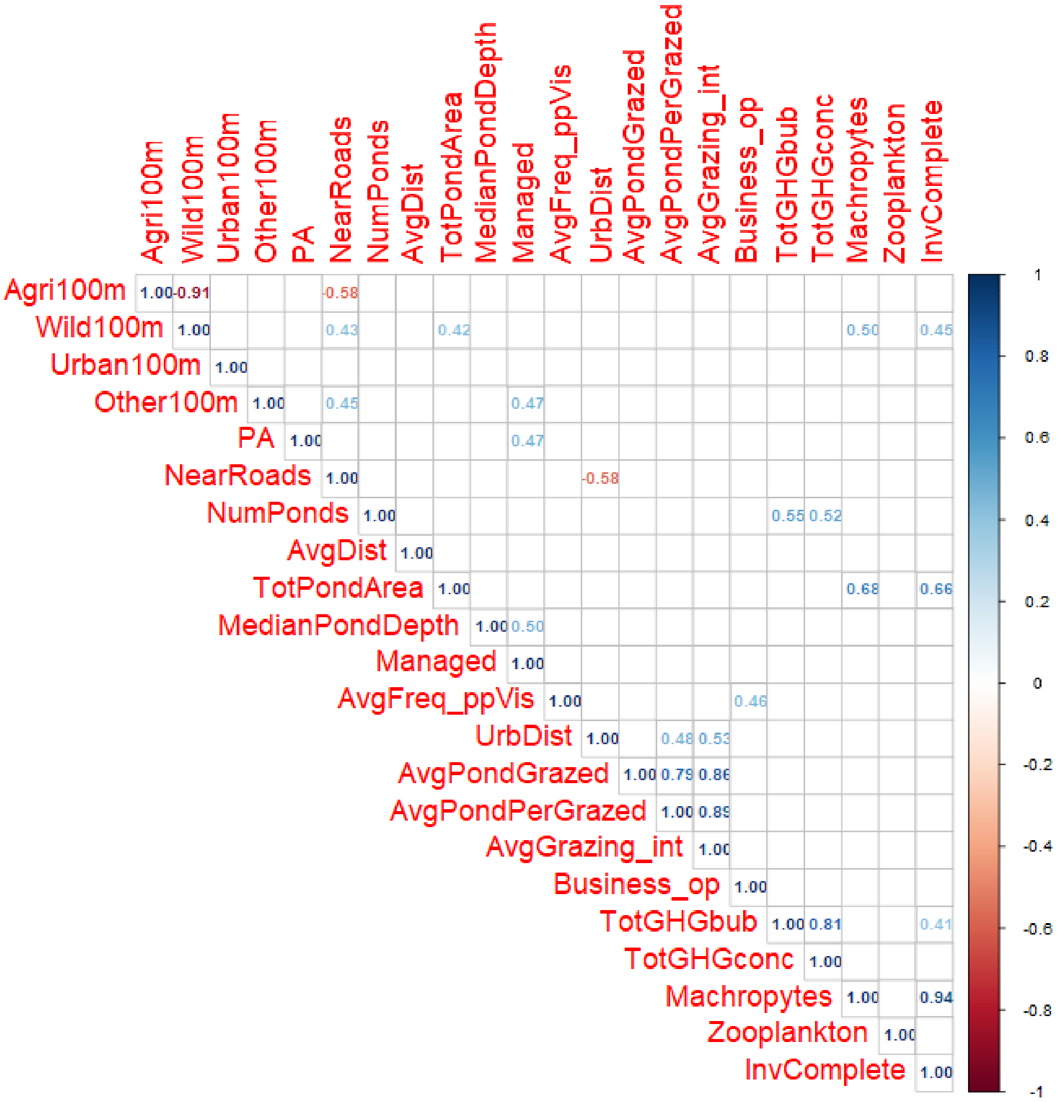
6. Annex

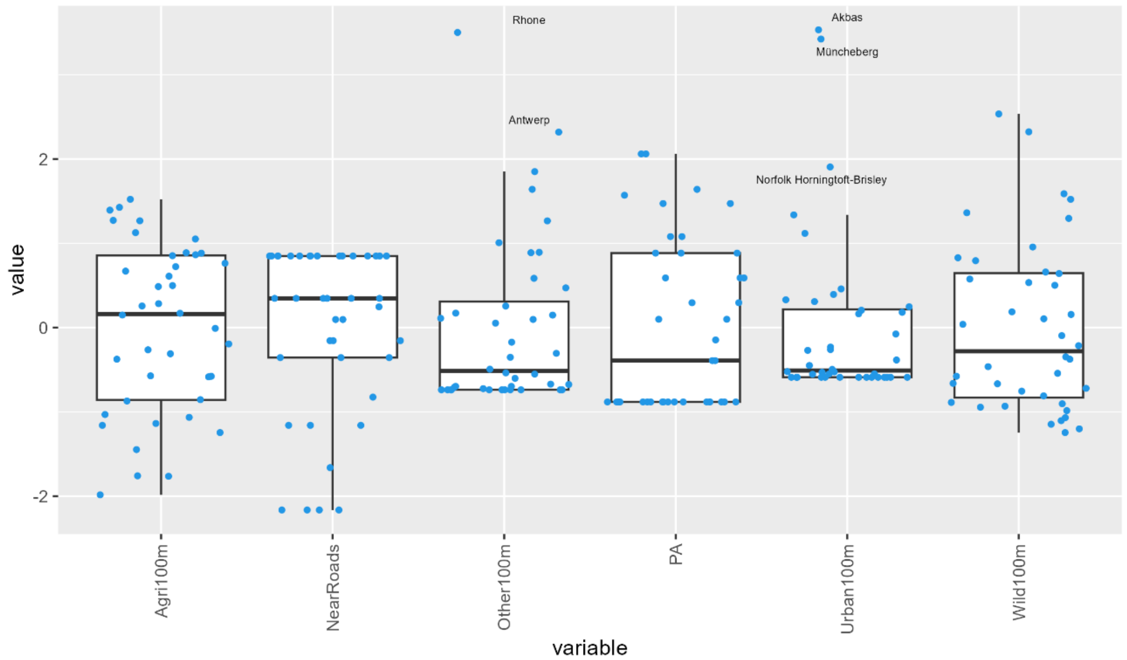
Annex A - Data exploration



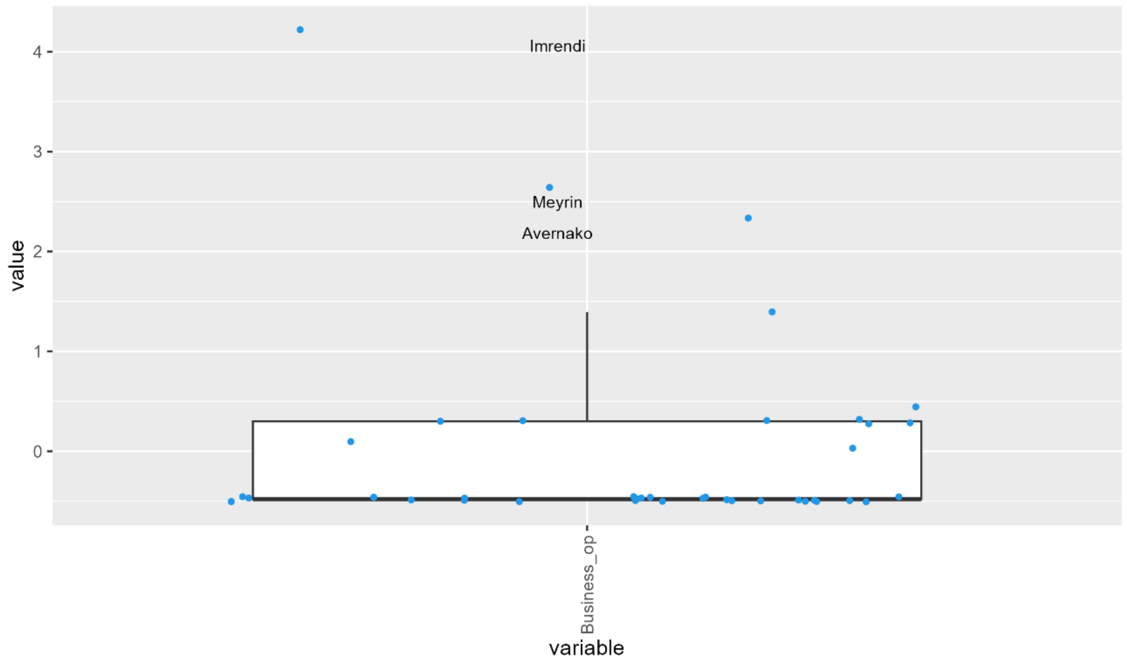
Annex Figure A.1. Network plot of significant correlations among pondscapes' variables.



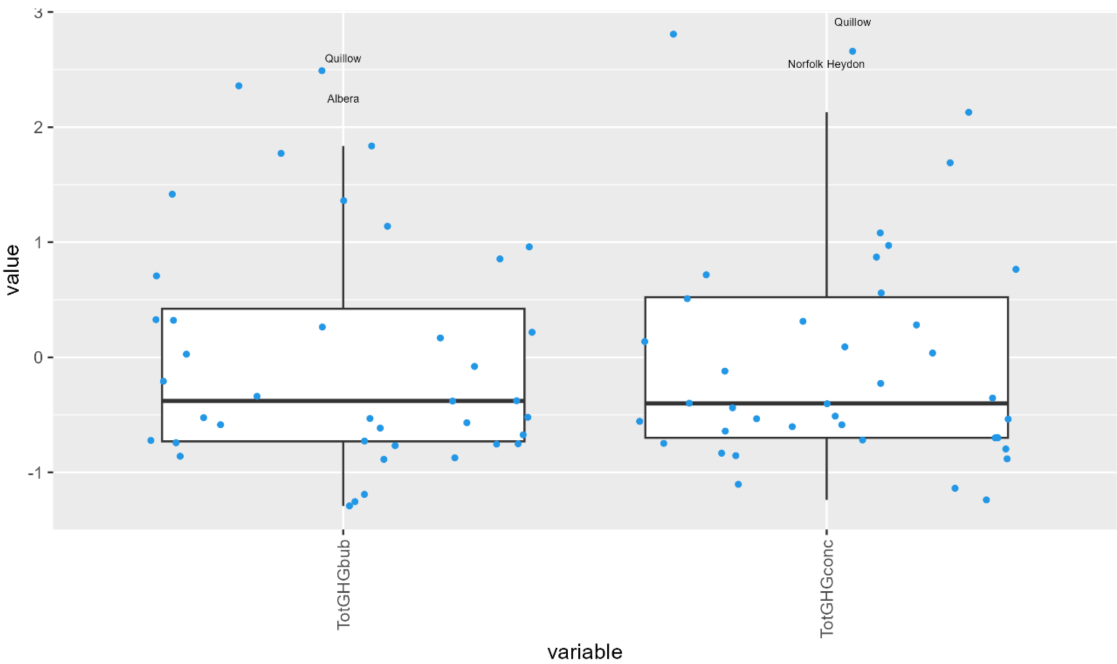
Annex Figure A.2. Matrix of significant correlations among pondscapes' variables.



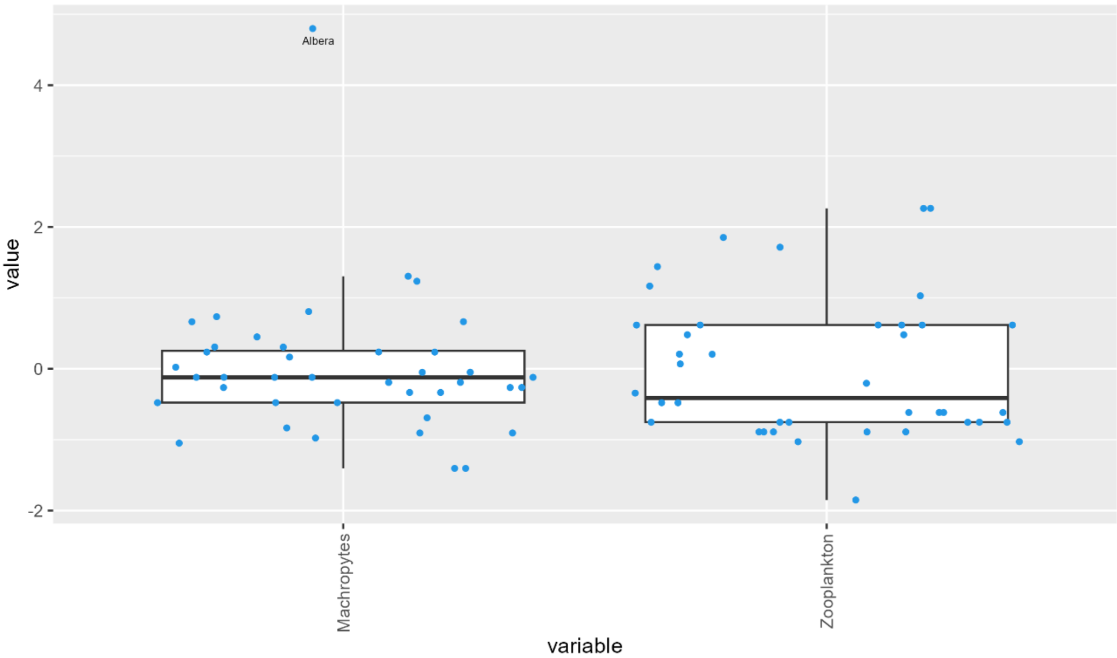
Annex Figure A.3. Boxplot of pondscape characteristics indicators (normalised).



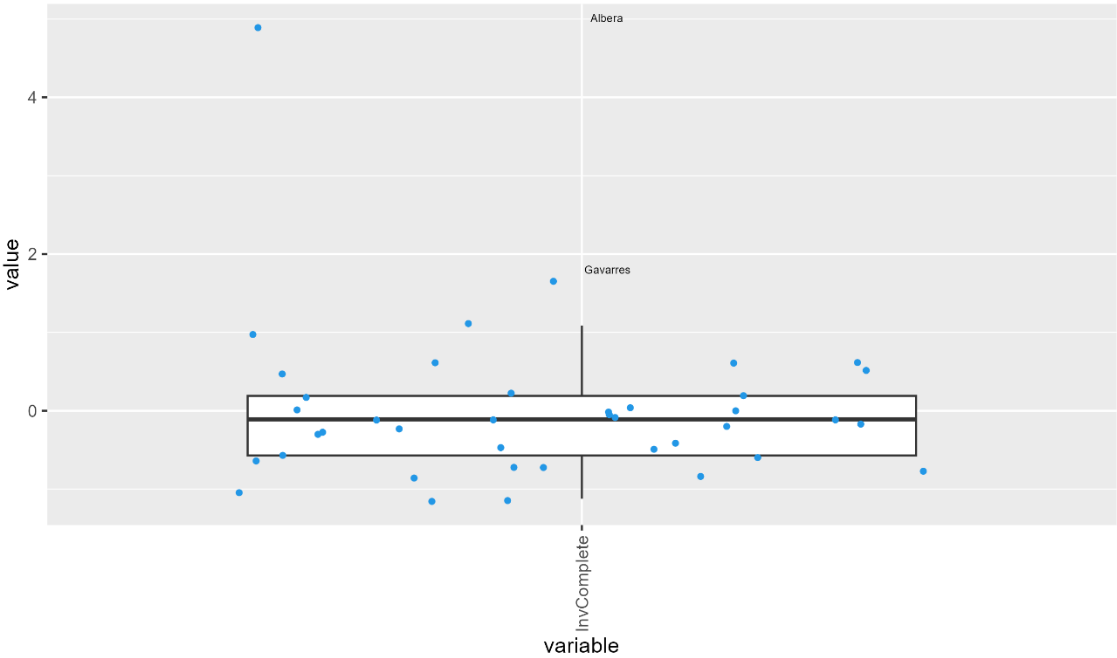
Annex Figure A.4. Boxplot of Business benefit indicators (normalised).



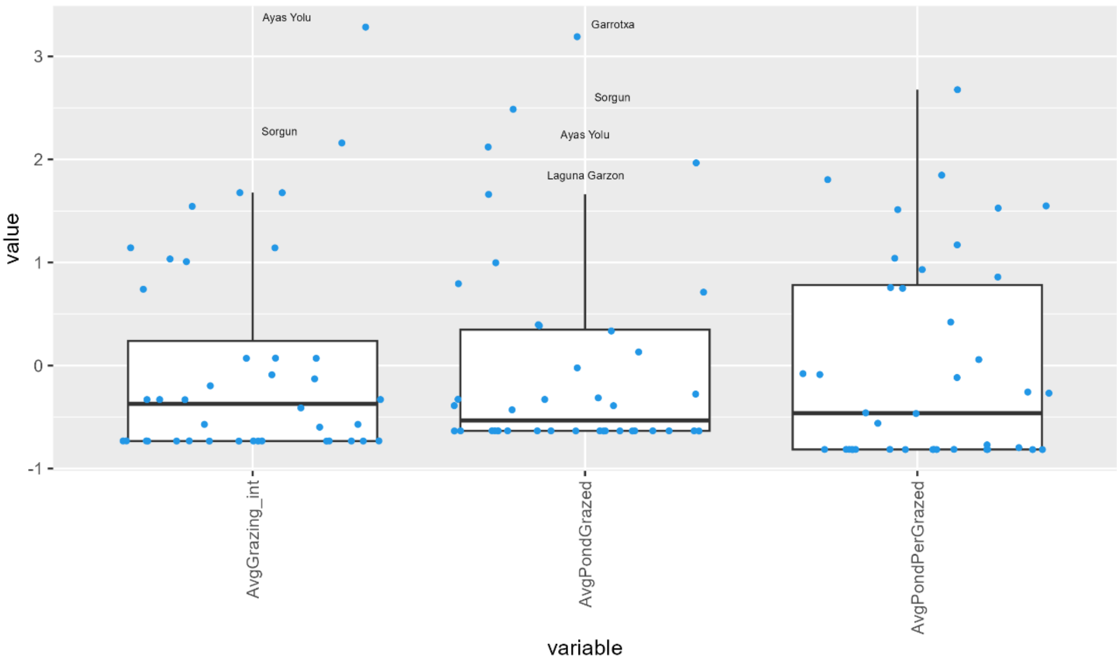
Annex Figure A.5. Boxplot of Atmosphere benefit indicators (normalised).



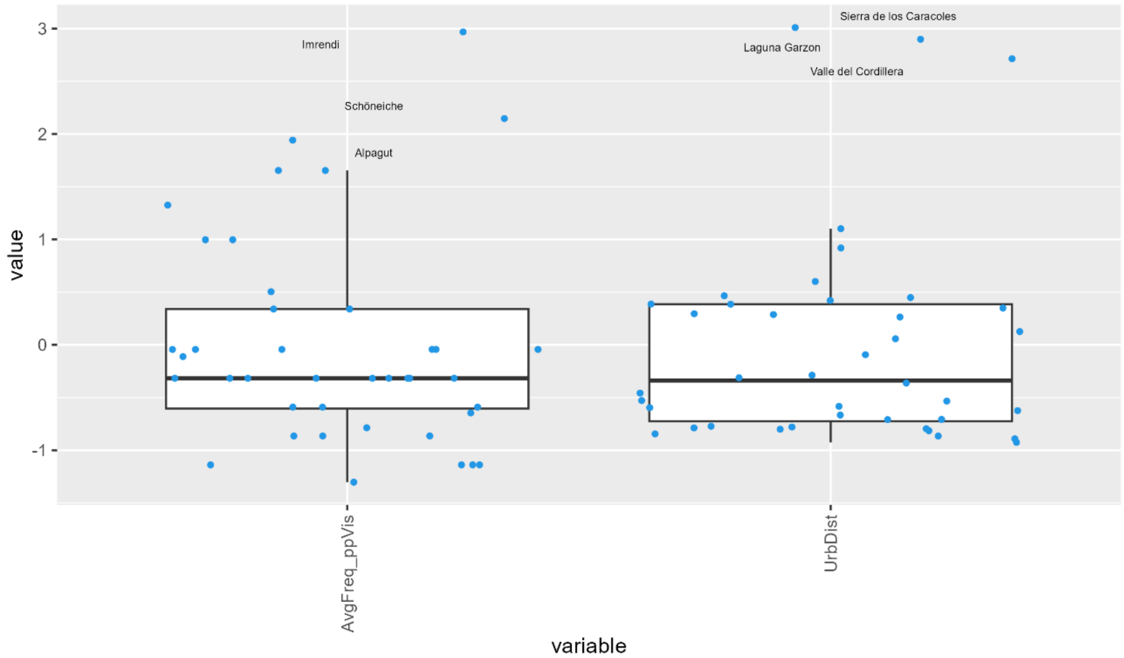
Annex Figure A.6. Boxplot of Lifecycle benefit indicators (normalised).



Annex Figure A.7. Boxplot of Pest benefit indicators (normalised).



Annex Figure A.8. Boxplot of Provisioning benefit indicators (normalised).



Annex Figure A.9. Boxplot of Recreational benefit indicators (normalised).

Annex B - AHP questionnaire

STAKEHOLDER

Characteristic		
Name		
Birth year		
Gender	Male	
	Female	
Education level	No formal education	
	Primary education	
	Secondary education	
	University education	
	PhD	
Occupation		

INSTRUCTIONS

In the following questionnaire, you will be asked to rate the relative importance of different types of benefits associated with the pondscape in your area. You are asked to rate each set of benefits on a scale of importance as described in the table below:

Relative Importance	Definition
1 (A over B)	A is **equally** important as B
2	A is **slightly more** important than B
3	A is **moderately more** important than B
4	A is **moderately plus more** important than B
5	A is **strongly more** important than B
6	A is **strongly plus more** important than B
7	A is **very strongly more** important than B
8	A is **very very strongly more** important than B
9	A is **extremely more** important than B

For example, if you choose:

Benefit A									Benefit B							
Extremely more	Very very strong	Very strong	Strong plus	Strong	Moderate plus	Moderate	Slightly more	**Equal**	Slightly more	Moderate	Moderate plus	Strong	Strong plus	Very strong	Very very strong	Extremely more
9	8	7	6	5	4	~~3~~	2	**1**	2	3	4	5	6	7	8	9

This means that in your opinion, benefit A is **moderately more important** than benefit B. The results of this questionnaire will be used to calculate the importance of each socio-economic and environmental benefits. This information will further help us to rank among different pondscapes and other nature-based solutions. The structure of the questionnaire is described in Appendix 1, if you are interested, you can, but not compulsory to, read.
If any benefit is unclear, please refer to the Appendix 2 for a clearer explanation.

The questionnaire takes approximately 30 minutes.

1. GENERAL BENEFITS OF PONDSCAPES

Which benefit group do you consider more important, when assessing the benefits of pondscapes as nature-based solution?

Benefit A	Scale	Benefit B
Socio-Economic Benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Environmental & Biodiversity Benefits

2. SOCIO-ECONOMIC BENEFIT GROUP

Within socio-economic benefit group, which benefit do you consider more important, when assessing the benefits of pondscapes as nature-based solution?

Benefit A	Scale	Benefit B
Recreational benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Educational benefits
Recreational benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Provisioning benefits
Recreational benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Business & job opportunities
Recreational benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Participatory planning & governance
Recreational benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Social justice & cohesion
Educational benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Provisioning benefits
Educational benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Business & job opportunities
Educational benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Participatory planning & governance
Educational benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Social justice & cohesion
Provisioning benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Business & job opportunities
Provisioning benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Participatory planning & governance
Provisioning benefits	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Social justice & cohesion
Business & job opportunities	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Participatory planning & governance
Business & job opportunities	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Social justice & cohesion
Participatory planning & governance	9 8 7 6 5 4 3 2 **1** 2 3 4 5 6 7 8 9	Social justice & cohesion

1

Annex Figure B.1. Stakeholder preferences AHP questionnaire, page 1.

3. ENVIRONMENTAL & BIODIVERSITY BENEFIT GROUP

Within environmental and biodiversity benefit group, which benefit do you consider more important, when assessing the benefits of pondscapes as nature-based solution?

Atmospheric compositions and conditions	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Water conditions
Atmospheric compositions and conditions	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Regulation of baseline flow & extreme events
Atmospheric compositions and conditions	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Lifecycle maintenance, habitat and gene pool protection
Atmospheric compositions and conditions	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Pest and disease control
Atmospheric compositions and conditions	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Regulation of soil quality
Water conditions	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Regulation of baseline flow & extreme events
Water conditions	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Lifecycle maintenance, habitat and gene pool protection
Water conditions	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Pest and disease control
Water conditions	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Regulation of soil quality
Regulation of baseline flow & extreme events	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Lifecycle maintenance, habitat and gene pool protection
Regulation of baseline flow & extreme events	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Pest and disease control
Regulation of baseline flow & extreme events	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Regulation of soil quality
Lifecycle maintenance, habitat and gene pool protection	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Pest and disease control
Lifecycle maintenance, habitat and gene pool protection	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Regulation of soil quality
Pest and disease control	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Regulation of soil quality

4. PROVISIONING BENEFITS GROUP

Which **provisioning benefits** do you consider more important, when assessing the benefits of pondscapes as nature-based solution?

Agricultural production	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Water production
Agricultural production	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Energy production
Water production	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Energy production

5. ATMOSPHERIC REGULATION BENEFIT

Which **atmospheric regulation benefit** do you consider more important, when assessing the benefits of pondscapes as nature-based solution?

Regulation of chemical composition of atmosphere	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Regulation of temperature and humidity, including ventilation and transpiration

6. REGULATION OF BASELINE FLOW & EXTREME EVENTS BENEFITS

Within the regulation of baseline flow & extreme events benefits, which benefit do you consider more important, when assessing the benefits of pondscapes as nature-based solution?

Control of erosion rate	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Hydrological cycle and water flow regulation (Including flood control, and coastal protection)
Control of erosion rate	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Fire protection
Hydrological cycle and water flow regulation (Including flood control, and coastal protection)	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Fire protection

7. LIFE CYCLE MAINTENANCE, HABITAT AND GENE POOL PROTECTION

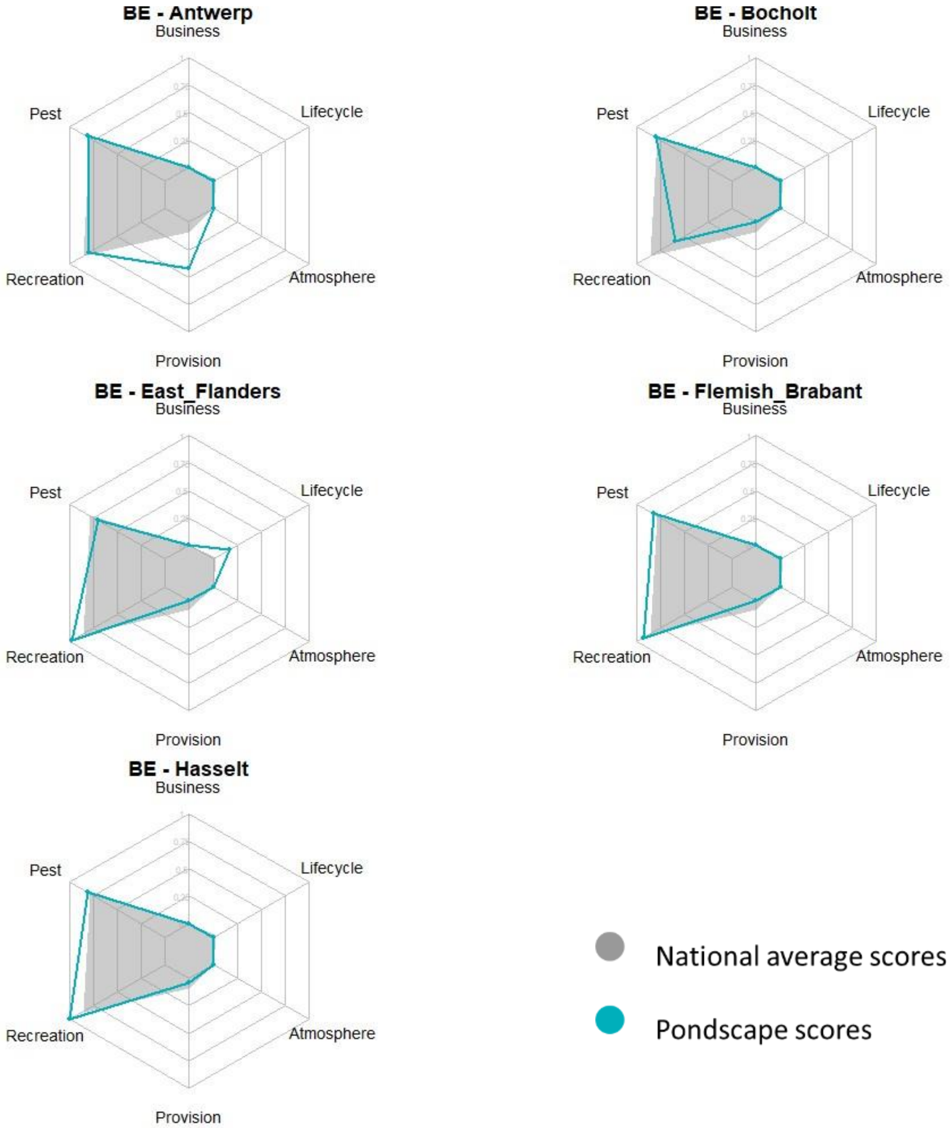
Which benefit do you consider more important, when assessing the benefits of pondscapes as nature-based solution?

Maintaining nursery populations and habitats (Including gene pool protection)	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Pollination and seed dispersal

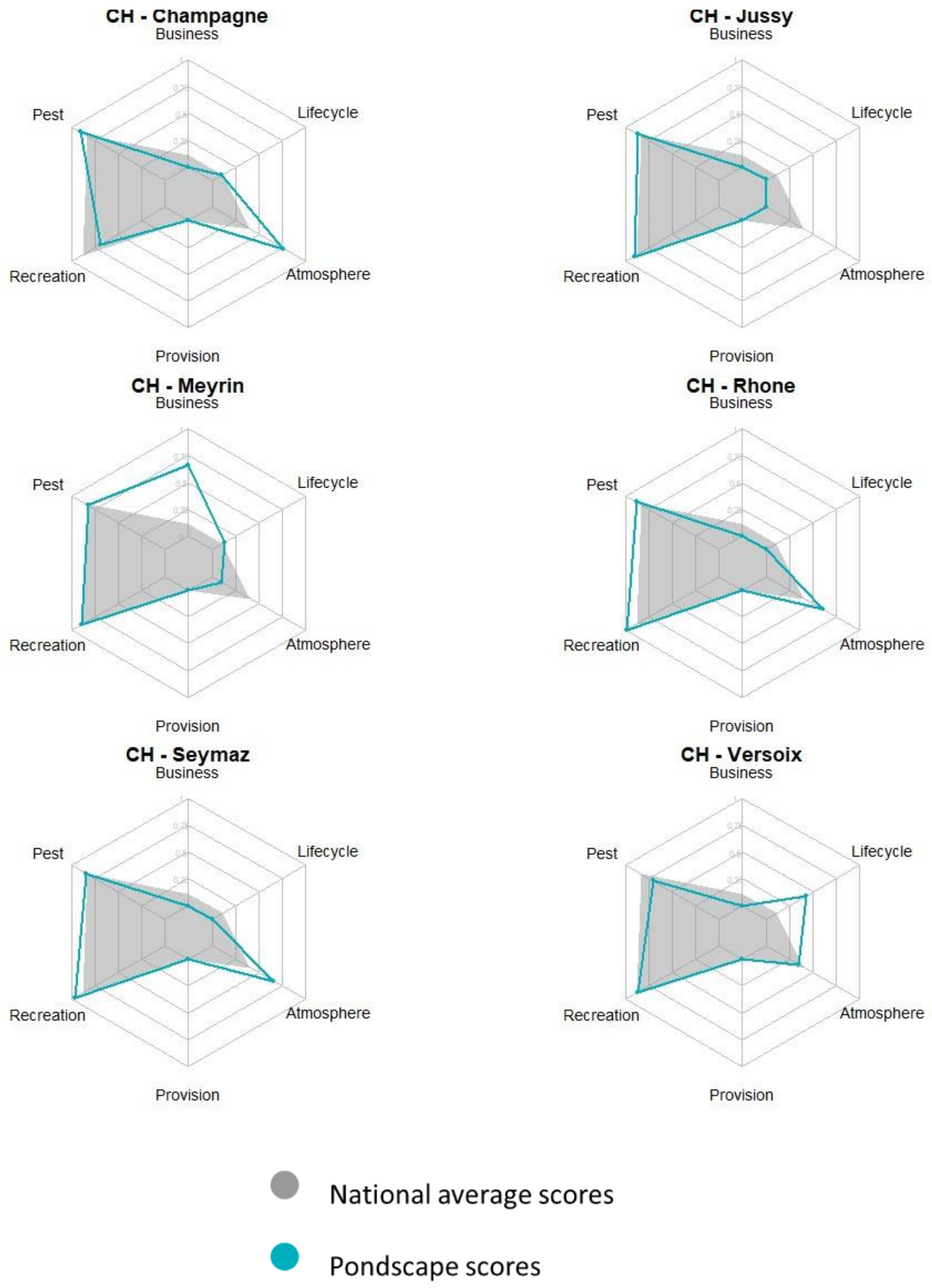
2

Annex Figure B.2Stakeholder preferences AHP questionnaire, page 2.

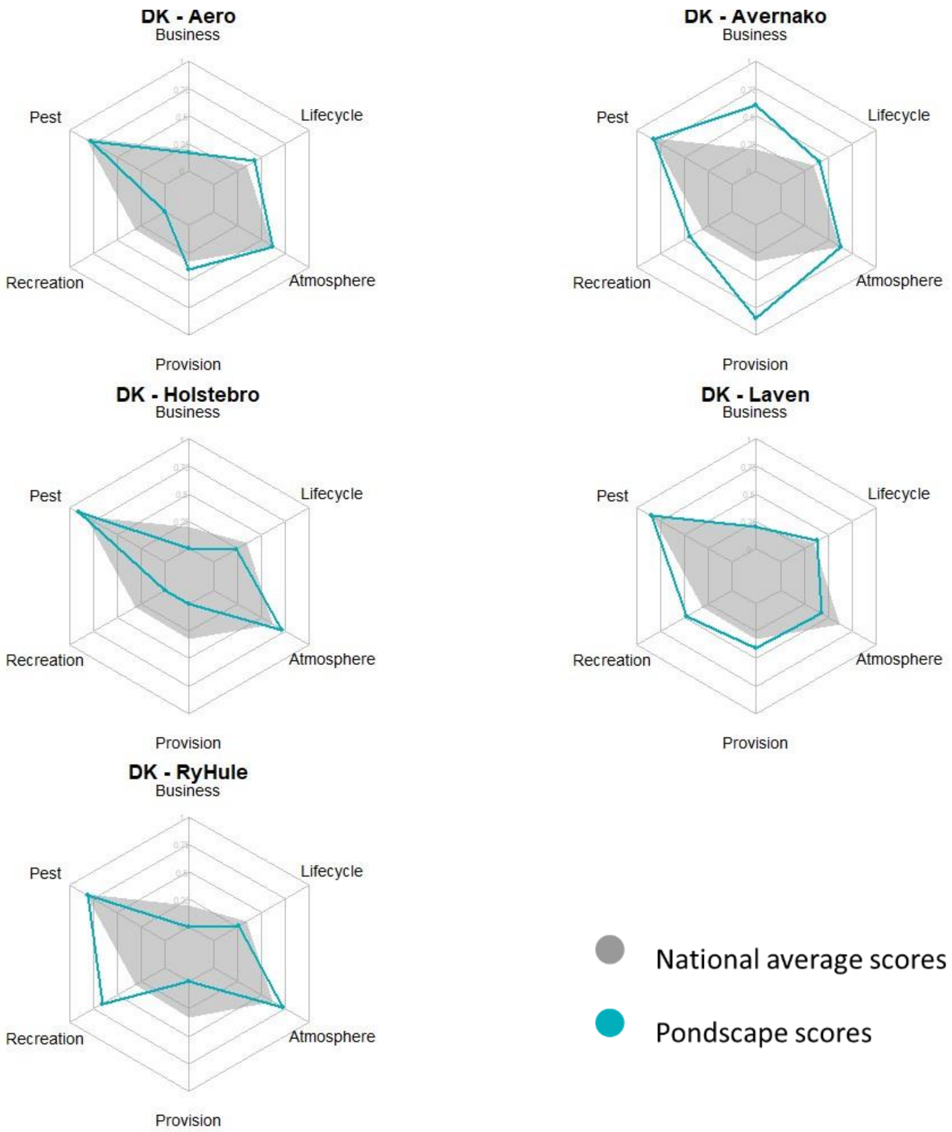
Annex C - Pondscapes sub-criteria CI



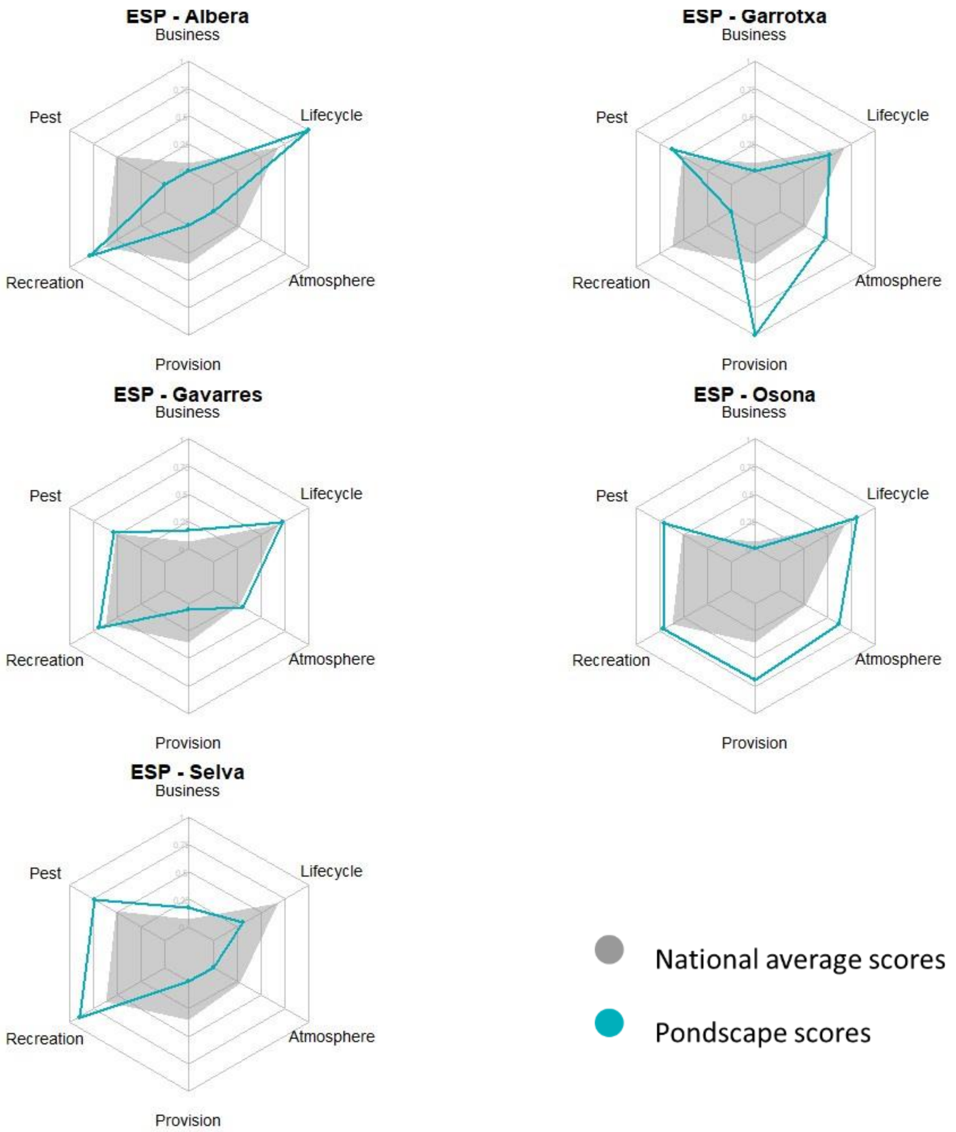
Annex Figure C.1. Pondscapes CI for all six sub-criteria (Approach 1), in Belgium (normalised).



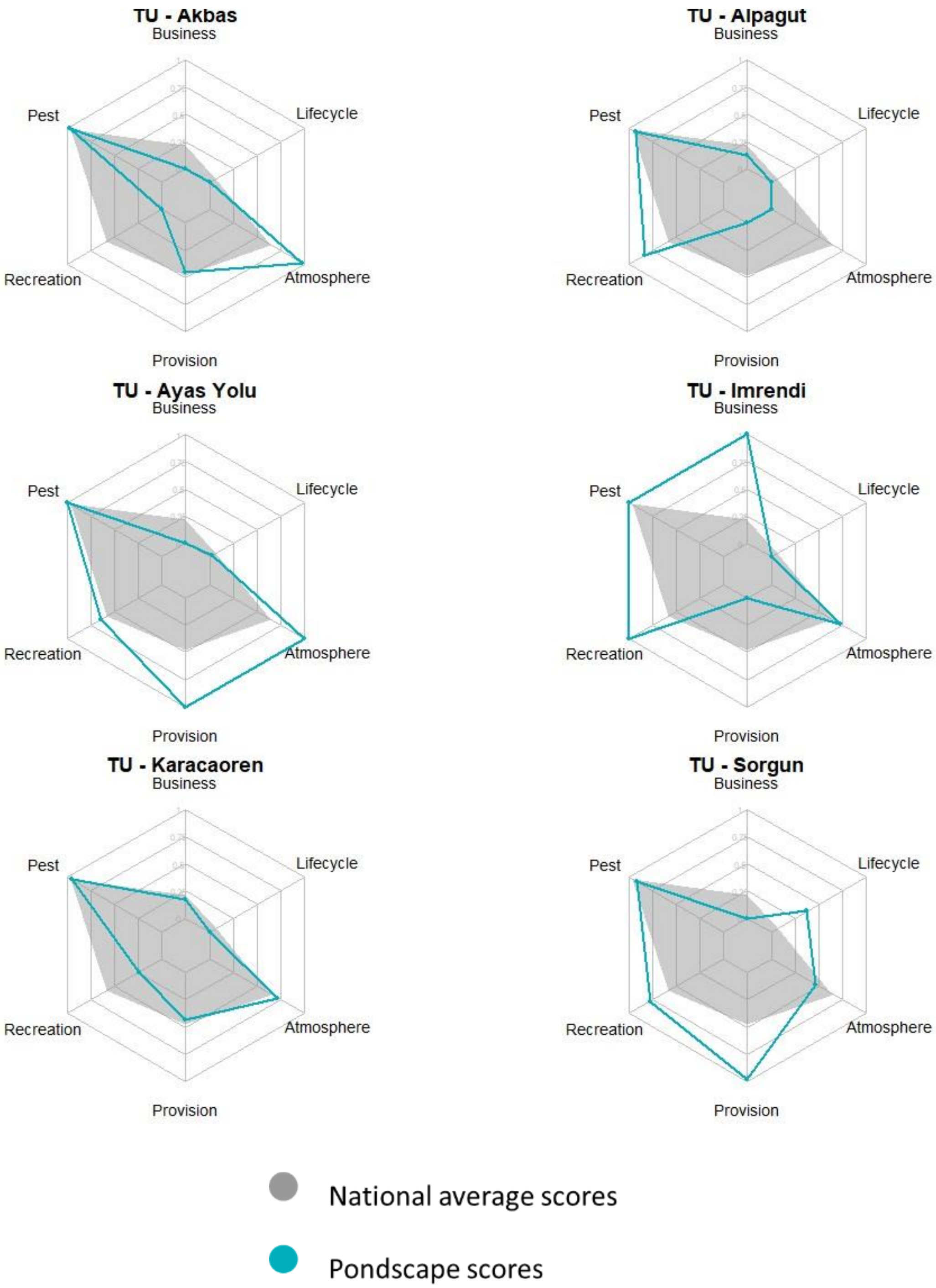
Annex Figure C.2. Pondscapes CI for all six sub-criteria (Approach 1), in Switzerland (normalised).



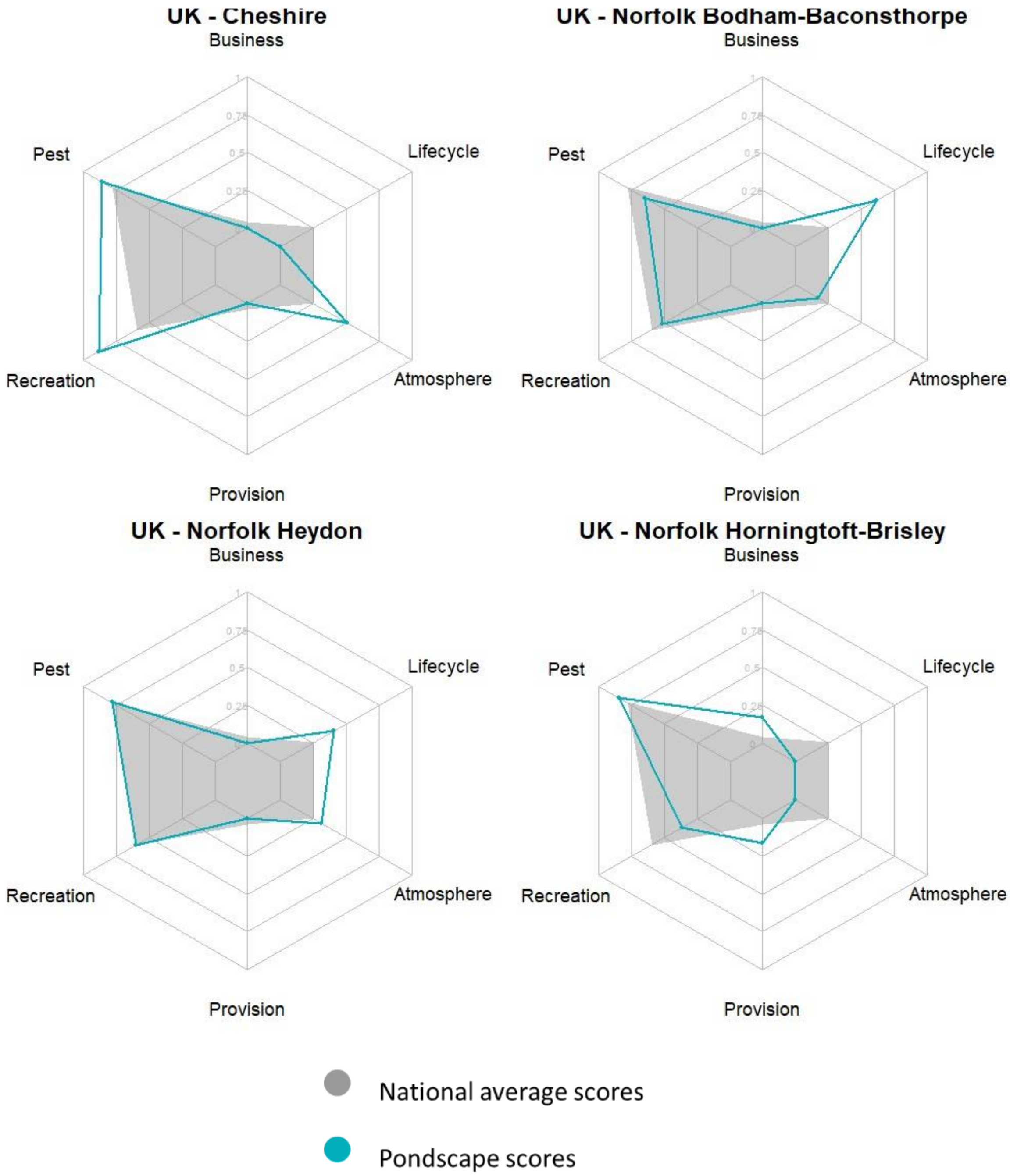
Annex Figure C.3. Pondscapes CI for all six sub-criteria (Approach 1), in Denmark (normalised).



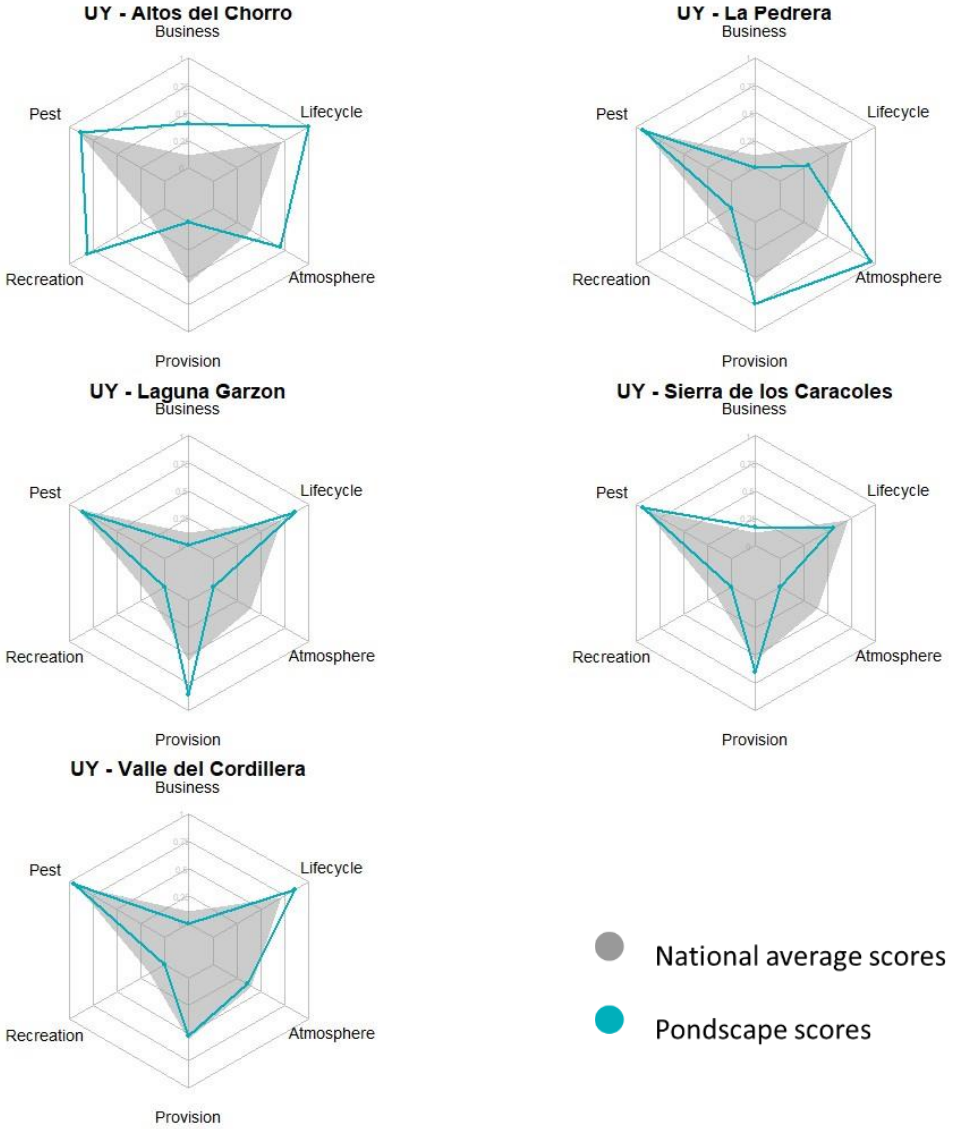
Annex Figure C.4. Pondscapes CI for all six sub-criteria (Approach 1), in Spain (normalised).



Annex Figure C.5. Pondscapes CI for all six sub-criteria (Approach 1), in Turkey (normalised).



Annex Figure C.6. Pondscapes CI for all six sub-criteria (Approach 1), in the UK (normalised).



Annex Figure C.7. Pondscapes CI for all six sub-criteria (Approach 1), in Uruguay (normalised).

Annex D - Criteria and Sub-criteria CI

Annex Table D.1. robust BoD scores from Approach 1 (normalised).

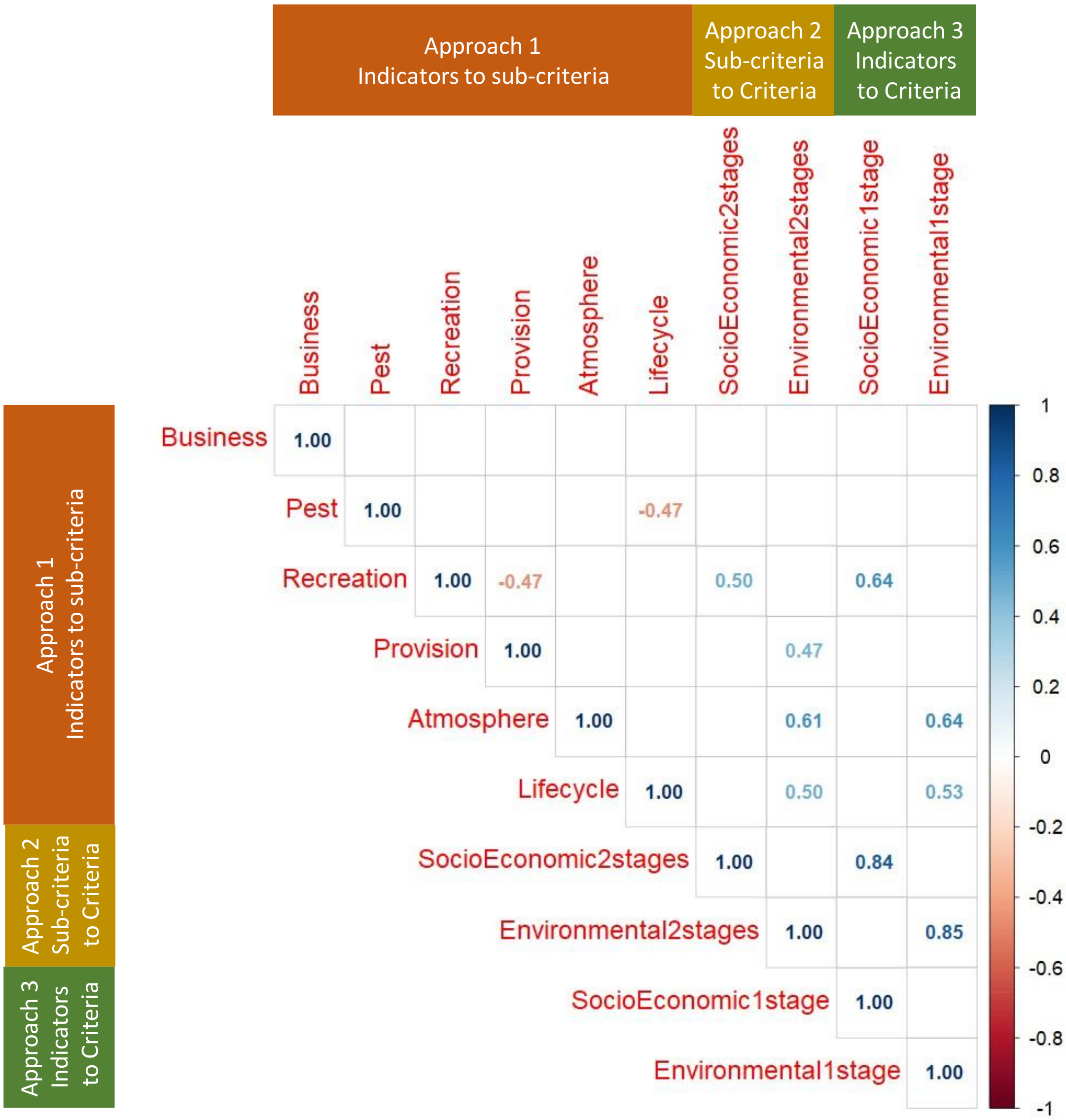
Robust BoD CI sub-criteria level							
Pondscape	**Country**	**Business**	**Pest**	**Recreation**	**Provision**	**Atmosphere**	**Lifecycle**
Altos del Chorro	UY	0.400	0.892	0.820	0.000	0.704	1.000
Avernako	DK	0.600	0.831	0.448	0.836	0.639	0.416
Imrendi	TU	1.000	1.000	1.000	0.000	0.737	0.000
Ayas Yolu	TU	0.000	1.000	0.649	1.000	1.000	0.033
Osona	ESP	0.000	0.708	0.716	0.688	0.620	0.813
Sorgun	TU	0.000	0.923	0.780	0.979	0.472	0.380
La Pedrera	UY	0.000	0.938	0.000	0.737	0.953	0.298
Laven	DK	0.200	0.846	0.488	0.404	0.430	0.392
Schöneiche	DE	0.000	0.723	1.000	0.000	0.754	0.254
Valle del Cordillera	UY	0.000	0.954	0.000	0.524	0.360	0.865
Meyrin	CH	0.667	0.831	0.900	0.000	0.105	0.140
Garrotxa	ESP	0.000	0.631	0.000	1.000	0.477	0.533
Laguna Garzon	UY	0.000	0.862	0.000	0.853	0.000	0.861
Karacaoren	TU	0.167	0.954	0.246	0.437	0.716	0.000
Gavarres	ESP	0.167	0.538	0.698	0.053	0.310	0.734
Rhone	CH	0.000	0.892	0.994	0.000	0.613	0.000
Champagne	CH	0.000	0.908	0.699	0.000	0.773	0.098
Seymaz	CH	0.000	0.846	0.969	0.000	0.656	0.000
RyHule	DK	0.000	0.815	0.661	0.000	0.730	0.265
Akbas	TU	0.000	0.985	0.000	0.450	0.986	0.000
Aero	DK	0.167	0.785	0.000	0.394	0.626	0.431
Versoix	CH	0.000	0.708	0.875	0.000	0.350	0.433
Sierra de los Caracoles	UY	0.167	0.938	0.000	0.647	0.000	0.562
Cheshire	UK	0.000	0.862	0.889	0.000	0.512	0.000
Selva	ESP	0.167	0.738	0.903	0.000	0.000	0.318
Norfolk Heydon	UK	0.000	0.785	0.601	0.000	0.313	0.407
Antwerp	BE	0.000	0.815	0.802	0.414	0.000	0.000
Norfolk Bodham-Baconsthorpe	UK	0.000	0.646	0.518	0.000	0.174	0.615
Alpagut	TU	0.125	0.938	0.836	0.000	0.000	0.000
Holstebro	DK	0.000	0.908	0.000	0.000	0.722	0.242
East_Flanders	BE	0.000	0.708	0.983	0.000	0.000	0.176
Hasselt	BE	0.000	0.815	1.000	0.036	0.000	0.000
Jussy	CH	0.000	0.877	0.916	0.000	0.000	0.012
Albera	ESP	0.000	0.000	0.796	0.000	0.000	1.000
Flemish_Brabant	BE	0.000	0.831	0.938	0.000	0.000	0.000
Norfolk Horningtoft-Brisley	UK	0.167	0.846	0.369	0.159	0.000	0.000
Bocholt	BE	0.000	0.800	0.597	0.000	0.000	0.000
Müncheberg	DE	0.111	0.815	0.408	0.000	0.000	0.000
Lietzen	DE	0.000	0.769	0.000	0.000	0.565	0.000
Quillow	DE	0.000	0.831	0.000	0.000	0.000	0.000

Annex Table D.2. robust BoD scores from Approach 2 (normalised).

Robust BoD 2-stages CI criteria-level			
Pondscape	**Country**	**SocioEconomic2stages**	**Environmental2stages**
Ayas Yolu	TU	1.000	1.000
Imrendi	TU	1.000	1.000
Sorgun	TU	1.000	0.763
Altos del Chorro	UY	0.744	1.000
Laguna Garzon	UY	0.834	0.907
Schöneiche	DE	1.000	0.725
Osona	ESP	0.813	0.870
La Pedrera	UY	0.682	1.000
Avernako	DK	1.000	0.663
Sierra de los Caracoles	UY	0.726	0.905
Albera	ESP	0.537	1.000
Garrotxa	ESP	1.000	0.486
Rhone	CH	0.987	0.487
Seymaz	CH	0.934	0.489
Valle del Cordillera	UY	0.388	1.000
Alpagut	TU	0.681	0.707
Akbas	TU	0.285	0.989
Karacaoren	TU	0.444	0.808
Jussy	CH	0.813	0.365
Gavarres	ESP	0.394	0.736
Cheshire	UK	0.751	0.297
Champagne	CH	0.315	0.703
Hasselt	BE	1.000	0.017
Aero	DK	0.358	0.657
Meyrin	CH	0.891	0.104
Flemish_Brabant	BE	0.863	0.105
East_Flanders	BE	0.964	0.000
Versoix	CH	0.718	0.242
RyHule	DK	0.227	0.689
Selva	ESP	0.844	0.055
Antwerp	BE	0.819	0.017
Laven	DK	0.436	0.341
Holstebro	DK	0.000	0.705
Norfolk Bodham-Baconsthorpe	UK	0.000	0.530
Norfolk Horningtoft-Brisley	UK	0.140	0.193
Lietzen	DE	0.000	0.323
Norfolk Heydon	UK	0.088	0.215
Quillow	DE	0.000	0.105
Bocholt	BE	0.080	0.000
Müncheberg	DE	0.021	0.017

Annex Table D.3. robust BoD scores from Approach 3 (normalised).

Robust BoD 1-stage CI criteria-level			
Pondscape	**Country**	**SocioEconomic1stage**	**Environmental1stage**
Schöneiche	DE	1.000	1.000
Avernako	DK	1.000	1.000
Osona	ESP	1.000	1.000
Garrotxa	ESP	1.000	1.000
Imrendi	TU	1.000	1.000
Ayas Yolu	TU	1.000	1.000
Sorgun	TU	1.000	1.000
Laven	DK	0.975	0.982
Gavarres	ESP	0.947	0.994
Altos del Chorro	UY	0.858	1.000
Albera	ESP	0.841	1.000
Laguna Garzon	UY	0.846	0.964
Alpagut	TU	0.889	0.907
Seymaz	CH	0.967	0.810
Sierra de los Caracoles	UY	0.852	0.923
La Pedrera	UY	0.734	1.000
Champagne	CH	0.695	1.000
Versoix	CH	0.869	0.823
Rhone	CH	0.992	0.673
Karacaoren	TU	0.747	0.903
RyHule	DK	0.648	0.997
Aero	DK	0.637	1.000
Jussy	CH	0.915	0.704
Cheshire	UK	0.917	0.693
Meyrin	CH	1.000	0.574
Norfolk Heydon	UK	0.598	0.944
Valle del Cordillera	UY	0.526	1.000
Norfolk Bodham-Baconsthorpe	UK	0.516	1.000
Akbas	TU	0.471	0.987
Selva	ESP	0.967	0.348
East_Flanders	BE	0.982	0.236
Flemish_Brabant	BE	0.946	0.103
Hasselt	BE	1.000	0.017
Antwerp	BE	1.000	0.017
Holstebro	DK	0.000	1.000
Norfolk Horningtoft-Brisley	UK	0.719	0.248
Lietzen	DE	0.000	0.655
Bocholt	BE	0.596	0.000
Müncheberg	DE	0.458	0.017
Quillow	DE	0.000	0.104



Annex Figure D.1. CI correlation matrix (criteria and sub-criteria levels).

Annex E - MCDA ranking

Annex Table E.1. MCDA ranking by CI approach.

Pondscape	Country	BoD Approach 1	BoD Approach 2	BoD Approach 3
Osona	ESP	1.0	6.5	6.0
Ayas Yolu	TU	2.0	3.5	1.5
Sorgun	TU	3.0	3.5	7.0
Altos del Chorro	UY	4.0	11.0	5.0
Laguna Garzon	UY	5.0	14.0	4.0
Gavarres	ESP	6.0	8.0	17.0
Avernako	DK	7.0	1.0	11.0
Imrendi	TU	8.0	3.5	1.5
Albera	ESP	9.0	10.0	3.0
Valle del Cordillera	UY	10.0	28.0	15.0
Schöneiche	DE	11.0	3.5	9.0
Garrotxa	ESP	12.0	6.5	19.0
Sierra de los Caracoles	UY	13.0	15.0	10.0
La Pedrera	UY	14.0	19.0	8.0
Laven	DK	15.0	9.0	27.0
Akbas	TU	16.0	24.0	12.0
Karacaoren	TU	17.0	20.0	14.0
Versoix	CH	18.0	21.0	26.0
RyHule	DK	19.0	16.0	22.0
Aero	DK	20.0	17.0	21.0
Norfolk Bodham-Baconsthorpe	UK	21.0	22.0	29.0
Selva	ESP	22.0	31.0	33.0
Norfolk Heydon	UK	23.0	23.0	37.0
Champagne	CH	24.0	13.0	20.0
Meyrin	CH	25.0	29.0	28.0
Cheshire	UK	26.0	27.0	25.0
Rhone	CH	27.0	25.0	16.0
Seymaz	CH	28.0	18.0	18.0
Holstebro	DK	29.0	30.0	24.0
Alpagut	TU	30.0	12.0	13.0
East_Flanders	BE	31.0	33.0	32.0
Antwerp	BE	32.0	37.0	34.0
Hasselt	BE	33.0	36.0	31.0
Flemish_Brabant	BE	34.0	35.0	30.0
Jussy	CH	35.0	26.0	23.0
Norfolk Horningtoft-Brisley	UK	36.0	34.0	36.0
Lietzen	DE	37.0	32.0	35.0
Bocholt	BE	38.0	38.0	39.0
Müncheberg	DE	39.0	39.0	40.0
Quillow	DE	40.0	40.0	38.0

Annex Table E.2. MCDA ranking comparison.

Pondscape	Country	Low	Up	Average (between 3 approaches)	Diff (upper-lower)
Ayas Yolu	TU	1.50	3.50	2.33	2.0
Imrendi	TU	1.50	8.00	4.33	6.5
Osona	ESP	1.00	6.50	4.50	5.5
Sorgun	TU	3.00	7.00	4.50	4.0
Avernako	DK	1.00	11.00	6.33	10.0
Altos del Chorro	UY	4.00	11.00	6.67	7.0
Albera	ESP	3.00	10.00	7.33	7.0
Laguna Garzon	UY	4.00	14.00	7.67	10.0
Schöneiche	DE	3.50	11.00	7.83	7.5
Gavarres	ESP	6.00	17.00	10.33	11.0
Garrotxa	ESP	6.50	19.00	12.50	12.5
Sierra de los Caracoles	UY	10.00	15.00	12.67	5.0
La Pedrera	UY	8.00	19.00	13.67	11.0
Karacaoren	TU	14.00	20.00	17.00	6.0
Laven	DK	9.00	27.00	17.00	18.0
Akbas	TU	12.00	24.00	17.33	12.0
Valle del Cordillera	UY	10.00	28.00	17.67	18.0
Alpagut	TU	12.00	30.00	18.33	18.0
Champagne	CH	13.00	24.00	19.00	11.0
RyHule	DK	16.00	22.00	19.00	6.0
Aero	DK	17.00	21.00	19.33	4.0
Seymaz	CH	18.00	28.00	21.33	10.0
Versoix	CH	18.00	26.00	21.67	8.0
Rhone	CH	16.00	27.00	22.67	11.0
Norfolk Bodham-Baconsthorpe	UK	21.00	29.00	24.00	8.0
Cheshire	UK	25.00	27.00	26.00	2.0
Meyrin	CH	25.00	29.00	27.33	4.0
Holstebro	DK	24.00	30.00	27.67	6.0
Norfolk Heydon	UK	23.00	37.00	27.67	14.0
Jussy	CH	23.00	35.00	28.00	12.0
Selva	ESP	22.00	33.00	28.67	11.0
East_Flanders	BE	31.00	33.00	32.00	2.0
Flemish_Brabant	BE	30.00	35.00	33.00	5.0
Hasselt	BE	31.00	36.00	33.33	5.0
Antwerp	BE	32.00	37.00	34.33	5.0
Lietzen	DE	32.00	37.00	34.67	5.0
Norfolk Horningtoft-Brisley	UK	34.00	36.00	35.33	2.0
Bocholt	BE	38.00	39.00	38.33	1.0
Müncheberg	DE	39.00	40.00	39.33	1.0
Quillow	DE	38.00	40.00	39.33	2.0

Annex F - DEA results

Annex Table F.1. DEA input variables comparison. Lowest values are in green, highest in red.

Pondscape	Country	NumPonds	AvgDist	TotPondArea	MedianPondDepth	Managed
Antwerp	Belgium	6	4.064909	7340	44.285	0%
Flemish_Brabant	Belgium	6	10.35026	1726	81.375	0%
Bocholt	Belgium	6	3.094657	4914	77.005	0%
Hasselt	Belgium	5	6.442387	1740	72.5	0%
East_Flanders	Belgium	5	5.101922	2982	98.5	0%
Jussy	Switzerland	7	1.873578	14810.96	90	100%
Rhone	Switzerland	5	1.568199	18427.19	199	100%
Versoix	Switzerland	6	1.308743	14923.63	111	100%
Champagne	Switzerland	2	2.875603	4067.983	189.5	100%
Meyrin	Switzerland	3	0.987523	4064.428	83	100%
Seymaz	Switzerland	5	2.129321	17681.51	59	100%
Müncheberg	Germany	9	3.68595	16667	38	11%
Lietzen	Germany	4	0.689732	6869	42	0%
Quillow	Germany	8	6.36948	6148	71.5	0%
Schöneiche	Germany	4	2.2531	6216	85	25%
Laven	Denmark	5	2.665428	7225	140	0%
Avernako	Denmark	5	0.908396	3310	70	0%
Aero	Denmark	6	3.340548	5697.5	72.5	0%
Holstebro	Denmark	6	4.95409	15310	102.5	0%
RyHule	Denmark	5	1.704576	5190	120	20%
Albera	Spain	6	3.52095	109604.6	30.7	17%
Osona	Spain	6	1.018765	1300.29	34.75	0%
Selva	Spain	6	1.843613	2648.46	82.35	17%
Garrotxa	Spain	6	2.776025	654.34	26.05	0%
Gavarres	Spain	6	3.22549	2553.24	51.3	17%
Alpagut	Turkey	8	0.549499	10747.5	2.95	0%
Imrendi	Turkey	3	1.422597	21922	4	0%
Akbas	Turkey	5	4.796154	5277	1.8	0%
Ayas Yolu	Turkey	2	0.956964	300	0.9	0%
Sorgun	Turkey	5	6.685098	13187.6	0.8	20%
Karacaoren	Turkey	6	2.525684	11100	1.75	0%
Norfolk Bodham-Baconsthorpe	UK	6	2.630797	5870	134.7	17%
Norfolk Horningtoft-Brisley	UK	6	2.504271	1115	66.1	17%
Norfolk Heydon	UK	6	4.896113	1650	93.1	17%
Cheshire	UK	4	2.809799	2520	84.2	0%
Sierra de los Caracoles	Uruguay	6	2.924996	3500	66.5	17%
La Pedrera	Uruguay	6	0.994008	14888	191	33%
Laguna Garzon	Uruguay	6	1.029643	13852	79.5	0%
Altos del Chorro	Uruguay	5	2.36435	12745	202	60%
Valle del Cordillera	Uruguay	6	2.043116	5328	87	0%

Annex G - Comparing pondscapes and other NBS

Annex Table G.1. Comparing several NBS by ES delivery.

	Provisioning			**Regulatory and maintenance**				**Cultural**				**Abiotic**			**Rank**
	Water Storage	Fish Stocks and Recruiting	Natural Biomass Production	Biodiversity Preservation	Climate Change Adaptation and	Groundwater/Aquifer Recharge	Flood Risk Reduction	Erosion/Sediment Control	Filtration of Pollutants	Recreational Opportunities	Aesthetic/Cultural Value	Navigation	Geological Resources	Energy Production	
Land use conversion	6	3	6	6	6	6	6	6	6	6	6				**1**
Floodplain restoration and management	6	6	6	6	3	6	6	6	3	6	6				**2**
Maintenance of forest cover in headwater areas	6	1	6	3	6	6	6	6	6	6	6				**3**
Afforestation of reservoir catchments	3	1	6	6	6	6	3	6	6	6	6				**4**
Re-Meandering	3	3	6	6	3	6	6	6	3	6	6				**5**
Targeted planting for "catching" precipitation	6		6	3	6	6	3	6	6	6	6				**5**
Lake restoration	6	6	6	6		3	3	6	1	6	6				**7**
Natural bank stabilisation	1	6	6	6	1	1	3	6	6	6	6				**8**
Trees in urban areas	3		3	6	6	3	2	2	6	6	6				**9**
Urban forest parks	3	1	3	6	6	3	2	2	3	6	6				**10**
Retention ponds	3		3	6	3		6	3	6	3	6				**11**
Wetland restoration and management	3	6	3	6	3	3	3	1	3	3	3				**12**
Infiltration basins	3		1	3	3	6	6	2	6	3	3				**13**
Continuous cover forestry	3	2	3	6	6	1	3	3	3	3	3				**13**
Restoration and reconnection of seasonal streams	3	3	2	6	3	3	3	6	3		3				**15**
Reconnection of oxbow lakes and similar features	3	3	1	6	3	3	3	6	3	1	3				**15**
Basins and ponds	6	2	2	2		6	6	1	3	3	3				**17**
Sediment capture ponds	3	6		6	2	2	3	6	6						**17**
Stream bed re-naturalization	2	2	3	6		2	3	6	3	3	3				**19**
Elimination of riverbank protection	3	3	3	3		1	6	3	3	3	3				**20**
Re-naturalization of polder areas	6	3	3	6		3	3	1	1	1	3	1			**20**
Riverbed material renaturalization	3	3	3	6			3	6	3		2				**22**
Rain gardens	2		1	3	3	3	6	2	3	3	3				**22**
Detention basins	3		1	3	3	1	6	3	3	3	3				**22**
Forest riparian Buffers	2	3	2	6		1	2	6	3	1	2	1			**22**

Peak flow control structures in managed forests	3	3		3	1	3	2	6	6	1	1				**22**
Buffer strips and hedges			2	2	3	3	6	6	6						**27**
Overland flow areas in peatland forests	3	3		3		1	6	6	6						**27**
Green cover			1	2	3	3	6	6	6						**29**
Appropriate design of roads and rtream crossings	2	6		6			2	6	1		3	1			**29**
"Water sensitive" driving		6		6			2	6	3		3				**31**
Early sowing					3	6	6	6	3						**32**
Removal of dams and other longitudinal barriers		6		6			1	3				3		3	**33**
Swales	1		1	3	3	3	3	2	3		3				**33**
Infiltration trenches	2				2	6	6	2	3		1				**33**
Meadows and pastures					3	3	6	6	3						**36**
Filter strips			1	3	1	1	1	3	6		3				**37**
No till agriculture				3	3	3		6	3						**38**
Traditional terracing							3	6	3		6				**38**
Soakaways	2				2	6	6		2						**38**
Intercropping	1			3	1		3	3	6						**41**
Green roofs			2	2	3		3		2	2	3				**41**
Coarse woody debris		6		6			3	1		3		-3			**43**
Strip cropping						3	3	6	3						**44**
Restoration of natural infiltration to groundwater	3				1	3	1	1					6		**44**
Permeable paving	3				2	3	3	2	1						**46**
Crop rotation				1		3	1	2	3		3				**47**
Channels and rills			1	1	1		2	2	2		3				**48**
Controlled traffic farming						2	3	3	3						**49**
Reduced stocking density						2	3	3	3						**49**
Rainwater harvesting	6				3		2								**49**
Mulching						3	3	1							**52**
Low till agriculture					2	3									**53**

Source: NWRM website - http://nwrm.eu/catalogue-nwrm/benefit-tables

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Pond Ecosystems for Resilient Future Landscapes in a Changing Climate

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