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Monetization of Ecosystem Services from Nature-Based Solutions for Agricultural Diffuse Pollution Control: Simplified Value Transfer Method at European Scale

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Abstract: When nature-based solutions (NBS) are developed with a primary scope, they also provide simultaneous additional economic, social, and environmental benefits, i.e., Ecosystem Services. A monetary assessment that accounts for these additional benefits is provided by this work, with a focus on Europe. Specifically, this is intended to evaluate nine identified benefits of those wetlands and buffer strips designed to primarily address agricultural diffuse pollution, which must surely be listed among the negative externalities of economic activities that NBS can help resolve. The aim of developing a simplified value transfer methodology for a rapid evaluation of NBS benefits with the adjusted unit Value Transfer method is to create an accessible solution when time, funding, or other constraints prevent the use of highly technical primary monetization approaches. The developed exercise allows us to gather insights from several primary valuation studies and to appropriately transfer the monetary valuation outcomes to new policy sites. In order to reduce the distance from the expected and required concrete achievements of the economic valuations, the study has been integrated with an case study located in the Venice lagoon catchment in Northwestern Italy. The results obtained are to be considered sound, with existing evidence showing that the most valuable benefits of the considered NBS are both water quality and recreation and tourism, to which is added, in the case of wetlands, water supply.

Keywords: value transfer; nature-based solutions; ecosystem services; agricultural diffuse pollution; wetlands; buffer strip; decision-making process

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1. Introduction

Nature-Based Solutions (NBS) are defined as "actions inspired by, supported by or copied from nature and which aim to help societies address a variety of environmental, social and economic challenges in sustainable ways" [1].

Among the different issues NBS aim at resolving, diffuse pollution in agriculture must certainly be listed; these measures can stimulate the retention and treatment of diffuse pollutants generated by farming practices, such as nitrogen, phosphorus, sediments, and pesticides. In particular, wetlands and buffer strips are reported as effective instruments for tackling these persistent releases from agricultural fields surrounding freshwater ecosystems [2–5].

When NBS are developed with one primary scope, they also provide additional economic, social, and environmental benefits [1], i.e., Ecosystem Services (ES). NBS are considered to be multi-functional [6], this being one of their main advantages over grey infrastructures [7].

The European Union has recognised these attributes for several years, and has launched investments into enhancement activities for the establishment of a nature-based scenario [8]. Despite this, there are still calls for further research to be conducted [1]; there is a need to assess the implementation process and evaluate the direct and collateral benefits deriving from NBS, including non-tangible benefits for both people and nature [9]. These must be assessed ex-post, but particular demands have been made—by authors such as [7,10–12]—for the evaluations to be fulfilled before the beginning of the projects.

In fact, the same authors have pursued the same consistent line of analysis: ref. [7] evaluated NBS benefits through a retrospective multi-criteria analysis for integrated valuation, thereby determining how the same could be carried out prospectively in order to assess new projects; ref. [12], performed a multi-criteria analysis that made use of value transfer to assess the additional ES from NBS implementation, aiming to guide choices between green and grey infrastructure from the outset of the decision stage; ref. [10] has systematically reviewed if and how ES economic valuation is actually used as a support for decision-making processes, concluding that "The common rule is to present an economic valuation, then suggest that it be used for decision-making, but without this use being either explicited or contextualized, and without concrete examples being provided nor analysed" ([10], p. 217).

The economic evaluation of ecosystem services appraisal can, therefore, be an appropriate exercise for the achieving the aforementioned aims, being an efficient political lever for NBS development [10]. Monetary assessment allows the wider economic aspects characterizing NBS to be accounted for, highlighting benefits that might not otherwise be included in decision-making processes [13]. Indeed, it may help policymakers and governments in choosing, for example, whether to prioritize green-blue infrastructures over grey ones and to weigh the externalities associated with each [8], ultimately accelerating the spread of NBS.

An accessible solution when time (or funding or other constraints) prevents the use of highly technical primary monetization approaches is the reliance on indirect valuation techniques [14], e.g., value transfer (VT) methods. In particular, the Adjusted Unit Value Transfer may also be suitable for simpler ex-ante application, as well as strengthening advocacy and awareness-raising [11]. The Adjusted Unit VT is an alternative economic valuation method that can be applied to ecosystems, or ecosystem goods and services, by extrapolating the results of pre-existing primary studies at one or more study sites to estimate, indirectly and through a relatively standard process, the value of some characteristics of similar unstudied policy sites [15].

The Adjusted Unit VT process allows the practitioner to use economic evaluation more easily and, thus, more frequently in practice; the methodology proposed below is designed to be applied by those decision makers who do not necessarily have a background on economic evaluation.

To answer to the lack of simplified tools for the economic valuation of ES [10], this research seeks to develop a method for non-expert use by illustrating the immediacy of implementation through a case study application. What the work proposes is a Value Transfer with the Adjusted Unit VT method for a rapid evaluation of ES resulting from NBS implementation, aimed at the control of agricultural diffuse pollution, with particular attention paid to replicability and scalability on a European scale.

After a presentation of the methodology in Section 2, Section 3 highlights the main obtained results that can be used in future decision-making processes. Section 4 discusses the feasibility and limitations of the proposed tool and Section 5 summarizes the conclusions.

2. Material and Methods

VT can be applied using four different techniques [14,16], from the simplest Unit Value Transfer, which can be improved through adjustments, to Value Function and Meta-analytic Function Transfers, estimated through regression analyses (for more details on the methodology see [14]). The Adjusted Unit VT is chosen for its ease of application and its scalability, given that the data requirements for its replication are not resource intensive.

The process of VT analysis follows a series of phases common to any VT exercise, regardless of the method chosen. The relevant steps for the purpose of this methodology, listed in [14], are adopted in this work and explained in the following sections.

Over the past two decades, the literature on VT has been, in large part, focused on the validity and accuracy of the method [15]. Indeed, transferred values can significantly differ from the real value of the ecosystem service under consideration. Uncertainties occurring in the process of VT may arise both from inaccuracies from the original primary studies (denoted measurement errors) and generating from the transfer process itself (generalization errors) [15]. The latter occurs when values are transferred to policy sites that are different without carefully accounting for site differences [14]. Ref. [17] were among the first to recommend ideal criteria (on the basis of [18]) to guarantee, as much as possible, the more reliable and less uncertain value, as suggested by [15]. This methodology is developed with the aim of nullifying generalization errors, with the procedure explained in Section 2.3.

2.1. Literature-Based Review of Benefits

The economic valuation of NBS benefits followed a detailed procedure.

First, a literature review has been carried out with the aim of aggregating analyses, such as value transfer studies, meta-analysis, or narrative reviews, highlighting the most common benefits deriving from the implementation of relevant NBS investigated and the valorisation of associated ES benefits. Drawing from web-based sources (Google Scholar), the search followed a keyword process with different combinations of the terms "Wetlands", "Buffer Strips", "Benefits", "Nature-Based Solutions", "Multiple functions", "Multiple Benefits", "Meta-analysis", "Review". The search was run in April 2021. The studies considered in this phase do not attempt to provide a monetary evaluation of benefits but rather identify the potentially evaluable ESs [19–42].

The benefits then had to be filtered to select those most appropriate in the context of the studied NBS (Table S1 in Supplementary Materials).

2.2. Literature-Based Review of Economic Valuation

In the second phase, only the most appropriate environmental and social benefits were selected. We then conducted a specific investigation on the existing economic evaluations using this selection, as follow:

- the economic valuations must have addressed only study sites located in regions at similar latitudes and which share similar socio-economic characteristics with the target areas of the application of the methodology (i.e., EU and North America were considered);
- the environmental goods and services valued must be relevant to the benefits of the policy sites, thus economic valuations of the ecosystem services benefits deriving from the implementation of NBS for diffuse pollution control have been preferred. Some exceptions have been allowed for those benefits that report comparable values even in the case of generic ES valuations (as for Water Quality) and other exceptions have been allowed for those benefits of interest that have not been extensively assessed in previous NBS studies (i.e., Nuisance and Awareness/Education).

Overall, the types of study sources on economic valuation are:

- online databases and collections of values, considering two databases as sources of values ([43], appendix to [44]);
- summary studies, such as meta-analyses or value transfers of primary valuation literature using either conventional or non-conventional environmental valuation techniques;
- primary empirical analyses that use conventional techniques to determine individual preferences on environmental services;
- non peer-reviewed publications (master and doctoral thesis, technical reports and proceedings).

2.3. Value Transfer Methodology

To obtain comparable methods for the monetization of NBS benefits, a standardisation of the collected economic values was carried out in the third phase; through the literature review, different approaches have been identified, ultimately allowing us to develop a five-step method. The suggested methodology followed the approach proposed by [14] and allowed: (i) to consider inflation; (ii) to control for differences in price levels; (iii) to control the effect of income on the demand; (iv) to account for the different types of NBS and the different ecosystem services valuations; (v) to convert values into EUR (valued in 2021). The five steps are summarised and described in Table 1 (all indexes and indicators used for adjustments are reported in Table S3 of the online Supplementary Materials).

Table 1. Steps to calculate the adjusted VT of an ecosystem service for the policy site of interest.

Step	Year	Currency	Country	NBS	Description
(0)	year of the latest update of the value	currency used in the latest update of the value	study site	study site	Original value from the study site.
(1)	2021	currency used in the latest update of the value	study site	study site	To account for inflation, values have been adjusted to the general price level of the same year. To compare ecosystem service values computed in different years, they have been harmonized using the annual Consumer Price Index [45] *, with 2015 as the base year, transforming the values in the latest available "original" currency, which corresponds to the year 2021.
(2)	2021	USD	study site	study site	To control for differences in price levels, values have been transformed into USD 2021, using 2021 exchange rates [46] **, in order to proceed with step number (4) (which involves using a monetary measure expressed in USD).
(3)	2021	USD	study site	study site	To transfer the value to the NBS of interest, a correction factor was used, capable of taking into account the uncertainties due to the different evaluation contexts, evaluation methods, and indicators used to estimate the value of the ecosystem service. (This is applied after expert selection of the most appropriate study sites.)
The final steps in the methodology are left to the single study; when selecting an NBS benefit value, decision-makers should consider that the site-specific application of the methodology requires further adjustments in order to account for some effects.					
(4)	2021	USD	study site	policy site	To control for the effect of income on the demand and value of ecosystem services, estimates have been adjusted for differences in Gross Domestic Product per capita based on Purchasing Power Parity (PPP) [47] *** between study and policy site.
(5)	2021	EUR (or selected currency)	policy site	policy site	The values have finally been transformed into EUR 2021, using exchange rates [46] **. In the same way the practitioner may select a different currency, relevant to the policy site of interest.
To explicate the variability of the estimates, the values can be proposed as ranges: the maximum value corresponding to the adjusted economic value without applying the Correction Factor (the highest value may be chosen in case more than one suitable study site was selected); the minimum value corresponding to the economic value with the application of the Correction Factor (in case more than one study site was selected, the lowest value may be chosen).					

Notes: * https://data.oecd.org/price/inflation-cpi.htm#indicator-chart, accessed on 25 August 2022. ** https://data.oecd.org/conversion/exchange-rates.htm#indicator-chart, accessed on 25 August 2022. *** https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD, accessed on 25 August 2022.

As stated by [48], the attribution of a monetary value to nature is not considered to be absolute; rather, it is an indication of the monetary value relative to a particular area, a given time period, a specific beneficiary group, which depends on the context of valuation and on the use. The adjustments may be not sufficient to remove transfer errors (or generalization errors [15]), therefore, consistent with guidelines in [14], an additional correction factor was applied for their selection: a measure of monetization reliability (i.e., decision maker's confidence level), inspired by [49]. In addition, applying a Correction Factor allows to make a conservative choice by underestimating the original value.

The correction factor used in step (3) is calculated considering three different attributes:

i. NBS characteristics;
ii. The monetary valuation technique used to calculate the economic value; ref. [50] claim that the introduction of a rank ordering on monetary valuation techniques allows to better compare different studies, guiding the valuation process;
iii. The indicator used to quantify the extent of the benefits.

For each attribute of the correction factor, a score methodology was defined, reported in Table 2.

Table 2. Scores associated to the attributes for the VT step (3).

	Confidence Level Attributes	Type	Evaluation Method
(i)	Evaluation of the suitability of the NBS characteristics of the study site with the NBS of the policy site (object of the application of the methodology).	Categorical Score: 1–5	Expert-based evaluation 1 = very low 2 = low 3 = sufficient 4 = high 5 = very high
(ii)	Monetary valuation technique used for the economic value calculation.	Binary Score: 0–1	0 = Value Transfer 1 = Cost-based/direct market pricing if per hectare terms; Contingent Valuation/Choice experiment if per beneficiary terms
(iii)	Indicators used to quantify the extent of benefits—ecological, biophysical, or other appropriate indicators such as ES in the case of VT.	Binary Score: 0–1	Expert-based evaluation 0 = low reliability 1 = high reliability

Based on the sum of the attributes' scores, the correction factor is calculated as reported in the following:

- 1 when confidence level final scores [(i) + (ii) + (iii)] is 7
- 0.9 when confidence level final scores [(i) + (ii) + (iii)] is 6
- 0.8 when confidence level final scores [(i) + (ii) + (iii)] is 5
- 0.7 when confidence level final scores [(i) + (ii) + (iii)] is 4
- 0.5 when confidence level final scores [(i) + (ii) + (iii)] is less than 4

In conclusion, VT of ecosystem services for different NBS is calculated as follows:

$$VT^{PS}_{NBS,2021,€} = VT^{SS}_{NBS,2021,\$} \cdot CF \cdot \frac{GDP^{PS}_{2021}}{GDP^{SS}_{yearofVT}} \cdot c_{\$\ to\ €,2021}$$

where:

$\boldsymbol{VT^{PS}_{NBS,i,2021,€}}$ is the value transfer of the ecosystem service in the policy site (PS) for the NBS of interest in 2021, expressed in EUR (VT steps 1 + 2 + 3 + 4 + 5)

$\boldsymbol{VT^{SS}_{NBS,2021,\$}}$ is the value transfer of the ecosystem service in the study site (SS) for the NBS of interest in 2021, expressed in USD (VT steps 1 + 2)

$\boldsymbol{CF}$ is the Correction Factor assumed by the decision maker (VT step 3)

$\boldsymbol{GDP^{SS}_{yearofVT}}$ is the GDP per PPP for the SS country, expressed in USD (VT step 4)

$\boldsymbol{GDP^{PS}_{2021}}$ is the Gross Domestic Product (GDP) per capita based on Purchasing Power Parity (PPP) for the PS country, expressed in USD (VT step 4)

$\boldsymbol{c_{\$to€,2021}}$ is the Dollar to Euro exchange rate in 2021, equal to 0.845494 EUR/USD (VT step 5)

2.4. Case Study Application

The methodology is tested on a case study developed under the JRC-EC project aimed at studying the potential of NBS for climate change adaptation and water pollution retention in agricultural regions [51]. As described above, the Italian case study provides an example of how decision makers can use readily available economic values, transferring them to appropriately selected policy sites on a European scale.

The selected case study (for details see Supplementary Materials—Study Site description) regards two sub-basins (Marzenego and Dese-Zero—Figure 1), for a total surface of 37,785 hectares; they are located in the Venice lagoon catchment, in Northwestern Italy (Veneto Region), an important water body that, due to the huge economic growth that has occurred in the area, has suffered a dramatic deterioration of its ecological conditions since 1960.

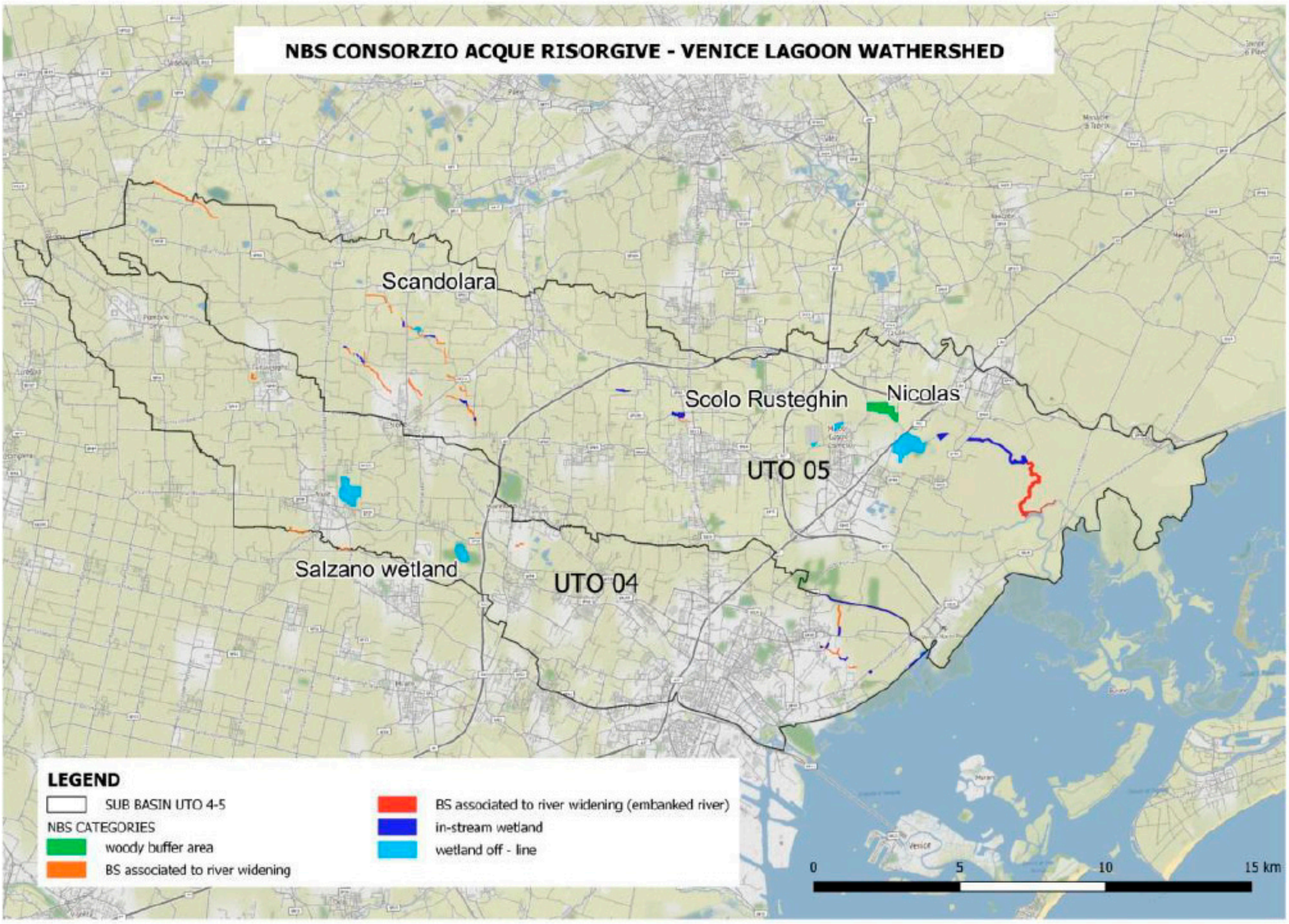

Figure 1. The two sub-basins (UTO) of the Consorzio di Bonifica—Acque Risorgive, where most of the NBS have been implemented since the year 2000, and the location of four of the implemented NBS.

Several national and regional laws determine the regulatory framework in the area, distributing tasks among the different administrative bodies (State, Region, Province, Municipalities): the most recent is the Regional Strategic Master Plan (SMP), which sets quantitative objectives of pollutant removal, envisaging, as a solution, the implementation of NBS. Since then, various NBS have been implemented by the Consorzio di Bonifica Acque Risorgive (A public body in charge of managing the water and preventing floods. The Regional Strategic Master Plan, approved in the year 2000, sets quantitative objectives for the removal of pollutants that includes nitrogen (the limiting factor controlling eutrophication in the Venice lagoon) from point and diffuse sources. The removal target set by the Strategic Master Plan is: 3000 tons per year for nitrogen for the entire region, including point and diffuse pollution sources), thanks to the financial resources provided by the government and allocated by the Regione Veneto, including in-stream and off-stream wetlands, buffer strips, and woody buffer areas along the network of diffuse water bodies that flow into the lagoon catchment, covering an area of approximately 252 hectares. The existing NBS in the two sub-basins are listed in Supplementary Materials—Study Site description.

The NBS that have been selected for the monetization of ES with the simplified approach proposed in this work are only those defined as landscape elements addressing diffuse sources of pollution due to fertilizers (and associated contaminants) and/or pesticides, i.e., wetland and buffer strips [2–5].

In the two sub-basins of Marzenego and Dese-Zero, 23 NBS of these types were created. As an example, Figure 2 shows the satellite views of two wetlands (Salzano and Rusteghin) and two buffer strips (Scandolara and Nicolas—selected because of their long-term monitoring activity [52–55] realized within the basin, which are described more in details in Supplementary Online Materials.

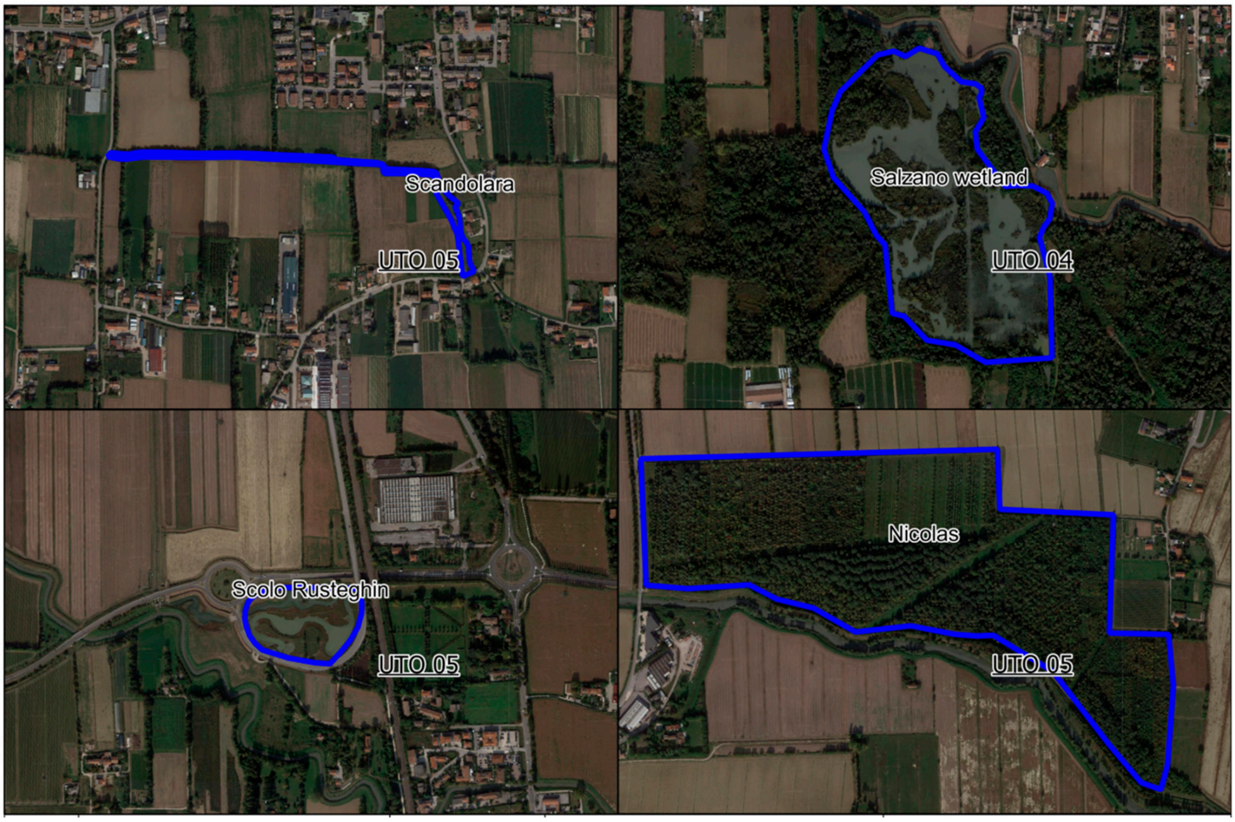

Figure 2. Satellite view of four NBS within the two sub-basins of Marzenego and Dese-Zero: the Scandolara buffer strip (**top right**), the Salzano wetland (**top left**), the Rusteghin wetland (**bottom left**), and the Nicolas buffer strip (**bottom right**).

3. Results

3.1. ES Identification and Classification

From the literature review on the benefits of selected NBS, 24 studies were detected, with the oldest dating from 1993 and the most recent one from 2019. The geographic focus was on advanced economies (particularly Europe and North America) with global reviews allowed. The outcome of this phase is the identification of 19 benefits from ES.

One problem that immediately arose is the use of different ES classification systems. Among the research adopting a classification, the Millennium Ecosystem Assessment [56] was the most used, followed by the Economics of Ecosystem and Biodiversity [57]. For this study, it was decided to categorize the benefits according to the Common International Classification of Ecosystem Services (CICES), as it builds on the previous two and it introduces a detailed hierarchical structure [58]. Another reason is that it is the only classification including a specific category for nuisance (Code: 2.1.2.3), which is of interest for the present study.

As displayed in Figure 3, some of the benefits associated with implementing Wetlands or Buffer Strips have been described by several studies, while others have only been identified by one or two researchers.

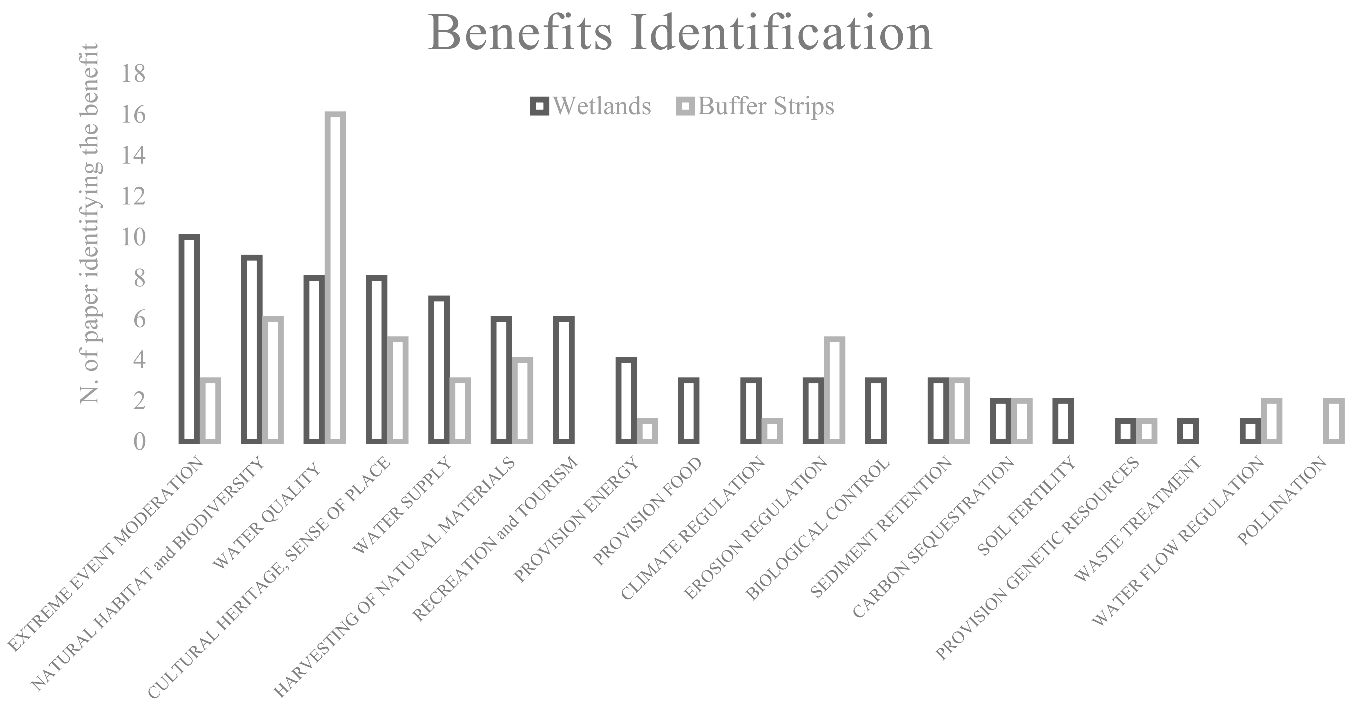

Figure 3. Identification of the benefits from Wetlands and Buffer Strips implementation, through literature review.

The nineteen benefits identified have been filtered out to select the most appropriate ones in the context of the studied NBSs. The selection has been carried out through expert judgment by considering the physical measurement of the service, the expected effects, and the CICES classification. The nine ES selected are reported in Table S4 (Supplementary Materials), associated with a brief description of the physical measurement of the service, the expected effects, and the CICES codes (both CICES version 4.3 and 5.1 codes are reported).

3.2. Study Site Collection

The revision of ES economic evaluation identified a total of 86 benefits' economic values. The number of articles reviewed is lower than the overall number of benefits, as a paper could focus on more than one NBS benefit ([40,59–94]; see Table S2 in Supplementary Materials). Ref. [63] is a high-frequency author; his work focuses on wetlands in the region of Catalonia, Spain, valuing ten benefits included in our samples. He is followed by [61], although the geographical focus, Canada, is less interesting for our purpose. Estimates of the benefits of buffer strips are mainly enhanced by the values reported by [73,91], from United Kingdom and United States, respectively.

During this screening, a large disparity emerged between studies focusing on one or the other NBS of our interest. Sixty-one records refer to wetland benefits, while only nineteen values are attributed to buffer strips benefits, with a further three values in common (i.e., Nuisance and Awareness/Education).

Monetization was included in a dataset, containing details on some interesting features, useful for selecting the most appropriate study site (Table S2 in Supplementary Materials).

The benefits' economic valuations were originally determined over the period from 1980 to 2018. However, not all the values have been extracted from the original research. Indeed, it has not always been possible to track down the original work; many values are reported from more recent research, referencing the original. In addition, as some values had already been updated in online databases and collections of values, it was preferred to keep this last adjustment in our dataset.

The values collected represent 13 countries (Austria, Belgium, Canada, Denmark, France, Germany, Greece, Italy, Poland, Spain, Sweden, United Kingdom, and United States).

The economic values collection was used to identify the measurement units (Figure 4) and allowed us to associate the best unit for each benefit. In the whole sample, the most used is per unit of ecosystem area measurement (currency/ha/year), covering 71% of the cases. Only one benefit shows a prevalence of per-beneficiary terms, as the literature suggests [14], a social benefit, Awareness/Education. To not increase the possibility of error in the final transfer, the base units have not been transformed into a common measure; converting to hectare units would increase the uncertainty in the transfer as the number of people involved in the valuation and/or population density and/or direct/indirect users must be taken into account, but the information provided is not sufficient.

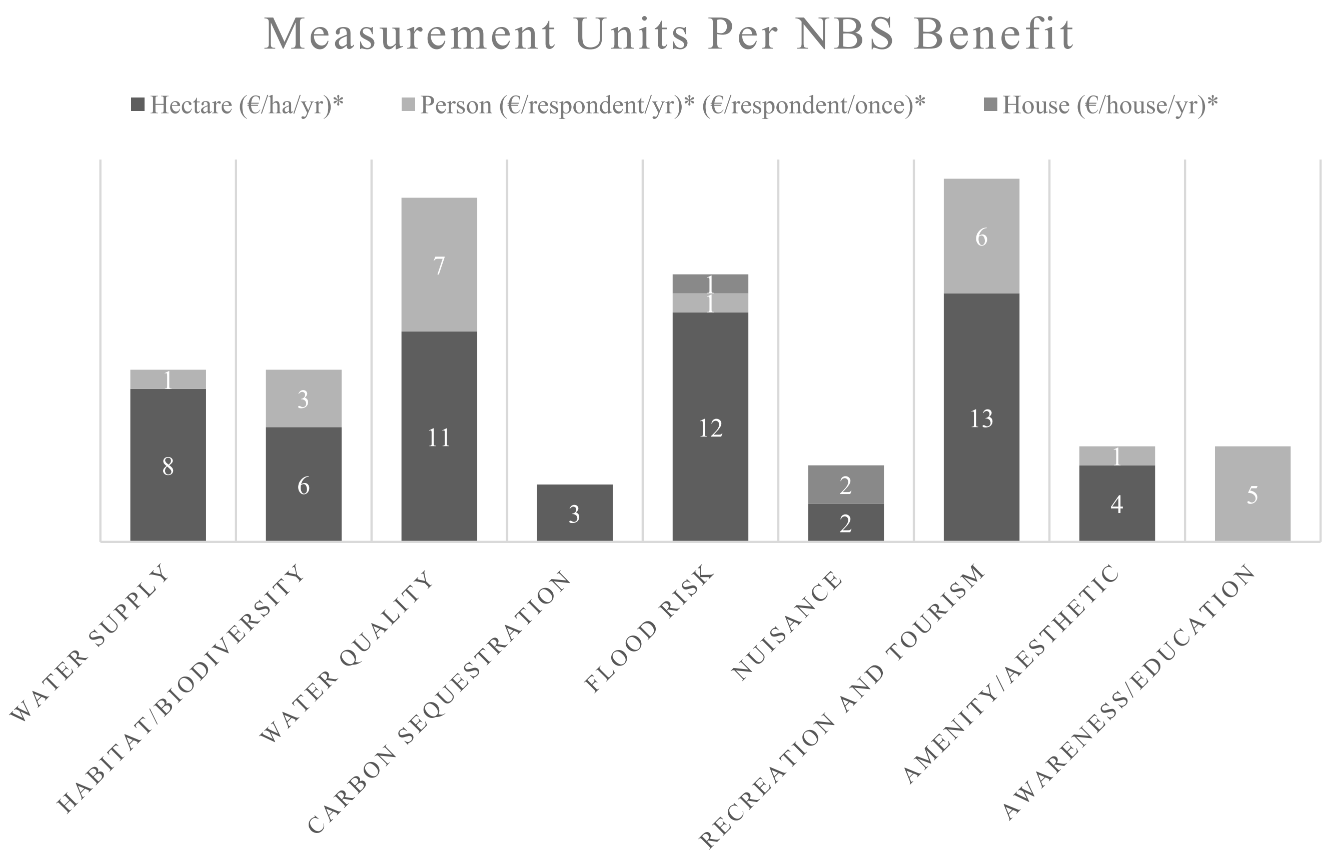

Figure 4. Most common measurement units in the study sites economic valuations, per NBS benefit (* EUR or any currency used in the study site economic valuations).

The only correction made in this phase, for a few cases, has been to homogenize the measurement units to our dataset (for example values expressed in per acre/year have been converted to per hectare/year).

Additionally, a specific set of information on the study site context has been collected to better understand the biophysical characteristics of the study sites candidates. However, these ecological, biophysical, or other appropriate indicators vary depending on the context as each decision-making situation is unique in space and time [50]. The results confirm that no study uses the same exact method as another. This is a major obstacle to the value transfer exercise, as the comparison and selection of a study site among many values based on different indicators lead to high uncertainty.

Valuation techniques used to associate economic values with physical measurements also differ considerably [50,95]. Even though different methods allow for different components of the Total Economic Value of the ES to be captured, this variety also further increases the uncertainty in the transfer. As anticipated, we also based the choice of the study site for each benefit to limit this uncertainty. In the pie chart (Figure 5) are depicted the most common monetary valuation techniques used to value the benefits of ES in our sample.

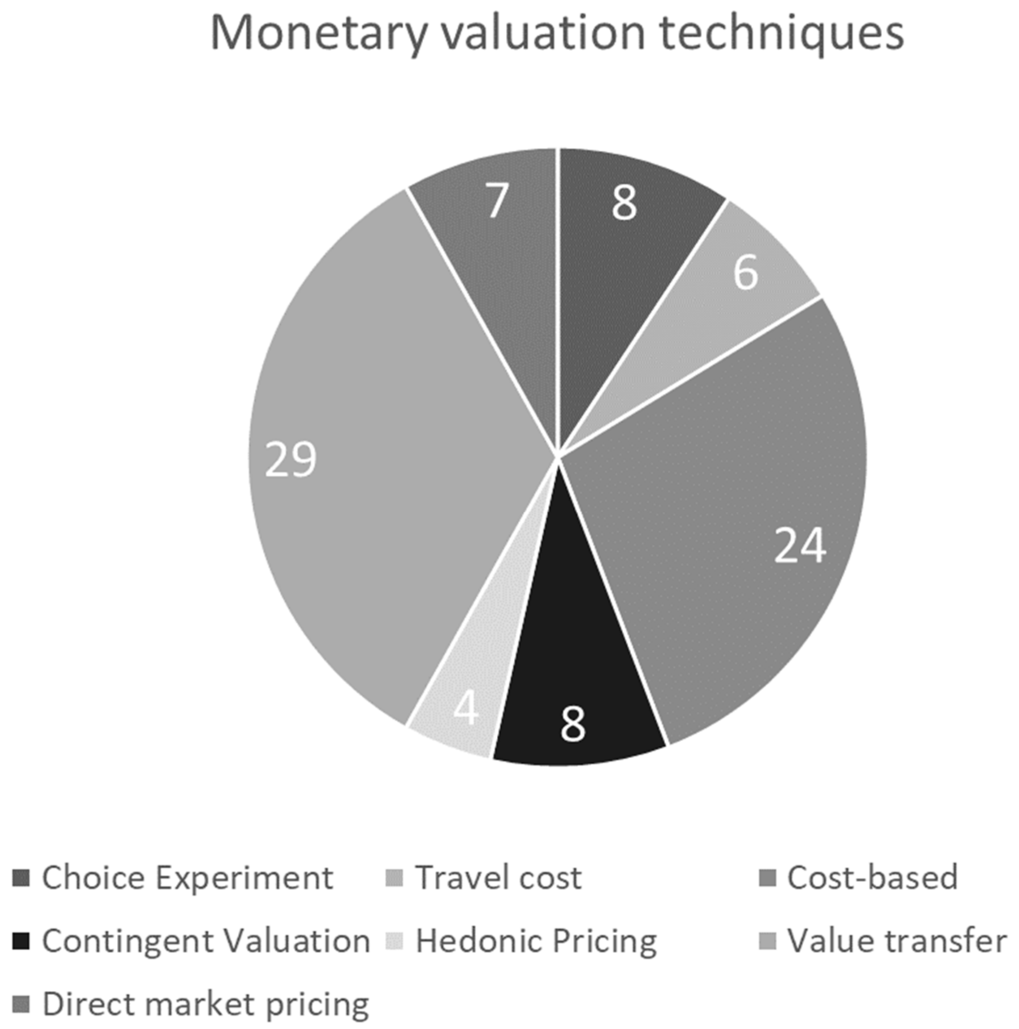

Figure 5. Most common monetary valuation techniques in the study sites economic valuations.

The cost-based approach (which comprises costs of avoided damage, replacement costs, and substitution costs methods) is the second most widely used method, while value transfer is the first. This is not to the advantage of this study as estimates obtained through the VT method are themselves endowed with transfer errors. Often not much information is provided either about the original monetary valuation technique involved in the VT exercise, or the indicator used to quantify the ES. Indeed, the only information collected in this category is on the ES on which the values has been transferred.

As anticipated, the factors described above increase the basket of measurement errors—i.e., inaccuracies from the original primary studies [15]—involved in the value transfer. The most appropriate study sites were chosen to reduce these sources of error, and a series of adjustments were performed to decrease the potential generalization errors—i.e., uncertainties generating from the transfer process itself [15].

3.3. Application of Adjusted Value Transfer Methodology—VT Steps (1) to (3)

In the third phase of the work, the economic values of the 86 benefits composing the initial sample have been adjusted for the comparison—through the adjustments planned in step (1) and (2) of the methodology—and for the selection.

The choice consisted of several criteria, aiming at excluding the study sites whose degree of correspondence [96] with the policy site is the lowest:

- values expressed in per hectare per year have been preferred; this is because the benefits computed through monetary valuation techniques based on stated preference method (i.e., Contingent Valuation and Choice Experiment) are based on subjective measures and represent more demand for ES (involving preferences) rather than supply [48]. In the case of Awareness/Education, the per beneficiary unit has uniquely been considered the most appropriate. Both the unit per beneficiary and the per hectare per year were gathered for the Recreation and tourism benefit. In the case of Nuisance, the unit EUR/house/year has also been kept.
- study site characteristics such as the type of wetland, surrounding environment, and threats to ecosystem stability have been weighted, reflecting the confidence level of the attribute; to this end, we tried not to select study sites with a low policy-site-fit values.
- the year of calculation of the value also assumed great importance in the choice. Since calculation methods vary over time, and so do people and preferences, recent studies have been preferred over older ones.

A maximum of three economic valuations (composed by a single value or a range) were selected for each benefit and for each NBS. The values in the final sample do not come from the same study site but, among all, ref. [63] has been a favourite.

Furthermore, the proposed VT requires the definition of a Confidence Level through which a Correction Factor is applied to the selected values, aiming to achieve the maximum possible reduction of the differences detected between the context of implementation and the source case/cases [14]. The choice of the score to be assigned to each of the attributes associated with each Study Site has been based on literature suggestions, as detailed in Section 2.3.

The selection is reported in the Supplementary Materials (Table S5); the values correspond to those obtained starting from the original value, with the adjustments up to step (3) of the methodology; the Correction Factor applied for each of the value included in this final selection is reported in Table 3.

Table 3. Correction factors for the value transfer of the selected study sites.

Benefit	Reference	(i) Policy-Site-Fit	(ii) Monetary Valuation Technique		(iii) Biophysical Indicator		Confidence Level	Correction Factor
Water Supply (Wet)	[63]	5	Value transfer	0	ES. Water supply: Filtering, retention AND storage of fresh water (e.g., aquifers) → Provision of water for consumptive use (e.g., drinking, irrigation, industrial)	1	6	90%
	[79]	3	Cost-based	1	Total calculated floodplain water storage was multiplied by the unit cost of water storage (EUR/m^3/year) assessed on the basis of economic evaluation of artificial reservoirs.	1	5	80%
Natural Habitat And Biodiversity Support (Wet)	[63]	5	Value transfer	0	ES. Suitable living space for wild species → Maintenance of biological AND genetic diversity; thus the basis of most other functions (e.g., community structure of sea grass meadows) AND Suitable reproduction/grow habitat → Maintenance of wild/commercially harvested species (e.g., sea grass meadows, coraligen AND littoral rock for fish juveniles)	1	6	90%
Water Quality (Wet)	[87]	5	Cost-based	1	Quantification of nitrogen retention within the flooded area resulting from the decreased running velocity. Two substitutes for the service 'improvement of water quality' are considered: (a) the marginal costs of waste water treatment in sewage treatment plants: mean 7.7 EUR/kg N (ranges from 5–8 EUR/kg N) (b) the marginal costs of avoidance of nitrogen loads by agricultural measures: mean 2.5 EUR/kg N (with a wide range depending on measures and production systems considered).	1	7	100%
	[63]	5	Value transfer	0	ES. Role of vegetation AND biota in removal of xenic compounds → Pollution control, detoxification, decomposition, filtering of particles by bacteria and other organisms; removal of nutrients such as nitrogen and phosphorous; beneficial trophic dynamics; abatement of noise pollution	0	5	80%

Table 3. *Cont.*

Benefit	Reference	(i) Policy-Site-Fit	(ii) Monetary Valuation Technique		(iii) Biophysical Indicator		Confidence Level	Correction Factor
Carbon Sequestration (Wet)	[82]	2	Direct market pricing	1	The social welfare value of GHG mitigation captures the value of the damages avoided by mitigating the risks of climate change. This is typically estimated with the use of integrated assessment general equilibrium models to capture the social cost of carbon, or SCC. The stream of total GHG flux per hectare is multiplied by the market and social value prices and then discounted back to the present with a 4% real discount rate.	1	4	70%
Flood Risk (Wet)	[72]	4	Cost-based	1	Reduction in house price from external cost caused by odor from an animal waste processing facility depending on odor perception distance.	0	5	90%
Nuisance (Odours, Rumors, Obstacles To Common Farming Practices) (Wet)	[74]	5	Hedonic Pricing	1	Reduction in house price from external cost caused by odor from an animal waste processing facility depending on odor perception distance.	0	6	90%
Recreation and tourism (Wet)	[72]	4	Value transfer	0	Recreational value: adjusted value transfer of willingness to pay for access	0	4	70%
	[63]	5	Value transfer	0	ES. Attractive land/seascape features → Enjoyment of scenery (e.g., scenic roads, housing, coastal/seascape) AND Land/seascapes with recreational uses → Travel to natural ecosystems for eco-tourism, rural-tourism AND nature study/enjoy; coast related cultural AND sports events	1	6	90%
	[59]	3	Travel Cost	1	Travel costs calculated as: Opportunity costs, which are based on the fact that a person who devotes time for leisure activities is paying for it, because he/she will not receive any wages during this time. Salaries are usually accepted as a proxy variable that reflects the opportunity costs of taking part in this recreational activity and therefore have been used in this study. (minimum interprofessional wage 18 EUR/day) → 1.5 h (time spent to reach the park + time spent at the park) × opportunity cost	0	4	70%

Table 3. *Cont.*

Benefit	Reference	(i) Policy-Site-Fit	(ii) Monetary Valuation Technique		(iii) Biophysical Indicator		Confidence Level	Correction Factor
Visual impact/Amenity And Aesthetic (Wet)	[63]	5	Value transfer	0	ES. Natural features with cultural AND artistic value → Use of nature as motive in books, films, painting, folklore, architecture, marketing AND Natural features with spiritual AND historic value → Use of nature for religious or historic purposes (e.g., heritage value of natural ecosystems AND features, small fisherman)	0	5	80%
Awareness/Education (Wet)	[62]	2	Travel cost	1	Environmental education: estimate of total cost visit to a national forest interpretive facility	1	4	70%
Water Supply (BF)	[63]	4	Choice Experiment	1	Marginal WTP for an improvement in wetland management attribute: educational, research and cultural information that may be derived from the existence of the wetland, including visits by scientists, students, and school children to learn about ecology and nature	1	6	90%
Natural Habitat And Biodiversity Support (BF)	[73]	5	Value transfer	0	ES. Water supply: Filtering, retention AND storage of fresh water (e.g., aquifers) → Provision of water for consumptive use (e.g., drinking, irrigation, industrial)	1	6	90%
Water Quality (BF)	[91]	1	Cost-based	1	Net benefit from reduced nitrate concentrations (−50%) in shallow groundwater estimated through average annual drinking water costs for the residents	0	2	50%
Carbon sequestration (bf)	[73]	4	Value transfer	0	Climate regulation (local temperature/precipitation, GHG sequestration, etc.): transition from values in the literature for permanent grassland towards those derived for wetted, carbon accreting soils or to wet woodland, using a marginal cost of carbon of £27 per tonne	0	4	70%
Flood risk (bf)	[63]	5	Value transfer	0	ES. Influence of ecosystem structure on dampening environmental disturbances → Storm protection (e.g., natural beaches, dunes, small bays or calas); flood protection (e.g., wetlands, forest, rieras)	0	5	80%

Table 3. *Cont.*

Benefit	Reference	(i) Policy-Site-Fit	(ii) Monetary Valuation Technique		(iii) Biophysical Indicator		Confidence Level	Correction Factor
Nuisance (odours, rumors, obstacles to common farming practices) (bf)	[74]	5	Hedonic Pricing	1	Reduction in house price from external cost caused by odor from an animal waste processing facility depending on odor perception distance.	0	6	90%
Recreation and tourism (bf)	[63]	5	Value transfer	0	ES. Attractive land/seascape features → Enjoyment of scenery (e.g., scenic roads, housing, coastal/seascape) AND Land/seascapes with recreational uses → Travel to natural ecosystems for eco-tourism, rural-tourism AND nature study/enjoy; coast related cultural AND sports events	1	6	90%
Visual impact/amenity and aesthetic (bf)	[73]	4	Value transfer	0	Local amenity and informal enjoyment: attractive river walk alternative of the upper Bristol Avon in its poached state (Assuming that 1 person per week might otherwise drive 10 miles −40 p per mile- for an alternative)	0	4	70%
Awareness/education (bf)	[80]	2	Travel cost	1	Environmental education: estimate of tc visit to a national forest interpretive facility	1	4	70%

3.4. Application of the Adjusted Value Transfer Methodology Steps (4) to (5)—Case Study

The methodology has been tested as an example of a specific application of decision makers, respecting the defined set of possibilities; the methodology, which can be applied at European scale, is employed on Italian case studies and has been used on wetlands and buffer strips, as it can be applied to NBS defined as landscape elements addressing diffuse sources of pollution due to fertilizers (and associated contaminants) and/or pesticides.

Given the definition of one European country (Italy) and an associated relevant currency (euro) through which to express the methodology output, steps (4) and (5) of the methodology have been computed.

Additionally, as virtually almost all transfers violate the ideal criteria of correspondence between study sites and policy sites [15], it is proposed to the practitioner to express values as ranges in order to explicitly state the variability of the estimates; this suggestion follows [14], who highlights that different ways to communicate uncertainties in final transfers might be a proper solution to apply.

Table 4 summarizes the resulting values by proposing them as ranges: the maximum value of the range is represented by the adjusted economic value without applying the Correction Factor (the highest value is opted for in case more than one suitable study site was selected); the minimum value of the range corresponds to the economic value with the application of the Correction Factor (in case more than one study site was selected, the lowest value was chosen).

Table 4. Final unitary economic values for each NBS benefit of case study.

	Wetlands			**Buffer Strips**		
	Value		**Units**	**Value**		**Units**
Water Supply	1417	7509	EUR/ha/yr	8409	9343	EUR/ha/yr
Natural Habitat And Biodiversity Support	494	549	EUR/ha/yr	16	20	EUR/ha/yr
Water Quality	3261	10,157	EUR/ha/yr	76	151	EUR/ha/yr
Carbon Sequestration	120	223	EUR/ha/yr	2261	3230	EUR/ha/yr
Flood Risk	209	232	EUR/ha/yr	342	427	EUR/ha/yr
Nuisance (Odours, Rumors, Obstacles To Common Farming Practices)	5066	49,268	EUR/house/yr	5066	49,268	EUR/house/yr
Recreation And Tourism	6154	6838	EUR/ha/yr	5996	6662	EUR/ha/yr
	4	6	EUR/person/visit			-
Visual Impact/Amenity And Aesthetic	3462	4328	EUR/ha/yr	1840	2628	EUR/ha/yr
Awareness/education	19	21	EUR/person/once	2	4	EUR/student/trip

Finally, the unitary values reported in Table 4 must be extended to the entire significant area under consideration. On the whole territory of the sub-basins of the case study (Marzenego and Dese-Zero), the quantitative values used for the value transfer were: 1727 and 796 hectares of wetlands and buffer strips, respectively; 21,322 people living within 1 km of the NBS (potential recreational users); 1760 pupils who could be involved in educational activities per year (for details see Supplementary Materials—Description of the Study Site). The results of the VT to the case study are summarised in Table 5.

Table 5. Results of the VT methodology to the case study of the Sub-basins, Marzenego and Dese-Zero, Italy.

Benefit	Sub-Basins: Marzenego and Dese-Zero			
	Wetlands		Buffer Strips	
	Min (EUR/Year)	Max (EUR/Year)	Min (EUR/Year)	Max (EUR/Year)
Water Supply	2,447,604	12,967,047	6,696,159	7,440,176
Natural Habitat and Biodiversity Support	853,480	948,311	13,001	16,251
Water Quality	5,631,403	17,539,990	60,248	120,496
Carbon Sequestration	208,035	385,829	1,800,662	2,572,374
Flood Risk	360,073	400,081	272,091	340,113
Nuisance (Odours, Rumors, Obstacles to Common Farming Practices)	8,747,849	85,064,599	4,033,840	39,225,301
Recreation and Tourism	10,627,201	11,808,001	4,774,910	5,305,455
	88,420	197,588		
Visual Impact/Amenity and Aesthetic	5,979,457	7,474,322	1,465,069	2,092,956
Awareness/Education	33,355	53,532	1892	7567

The results show that the total value of wetlands benefits lies in the approximate range from 34,000,000 and above 136,000,000 EUR/year, while the total value of buffer strips benefits lies in the approximate range from 19,000,000 and above 57,000,000 EUR/year.

For the sub-basins of Marzenego and Dese-Zero—by omitting nuisance, whose very high maximum value determines the widest range among the results—and for both types of NBS considered, the most valuable benefits are water quality and recreation and tourism (to which water supply is added, in the case of wetlands).

As expected, and equally as remarkable, the only benefit reaching a higher value for buffer strips than for wetlands is that associated with the ecosystem service of carbon sequestration.

4. Discussion

Due to the increasing sophistication and the number of empirical economic valuation studies in the literature [43,67], value transfer methods are beginning to be preferred, since they permit insights to be gathered on the numerous primary valuation studies and to appropriately transfer the monetary valuation outcomes on new policy sites [14].

The exercise here developed wants to contribute to proposing simplified VT methods for the evaluation of NBS for diffuse pollution control. What is immediately comparable with the unitary values obtained through the application of the methodology is the set of economic values collected through the preliminary literature review (Table S2—Supplementary Materials). Indeed, since only the output of one or two valuation exercises have been used in the transfer, the other economic values can be used as literature benchmarks for an immediate comparison. None of the values selected for the transfer represents an outlier or can be placed at the far extremes of these range; the extremes have been purposely avoided in the selection. In particular, overestimation has been accurately deflected in the case of the benefits Water Quality, Flood Risk, and Recreation and Tourism, highly appraised by some scholars [59,93], in order to avoid making the mistake of producing unrealistic expectations from the NBS, as [12] warns against. Against this background and considering each benefit separately, the unitary values displayed in Table 4 are reasonably within the spectrum of available EV from the existing literature.

The benefit transfer method can be considered as an alternative to primary valuation methods that allow its adoption by non-expert decision makers. VT, however, is not to be recognised as a valuation method; indeed, it only transfers values estimated in other studies dealing with similar goods or services [97]. Indeed, if value transfer produces results that are easily replicable and scalable, they may be less conclusive and consequently endowed with uncertainty on highly site-specific applications [98]. Contrary to a standardized method (such as VT), there is the opportunity to pursue a more precise analysis by refining the economic valuation of the NBS benefits; this would undoubtedly make the exercise more appropriate for technical purposes [10].

Among the different VT methods, although higher quality of the results can certainly be achieved through complex VT methods—more suitable for critical steps such as accounting, priority-setting, instrument design, or litigation [99]—this simplified method, allowing for less consumption of resources, both in terms of money and time, is suggested when the decision-making process is at an early stage [12,14]. The structure and meaning of this methodology are supportive of policy recommendations to have the economic appraisal of NBS benefits carried out ex-ante [7,10–12].

However, some authors [10,100] highlight that, in the literature, the ambitions of economic valuation seem to remain peripheral or distant from the concrete achievements expected and required [99] in terms of agents and processes of influence in the decision-making arena. Accordingly, what is claimed [10] is that the required approach, which this methodology embeds, is the standardization of non-market valuation methods, as opposed to proceeding with more precise studies.

The scope of this work is limited to the objectives below; the methodology starts at the identification of the benefits of wetlands and buffer strips designed to primarily address agricultural diffuse pollution in the European region—and only to these can it be referred—and subsequently associating with them a monetary evaluation. When the methodology is to be applied to a case study, it is fundamental to conduct a prior biophysical evaluation of the ecosystem services and then, only after, applying to them monetary estimates. This is also the procedure followed for the study site presented in this work; this paper, however, does not present all the phases of the assessment carried out for the wetlands of Scolo Rusteghin and Salzano and the buffer zones of the Scandolara and NICOLAS sites (part of Joint Research Center project—see Acknowledgement) but only the economic evaluation. Even though biophysical assessment is left out of the boundaries of this research, the methodology tries to account for the lack of explicit links with qualitative or quantitative characteristics of the ecosystem services evaluated; the first attribute of the correction factor (expert evaluation of the suitability of the NBS characteristics of the study site with the NBS of the policy site) and the third one (expert evaluation of the indicators used to quantify the extent of benefits (ecological, biophysical, or other appropriate indicators)) tries to minimize the distance between the monetary assessment transferred on the study sites and the biophysical estimations. If more in-depth analysis on this site must be conducted, VT is not the appropriate method as it responds to the aim of having an accessible solution when time, funding, or other constraints prevent the use of highly technical approaches.

Looking at the proposed methodology itself, it is necessary to point out some possible pitfalls.

First, it is clear that the selected benefits are quantified with different valuation methods. Since the collection of samples from only the same valuation method was not possible for each NBS and each ES, it was decided to select samples from different evaluation methodologies and to assign dedicated confidence levels (as also suggested by [14]). The same solution was adopted to solve the second issue; the physical measurement of the services upon which the economic valuation is build is almost never consistent among benefits, making it difficult to compare values based on different biophysical indicators and, ultimately, to select a study site very similar to a policy site [17,18].

Following the well-known guidelines presented in [14], the methodology embeds most of the required adjustments—inflation, differences in price levels, effect of income on the demand and value of ecosystem services, currency—but it also integrates a correction factor able to take into account the uncertainties arising from the transfer itself, i.e., generalization errors—different evaluating context, evaluation methods, and indicator used—and one last detail to communicate uncertainty, i.e., expressing values as ranges.

5. Conclusions

So as not to fall in the usual presentation of economic valuations, lacking a guide for application [10] comprehensive of replicability and scalability opportunity [9], a detailed monetary assessment accounting for the benefits of NBS has been proposed.

This was intended to evaluate nine identified benefits (water supply; natural habitat and biodiversity support; water quality; carbon sequestration; flood risk; nuisance; recreation and tourism; visual impact/amenity and aesthetic; awareness/education) of wetlands and buffer strips designed to address agricultural diffuse pollution, particularly in Europe. The identification of a total of 86 benefits' economic values available in the literature, allowed to select the most suitable valuation for the application of an Adjusted Unit Value Transfer methodology available for decision makers when time, funding or other constraints do not permit the use of highly technical primary monetization approaches. In order to reduce the distance from the expected and required concrete achievements of the economic valuations, i.e., to show the easiness of application, the exercise has been integrated with an exemplifying case study located in the Venice lagoon catchment, in Northwestern Italy. Here, quantitative objectives of pollutant removal have been set, envisaging the implementation of NBS as a solution—including on-stream and off-stream wetlands, buffer strips, and woody buffer areas along the network of diffuse water body draining into the lagoon catchment.

The exercise allows to gather insights on the numerous primary valuation studies and to appropriately transfer the monetary valuation outcomes to new policy sites; the results obtained are to be considered sound with existing evidence showing that the most valuable benefits of the considered NBS are water quality, and recreation and tourism, to which is added, in the case of wetlands, water supply.

This work is intended as a guideline for non-expert practitioners, including decision makers, both in its methodological section, which takes them through the steps required to replicate it, and in the application of the methodology to the two sub-basins (Marzenego and Dese-Zero) provided as an additional guide for them.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/w16060898/s1, Excel file (Table S1—Literature review for the selection of NBS benefits; Table S2—86 benefits' economic values; Table S3—Indicators used for adjustments; Table S4—Identified NBS benefits and their main features; Table S5—Details on selected study sites and adjusted values). Word file (Study Site description).

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