Guidance document for the ESVD Value Transfer Tool

This purpose of this guidance document is to elaborate and explain the Ecosystem Services Valuation Database (ESVD) Value Transfer Tool (VTT), which is available on esvd.net. The document provides 1. a general introduction to value transfer functions; 2. an explanation of the VTT and how to use it; 3. some example applications to illustrate the use of the tool.

1. Introduction to value transfer functions

Value transfer involves the use of results from existing primary valuation studies for other ecosystems ("study sites") to ecosystems that are of current investment or policy interest ("policy sites"). Value transfer is also known as benefit transfer but since the values that are transferred may be costs as well as benefits, the term value transfer is more generally applicable.

The advantages of using value transfers instead of conducting new primary valuation studies are that primary valuation studies are often time-consuming, expensive, require technical expertise and are generally only feasibly conducted at local scales or for a limited number of ecosystems. Value transfer, when executed correctly, can be cheaper, less time-consuming and can be executed at different scales, while still accounting for local variation via the inclusion of various biophysical and socio-economic context variables.

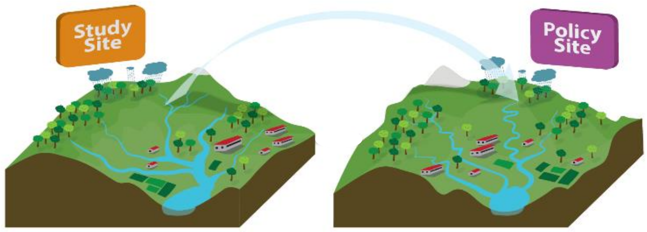

Figure 1: A value transfer function is used to create better and more accurate estimations of monetary values of ecosystem services of a policy site, using monetary valuation data from a study site.

In short, value transfer methodologies use existing value information from a 'study site' to estimate the value of a new 'policy site' (see figure 1).

There are several approaches to conducting value transfers, including unit transfer, adjusted unit transfer, value function transfer and, used in the VTT, meta-analytic value transfer. Meta-analytic value transfers (see figure 2) use data from multiple valuation studies (in this case from the ESVD) in a regression analysis to estimate a function that relates the monetary value an ecosystem service to the characteristics of:

- Beneficiaries (e.g. income, population)
- Study sites (e.g. extent, condition, scarcity)
- Valuation methods (e.g. CV, CE, HP, ….)

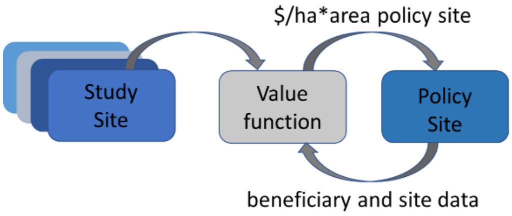

Figure 2: Visualization of a meta-analytic value transfer function.

In applying meta-analytic value transfer, the characteristics of the policy site(s) are plugged into the value function to estimate site specific values.

2. The ESVD Value Transfer Tool

The ESVD VTT can be used to estimate ecosystem service values that reflect policy site characteristics as entered by the user. Currently this tool is available for a limited set of biomes (tropical forests and agricultural land) and will be expanded to include other biomes in the near future as these value functions are developed.

2.1 Why the Value Transfer Tool

The ESVD currently contains over 10,000 value records covering all ecosystem services and biomes. This collection of information, although large, is not readily usable for conducting simple value transfers to inform policy making or to do research for two reasons:

1. The data is not globally representative of ecosystem service values but instead represents the availability of study results in the literature, which is determined by past research funding and interests. It is therefore difficult to use simple summaries of global data from the ESVD as representative of "average" ecosystem service values in specific contexts.
2. Ecosystem service values are inherently highly spatially variable and influenced by site and context characteristics that determine the supply and demand for ecosystem services. Direct application of summary values from the ESVD in value transfers are therefore likely to result substantial transfer errors (over or under estimation of values).

The VTT has been developed to address these challenges and to enable more context specific (localised) estimations. The use of value transfer functions, as implemented in the VTT, in combination with other data sources, have considerable potential to improve the precision of value transfers for ES but need to be used appropriately and with caution.

2.2 What the Value Transfer Tool tells us

The value of ecosystem services expressed in monetary units reflects the importance of nature in a language that is widely understood. In that light, it is very important to keep in mind that the transferred value provides an indication of the order of magnitude of the ecosystem service value at the policy site controlling for a set of relevant explanatory factors. It does not necessarily reflect all relevant determinants of ecosystem service value at the policy site and the estimated value may differ from the results of site-specific primary valuation studies. Estimated values should only be used in relevant contexts and validated using a broader set of decision-making tools.

The output of the VTT is in international dollars at 2020 price levels per hectare per year (Int$/ha/year). The output can be used to show the current ES value at a policy site, but it could also be used to explore changes in value in scenario analyses.

2.3 Who the Value Transfer Tool is for

The VTT is intended for anyone interested in estimating the monetary value of ES for a specific policy site. It is of potential use to:

- Public policy makers - In the development of public policy in relation to restoration and conservation, in scenario analyses of impacts of land cover change and in the development of Payment for Ecosystem Services (PES) schemes. It can be used to highlight the benefits of conservation and restoration.

- Private decision makers – New regulations, such as the CSRD in the EU, will require organizations and financial institutions to measure and disclose their impacts on nature. Additionally, companies and financial institutions are becoming aware of the risks of nature loss for their business as many are dependent on nature in some ways (for more information, see this influential DNB report). In both cases, the VTT could be used to assess impacts and dependencies on nature via impact and risk assessments.

- Research & academia – The VTT may be used by researchers to derive estimates for ES values for input to models and analysis related to ecosystem services and natural capital. An example of using the ESVD for value transfer functions can be found in the Natural Capital section of the ABC-Map developed by the FAO (see also section 4 below).

All outcomes of the VTT should be used with caution (see section 3 below for more information).

2.4 Step by step guidance of the VTT

Using the VTT on esvd.net involves the following steps:

1. Select the biome of interest from the drop-down list.
2. Select the ecosystem service category for which you want to estimate a value.
3. Enter data for each of the variables describing your study site. The units in which each variable is measured are provided under "Short explanation". The range of feasible values for each explanatory variable is limited to the range observed for the study sites of the selected biome contained in the ESVD. Further information on the definitions and data sources for the explanatory variables included in the value functions can be found here.
4. In the case that data for an explanatory variable is unavailable for your study site, it is possible to use a default value (select the checkbox on the right). The default value is the mean value for the variable across the study sites of the selected biome contained in the ESVD.
5. All fields are required to estimate an ecosystem service value.
6. Click on the "Calculate" button to estimate a value, which displays in the "Result" box below. Values are reported in International dollars/ha/year at 2020 price levels.

To give an example of the output of the VTT, figure 3 shows a hypothetical case for a tropical forest gives a value of $811,70 per hectare for all regulating ecosystem services for a tropical and subtropical lowland rainforest policy site. This value means that, given the current dynamics at the 'policy site' represented by the context variables, the combination of all regulating services reflects the value of approximately $800 per hectare. This value should be seen as an order of magnitude, reflecting the importance of ecosystems to humans. If one hectare is lost, $800 of value is lost and vice versa, therefore indicating the importance of this tropical forest in terms of ecosystem services. These $800 reflect a societal value to different types of stakeholders, depending to the context of your policy site. It is therefore also very important and recommended to use other sources and tools in addition to the VTT.

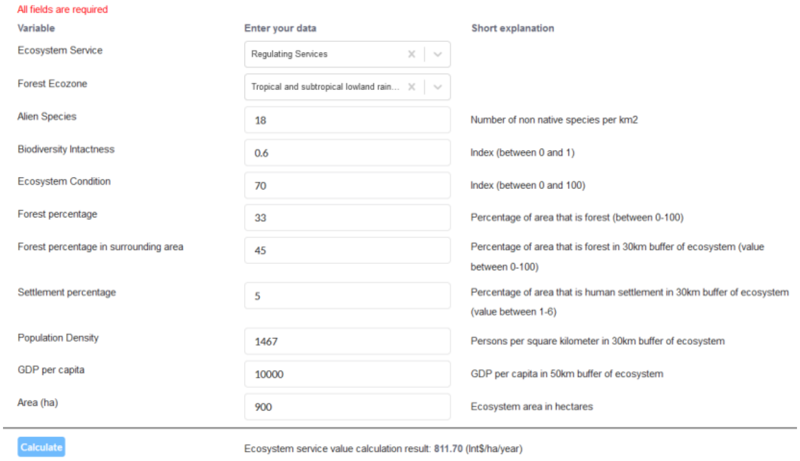

Figure 3: Example of the output of the VTT.

2.5 Context variables used in the value functions

A number of spatially defined context variables are used in the specification of the value functions used in the VTT, for more information on their units and background, see here.

<u>The tropical forest value function contains the following 9 context variables:</u>

1. Alien species (Number of non native species per km2)
2. Biodiversity intactness (Index (between 0 and 1)
3. Ecosystem condition Index (between 0 and 100)
4. Forest percentage (Percentage of area that is forest)
5. Forest percentage in surrounding area (Percentage of area that is forest in 30km buffer of ecosystem)
6. Settlement percentage (in 30km buffer of ecosystem)
7. Population Density (Persons per square kilometer in 30km buffer of ecosystem)
8. GDP per capita (GDP per capita in 50km buffer of ecosystem)
9. Area (Ecosystem area in hectares)

<u>The agricultural land value function contains the following 13 context variables:</u>

1. Fragmentation (in Km2)
2. Human appropriation of net primary productivity (Millions of kg of carbon per square meter
3. Population density (Persons per square kilometer in 30km buffer of ecosystem
4. Ecosystem area in hectares
5. Ecosystem condition (Index between 0 and 100)
6. Biodiversity Intactness (Index between 0 and 1)
7. Human modification index (Index between 0 and 1)
8. Net Primary Productivity (in kg*C/m^2)
9. Alien Species (Number of non native species per km2)
10. Night time light (nano Watt/cm2/sr)
11. Population mean age (years)
12. GDP per capita
13. GDP per capita in 50km buffer of ecosystem
14. Percentage of protected Area

Some specific observations related to the VTT:

- Tropical forest value transfer: Value estimates are for overarching categories of ecosystem services, namely for provisioning, regulating and cultural ecosystem services, and not for specific ES.
- Agricultural value transfer: Value transfers can be conducted for specific ecosystem services (TEEB classification)
- The variables in the VTT are not confounding, meaning that the various independent variables do not influence each other and therefore influence the outcome.
- Extreme input values for the various variables could provide very high or very low outcomes in terms of monetary values.
- Decreasing returns to scale: Larger areas of tropical forest tend to have lower values per unit of area.
- Abundance/scarcity effects: Tropical forests in regions with greater forest cover then to have lower values per unit of area due to effect of relative abundance of substitute ecosystems.
- Limited Scope: While VTTs can provide useful estimates of the economic value of ecosystem services, they may not capture the full range of ecosystem benefits, leading to an incomplete understanding of the overall value of ecosystems.
- The VTT relies on and is bounded by the data from the primary valuation studies included in the ESVD. This means that minimum and maximum values used as input in the VTT variables cannot exceed the minimum and maximum values observed in the underlying primary valuation studies. Therefore, it may not be possible to specify the unique characteristics of ecosystems in the policy site of interest.

3. Responsible use of the Value Transfer Tool

The VTT is a specialized tool and requires specific knowledge of using value transfer functions, both in terms of data as well as in terms of interpretation of results and variation in the outcomes. For collaboration regarding the use of value transfers for decision making and research, please get in touch via esvd@fsd.nl.

In no event will the Foundation for Sustainable Development, their affiliates, agents or collaborators be liable for any damages; including without limitation, direct or indirect, special or incidental, moral or consequential, arising in connection with use of the ESVD VTT.

4. Example application of the agriculture value function

To test the accuracy of using the estimated meta-analytic value function for value transfers, we conduct an in-sample prediction of values by inputting the parameter values of each study site into the function. The predicted and observed values (i.e., the primary value estimates recorded in the ESVD) are compared by computing the absolute percentage error (APE). The minimum APE is close to zero and the maximum is 508. Across the whole sample the mean APE is 7.5891. This is in line with similar analyses in the literature (Brouwer et al., 2022) and shows that transfer errors are generally low but can be high in some cases. It should be noted, however, that the observed primary values to which predicted values are compared are not necessarily accurate themselves.

To illustrate the potential for using meta-analytic value transfer for estimating spatially variable ES values, we conduct a value transfer exercise to estimate the economic value of a single ecosystem service in a specific context. For this purpose, we randomly selected a “study site” from the ESVD to which values are transferred. This is an area of cropland covering 196,740 ha in Kelem Wellega, Ethiopia. The primary estimate of the value of the food provisioning service for this area is 2,782 Int$/ha/year (Tilahun, 2020). The predicted or transferred value for this site is computed by multiplying the estimated coefficients in the value function (Table 3, Column 2) by the parameter values for this specific site (Table 3, Column 3). The sum of these products (Table 3, Column 4) gives the natural log of the predicted value, and the value in Int$/ha/year can subsequently be computed as the exponent of this number. In this case, the predicted value is 2,029 Int$/ha/year, which is approximately 27% below the primary value estimate.

This example application can be extended to illustrate how the value of changes in site characteristics (e.g. a change in ecosystem condition through land restoration) can be estimated. For example, by changing the site parameter value for ecosystem condition from 18.22 to 27 (the mean value for our sample of study sites), the predicted value of food provisioning increases from 2,029 Int$/ha/year to 3,468 Int$/ha/year. Similarly, the cost (decline in value) of ecosystem degradation can be estimated. For example, by decreasing the site parameter value for biodiversity intactness from 0.93 to 0.85 (the mean value for our sample of study sites), the predicted value of food provisioning decreases from 2,029 Int$/ha/year to 1,434 Int$/ha/year.

Table 3. Example value transfer application to a cropland area in Ethiopia

	Value function coefficients (A)	Site parameter values (B)	A*B
Constant	45.354	1	45.35
Area_ha_ln	0.008	12.19	0.10
Cropland_Irrigated	2.833	0.00	0.00
Cropland_Extensive	2.266	0.00	0.00
Cropland_Intensive	2.256	0.00	0.00
Hedgerows	1.357	0.00	0.00
Plantation	3.628	0.00	0.00
Vinyards	2.592	0.00	0.00
Orchards	1.15	0.00	0.00
Pasture_Sown	1.601	0.00	0.00
Rice_Temp	-0.602	0.00	0.00
AgroForest_Peren	0.96	0.00	0.00
Aesthethic	1.195	0.00	0.00
Bio_Control	2.491	0.00	0.00
Climate_Reg	0.648	0.00	0.00
Erosion_Reg	3.16	0.00	0.00
Existence_Bequest	6.819	0.00	0.00
Food	0.867	1.00	0.87
Cognitive_Dev	0.958	0.00	0.00
Inspiration	0.864	0.00	0.00
Maintain_Life_Cycles	0.905	0.00	0.00
Maintain_Soil	3.404	0.00	0.00
Extreme_Event_Reg	0.513	0.00	0.00
Recreation_Tourism	1.137	0.00	0.00

Pollination	3.318	0.00	0.00
Raw_Materials	0.503	0.00	0.00
Water_Flow_Reg	3.385	0.00	0.00
Water_Prov	3.852	0.00	0.00
EcosystemCondition_A	0.061	18.22	1.11
Biodiversity_Intact_A	4.448	0.93	4.13
Human_Mod_A	8.365	0.01	0.05
Fragmentation_A	-5.047	0.23	-1.17
NPP_A_ln	-0.289	8.56	-2.47
HANPP_A_ln	-0.337	11.22	-3.78
Alien_Species_A_ln	-3.53	4.38	-15.47
Night_Light_A_ln	-2.212	0.24	-0.53
Pop_Dens_B30_ln	0.242	4.10	0.99
PA_Percent_B30_ln	0.318	3.26	1.04
GDPPC_B30_ln	-1.162	7.55	-8.77
Pop_Age_B30_ln	-4.381	3.16	-13.83
Int$/ha/year (ln)			7.615
Int$/ha/year			2,029

Discussion

The proposed approach for using meta-analytic value functions to estimate ecosystem service values accounting for spatial variation in site and context characteristics is shown to be feasible and justified. Given the substantial spatial variation in the value of ecosystem services, there is good reason to invest in developing the necessary data and methods to enable meta-analytic value transfers that can account for local scale determinants of supply and demand.