Topics in Sustainable Finance:
Valuation of Ecosystem Services

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November 2022

Research laboratory on Socio-Economic and Environmental Sustainability
ReSEES

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Alliance of Excellence for Research and Innovation on Aephoria

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Accelerators

- Sustainable Development Solutions Network – A Global Initiative for the United Nations – Global Climate Hub (Athens University of Economics and Business; ATHENA Research & Innovation Information Technologies)
- eit Climate-KIC Hub Greece – Funded by the European Union
- ClimAccelerator Maritime – eit Climate-KIC – Co-funded by the European Union
- BRIGAID CONNECT – Innovation for Resilience

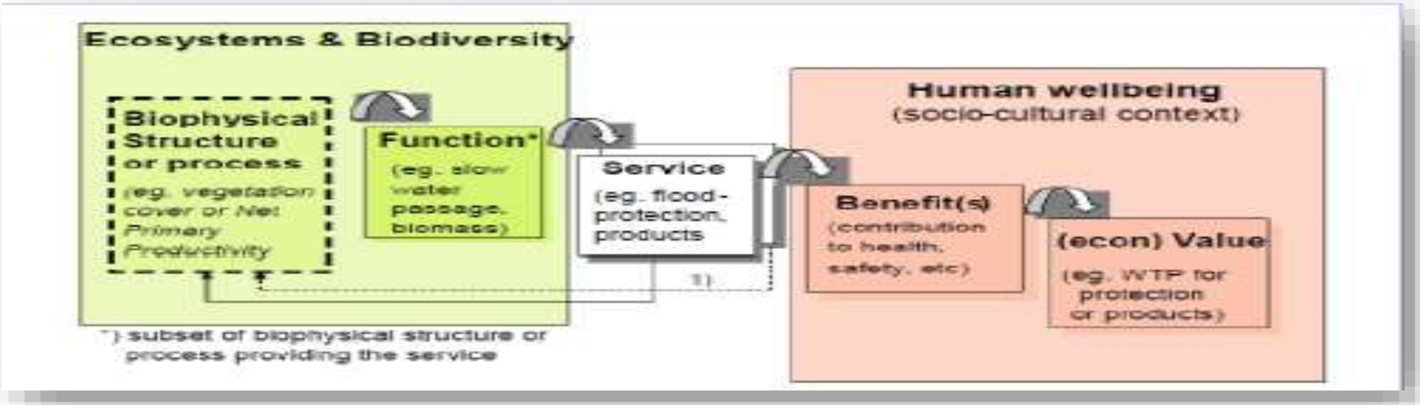
Academies, Networks, Associations

- Sustainable Development Solutions Network – A Global Initiative for the United Nations
- Academia Europaea ~1988~
- SDSN Europe
- SDSN Greece
- World Academy of Art and Science
- EAERE – European Association of Environmental and Resource Economists
- Water Europe – Technology & Innovation
- Nexus Cluster
- iap – Science, Health, Policy – the interacademy partnership

Sustainable Finance

Integrating the Value of Natural Capital

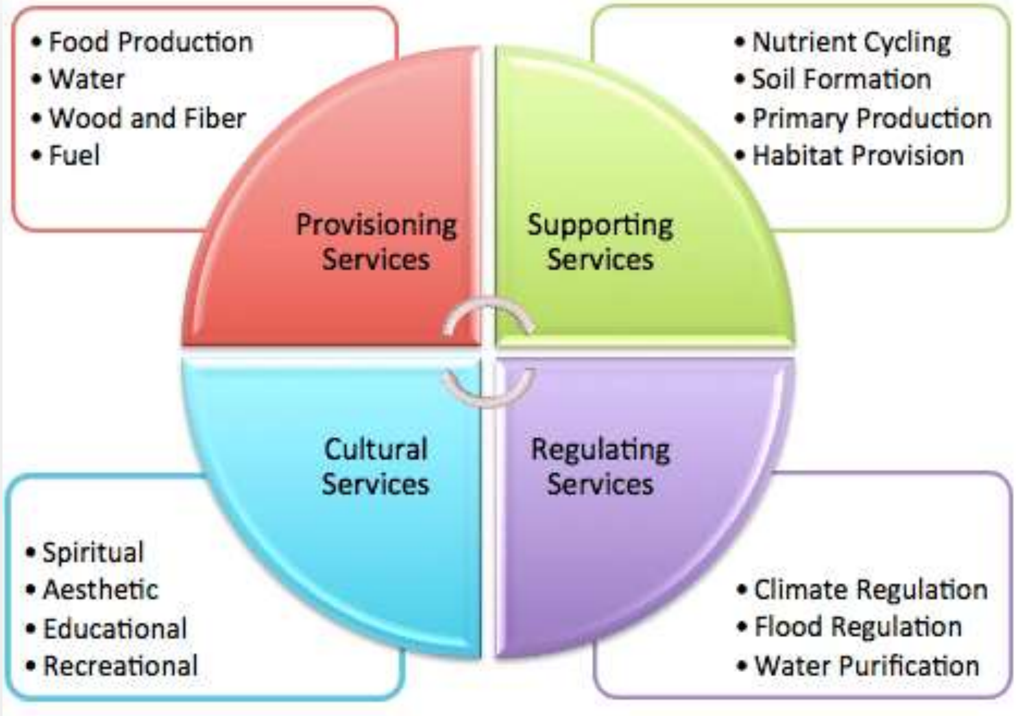
Ecosystem services (Millennium Ecosystem Assessment)



*Ecosystem services are the **conditions** and **processes** through which natural ecosystems, and the species that make them up, **sustain and fulfill human life**.*

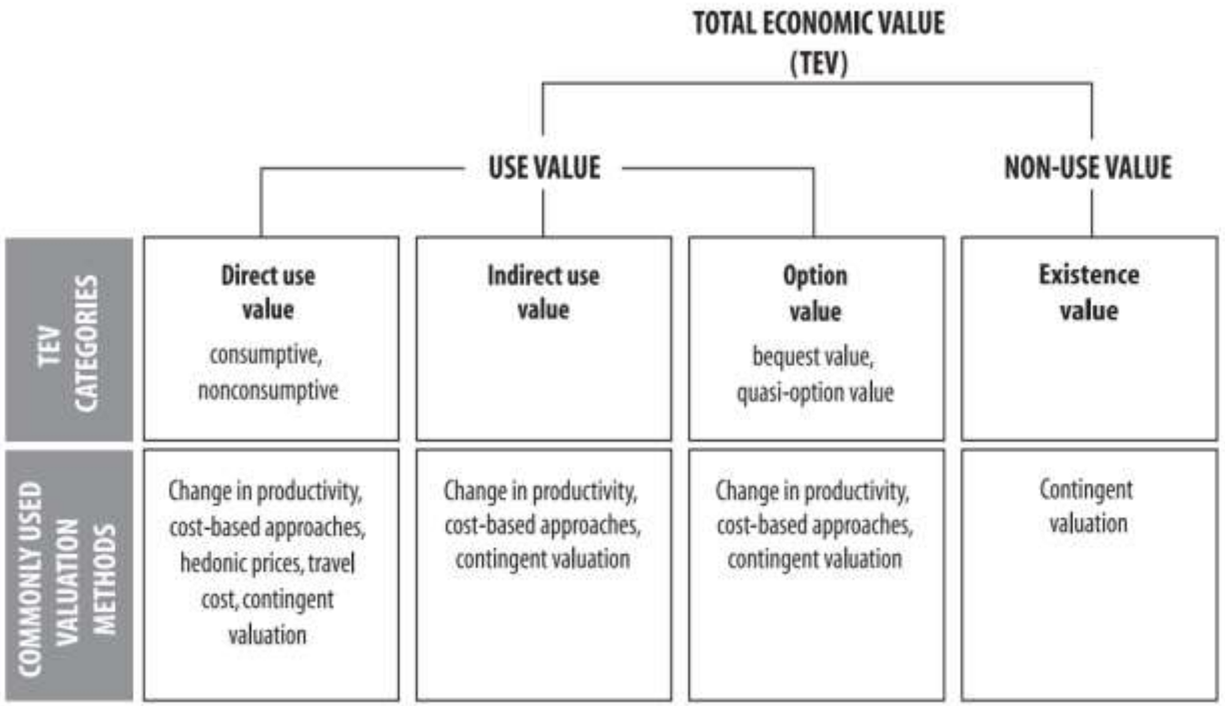
Daily 1997

Provisioning Services: The **products** obtained from ecosystems
Regulating Services: The benefits obtained from the regulation of ecosystem processes
Cultural Services: The nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences
Supporting services: Services that are necessary for the production of all other ecosystem services



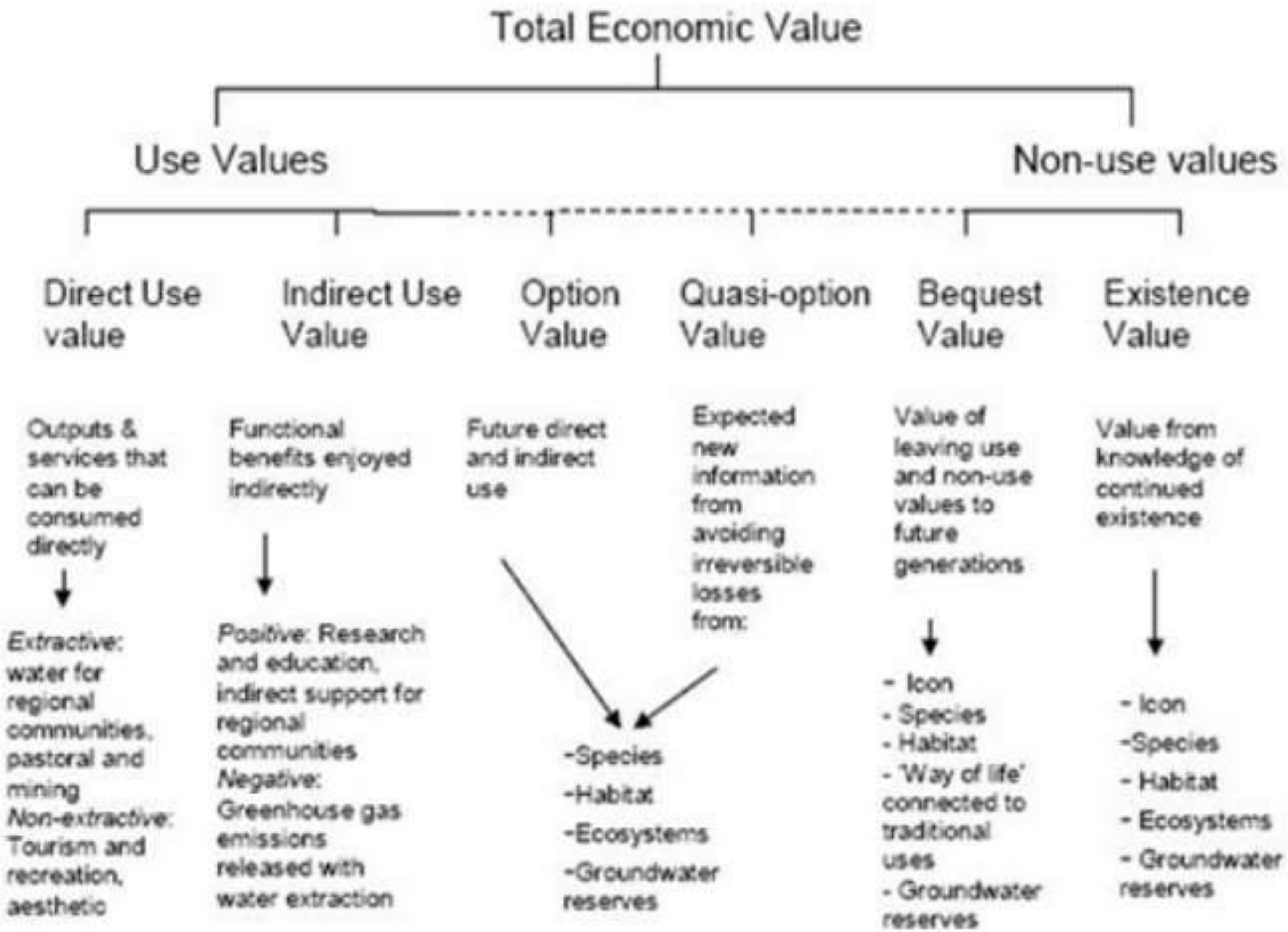
Source: Millenium Ecosystem Assessment, 2005.

The Total Economic Value Framework



- **Use value includes:**
  - **Direct use value:** Individuals make actual or planned use of an ecosystem service.
    - **Consumptive use** -> the use of resources extracted from the ecosystem (e.g. food, timber)
    - **Non-consumptive use** -> the use of the services without extracting any elements from the ecosystem (e.g. recreation, landscape amenity).
  - **Indirect use value:** individuals benefit from ecosystem services supported by a resource rather than directly using it.
  - **Option value:** the value that people place on having the option to use a resource in the future even if they are not current users
- **Non-use value (passive use):** Is derived from the knowledge that the natural environment is maintained.
  - **Existence value:** derived from the existence of an ecosystem resource, even though an individual has no actual or planned use of it. For example, people are willing to pay for the preservation of whales, through donations, even if they know that they may never actually see a whale.

Non-use value is relatively challenging to capture since individuals find it difficult to 'put a price' on such values as they are rarely asked to do so. However, in some circumstances, nonuse value may be more important than use value.



Total Economic Value
Use Values
Non-use values
Direct Use value
Indirect Use Value
Option Value
Quasi-option Value
Bequest Value
Existence Value
Outputs & services that can be consumed directly
Functional benefits enjoyed indirectly
Future direct and indirect use
Expected new information from avoiding irreversible losses from:
Value of leaving use and non-use values to future generations
Value from knowledge of continued existence
Extractive: water for regional communities, pastoral and mining
Non-extractive: Tourism and recreation, aesthetic
Positive: Research and education, indirect support for regional communities
Negative: Greenhouse gas emissions released with water extraction
-Species
-Habitat
-Ecosystems
-Groundwater reserves
- Icon
- Species
- Habitat
- 'Way of life' connected to traditional uses
- Groundwater reserves
- Icon
-Species
- Habitat
- Ecosystems
- Groundwater reserves

Valuation Methods

Valuation method	Element of TEV captured	Ecosystem service(s) valued	Benefits of approach	Limitations of approach
Market prices	Direct and indirect use	Those that contribute to marketed products e.g. timber, fish, genetic information	Market data readily available and robust	Limited to those ecosystem services for which a market exists.
Cost-based approaches	Direct and indirect use	Depends on the existence of relevant markets for the ecosystem service in question. Examples include man-made defences being used as proxy for wetlands storm protection; expenditure on water filtration as proxy for value of water pollution damages.	Market data readily available and robust	Can potentially overestimate actual value
Production function approach	Indirect use	Environmental services that serve as input to market products e.g. effects of air or water quality on agricultural production and forestry output	Market data readily available and robust	Data-intensive and data on changes in services and the impact on production often missing
Hedonic pricing	Direct and indirect use	Ecosystem services that contribute to air quality, visual amenity, landscape, quiet i.e. attributes that can be appreciated by potential buyers	Based on market data, so relatively robust figures	Very data-intensive and limited mainly to services related to property
Travel cost	Direct and indirect use	All ecosystems services that contribute to recreational activities	Based on observed behaviour	Generally limited to recreational benefits. Difficulties arise when trips are made to multiple destinations.
Random utility	Direct and indirect use	All ecosystems services that contribute to recreational activities	Based on observed behaviour	Limited to use values
Contingent valuation	Use and non-use	All ecosystem services	Able to capture use and non-use values	Bias in responses, resource-intensive method, hypothetical nature of the market
Choice modelling	Use and non-use	All ecosystem services	Able to capture use and non-use values	Similar to contingent valuation above

Source: Based on eftec (2006) *Valuing our Natural Environment*

Non-Market Valuation Methods

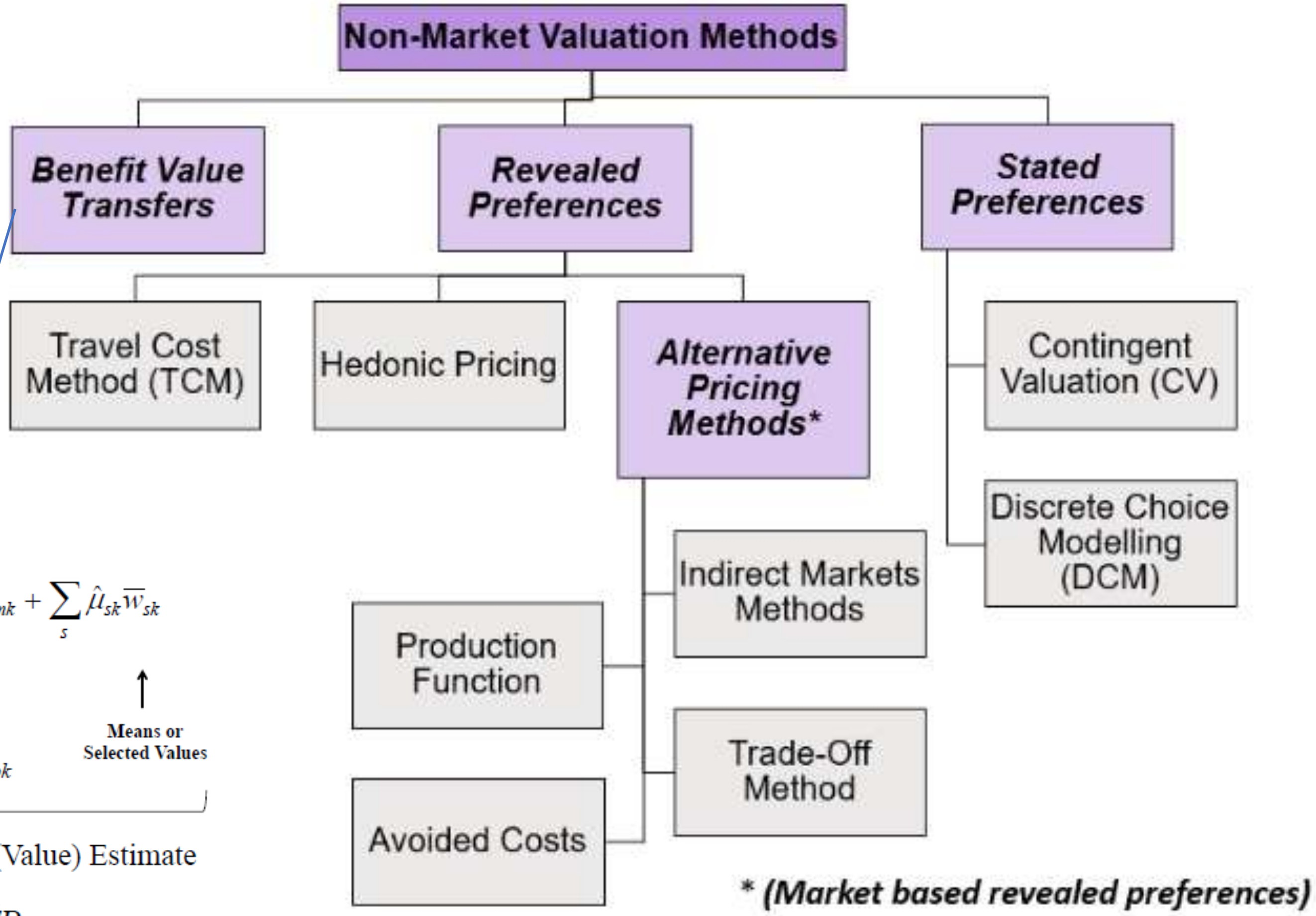
- Environmental and Social Impacts and Intangible Assets often refer to goods and services (natural and social capital) which are not traded in markets or cannot be traded in markets, e.g. no market price is observed.

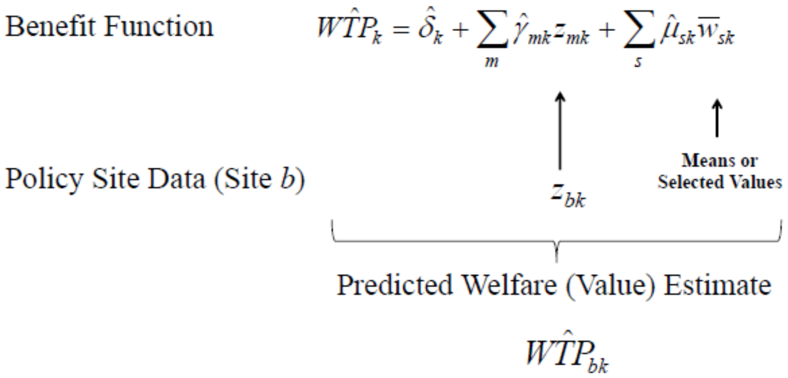
- Non-market Valuation Methods are used to evaluate intangible impacts, such as climate abatement, pollution costs or common and public goods.

- Calculate the Shadow price (direct and indirect use value) for the underlying good or service.

- Several ***Econometric Models*** based on the type of good/service and the economic value to be estimated.

- **Shadow Prices** are also defined as the Willingness to Pay for a non-market good or service.





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Integrating the Value of Natural Capital

Primary Valuation Method Example -

Valuation Methods

Valuing a Wind Farm Construction: A contingent valuation study in Greece

Introduction

- The aim of the study is to elicit individual’s preferences towards renewable power generation and their Willingness to Pay for the construction of a wind farm in the area of Messanagros in the island of Rhodes, Greece .

Motivation

- The vital role of energy from Renewable Sources (RES) in mitigation of greenhouse gas emissions is highly acknowledged, since under EU legislation all member states have implemented national policies to increase the proportion of renewable energy in their total energy mix.

- Greece was one of the first European countries to exploit renewable energy sources and especially wind power in the early eighties. The **potential** of developing infrastructure for energy production from wind and solar power in Greece is extremely high.

- However, although the public generally expresses a positive attitude towards wind power, the experience often shows that specific wind power projects face resistance from the local population (Not In My BackYard behaviour)

Previous Research

- Several studies have been conducted over recent years using different valuation techniques to explore individual preferences for renewable power generation reporting positive WTP for green energy premia.

- In summary, WTP is higher among respondents with high incomes among younger people , those who are more liberal, do not rent their home, are women, do not have children and are highly educated.

- Wiser (2007) suggests that elicited WTP for renewable energy is higher under a collective payment method than under a voluntary one .

- findings suggest that the location of the renewable energy project is of vital importance (Ek, 2005)

- Begona and Hanley (2002) report significant social costs can be associated with a wind farm construction.

Total Economic Value

- Like any other investment, investment in renewable energy involves incurring costs today for benefits in the future. Whether a public investment is efficient or not is determined by social cost benefit analysis (CBA).
- It follows that the identification of the Total Economic Value (TEV) of a renewable resources project is critical in determining whether the project will pass the CBA test and thus be implemented.
- Many of the benefits associated with a renewable energy project are non-marketed and thus are hard to quantify in monetary terms for CBA purposes.

Total Economic Value

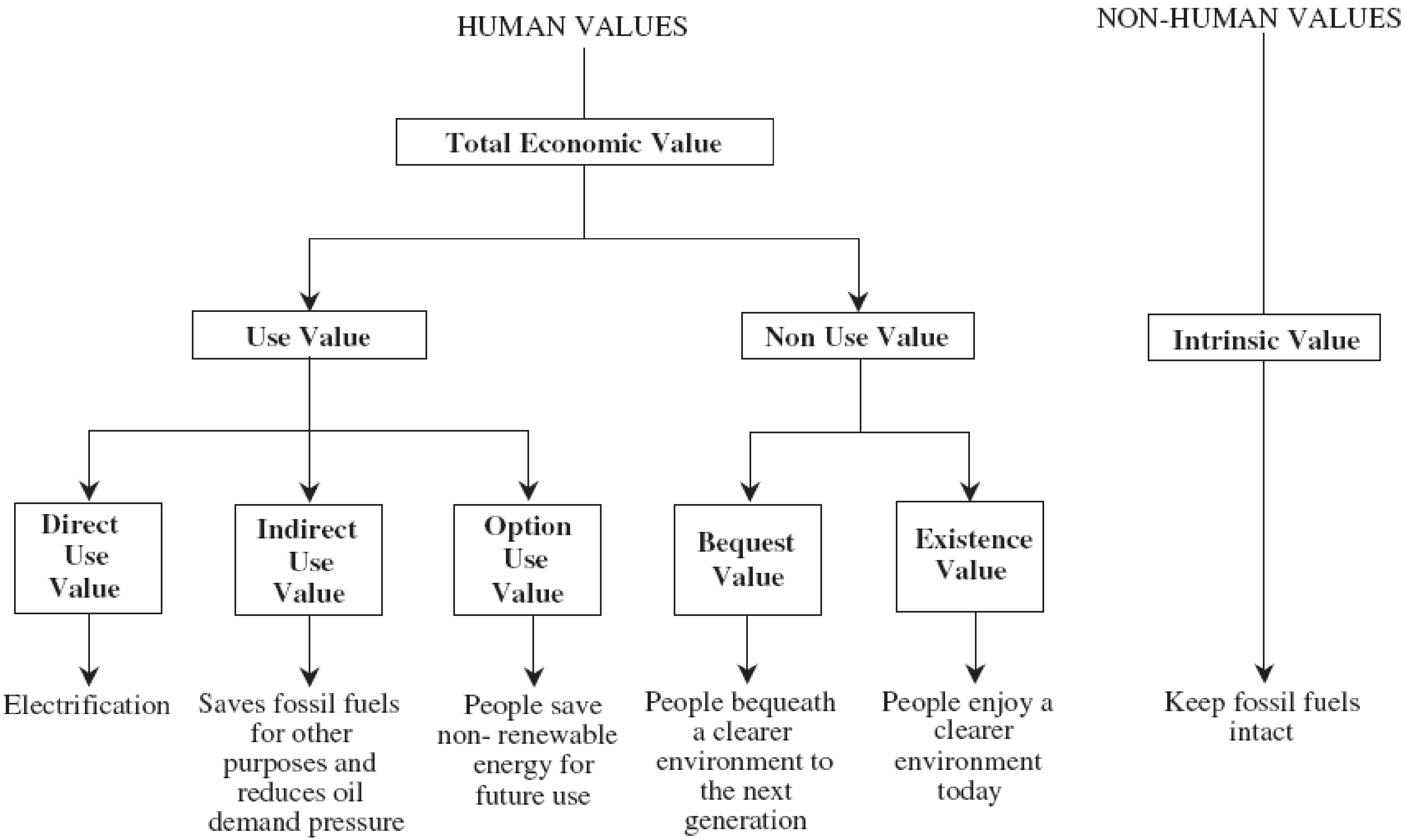


Fig. 1. Total value disaggregation for renewable energy.

Primary Valuation Methods

- Two broad categories of economic valuation developed to capture the TEV of environmental resources are distinguished in the environmental economics literature：

  - Revealed Preference (Hedonic pricing, Travel Cost)

    - analyse of data derived from actual markets that are related to the non-market resource under valuation

  - **Stated Preference** (Choice Experiments , **Contingent valuation**)

    - the market for the good is ‘constructed’ through the use of questionnaires

Contingent Valuation Method (CVM)

- circumvents the absence of markets for environmental goods and services by presenting consumers with hypothetical markets in which they have the opportunity to pay or accept compensation for the environmental good or service in question
- to elicit accurate measures of non-market benefits, the survey must simultaneously meet the methodological imperatives of survey research and the requirements of economic theory

The survey design

- The questionnaire for the contingent valuation application was developed with the cooperation of the Greek Centre for Renewable Energy Sources (CRES) and comprised of three parts:
- Environmental Consciousness measures (knowledge, attitudes, behaviour)
    - Knowledge regarding various energy sources conventional and renewable
    - Actions undertaken to reduce energy consumption
    - Perceived positive/negative implications from the construction of the wind farm in the area.
- The valuation scenario and the contingent valuation questions
- Socioeconomic data (age, gender, education, employment, household income, number of children etc)

The Contingent Valuation Questions

- The valuation scenario primarily stated the commitment undertaken by the Greek government to produce 20% of total energy from renewable sources by 2010.

- The project under evaluation was then presented. Respondents were informed that
  - a new wind farm is planned in the area of Messanagros in southern Rhodes, 1.5km from the village of Messanagros.
  - in total six generators are planned to be constructed and the capacity of the wind farm will sufficient for supplying approximately 5,000 households with energy for a year
  - wind turbines will be visible from approximately 5km

Payment Vehicle

- The payment vehicle was the establishment of **lump sum charge** levied on the bi-monthly electricity bill for each household
- In the first valuation question respondents were asked if they were WTP one of [2, 4, 6, 8 and 12] Euros.
    - Those that were WTP the given amount, in the second question were asked to state if they were WTP [4, 6, 8, 12, and 14] Euros respectively.
    - Those not WTP in the first question were asked to state if they were WTP [1, 2, 4, 6, and 10] Euros respectively. (Double bounded dichotomous choice format)
- Respondents were randomly assigned to bid levels in order to minimize the possibility of starting point bias

Sample - Data

- a survey was implemented
- the sampling frame was the adult (over 18) population of Rhodes
- a quota sample of 200 individuals residing in various areas of the island was selected from telephone directories

Table 1: Descriptive Statistics

Variable	Mean	Standard Error
Pay the first proposed bid (1=yes, 0=no)	0.655	0.477
Pay the higher bid (1=yes, 0=no)	0.702	0.459
Pay the lower bid (1=yes, 0=no)	0.130	0.339
Age (years)	43.195	16.283
Gender (1=male, 0=female)	0.515	0.501
Urban (1=urban resident, 0=otherwise)	0.540	0.500
Household size	3.330	1.353
Child (1=child in household, 0=otherwise)	0.475	0.501
Number of children in household	0.940	1.247
Education (1=tertiary education and higher, 0=otherwise)	0.175	0.381
Employment (1=in full time employment, 0=otherwise)	0.545	0.499
Household income (€ per month)	1561.35	1008.487
Member in environmental organization (1=member, 0=otherwise)	0.035	0.184
Informed about environmental matters (1=yes, 0=no)	0.820	0.385
Positive impact from the wind farm (1=yes, 0=no)	0.935	0.247
Negative impact from the wind farm (1=yes, 0=no)	0.150	0.358

The model

- The individual's true maximum WTP for the project under evaluation is assumed to be a function of economic variables (income); demographic and attitudinal variables (age or sex, or whether or not the respondent is an environmentalist).
- By virtue of the random utility framework, WTP is specified as

$$WTP_j = \mu + \varepsilon_j$$

where WTPj is the WTP of individual *j* , *μ* is the mean WTP and *εj* is the error term.

- The WTP determinants were examined by estimating an interval regression model using the higher and lower limits defined by the two valuation questions.

Econometric Results

$$Y_a = \alpha_a + \sum_j \beta_{aj} x_{aj} + \varepsilon_a$$

Willingness to Pay Determinants

Variable	Coefficient (St. Error)
Constant	7.984*** (1.577)
Age	-0.017 (0.021)
Information	1.464** (0.746)
For wind power	-1.204 (0.886)
Negative Impact	-1.465* (0.898)
Household Size	0.586** (0.275)
Children Living in Household	2.041** (1.043)
Number of Children Living in Household	-1.243** (0.440)
Employment	-1.590** (0.684)
Education	2.478*** (0.868)
Log Likelihood	-313.04476
Obesrvations	200

*** indicates significance at 1% level, ** indicates significance at 5% level and * indicates significance at 10% level.

Econometric Results
Interval Regression Model
Mean and Median Willingness to Pay

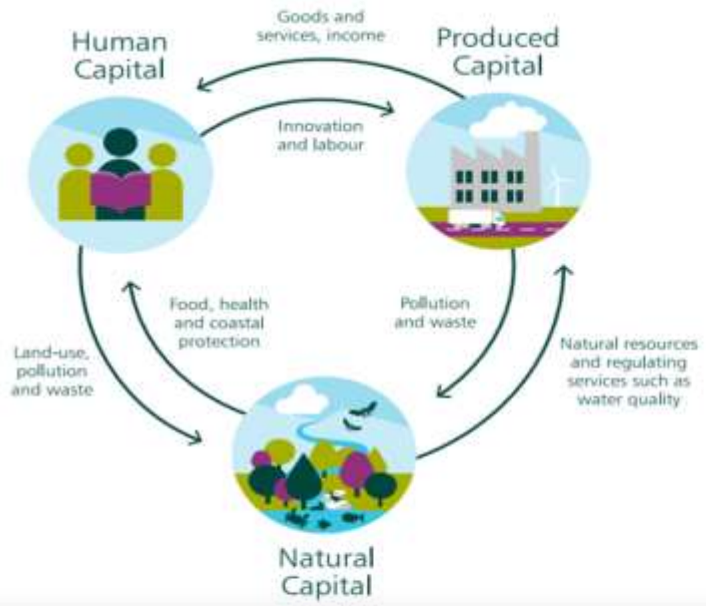
Low Estimate of the Lower Bound		High Estimate of the Lower Bound		Mid Point Estimate	
Mean WTP (€)	Median WTP (€)	Mean WTP (€)	Median WTP (€)	Mean WTP (€)	Median WTP (€)
5.3	4	10.16	12	7.73	9

Sustainable Finance

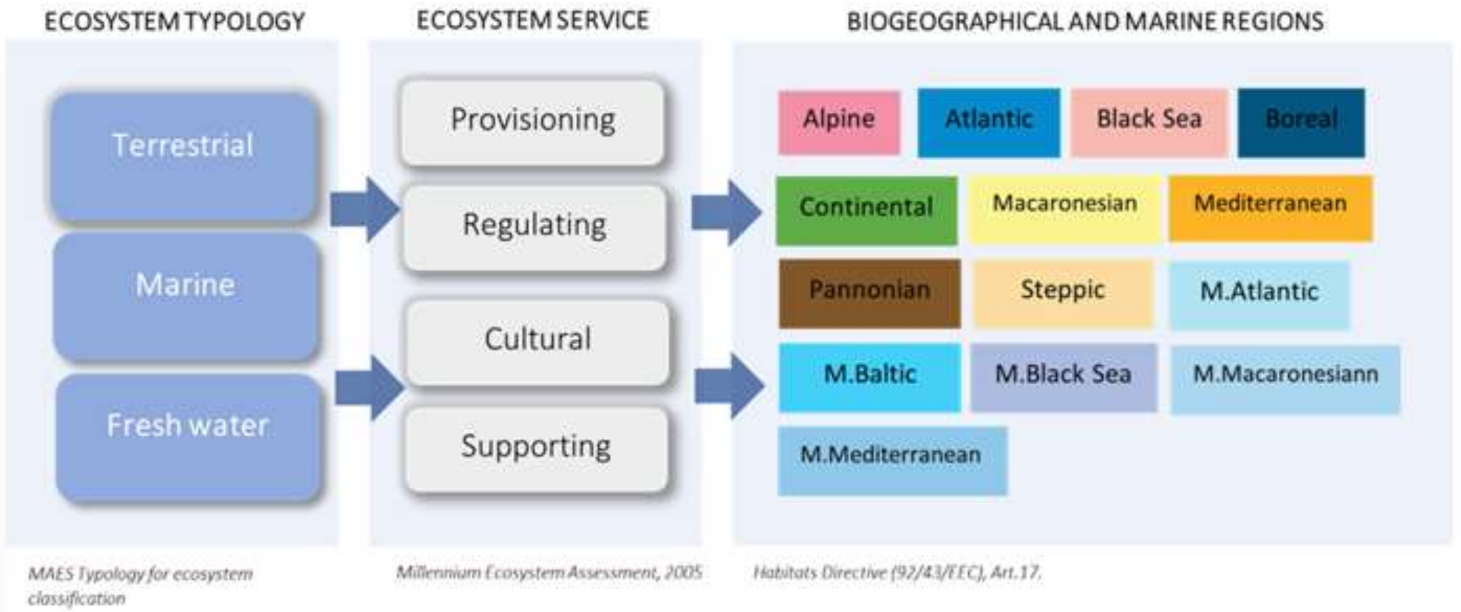
Integrating the Value of Natural Capital

Benefit Transfer Method

Integrating Ecosystem Valuation to Decision Making



- Valuation of European Ecosystem Services
- 4 Types of Ecosystem Services: Provisioning, Regulating, Cultural, Supporting
- 6 Biogeographical and Marine Regions
- Total Economic Value = Use Value + Non-use value



2-Stages Approach

1° STAGE:

Find the economic value of nature

- Step 1.1: IDENTIFICATION of the full range of ecosystem services in each biogeographical region
  - Mapping of different ecosystems
  - Establishment of the geographical area of reference
- Step 1.2: ESTIMATION of the value of ecosystem services
  - Using data from literature databases (EVRI, ESVD)
- Step 1.3: CAPTURING the value of ecosystem services
  - Average unit values per region in order to find the total economic value of these ecosystems (e.g. benefit of transfer method)

2° STAGE:

Integration of ecosystems valuation with SDGs

- Step 2.1: Integrate ecosystem valuation in SDG Index
- Step 2.2: Measure the SDG implementation by taking into account ecosystem valuation

Meta Regression Value Transfer Method

- **Step 1.1**: IDENTIFICATION of the full range of ecosystem services in each **biogeographical region**
  - Mapping of different ecosystems
  - Establishment of the geographical area of reference

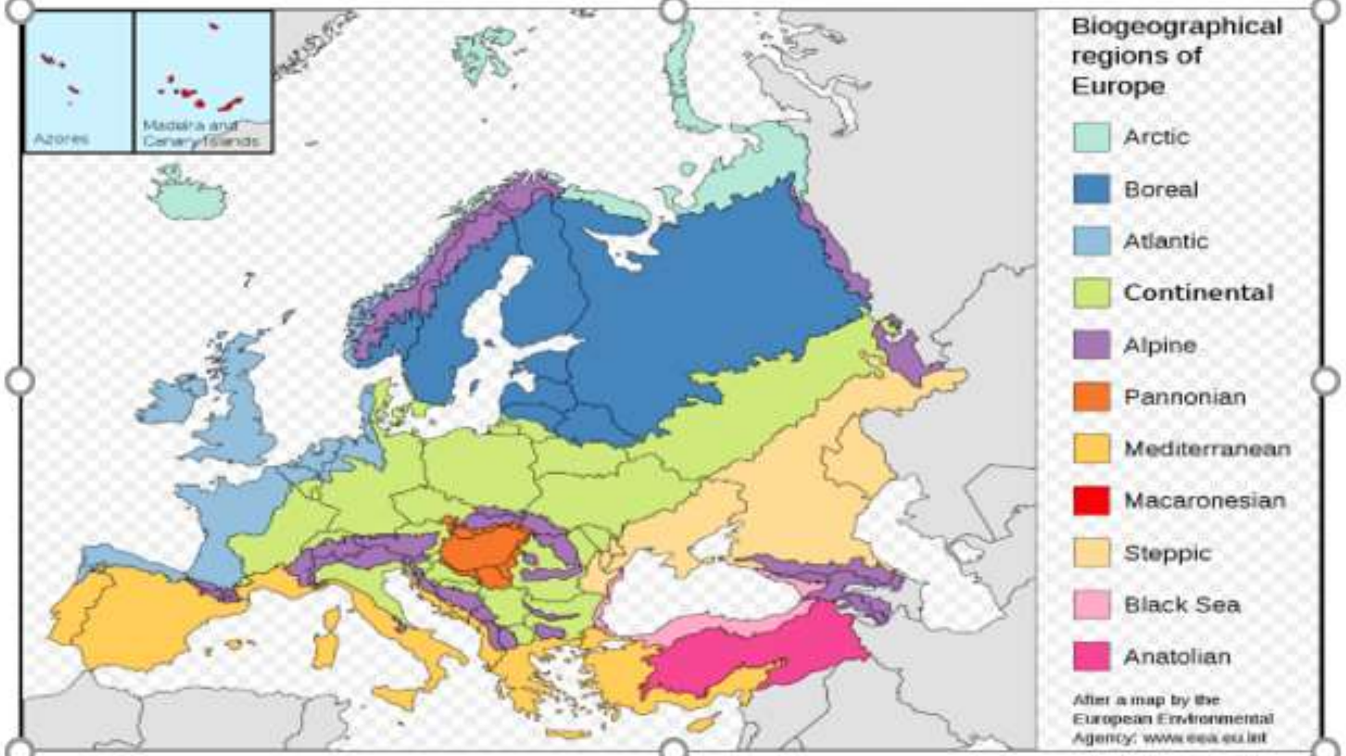


Figure 20 European Bio Geographical Regions

- **Step 1.2**: ESTIMATION of the value of ecosystem services
  - Using data from literature databases (EVRI, ESVD)

- **Step 1.3**: CAPTURING the value of ecosystem services for EU countries and Biogeographical Regions

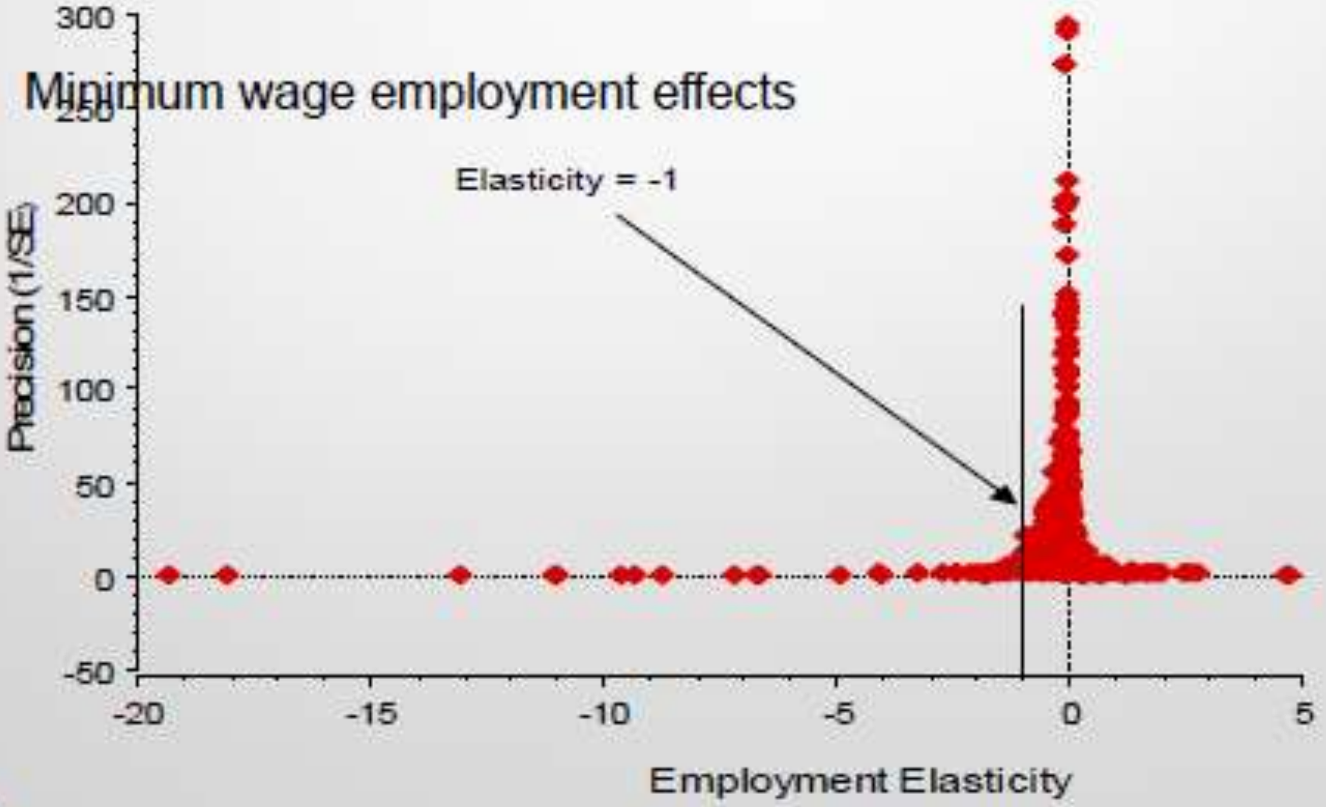
Meta-Regression Analysis: Motivation and Introduction

- "Meta-analysis refers to the **statistical** analysis of a **large collection** of results from individual studies for the purpose of **integrating** the findings. It connotes a **rigorous alternative** to the casual, narrative discussions of research studies that typify our attempt to make sense of the rapidly expanding research literature."

  Glass (1976)

Conflicting Empirical Findings

- Rarely do single studies provide definitive answers upon which to base policy or to settle theoretical disputes.
- Very large research variation is the norm.



Practical Applications of Meta-Analysis

- Meta-analysis is often discussed in terms of its relevance for understanding the scholarly literature.
- Results can (at least in concept) inform decisions in the real world, but sometimes impacts are indirect or unclear.
  - Example—Do minimum wages affect employment?
  - MRA results challenge common wisdom.
- MRA can also provide direct inputs for policy analysis. Here, the effect is more clear.
- Multiple examples are found in environmental economics.
  - VSL is a good example. This is frequently used as a direct input in benefit-cost analysis (BCA).

Non Market Valuation

- MRA is commonly used to provide estimates of non-market values for use within BCA and other types of policy analysis.
- Non-market valuation provides estimates of economic value for environmental goods and services that are not exchanged in markets.
  - Ecosystem service values are often non-market values.
  - Common examples include the value of improved air quality, water quality, fish stocks, wildlife stocks and many others.
  - These values are often measured using estimates of willingness to pay (WTP), reflecting Hicksian compensating surplus or variation.

Example—Non-Market Value of Recreational Fishing

- What is the true value of recreational fishing to an angler (a recreational fisherman)?
- How much more would an angler be willing to pay (in time and travel costs) to go fishing at a site where he expects to catch one more fish compared to current sites?
- The angler cannot directly “buy” improved fishing quality.
- There is no market, so this is a non-market value.
- But, the observed tradeoff between time/travel and additional catch reveals an economic value.
- This value can be estimated by analyzing fishing behavior.

- Johnston et al. (2006): Mean willingness to pay per fish caught.

Marginal Value per Fish, by Region and Species							
Species	California	North Atlantic	Mid-Atlantic	South Atlantic	Gulf of Mexico	Great Lakes	Inland
big game	$12.32	$6.19	$5.95	$13.57	$13.26		
small game	$6.38	$5.22	$5.19	$5.03	$4.95		$4.71
flatfish	$8.57	$5.24	$4.94	$4.93	$4.82		
other saltwater	$2.60	$2.62	$2.56	$2.50	$2.44		$2.54
salmon	$13.67					$11.66	$13.88
steelhead	$11.25					$12.57	$11.42
musky						$61.37	$64.71
walleye/pike						$3.61	$3.60
bass						$7.52	$7.92
panfish			$0.93	$0.93		$1.17	$0.93
rainbow trout						$7.38	$2.84
other trout						$8.29	$2.48
generic freshwater						$5.46	$1.96
generic saltwater	$2.73	$2.64	$2.85	$2.51	$3.22		$2.79

Environmental Benefit Transfer

- The time and money required for high quality primary valuation research has led to the common use of *benefit transfer* to estimate values for policy analysis.
- Benefit transfer uses results from prior research at one or more study sites to predict value estimates at other policy sites for which value estimates are unavailable.
- Benefit transfer involves transfer errors, but is often the only option to estimate non-market benefits or costs for environmental policy analysis.
- Benefit transfer is a nearly universal component of large-scale BCA in the US, EU and other countries (Johnston et al. 2015).


Transferred Value Estimate or Benefit Function
$\text{Value}_A = f(X_A, \beta_A)$
Study Site A
(Economic Value
Measured Here by Prior
Primary Research)
Policy Site B
(Value Estimate
Required for BCA)
$\text{Transfer Value} = f(X_B, \beta_A)$
Observed Conditions
at Policy Site B

MRM Models - Benefit Functions

- Benefit functions (used for benefit transfer) can be
  - transferred directly from one prior study, or
  - estimated using information from many prior studies in the literature.
- Meta-regression models (MRMs) are often used to estimate these benefit functions.
- Use of MRMs enables benefit functions that are more flexible and generally applicable than benefit functions taken from a single published study.

MRM Models - Benefit Functions

- The dependent variable in a benefit transfer MRM is a comparable measure of economic value drawn from similar studies addressing the same good at many different sites.
    - Most often mean willingness to pay (WTP) from revealed or stated preference valuation studies.
- Independent variables characterize site, resource, population and methodological attributes hypothesized to explain variation in value.
- The goal is a statistical benefit function able to predict economic values at sites where no primary valuation studies have been conducted.

Non-Market Valuation MRM

Primary Study a

$$Y_a = \alpha_a + \sum_j \beta_{aj} x_{aj} + \varepsilon_a$$

Behavioral Measure (e.g., trips)

Primary Study Calculates

$$WTP_{ak} = \beta_{ak} \Big/ \beta_{a\_cost}$$

WTP from Multiple Studies (1…A)

Policy, Site, Population & Resource Variables

Methodological Variables

MRM

$$\begin{bmatrix} WTP_{1k} \\ WTP_{2k} \\ \cdots \\ WTP_{Ak} \end{bmatrix} = \delta_k + \sum_m \gamma_{mk} \begin{bmatrix} z_{1mk} \\ z_{2mk} \\ \cdots \\ z_{Amk} \end{bmatrix} + \sum_s \mu_{sk} \begin{bmatrix} w_{1sk} \\ w_{2sk} \\ \cdots \\ w_{Ask} \end{bmatrix} + \varepsilon_k$$

Non-Market Valuation MRM - Predictions

Benefit Function

$$\hat{WTP}_k = \hat{\delta}_k + \sum_m \hat{\gamma}_{mk} z_{mk} + \sum_s \hat{\mu}_{sk} \overline{w}_{sk}$$

Policy Site Data (Site b)

z_{bk}

Means or Selected Values

Predicted Welfare (Value) Estimate

$$\hat{WTP}_{bk}$$

Some Differences Between Traditional MRA and MRMs for Benefit Transfer

- Goal of MRMs used for BT is to *predict (or forecast)* a value of the dependent variable *out-of-sample*.
  - Not to estimate a mean treatment effect.
- Standard errors (or other comparable measures of precision) are generally not available for all WTP estimates in the sample.
- Selection biases are often addressed using different methods (Rosenberger and Johnston 2009).
- Valuation MRMs face a range of challenges
  - Example—commodity and welfare consistency
  - Effect of spatial and other variables that are unreported by primary studies

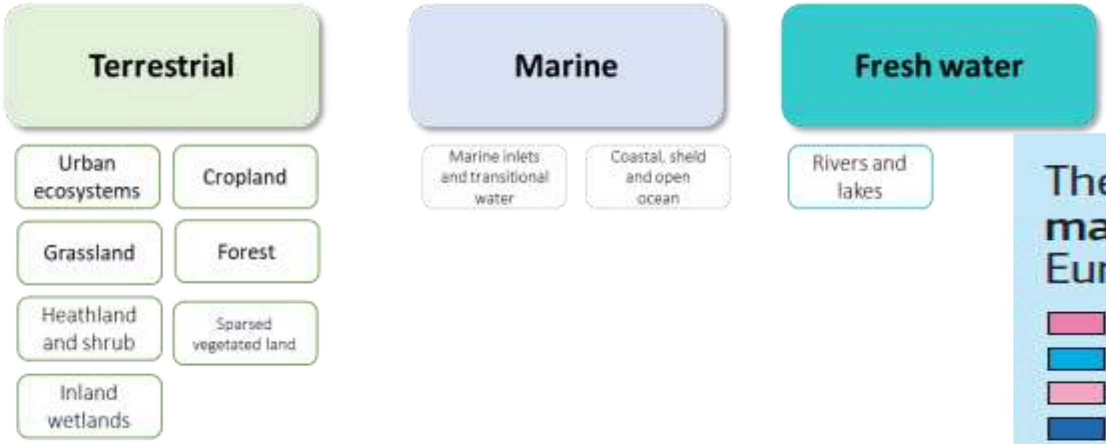
MRMs of Environmental Value

- There roughly 200 published MRMs in the environmental economics literature (Nelson and Kennedy 2009; Johnston et al. 2015). Examples include MRMs on the value of:
  - Water quality (Johnston et al. 2005, 2016; Johnston and Thomassin 2010; Poe et al. 2001; Van Houtven et al. 2007).
  - Wetlands (Brouwer et al. 1999; Woodward and Wui 2001; Ghermandi and Nunes 2013; Brander et al. 2012).
  - Coral reefs (Brander et al. 2007; Londoño and Johnston 2012).
  - Outdoor recreation (Bateman and Jones 2003; Johnston et al. 2006; Rosenberger and Loomis 2000a,b; Moeltner et al. 2007; Moeltner and Rosenberger 2008, 2014; Stapler and Johnston 2009).

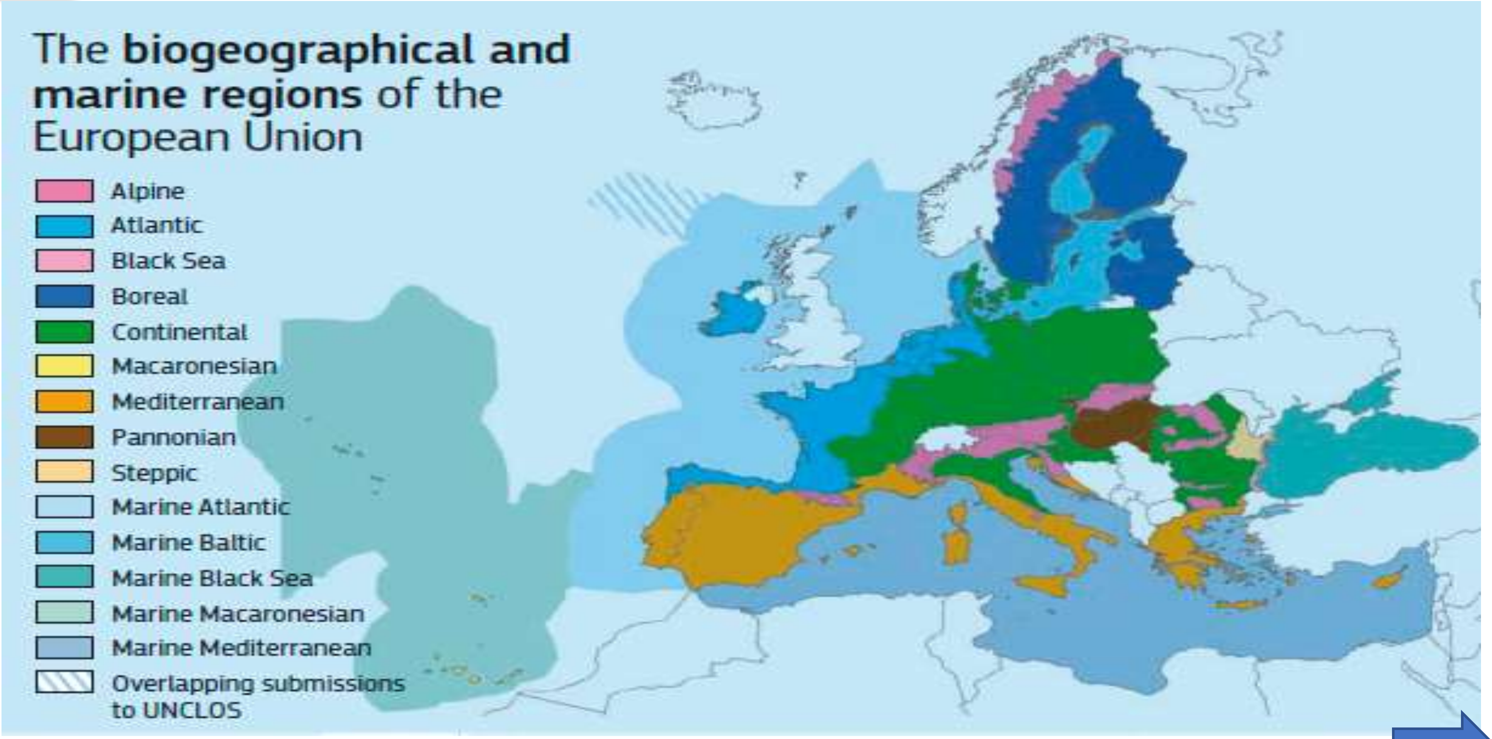
Step 1.1: Identification of the full range of ecosystem services in each biogeographical region

- For each decision **IDENTIFY and ASSESS the full range of *ecosystem services***

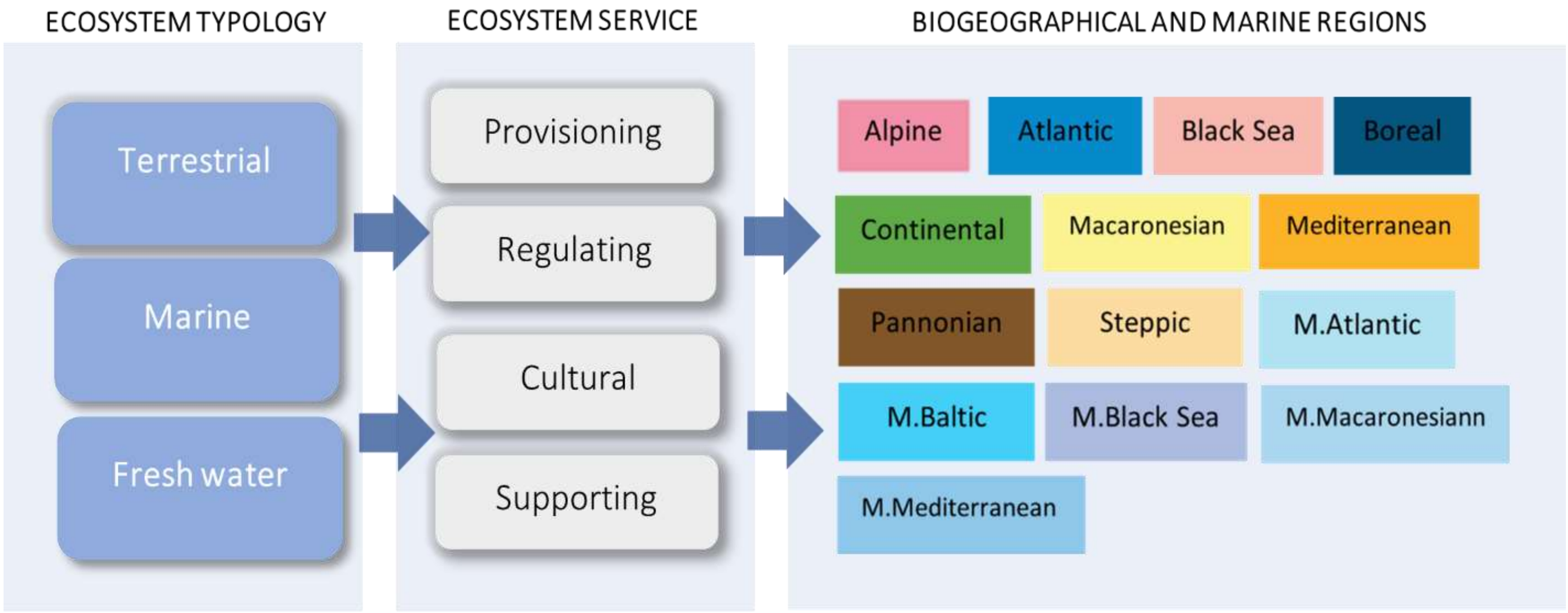
❑ **Mapping of different ecosystems**



❑ **Establish the geographical area of reference**:
Each region have its proper ecosystems. Therefore in each ecosystem it is possible to distinguish specific territorial, marine and freshwater ecosystems



Mapping of Ecosystems Typology to Services across Biogeographical regions



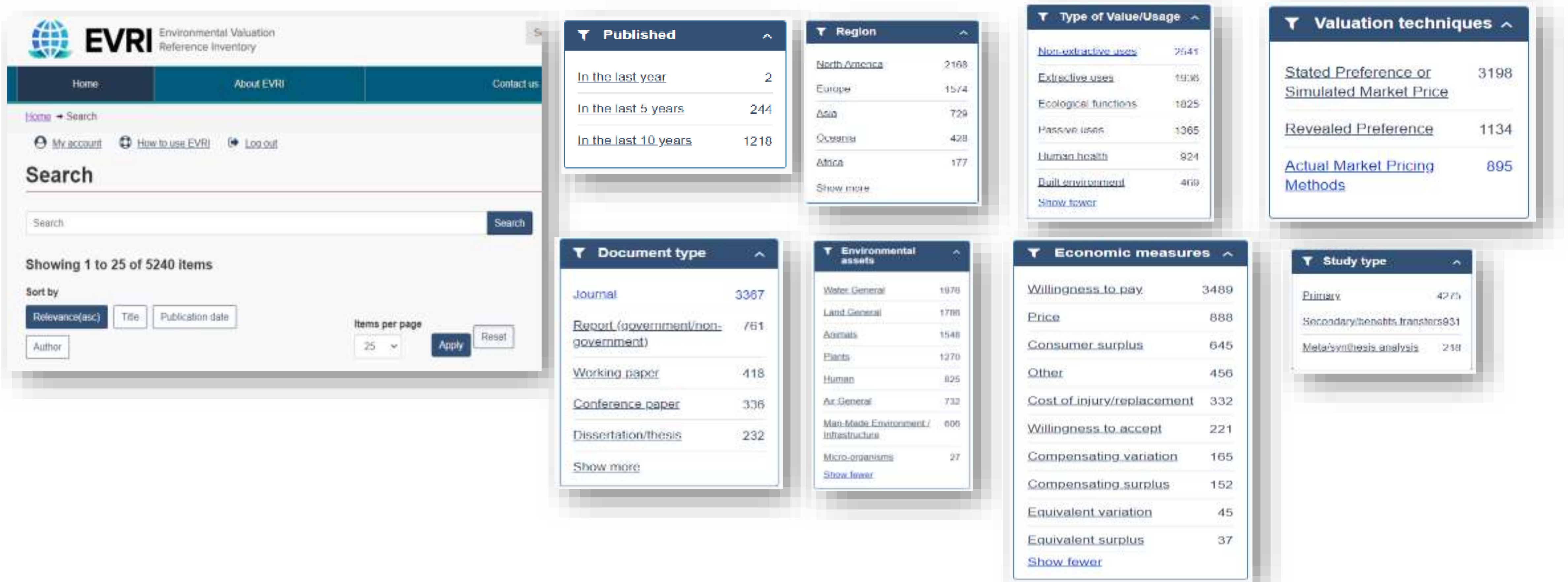
MAES Typology for ecosystem classification

Millennium Ecosystem Assessment, 2005

Habitats Directive (92/43/EEC), Art.17.

Step 1.2: Collecting the Meta Data

- ✓ Literature review aimed at identifying the value of ecosystems in specific EU countries.
- ✓ [EVRI](#) database is used – An open–access repository with many filtering options.
- ✓ Primary literature related to ecosystem services valuation from 2012 to 2022 has been selected. Studies have been selected according to the ecosystem typology and the ecosystem services valued, and by the bio-geographical area in which the study has been conducted.



- Development of the metadata is the most difficult component of meta-analysis, and can be subject to unseen errors.
- No statistical method can fully overcome bias caused by a poorly conceptualized research question, ambiguous definition of effect sizes, or incomplete/erroneous coding.
- Transparency in literature search and coding is critical.
- Data inspection and summary, including formal testing for heterogeneity, is a critical initial step.
- Beware of naïve interpretations of weighted averages (FEE and REE)—WLS is almost always more informative.
- Heterogeneity is always found—leading to multiple MRA.

Meta Data

Table 1 Descriptive Statistics

Variable	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
WTP	76.8	12.9	165.7	0.0	93000.0	23.4	64.4	1404.6
ES Terrestrial	0.521	0.039	0.501	0.000	0.000	1.000	1.000	1.000
ES Marine	0.394	0.038	0.490	0.000	0.000	0.000	1.000	1.000
ES Fresh Water	0.085	0.022	0.280	0.000	0.000	0.000	0.000	1.000
Cultural	0.588	0.038	0.494	0.000	0.000	1.000	1.000	1.000
Provisioning	0.267	0.035	0.444	0.000	0.000	0.000	1.000	1.000
Supporting	0.436	0.039	0.497	0.000	0.000	0.000	1.000	1.000
Regulating	0.327	0.037	0.471	0.000	0.000	0.000	1.000	1.000
SD Interview	0.665	0.037	0.474	0.000	0.000	1.000	1.000	1.000
SD Questionnaire online	0.329	0.037	0.471	0.000	0.000	0.000	1.000	1.000
SD Secondary data	0.050	0.017	0.218	0.000	0.000	0.000	0.000	1.000
CE	0.461	0.039	0.500	0.000	0.000	0.000	1.000	1.000
CVM	0.400	0.038	0.491	0.000	0.000	0.000	1.000	1.000
REVEALED	0.139	0.027	0.347	0.000	0.000	0.000	0.000	1.000
Alpine	0.133	0.027	0.341	0.000	0.000	0.000	0.000	1.000
Atlantic	0.236	0.033	0.426	0.000	0.000	0.000	0.000	1.000
Boreal	0.139	0.027	0.347	0.000	0.000	0.000	0.000	1.000
Continental	0.212	0.032	0.410	0.000	0.000	0.000	0.000	1.000
Macaronesian	0.006	0.006	0.078	0.000	0.000	0.000	0.000	1.000
Mediterranean	0.279	0.035	0.450	0.000	0.000	0.000	1.000	1.000
Steppic	0.006	0.006	0.078	0.000	0.000	0.000	0.000	1.000
Marine Atlantic	0.176	0.030	0.382	0.000	0.000	0.000	0.000	1.000
Marine Black Sea	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Marine Baltic	0.042	0.016	0.202	0.000	0.000	0.000	0.000	1.000
AGE	44.221	0.624	6.301	28.620	40.088	43.000	49.350	58.000
INCOME	27969	1210	15160	2398	18267	24512	35371	104030
GENDER	0.489	0.009	0.087	0.170	0.463	0.510	0.540	0.640
EDUC	0.554	0.178	2113.000	0.104	0.265	0.360	0.460	25.400

Policy, Site, Population & Resource Variables

Methodological Variables

MRM Estimation – Benefit Transfer

- $\mathbf{MRM: \ WTP_i = \beta' X_i + \varepsilon_i}$
  (Weighted Least Squares)

- Newey West Standard Error in parenthesis

- Bold denotes 5% statistical significance

	All Ecosystems	Terrestrial	Marine & Fresh Water
ALPINE	**148.94**	**105.93**	43.01
	[0.020]	[0.041]	[0.279]
ATLANTIC	**-86.23**	-21.91	**-64.32**
	[0.084]	[0.487]	[0.091]
BOREAL	-82.96	19.39	**-102.34**
	[0.286]	[0.748]	[0.040]
CONTINENTAL	-48.36	-7.07	-41.29
	[0.162]	[0.817]	[0.269]
MEDITERRANEAN	**-91.73**	**-54.37**	-37.36
	[0.057]	[0.069]	[0.344]
MARINE_ATLANTIC	**-74.40**	**-62.46**	-11.95
	[0.106]	[0.059]	[0.779]
PROVISIONING	**59.32**	25.77	33.55
	[0.075]	[0.292]	[0.259]
REGULATING	**53.19**	12.98	**40.21**
	[0.224]	[0.541]	[0.214]
SUPPORTING	**42.70**	13.46	29.24
	[0.117]	[0.599]	[0.312]
SD_QUESTIONNAIRE	-42.09	**-50.20**	8.11
	[0.351]	[0.118]	[0.803]
AGE	**3.77**	**1.14**	**2.64**
	[0.007]	[0.127]	[0.023]
EDUCATION	**-5.20**	-0.60	-4.60
	[0.187]	[0.853]	[0.387]
CHOICE_EXPERIMENT	**-79.15**	-0.52	**-78.63**
	[0.157]	[0.983]	[0.126]
CONTINGENT_VALUATION	-60.07	10.78	**-70.84**
	[0.297]	[0.704]	[0.161]
R-squared	0.32	0.27	0.18
Adjusted R-squared	0.20	0.15	0.04
F-statistic	**87.90**	**75.71**	**1.96**
	[0.000]	[0.000]	[0.0229]
MWTP	**80.53**	**38.42**	**42.10**

MRM - Benefit Transfer – Ecosystem Services / Regions

$$\hat{WTP}_k = \hat{\delta}_k + \sum_m \hat{\gamma}_{mk} z_{mk} + \sum_s \hat{\mu}_{sk} \overline{w}_{sk}$$

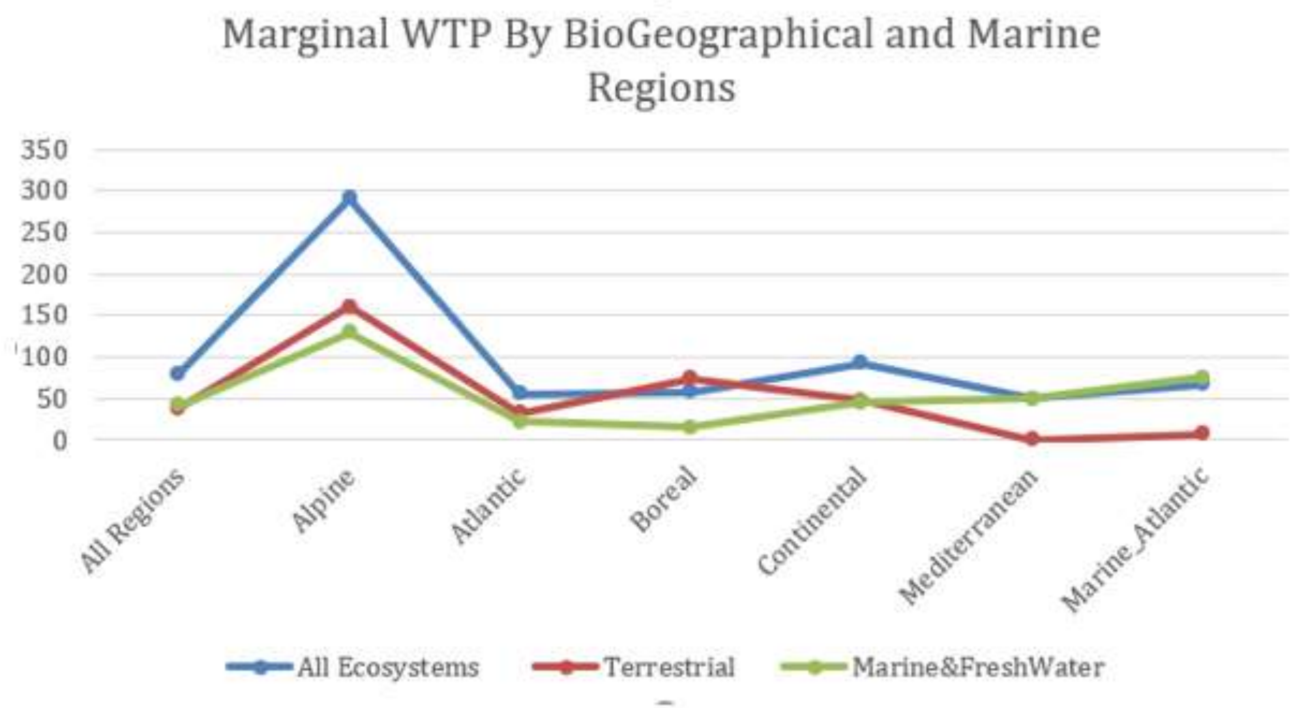


Figure 19 Annual Marginal WTP by Biogeographical Region

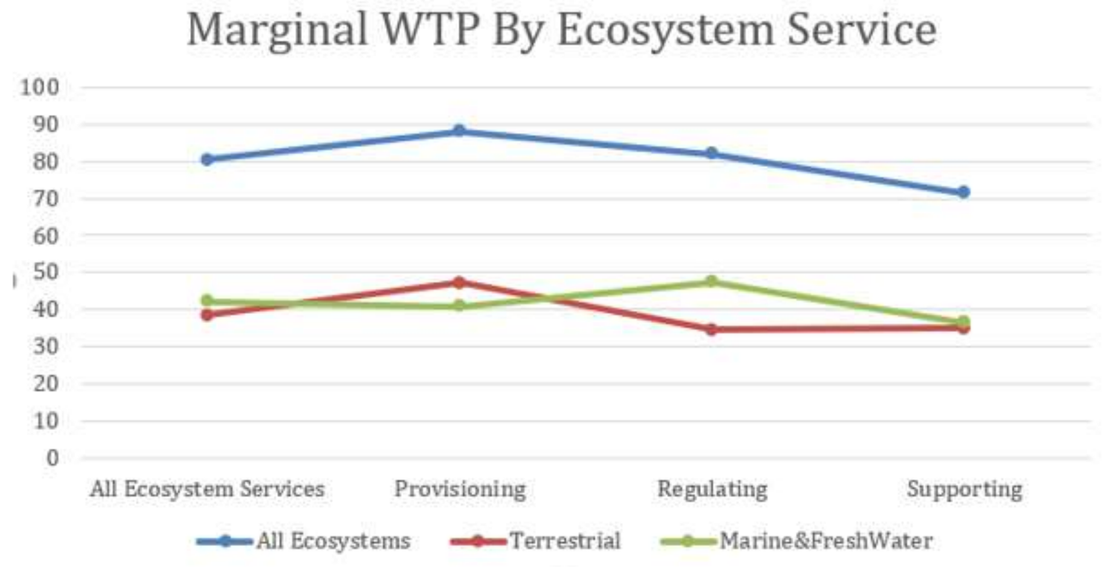
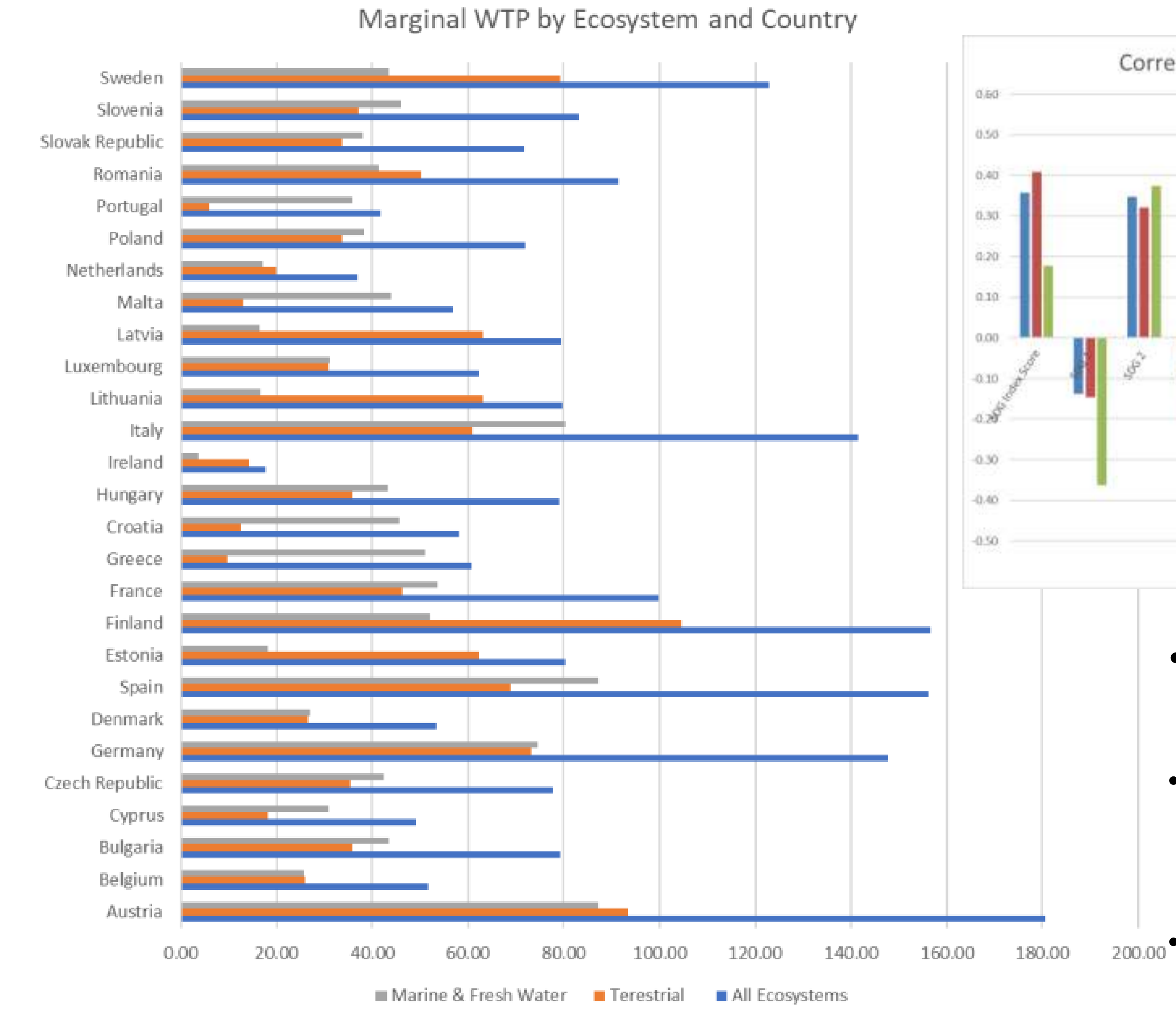
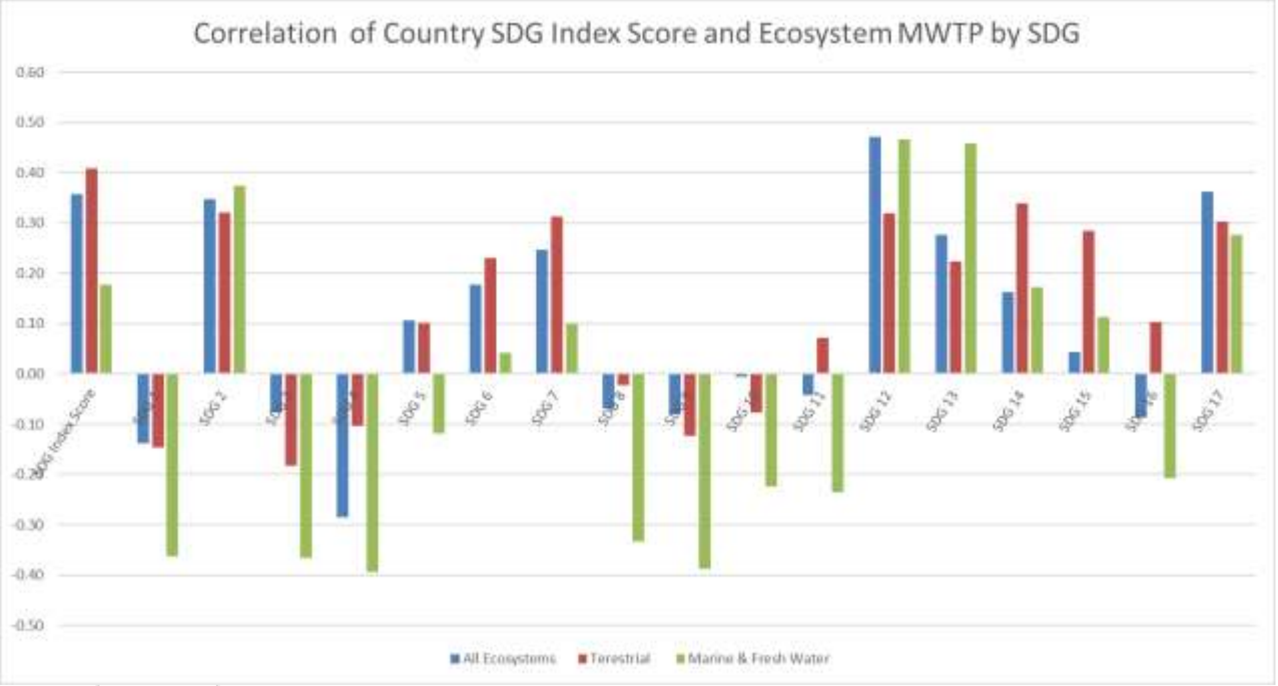


Figure 18 Annual Marginal WTP by Ecosystem Service

- **Higher WTP estimates for Alpine Region**
- WTP for Marine and Freshwater Ecosystems Higher for **Mediterranean and Marine Regions** , and WTP for Terrestrial Ecosystems higher for **Alpine** and **Boreal**
- **Regulating** Service more important for Marine and Freshwater Ecosystem and **Provisioning** for Terrestrial

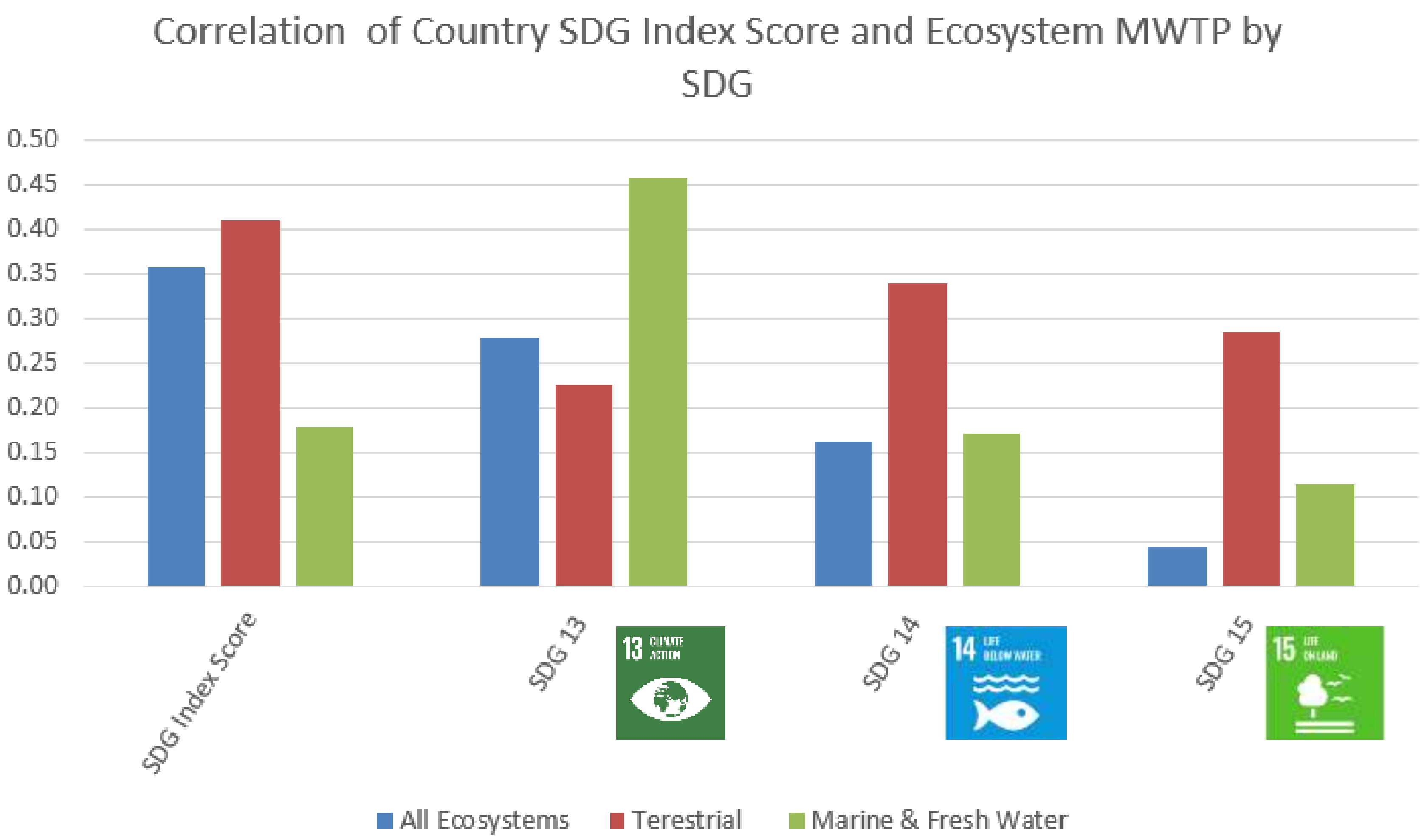
National MWTP – All Ecosystems





- Positive Correlation Implies a higher MWTP for SDGs with a high level of implementation.
- People's preferences are in the same direction with the intentions of government to make the transformations necessary to achieve SDGs.
- MWTP is high for a transformation that is **needed.**

Link to SDGs 13, 14 & 15

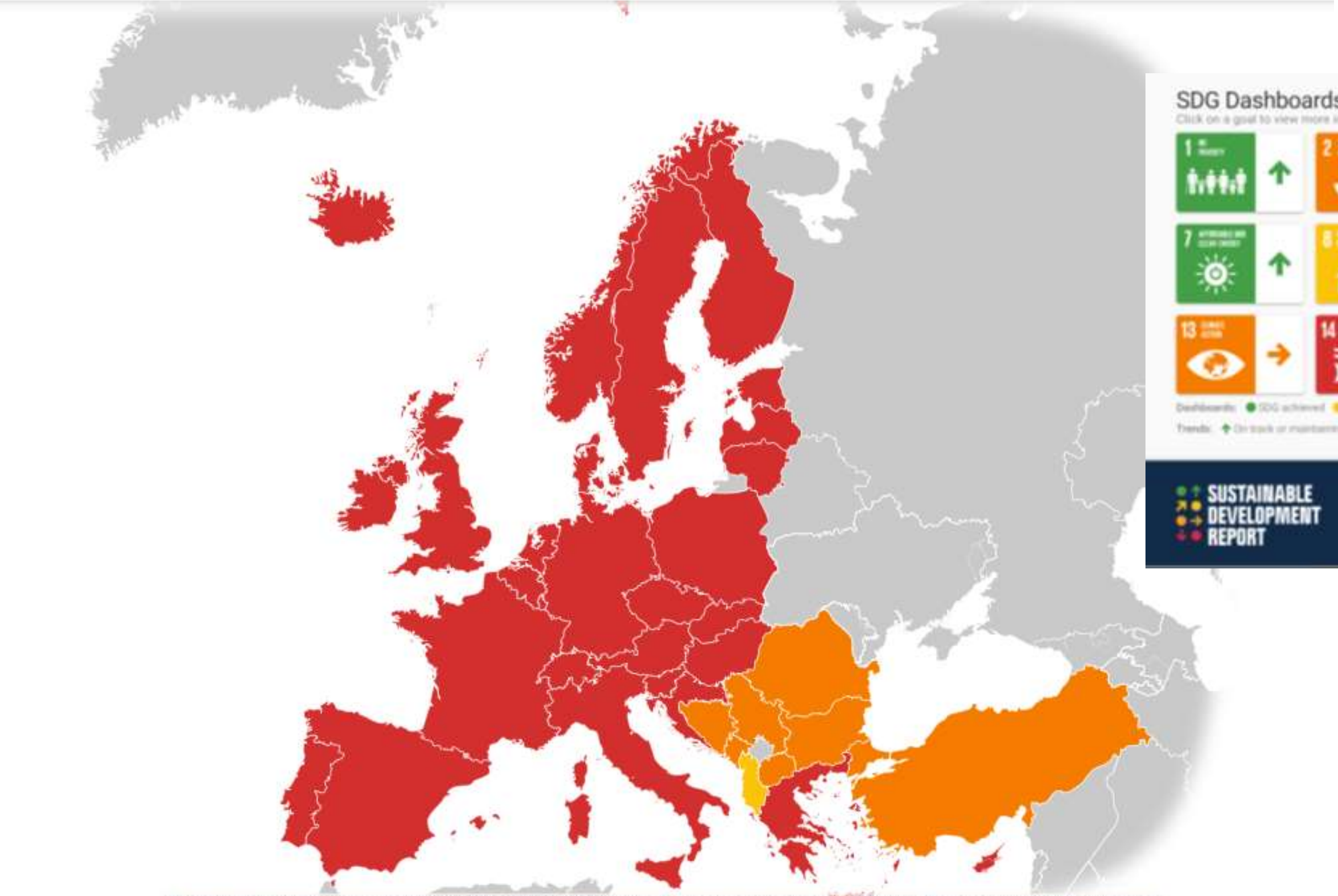


- **Positive Correlation between MWTP and SDGs performance – Integrating the Value of Capital in Investment and Policy Decisions**

- Terrestrial Ecosystem
  Higher Correlation to **SDG 15**

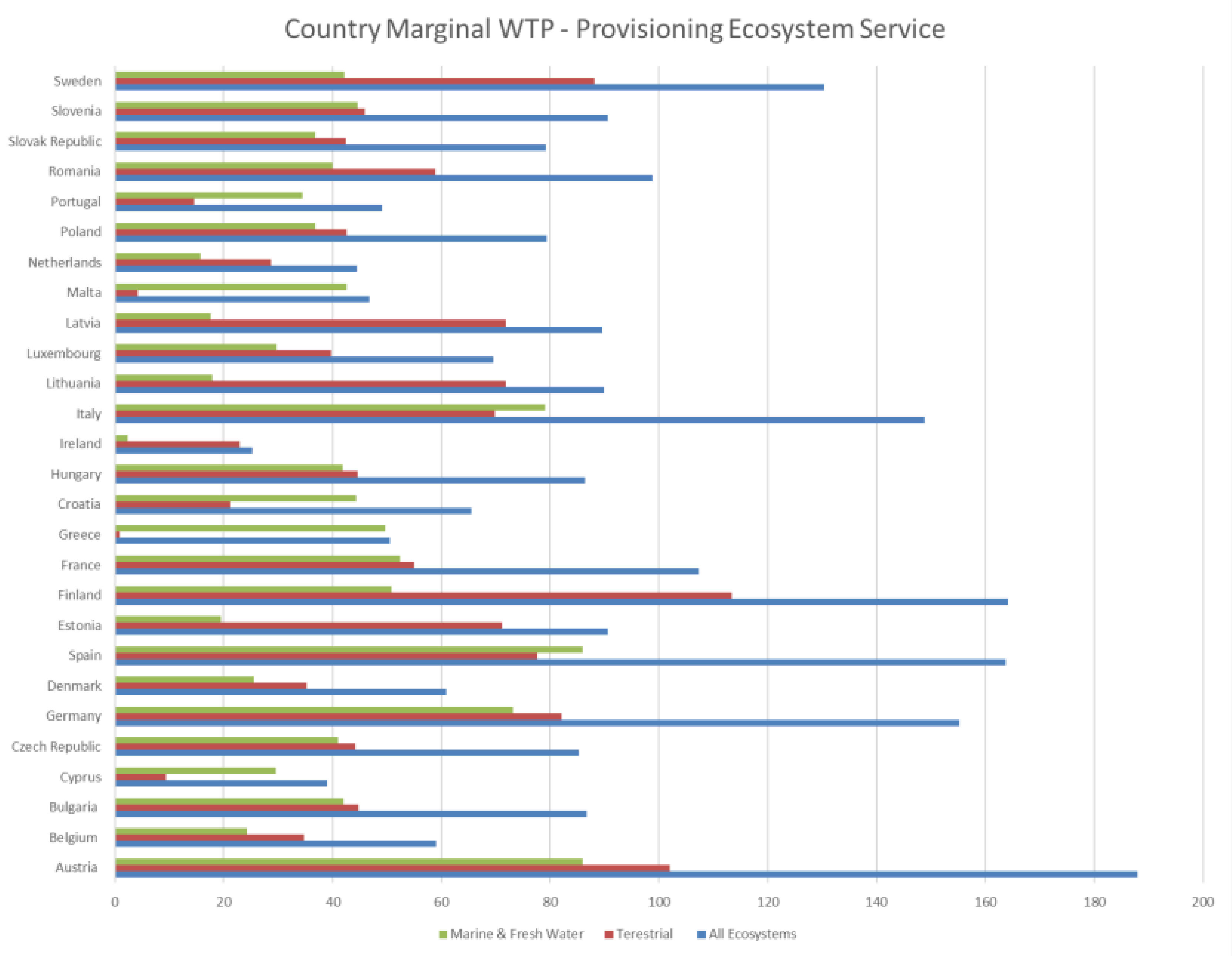
- Marine and Fresh Water
  Higher Correlation to **SDG 13**

Interactive MWTP tools/ dashboards for All EU Ecosystem Services

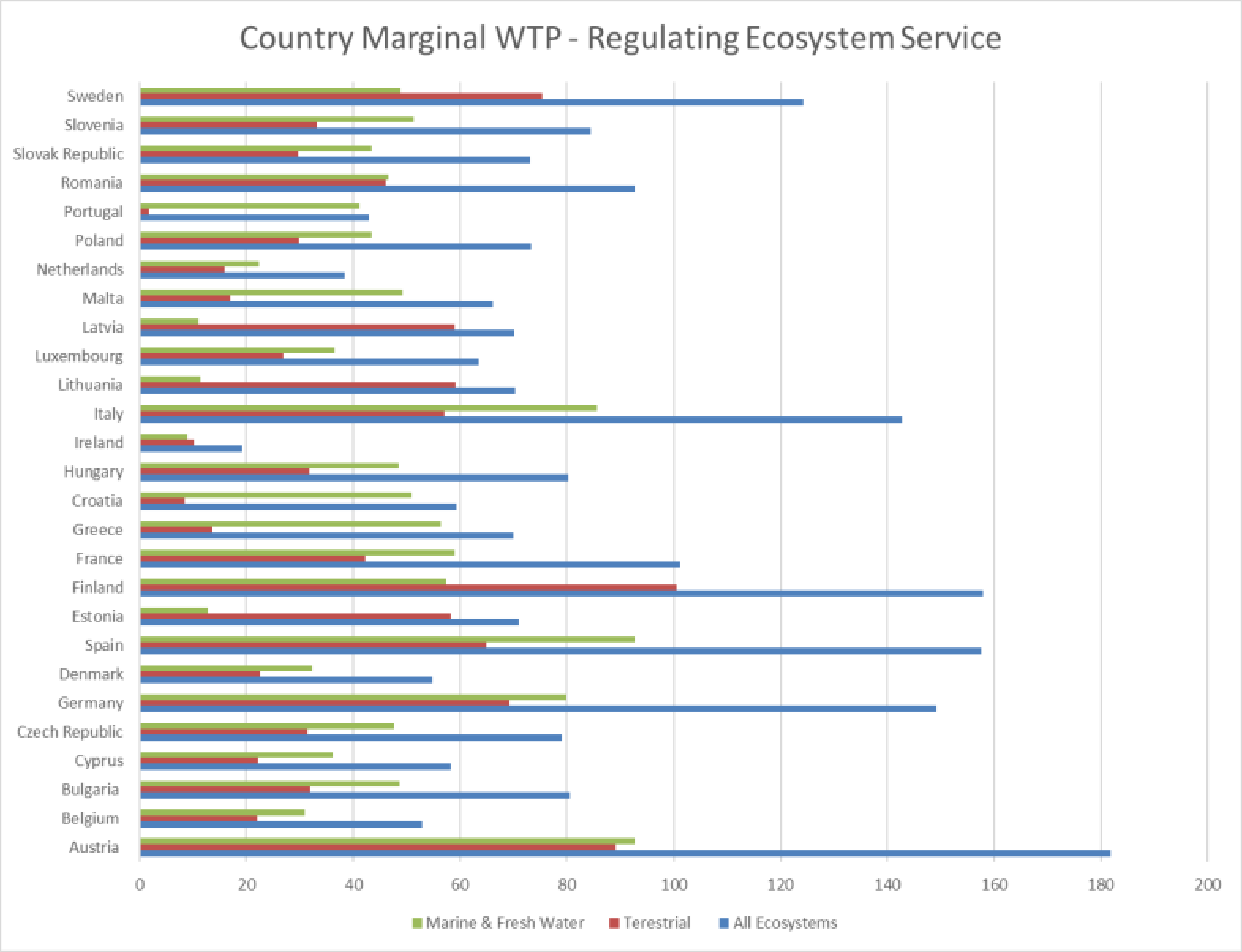


Sustainable Development Solutions Network & Institute for European Environmental Policy · Note on country boundaries

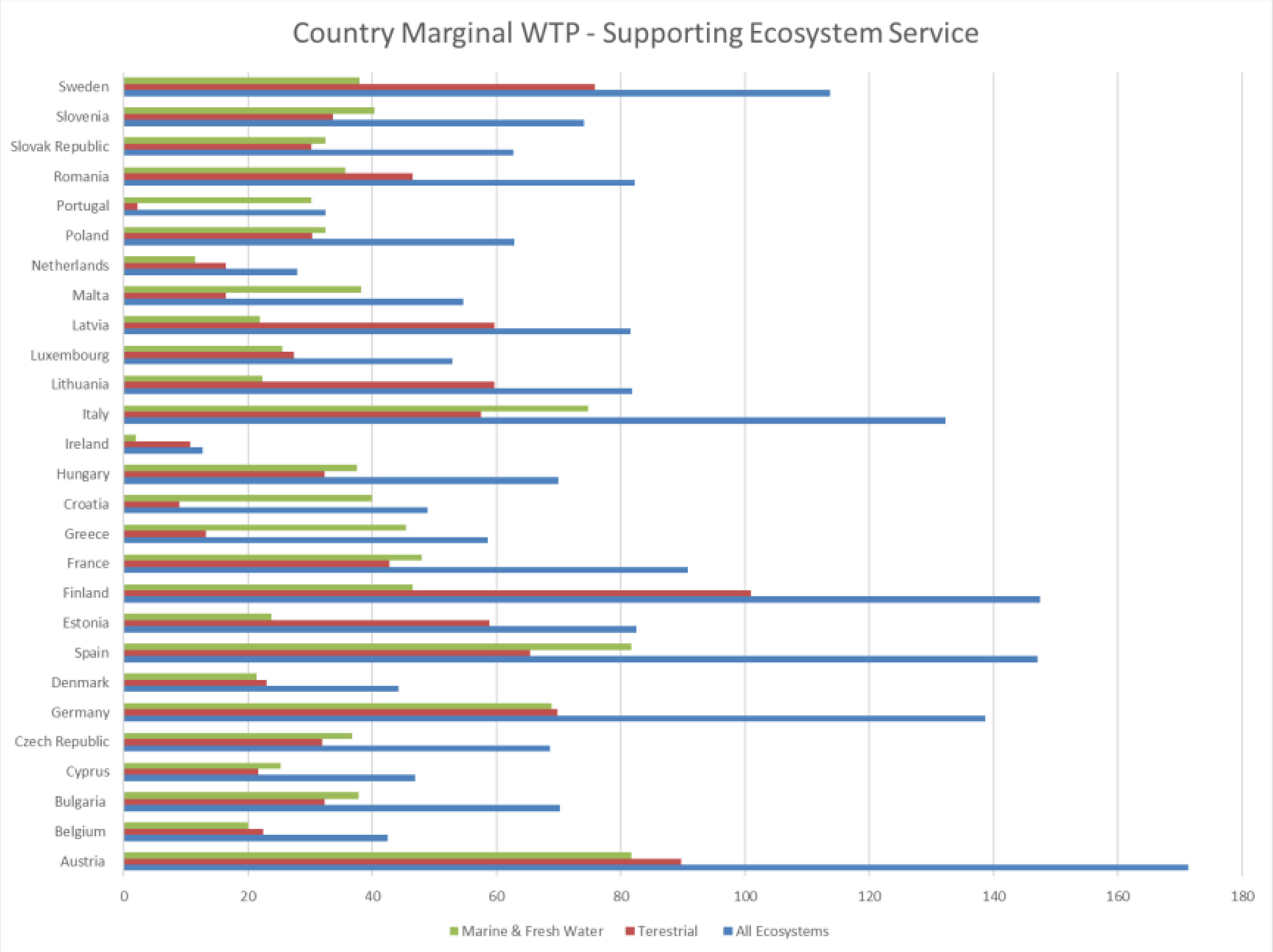
Provisioning Ecosystem Service



Regulating Ecosystem Service



Supporting Ecosystem Service



How Accurate Is Benefit Transfer?

- Like many economic phenomena, true WTP can never be observed, only estimated.
- Benefit transfer is only conducted when a primary study has not been conducted.
- Accuracy in actual situations is not known.
- But, if a primary valuation study *has been* conducted for a site, we can compare the value estimated using benefit transfer to the value estimated by the primary study.
  - This is called convergent validity testing.
  - Used to evaluate "how accurate" benefit transfer might be in actual policy uses.

Testing MRM Benefit Transfer

- To evaluate the out-of-sample accuracy of BT forecasts from the MRM (inversely related to transfer error), we apply an iterative leave-one-out convergent validity test.
  - Begin with metadata of n=1…N observations.
  - Omit n^{th} observation from the metadata.
  - Estimate MRM using the remaining N-1 observations.
  - Steps 2 and 3 iterated for each n=1…N observation, resulting in a vector of N unique sets of MRM parameter estimates, each corresponding to the omission of the nth observation.
  - For each iteration, results are used to forecast WTP for the nth omitted observation, resulting in N out-of-sample forecasts.
  - Evaluate transfer error for each iteration.

Convergent Validity Test Results

	Mean Absolute Value Error ($)	Std. Dev.	Mean Absolute Value Error (%)	Std. Dev. (%)
Model Accuracy Measures	$3.03	$4.09	**68.23%**	133.45%

- On average, one expects a mean (absolute value) error of approximately 68%, when the model is used for benefit transfer in actual situations (forecasting out of sample).
- This is a common magnitude of error for MRM benefit transfers.
- If greater accuracy is needed, primary valuation studies should be conducted.

Sustainable Finance

Valuation of Cultural Heritage Services – Benefit Transfer

Cultural heritage provides goods and services to society that are non-marketed, hence they have no explicit price, but have value

- Cultural heritage comprises a variety of assets and sites that are often in need of maintenance, repair or refurbishment. Recently, there has been increasing recognition of the need to identify and assess the value of cultural heritage assets in order to guide investments in maintenance and conservation programs.

- World Heritage properties are affected by the impacts of climate change at present and in the future.

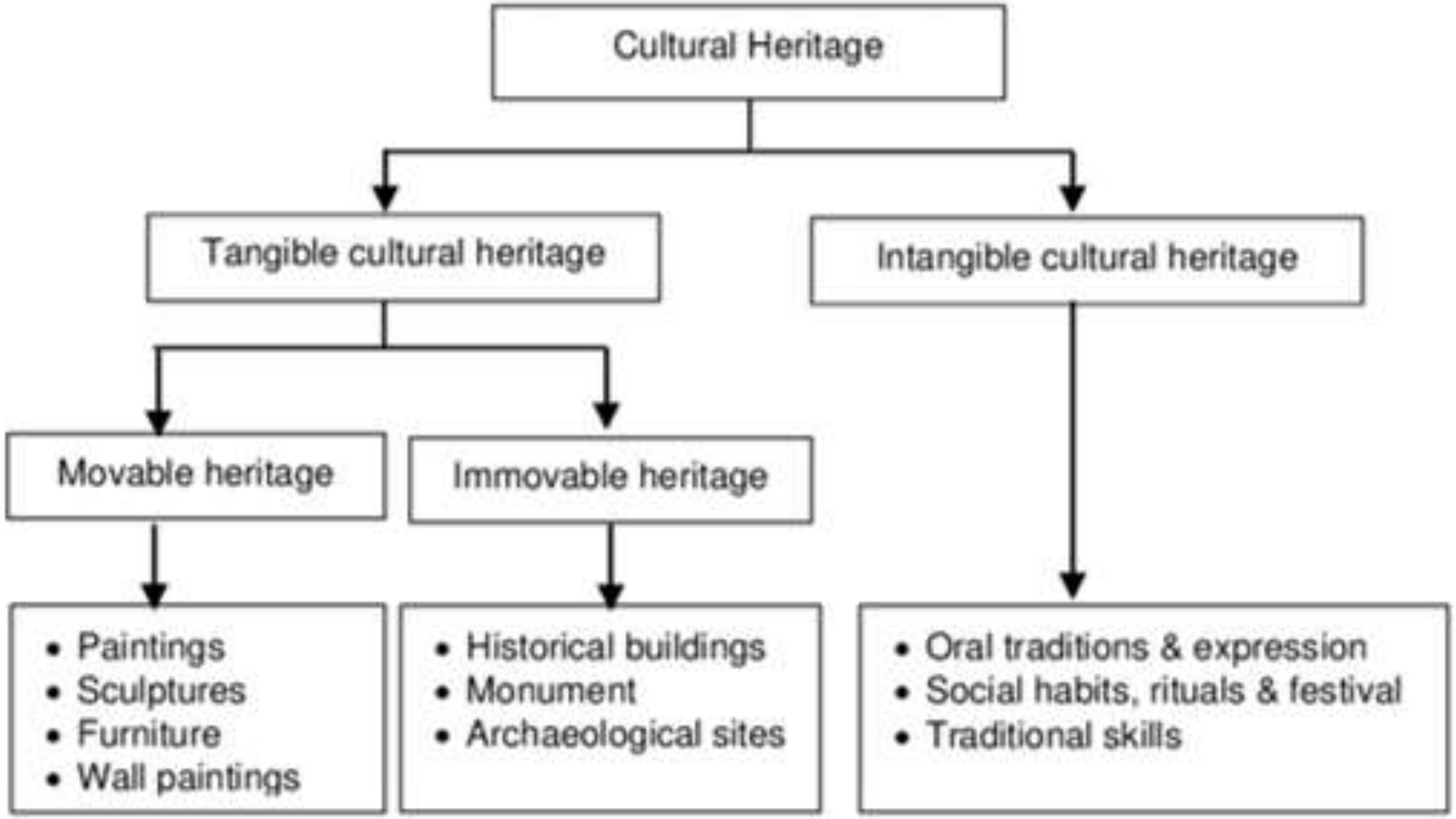
- Their preservation requires understanding these impacts to their Outstanding Universal Value and responding to them effectively.

- Cultural heritage CC adaptation:

  - reductions or avoidance of adverse effects from CC
  - exploitation of beneficial management opportunities

Total Economic Value of Cultural Heritage

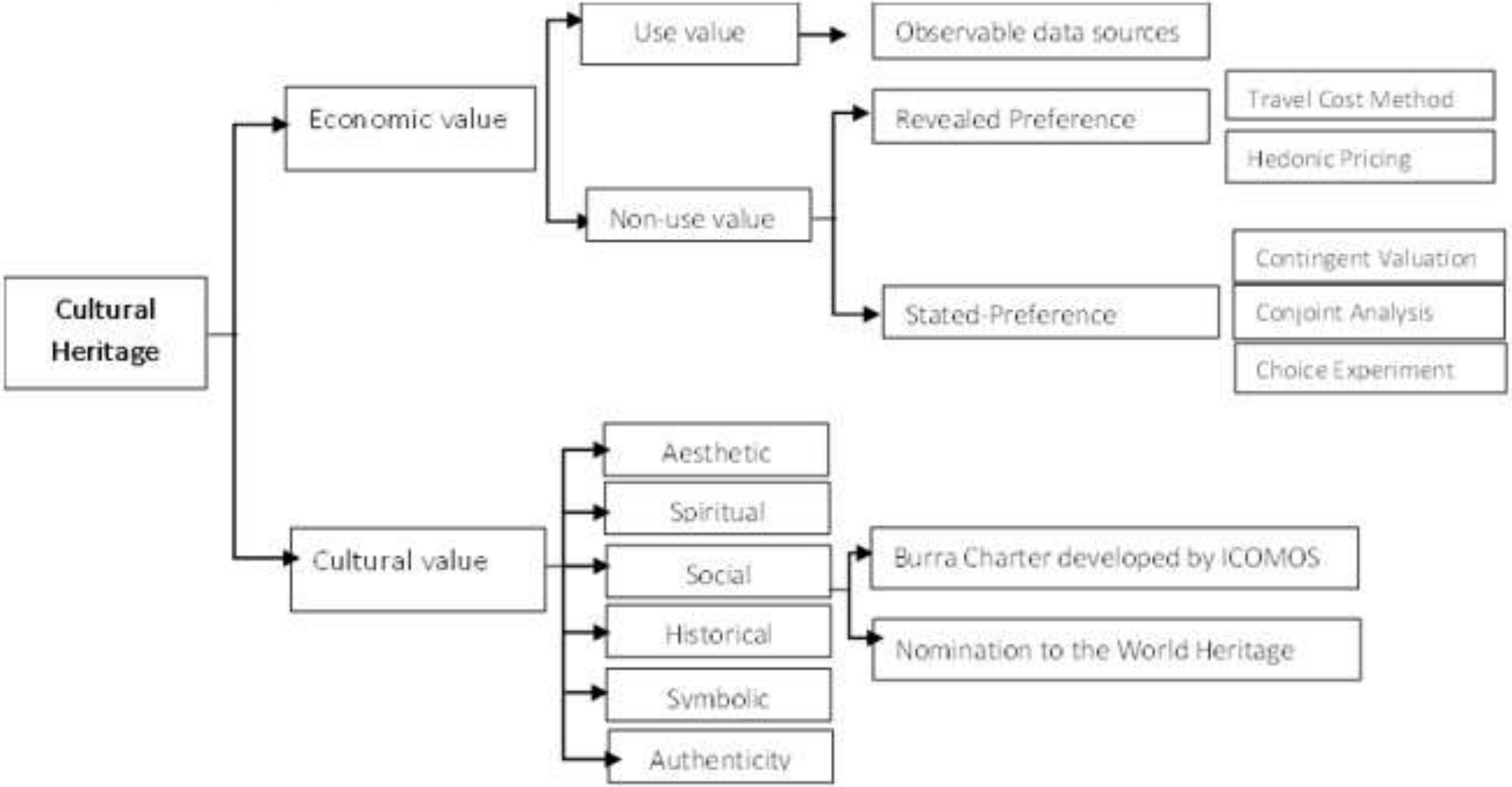
Fig. 1: Cultural Heritage Goods classification



Source UNESCO, 2003

Cultural Heritage - Valuation

Fig. 2: Cultural Heritage: economic and cultural value and valuation methodologies



Cultural Heritage – Meta-Regressions

Step 1: The dataset currently comprises 19 studies published between 2001-2020 and providing valuations for the shadow prices (WTP) of cultural heritage goods at various countries around the world.

Step 2: Meta-Regression Estimation of the value of ecosystem services using **Benefit Transfer Method** -Estimates economic values by transferring and adjusting existing benefit estimates, from studies already completed for another location.

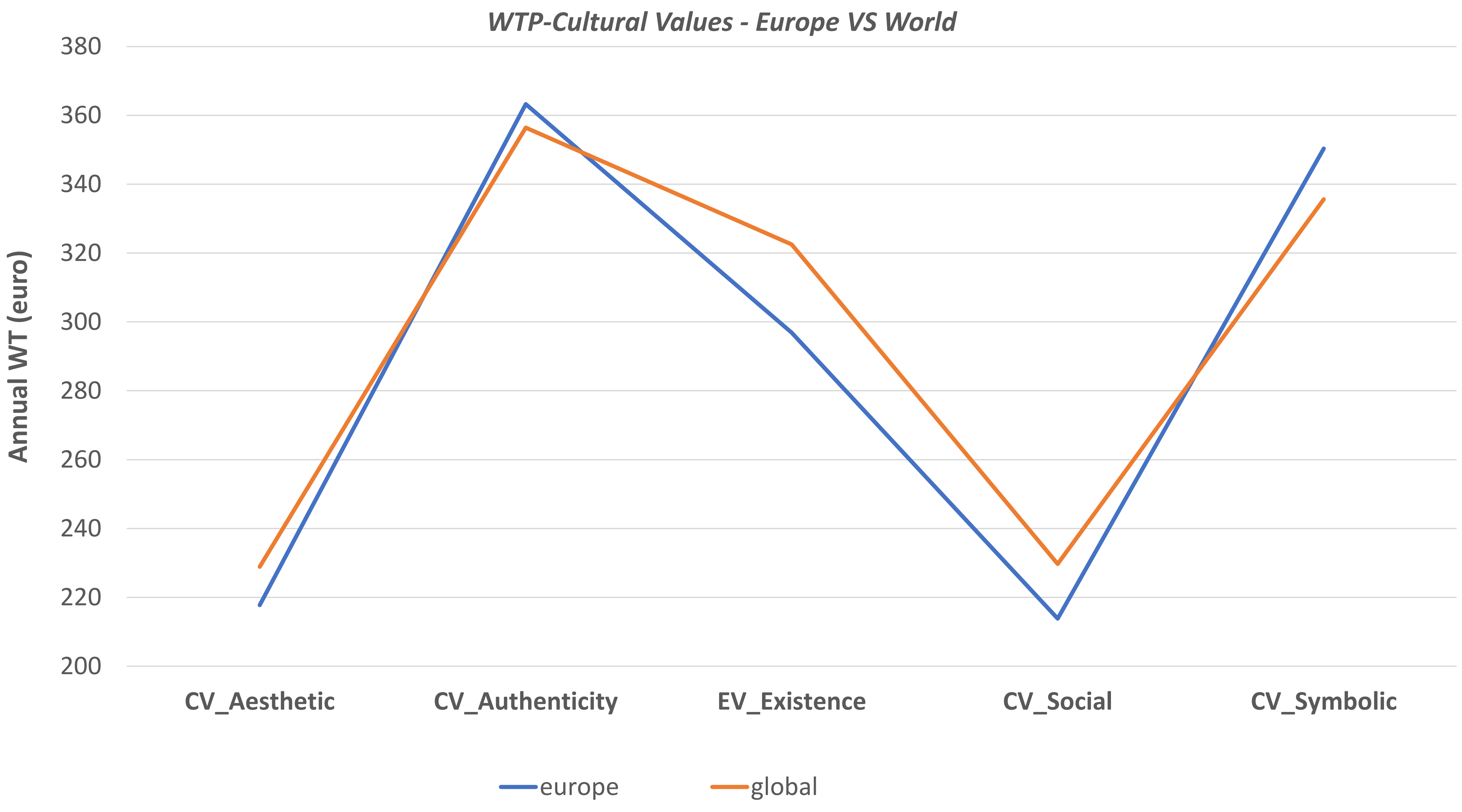
- Annual mean WTP for Cultural Services in Europe is *46.41euro*
- Annual WTP for Cultural Services at a International level is *39.78euro*

Table1 Cultural Heritage Meta-Regression Results

Variables	**EUROPE**	**GLOBAL**
Age	-5.7679 [0.338]	-2.3361 [0.3822]
Gender	**1184.085*** [0.0641]	**889.32**** [0.0198]
Income	0.002093 [0.3084]	**0.002147*** [0.0943]
CV_Aesthetic	**-179.8042**** [0.0480]	***-172.0732****** [0.0040]
CV_ Authentification	-34.2873 [0.6163]	-44.5934 [0.4121]
CV_Existence	***-100.636*** [0.2249]	**-78.50827*** [0.0941]
CV_Social	**-183.6599*** [0.0697]	**-171.2683***** [0.0041]
CV_Symbolic	-47.18176 [0.4920]	***-65.3534*** [0.2324]
R-square	0.67	0.60
Hetersoskedasticity Glejser test	[0.1177]	[0.4130]
ARCH test	[0.6958]	[0.5559]
Total WTP	**46.41**	**39.78**

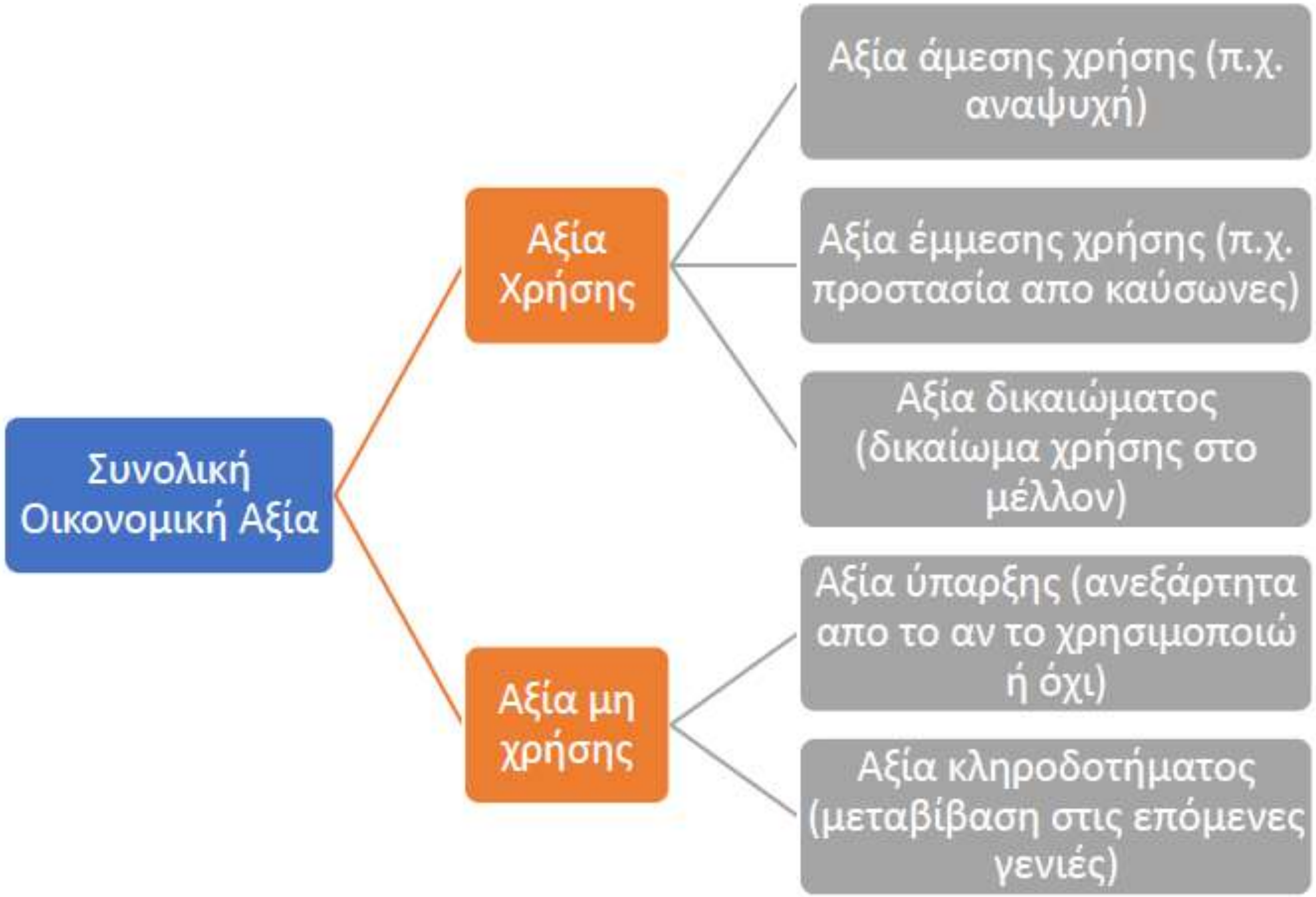
P-values in brackets

Cultural Heritage Services -WTP



Sustainable Finance

Valuation of Urban Parks in Greece– Benefit Transfer



Εικόνα 4 Απεικόνιση των συστατικών της Συνολικής Οικονομικής Αξίας

Πίνακας 3 – Περιγραφικά στατιστικά δείγματος

	WTP	POP	GEN	AGE	EDU	INCOME	EUROPE	ASIA
Μέσος	21.54	2494080	0.49	35.91	0.5	12782.47	0.36	0.52
Διάμεσος	7.86	1847000	0.49	35.91	0.5	10729.71	0	1
Μέγιστη Τιμή	103.64	8700000	0.6	46	0.84	38579.34	1	1
Ελάχιστη Τιμή	0.1	18000	0.41	23.57	0.15	371.25	0	0
Τυπική Απόκλιση	27.39	2757761	0.04	6.18	0.19	11617.28	0.49	0.51
Λοξότητα[11]	1.61	1.12	0.61	-0.26	0.1	0.63	0.58	-0.08
Κύρτωση[12]	4.69	2.84	4.34	2.58	2.18	2.13	1.34	1.01
Παρατηρήσεις	25	25	25	25	25	25	25	25

$$Y_i = \beta_0 + \sum_{j=1}^{k} \beta_j X_{i,j} + \varepsilon_i \quad (1)$$

Πίνακας 6 Αποτελέσματα Μετα-παλίνδρομης, εξίσωσης (1)

Μεταβλητή	Συντελεστής	Τυπικά Σφάλματα	t-Στατιστική	p value
β0	**-57.68***	29.64	-1.95	0.07
AGE	**2.25****	0.86	2.63	0.02
AGE*(1-ASIA)	**-2.59*****	0.79	-3.27	0.00
EDU	**-57.51****	25.71	-2.24	0.04
EDU*(1-ASIA)	**196.85*****	57.68	3.41	0.00
INCOME	**0.00095****	0.00045	2.13	0.05
POP	**0.0000053****	0.00000	2.49	0.02
R-squared	0.58			
Adjusted R-squared	0.43			
F-statistic	**4.08*****			
p value (F-statistic)	0.0093			
Schwarz criterion (BIC)	9.46			

$$\widehat{WTP} = \hat{\beta}_0 + \sum_{j=1}^{k} \widehat{\beta_J} \widetilde{X_{\iota,J}} \qquad (2)$$

Η εκτίμηση του Willingness to Pay (WtP), σε ετήσια κατά κεφαλήν βάση, προκύπτει από την εκτίμηση της σχέσης 1 του πίνακα 6 και την χρήση των Κοινωνικό-οικονομικών και δημογραφικών χαρακτηριστικά δήμου Αθηναίων ($\widetilde{X_{\iota,J}}$), από την σχέση 2:

$$\widehat{WTP} = 23{,}7 ευρώ$$

Που αντιστοιχεί στο κατά κεφαλήν ετήσιο ποσό που είναι πρόθυμοι να πληρώσουν οι Αθηναίοι πολίτες για την διατήρηση του πάρκου Ριζάρη.

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