Valuation of Marine Ecosystems and Sustainable Development Goals

Koundouri, Phoebe and Halkos, George and Landis, Conrad and Dellis, Konstantinos and Stratopoulou, Artemis and Plataniotis, Angelos and Chioatto, Elisa

March 2023

Valuation of Marine Ecosystems and Sustainable Development Goals

Phoebe Koundouri*, George Halkos**, Conrad Landis***, Konstantinos Dellis[+], Artemis Stratopoulou[++] Angelos Plataniotis[+++], Elisa Chioatto[a]

* School of Economics and ReSEES Research Laboratory, Athens University of Economics and Business; Department of Technology, Management and Economics, Denmark Technical University (DTU); Sustainable Development Unit, Athena RC; Academia Europea; pkoundouri@aueb.gr

**Professor, Department of Economics, University of Thessaly, Volos, Greece, halkosg@aueb.gr

*** ReSEES Research Laboratory, Athens University of Economics and Business; Visiting Faculty, India Institute of Management Rohtak, conrad@aueb.gr

[+] Sustainable Development Unit, ATHENA Research Centre; University of Piraeus, k.dellis@athenarc.gr

[++] Sustainable Development Unit, ATHENA Research Centre; Panteion University of Social and Political Sciences, a.stratopoulou@athenarc.gr

[+++] National and Kapodistrian University of Athens, Greece, aplataniotis@econ.uoa.gr

[a] Department of Economics and Business, University of Ferrara, Italy, elisa.chioatto@unife.it

ABSTRACT

This paper refers to the valuation of European, Marine and Fresh Water Ecosystem Services. Using a meta-regression approach, we estimate the Annual Willingness to Pay (WTP) for several classifications of the ecosystem services and various biogeographical and marine regions across all twenty-seven EU markets. Moreover, we explore the correlation between WTP and the national level of achievement of the 17 SDGs, with particular focus on SDG 14 - Life Below Water. Results indicate that regulating services of marine and freshwater ecosystems are ranked high and that in almost 63% of the European countries, the WTP for the improvement of the marine & freshwater ecosystem is high and exceeds estimates for terrestrial ecosystems. Valuing

ecosystem services and link them to the Sustainable Development Goals, we find that marine ecosystems are mainly positively correlated to SDGs 2,12,13, 14 and 17, while a high MWTP value is assigned to specific SDG14 individual indicators like fish caught from overexploited or collapsed stocks and fish caught that are then discarded. Overall, results indicate that societies attributing greater value to ecosystem services mark greater progress towards the implementation of SDGs and SDG 14 in particular.

KEYWORDS: Valuation, Sustainable Development Goals, Ecosystem Services, Meta-Regression, Marine, Freshwater

Introduction

The significance of natural capital is an indisputable fact. Natural capital can be considered as a stock in nature that provides a flow of benefits for people and the economy. The goods and services that natural capital give, such as food, water, shelter, or climate regulation, are called ecosystem services and they underpin healthy lives and economic activity. However, increasing pressures from climate change and biodiversity loss cause serious degradation in the provision of these services placing considerable challenges and risks for humans and businesses. This interaction between human, produced and natural capital is depicted in Figure 1.

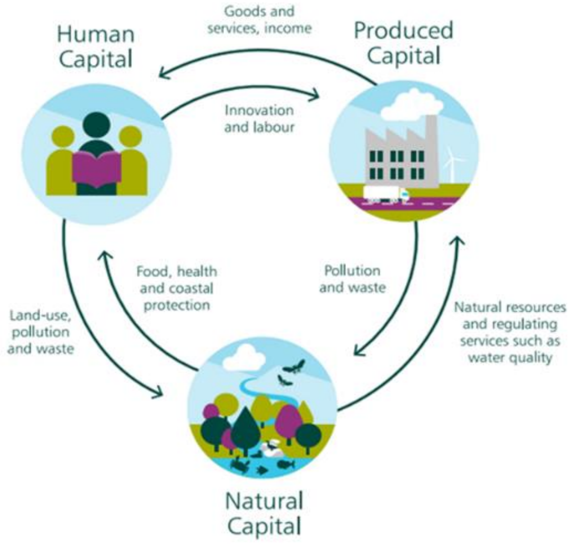

Figure 1: The relationship between different types of Capital. Source: The Dasgupta Review, 2021.

People derive economic value from natural resources and the environment, which may not be revealed in the markets. Total Economic Value (TEV) is composed of the use and non-use value. A resource's use value might be either a market value, such as minerals, wood, water and other goods, or a non-market value, such as outdoor recreation, landscape amenity, and many others. An example of non-use values can be the importance people attach to specific habitats or species. Despite the obvious importance of ecosystem service values, policy makers often ignore the value of environmental goods and services and their economic and social benefits due to the so-called market failures. And since many ecosystem services are not traded in the markets, they do not have a price. TEV represents the total benefit in well-being from a policy, which is the sum of the people's willingness to pay (WTP) and their willingness to accept the policy (WTA).

Thus, it is important to value ecosystem services because it helps people make informed decisions. Valuing ecosystem services ensures that policy decisions consider the costs and benefits of the natural environment and the implications for human well-being while helping policymakers pursue alternative policies. Indeed, the term “ecosystem services” indicates the link between natural capital and the economy, which corresponds to the utility people derive from exploiting ecosystems.

So far, metrics like the Gross Domestic Product (GDP) or even the UN Human Development Index (HDI) measure only economic progress and human well-being in the case of HDI, failing to corroborate benefits, such as pollination, regulation and nature's ability to mitigate disasters. This incapability to account for the total economic value of ecosystems jointly with the vicious cycle of overproduction and overexploitation, has significantly influenced ecosystem services degradation, jeopardizing the present and the future possibility of growth and prosperity. Consequently, incorporating the economic value of ecosystem services in the mainstream public and private decision-making is pivotal to invert ecosystems degradation.

Theoretical Background

Ecosystem services

The productivity of natural capital derives from its quality and quantity, in other words, its biodiversity. Therefore, maintaining the stock of this capital constant allows the provision of flows of ecosystem services which depends on human present and future prosperity (TEEB, 2010).

Ecosystem services (ES) are final products or results that directly and indirectly affect human well-being, and these factors can work well with an economic strategy. According to Daily (1997), ES are "The conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life", whereas Costanza *et al*. (1997) postulate that they are "Benefits human populations derive, directly or indirectly, from ecosystem functions".

The main reason for valuing ecosystem services is that it will help people make informed decisions. It will make sure that policy decisions consider the costs and benefits of the natural environment and the implications for human well-being while giving policymakers new ideas. Indeed, the term "*ecosystem services*" indicates the link between natural capital and the economy, which corresponds to the utility people derive from exploiting ecosystems.

The Millennium Ecosystem Assessment (MA, 2005)[1] has recognized four categories of ecosystem services (**Figure 2**):

- **Provisioning services**: products obtained from ecosystems, e.g., water, food, fiber;
- **Regulating services**: benefits guaranteed by the regulation of ecosystem processes, e.g., climate regulation, water regulation, and pollination.
- **Cultural services**: non-material benefits derived from ecosystems, e.g., recreation, aesthetic, spiritual and religious, and cultural heritage.
- **Supporting services**: services needed to produce all the other ecosystem services, e.g., nutrient cycling, soil formation, primary production.

In the context of ecosystem services of water and marine resources, which are closely related to the progress on Sustainable Development Goal 14 (henceforth

[1] The Millennium Ecological Assessment (MEA) was a four-year multinational work program aiming to provide scientific knowledge on the relationships between ecosystem change and human well-being to decision-makers. Millenium Ecosystem Assessment looked at the effects that changes in the ecosystem have on human well-being. From 2001 to 2005, more than 1,360 experts from all over the world worked on the MA. Scientifically, their findings show how ecosystems and the services they provide are in a state of flux around the world. They also show how to protect and use them in a way that is healthy for the planet and for people.

SDG14), ecosystem services include climate regulation; disturbance prevention (storm protection and flood prevention); water regulation (e.g., land cover, regulation of runoff, river discharge); water supply; waste treatment; aesthetic features; recreational uses; cultural, artistic, spiritual, historic, scientific, and educational values.

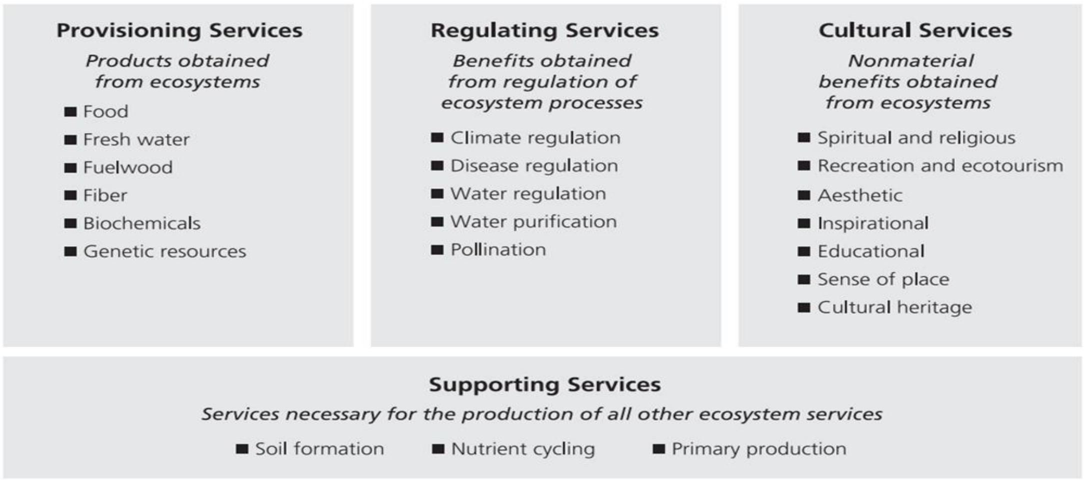

Figure 2: Ecosystem Services. Source: Millennium Ecological Assessment

So far, only a tiny fraction of products offered by nature are considered in current metrics that measure economic progress (GDP) and human well-being (Human Development Index), as highlighted by Dasgupta (2021). Moreover, other benefits, such as pollination, regulation, and nature's ability to mitigate disasters, have failed to be captured. This incapability to account for the total economic values of ecosystems and biodiversity, jointly with the intense pace of economic activity, has significantly influenced their degradation.

Valuation of ecosystem services

Assigning a value on ecosystem services is the last step in a long and often detailed study of how a policy change will affect them. Based on the type of ecosystem service and the amount and quality of data that can be used to value it, the suitable valuation method will be chosen. Ecosystem Services are of grave importance, primarily because they create value for humans. Total Economic Value (TEV) encompasses all channels through which ES contribute to tangible and intangible benefits and enhance well-being. Figure 3 presents the broader value categories, considering both the use and non-use values that people and society gain or lose from small changes in ecosystem services. Because many ecosystem services are not traded in markets, they do not have a price. So, to figure out how much these goods or services are worth, you need to use non-market valuation methods. Use value arises from the direct exploitation of ES for human wellbeing and includes: (i) direct use value, whereby humans deliberately use the ecosystem, for example, for nutrition, irrigation, timber etc. (ii) indirect use value, whereby the benefits accrue to humans without the immediate use of environmental resources, as is the case water regulation and (iii) option value, which describes the knowledge that humans are able to extract a direct or indirect use value in the future, hence it is the value attributed to preserving environmental resources. Finally, non-use value is based on the premise that acknowledging the existence of ES is of value to human beings.

TEV represents the total benefit in well-being from a policy, which is the sum of the people's willingness to pay (WTP) and their willingness to accept the policy (WTA). We are attempting to capture the overall value of a marginal change in the underlying ecosystem services (DEFRA, 2007).

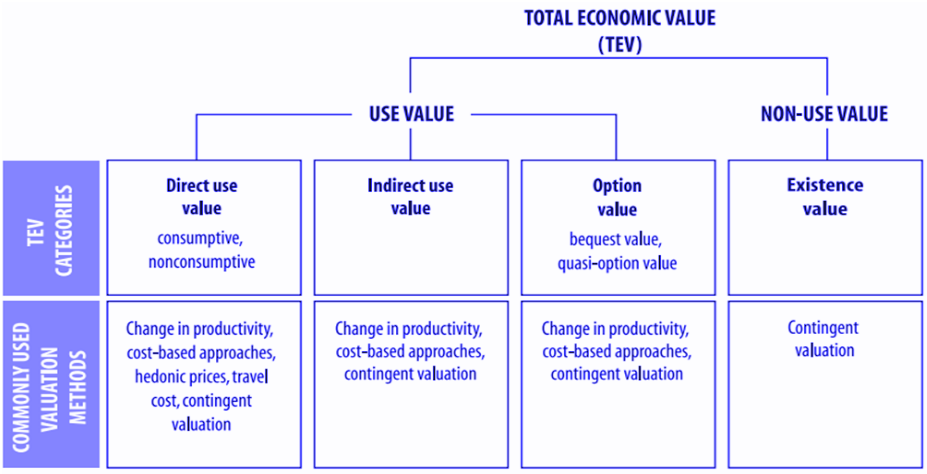

Figure 3: The Total Economic Value Framework. Source: Millennium Assessment

The concept of economic valuation of ES is focused on the estimation of the impacts of changes in ecosystem services on the welfare of individuals. Benefits and costs are approximated using pecuniary values (payments or compensations), which are based to the two basic concepts of willingness to pay (WTP) and willingness to accept (WTA). The services provided by the natural environment directly affect human utility and societal welfare in multiple ways, but lack of economic valuation results in their absence of policy dialogues and policymakers' priorities. Economic Valuation using the appropriate techniques is of utmost importance as it underscores the fact that although the environment is "free", it far from invaluable. It is common to use non-market valuation techniques to assign a monetary value to ecosystem goods and services, since they are not traded in markets. These methods, in turn, require the conceptualization and measurement of the link between changes in the quantity or quality of the resources and changes in the stated or observed behaviour of individuals. Among these non-market valuation techniques, the most widely used in the relevant empirical literature are the revealed preference and stated preference methods. Stated preference techniques usually refer to contingent valuation and choice modelling. The main revealed-preference methods that have been used to value ecosystem services are travel-cost, random utility modelling hedonic pricing, and production function models.

Critique on Valuation

The process of valuation of ecosystem services through the lens of economic theory as a means for policy action towards sustainable development has been criticized mainly on two grounds. Firstly, scholars from the fields of ecology and environmental studies strongly oppose to the economic definition of value for environmental resources and raise ethical concerns on the limits of the economic science, nature's commodification, and the purpose of the policy extents. According to Farber *et al*. (2002) "value" is a term that most ecologists and other natural scientists would prefer not to use at all, as environmental scientists view nature holistically as a system where natural processes are operating. Instead of assigning pecuniary value to the diverse ecosystem services, they consider the efficiency with which each aspect of the system contributes to the natural processes. Hence, most ecologists or environmental scientists do not recognize the merit in the economic valuation of environmental resources and ecosystem services. In addition, ES valuation procedures have been the subject of criticism due to methodological issues and, hence, the validity of their results. All proposed valuation methods pose significant challenges both in terms of design as well as implementation, which has let opponents question the values attributed to environmental resources following these methods. According to Chan *et al*. (2012) all valuation methods fail to fully capture the values associated with ecosystem services due to the conflation of services, values and benefits inherent in the environmental procedures and the sheer difficulty to encompass intangible values (such as cultural values) in a consistent manner which would shape sound environmental policy.

Having said that, there is merit in the economic valuation of ecosystem services as long as this considers the multifaceted nature of environmental resources and the complexities arising from natural processes. Measuring ES is crucial for their management and shaping economic and environmental policy, especially when this is mostly undertaken by governments and regions running on tight fiscal budgets. Economic valuation, albeit challenging can help raise awareness regarding environmental issues and prioritize environmental projects through a cost-benefit approach. Furthermore, dismissing the whole valuation discourse would imply an *a priori* zero value on ecosystem services and that can be detrimental for policies to tackle climate change and environmental degradation. Recent advances in data science and data availability can be of pivotal importance to improve valuation techniques that embed aspects from different scientific disciplines and attempts to adequately map human behavior. According to Daily *et al*. (2009) “The biophysical sciences are central to elucidating the link between actions and ecosystems, and that between ecosystems and services (biophysical models of “ecological production functions”). The social sciences are central to measuring the value of services to people (“economic and cultural models”). Because this value is multidimensional, it makes sense to characterize it as fully and systematically as possible, in ways that will be meaningful to many different audiences.”

Valuation and marine ecosystems

Coastal and marine ecosystems provide a variety of ecological functions and economic services to society. However, they are significantly affected and threatened by widespread and increasing pressures such as overfishing, water contamination and pollution, coastal habitat destruction, and general loss of biodiversity. Marine ecosystems are of utmost importance as oceans and seas play a critical role in climate regulation, absorbing almost a third of the carbon dioxide emitted annually. Furthermore, marine and coastal ecosystems are home to numerous plant and animal species, which all produce a bevy of useful services for humans. Consequently, valuing marine ecosystem services and quantify the benefits provided to people is crucial as it can be combined with other sources of value to society. UNEP-WCMC (2011) reviews some of the most commonly used methods for economic valuation of marine and coastal ecosystem services providing considerable policy implications for decision making and communication. Koundouri et al. (2015, 2019) present the ecosystem services approach with regards to the marine ecosystem and propose economic methods that capture the marine ecosystem's total economic value in relation to the opportunity cost of marine space. Koundouri *et al*. (2009), focusing on the marine and coastal ecosystems of the Mediterranean and the Black Sea, examine information from valuation studies in the area in order to draw important conclusions and provide suggestions in effectively managing coastal and marine environments, stopping the adverse effects of the generally poor current state of marine ecosystems in the region. In general, the total value of the services produced by marine and coastal ecosystems is valued at $29.5 trillion per year, more than the USA's gross national product in 2015 (Ocean and Climate Platform).[2]

[2] https://ocean-climate.org/en/marine-and-coastal-ecosystem-services/

However, it is urgent to assess the level of protection and the ecosystems' resilience in order to avoid further degradation and the loss of services. The framework of Sustainable Development Goals (SDGs) facilitates the achievement of sustainable development by providing a holistic set up of specific general targets. SDGs were adopted by the United Nations in 2015 to call for actions to end poverty, reduce inequalities, protect the planet, and ensure that all people have equitable access to a prosperous and peaceful life. More precisely, SDG 14 is about conserving and sustainably using the oceans, seas and marine resources, highlighting that healthy oceans and seas are essential to human existence and life on Earth. As marine ecosystems constitute the 70% of the planet and provide food, energy and water while absorbing around one third of the world's annual carbon dioxide (CO2) emissions, they are established as the largest ecosystem in planet on one hand, and on the other, as the most critical contributors in mitigating climate change and alleviating its impacts.

In the global context of environmental degradation and the multiple risks stemming from climate change, the dichotomy between sustainable economic development and environmental protection is outdated. One cannot inspire in achieving substantial progress on the SDG front without tackling the issues of environmental debasement, biodiversity loss and climate change (Vorosmarty *et al.*, 2018). Johnson *et al.* (2019) argue that addressing the challenges set by the SDG framework warrants a complex socio-economic approach whereby ecosystem service valuation and management are in the epicenter. Furthermore, the authors underscore that, apart from encouraging better management practices of environmental resources to support SDG 14 and SDG 15, interdisciplinary methods for ecosystem service valuation shed light to the interlinkages between environmental SDGs and goals associated with well-being (e.g., SDG2 and SDG 3).

Specifically, in the case of SDG 14 regarding the conservation and sustainable use of the oceans, seas, and marine resources, attributing value to water and marine ecosystem services cannot be disentangled from the progress in the respective targets within this goal. Marine ecosystems and water resources in general provide services in the form of clean water supplies, water for farming and irrigation as well as indirect benefits including building resilience to climate risks like flooding. Their non-use values are intangible, nonetheless of great importance to humankind. Addressing these issues with adequately designed tools based on environmental economics, cross-fertilized with knowledge embedded in other disciplines (behavioral economics, psychology, sociology, and ecology) is pivotal in understanding the value of water-related ecosystems and implementing sound policies towards the achievement of SDG14. The achievement of all SDGs will require sizeable funding from the international community, national governments, and private actors. Furthermore, green infrastructure represents a high share of the projects to be undertaken in the process. In this context and given tight government budgets and crisis-hit private enterprises, ecosystem services valuation stemming from scientific methods will be a prerequisite in order to mobilize scarce resources.

Pertaining to SDG14, the need of improving the sustainable use of marine natural capital necessitates the inclusion of ecosystem valuation in marine management decision models. And although ecosystem services valuation has advanced significantly the last years, still their results remain untapped for marine management and policy decisions. Koundouri and Vassilopoulos (2017) point to this fact by extensively discuss and justify the objectives of marine ecosystem services valuation.

Data and Methodology

For the economic valuation, a meta-regression analysis has been conducted using the publicly accessible database EVRI (Environmental Valuation Reference Inventory). Primary literature[3] related to ecosystem services valuation from 2012 to 2022 has been selected. Studies have been determined according to the ecosystem typology, the ecosystem services valued, and the geographical area in which the study was conducted.

Mapping and Assessment of Ecosystems and their Services (MAES) Typology for ecosystem classification (European ecosystem assessment-concept, data and implementation, EEA Technical Report, no 6/2015) has been followed to identify the typology of ecosystems. This includes three main groups 1) Terrestrial ecosystems: urban, cropland, grassland, forest, heathland and shrub, sparsed vegetated land, and inland wetlands; 2) Marine ecosystems: marine inlets and transitional water, coastal, shelf and open oceans; 3) Freshwater ecosystems: rivers and lakes (Figure 4).

On the other hand, ecosystem services have been distinguished between provisioning, regulating, cultural and supporting services in compliance with the

[3] A complete list of studies used in the meta-regressions are available upon request.

aforementioned MA classification. Finally, since ecosystem typologies vary across regions, the geographical area of the study has been defined according to Habitats Directive (92/43/EEC) and for the EMERALD Network set up under the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). This last distinguishes 9 EU biogeographical regions, i.e., Alpine, Atlantic, Black Sea, Boreal, Continental, Macaronesian, Mediterranean, Pannonian and Steppic and 5 EU marine regions, i.e., Marine Atlantic, Marine Baltic, Marine Black Sea, Marine Macaronesian and Marine Mediterranean.

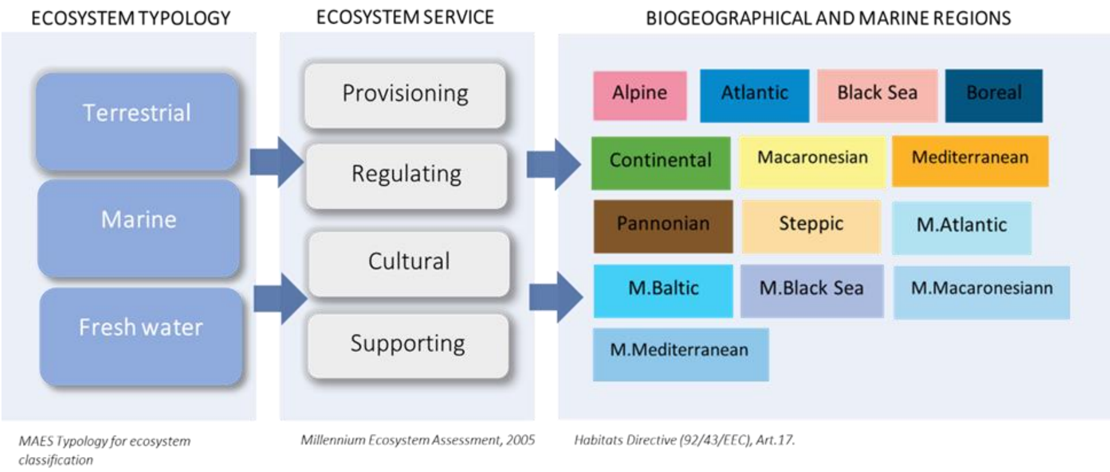

Figure 4: Mapping of Ecosystems Typology to Services across Biogeographical regions

Meta-regression analysis function transfer

To summarize and synthesize the empirical findings of various studies, in our research, we rely on the meta-regression analysis function transfer using the summary statistics provided. Our purpose is to statistically explain the variation found in the studies under consideration due to identifiable characteristics among the considered studies like the valuation method, geographic location, study-specific factors, survey mode, and other relevant determinants and demographic elements. The meta-analysis model is presented as follows:

$$Y_i = \gamma + \beta' X_i + \varepsilon_i \tag{1}$$

where i corresponds to each observation gathered from the studies under consideration, Y denoted the dependent variable in our case, Willingness to Pay (WTP), γ is the intercept, and β are parameters to be estimated as slopes of the specifications, X is a matrix containing the rest of explanatory variables and ε is the error term with the usual properties.

Specifically, **Willingness to pay** refers to the annual mean willingness to pay (in euros) for ecosystem services. Various explanatory variables were considered to explain the variation mentioned above, as, among others, the type of the ecosystem, the underlying ecosystem services, the survey design, the valuation method, the biogeographical region, the country and the Value elicitation methodology.[4] As socioeconomic variables, we have considered the following: Age, Income, Gender and Education.

The final dataset consists of 212 papers collected from the Environmental Valuation Reference Inventory (EVRI), where 165 were used for estimation.[5]

Empirical Results and Conclusions

Willingness to Pay by Ecosystem type and Country

Table 1 provides the descriptive statistics of all the variables used in the analysis.

[4] An extended description of all variables can be found here:

[5] In total 47 studies have been omitted. In general, these studies present net present values, total economic values and monetary values that are hardly compatible with the type of values expressed in the studies under review. In addition, a small number of cases were omitted because the values were too high and thus represented outliers in the database.

Table 1: Descriptive Statistics of the proposed variables

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

Next, we perform various stepwise specifications of the variables considered slightly elastic in the individual statistical significance of the explanatory variables (using Newey-West heteroskedasticity and autocorrelation Robust standard errors). Apart from the standard levels (of $\alpha = 0.01, \alpha = 0.05\ and\ \alpha = 0.1$), we have considered (in such analysis) p-values less than 0.25. BIC criterion was used for the model selection. The 1% extreme WTP observations were excluded from the analysis. Table 2 provides the meta-regression estimates and benefit transfer functions for a model including Marine & Freshwater ecosystem.[6] P values for the Newey West HAC standard errors are reported in brackets.

[6] Fresh Water ecosystem was covered only by 14 studies in our sample, so it was grouped together with the Marine Ecosystem.

Table 2: Meta Regression Estimates

	Marine & Fresh Water
ALPINE	43.01
	[0.279]
ATLANTIC	**-64.32**
	[0.091]
BOREAL	**-102.34**
	[0.040]
CONTINENTAL	-41.29
	[0.269]
MEDITERRANEAN	-37.36
	[0.344]
MARINE_ATLANTIC	-11.95
	[0.779]
PROVISIONING	33.55
	[0.259]
REGULATING	**40.21**
	[0.214]
SUPPORTING	29.24
	[0.312]
SD_QUESTIONNAIRE	8.11
	[0.803]
AGE	**2.64**
	[0.023]
EDUCATION	-4.60
	[0.387]
CHOICE_EXPERIMENT	**-78.63**
	[0.126]
CONTINGENT_VALUATION	**-70.84**
	[0.161]
R-squared	0.18
Adjusted R-squared	0.04
F-statistic	**1.96**
	[0.0229]
MWTP	**42.10**

Figure 5 and Figure 6 present the Annual Marginal WTP (MWTP) per household, by Marine and Freshwater Ecosystem Service and By Bio-Geographical Region. Figure 7 provides a map of the European Biogeographical Regions. Using the whole sample, we note that individuals assign greater value to the Regulating Services of marine and freshwater ecosystems with an average WTP of more than 40 euros per household. Moreover, the Alpine regions somewhat surprisingly attribute greater value to marine and freshwater ES, followed by Atlantic and Mediterranean regions.

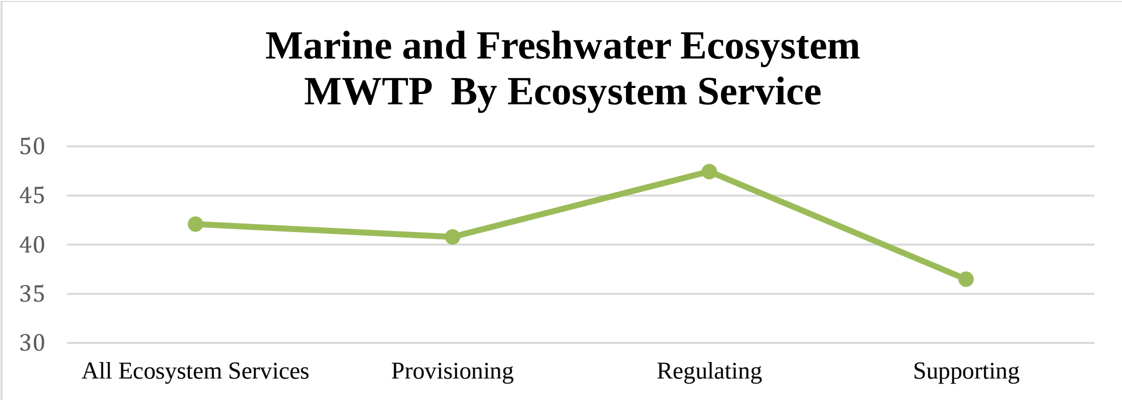

Figure 5: Marine and Freshwater Ecosystem - Annual Marginal WTP by Ecosystem Service. Source: Authors' calculations

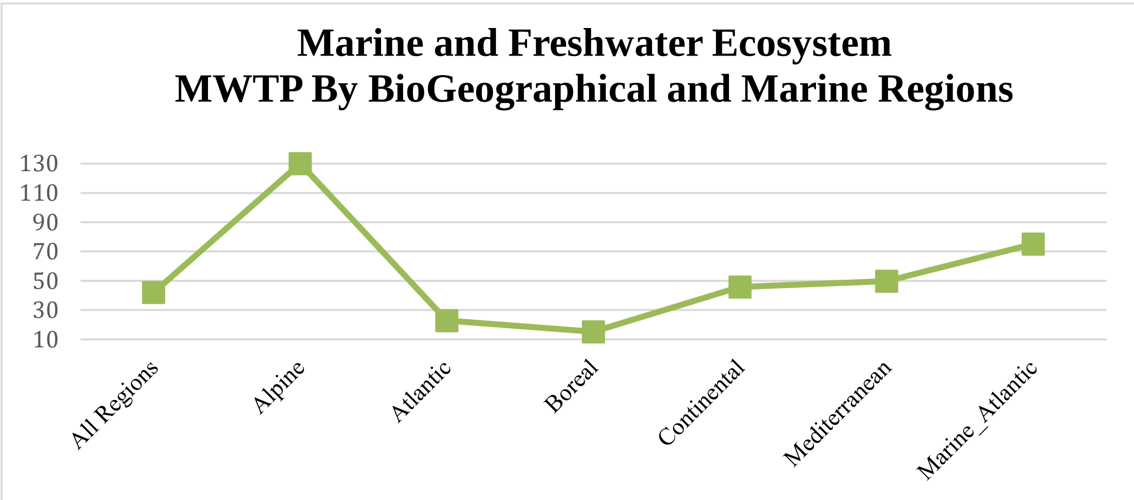

Figure 6: Marine and Freshwater Ecosystem - Annual Marginal WTP by Biogeographical Region. Source: Authors' calculations

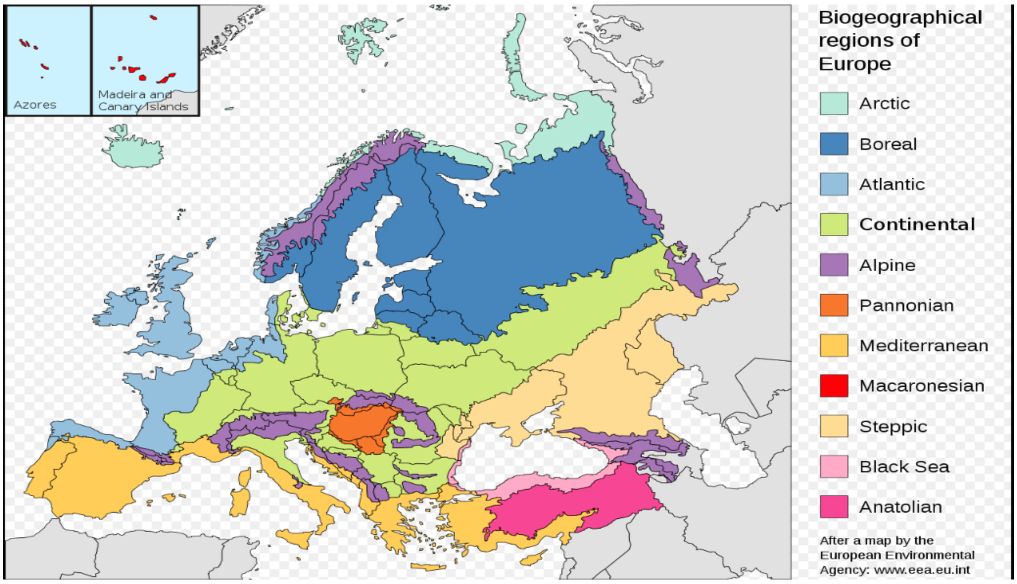

Figure 7: European Bio Geographical Regions. Source: European Environmental Agency

Figure 8 presents the Marginal Willingness to pay for Marine and Freshwater Ecosystem at the national level disaggregated into three ecosystem services (Provisioning, Regulating and Supporting). For the socioeconomic variables of the benefit transfer function (age and education), data for the year 2020 for all countries were collected from Statista (Median age of the world population 2020) and OECD (Share of people with tertiary education in OECD countries 2020). The classification of countries into Bio Geographical Regions follows the definitions by the European Environmental Agency. For all countries that mainly refer to a region not included in our model,[7] we normalize all the relevant dummy variables to add to 1.

[7] For example, for Hungary, which is classified as Pannonian, we set all the biogeographical dummy variables included in our model equal to 0.2.

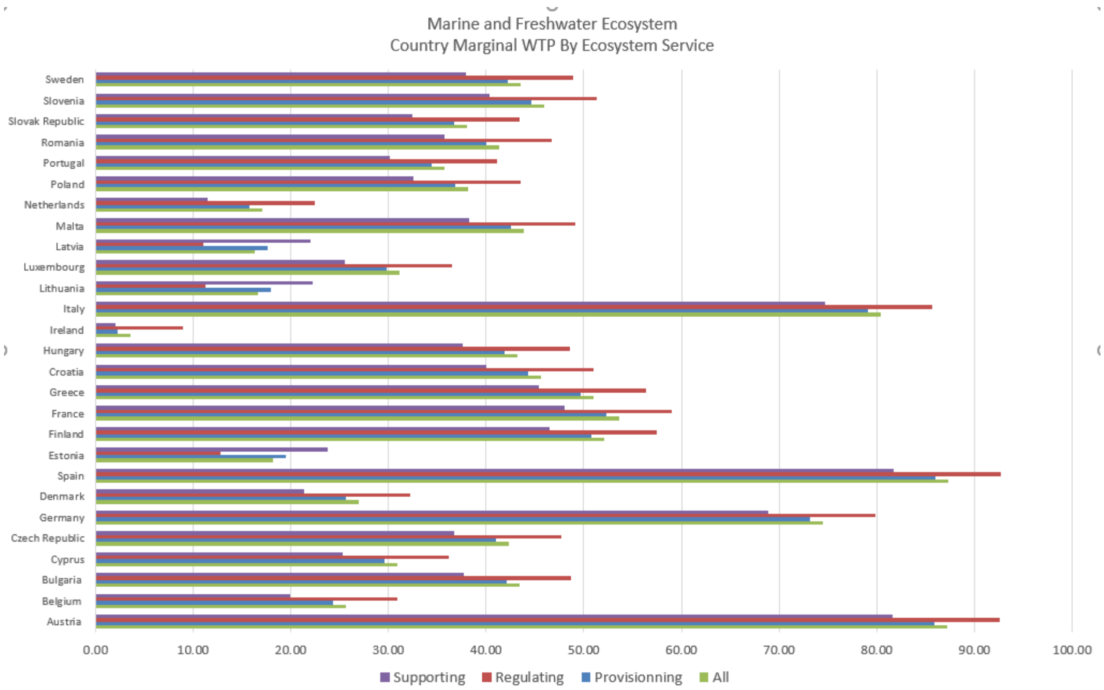

Figure 8: Marginal WTP by Ecosystem Service and Country

A quick conclusion that can be drawn from observing figure 8 is that in almost 63% of European countries (17 out of 27), the willingness to pay for the improvement of the marine & freshwater ecosystem is high and exceeds estimates for terrestrial ecosystems (Sachs et *al*., 2022).

The reason why this is happening needs further investigation, which is beyond the scope of this paper. However, one possible explanation, may be that the citizens of these countries recognize that marine and aquatic ecosystems are at greater risk of collapse than terrestrial ecosystems, so they are willing to spend part of their income on the restoration of aquatic ecosystems. Another possible explanation is that the citizens of these countries are dependent on the marine or aquatic ecosystem, e.g., due to fishery production, tourism, etc., to a greater extent than terrestrial, and are willing to bear the cost of maintaining these ecosystems in good condition.

For most of the EU28 Countries the Regulating ecosystem services are valued higher (46,15 euro on average) than Provisioning or Supporting, while Provisioning is valued higher than Supporting (40,97 and 37,77 euro on average respectively).

Valuing Ecosystem Services and Sustainable Development

Finding a balance between socioeconomic development and ecosystem services is a crucial challenge for sustainable development (McCartney *et al.*, 2014). In this subsection we examine the correlation between willingness to pay and the level of achievement of 17 SDGs overall, for the 27 countries of the European Union.

For the calculation of correlation coefficient, we used the scores per SDG of each country from the UNSDSN Sustainable Development Report Europe 2021,[8] and the MWTP per country calculated in the previous section.

In each of the following figures, the first entry with the label "SDG Index Score" refers to the aggregated Score for all 17 goals, while in the following entries refer to the cross-sectional (27 countries) correlation between WTP estimates and 17 SDG Score (s).

A positive correlation means that a high level of MWTP is associated with a high level of achievement of a specific SDG. The closer the correlation coefficient is to the value of 1, the stronger the association. Conversely, a negative correlation means that a high (or low) level of MWTP is associated with a low (or high) level of achievement of a specific SDG. Again, a correlation coefficient approaching the value of -1, the stronger the (negative) association.

Figure 9 presents the cross-sectional correlation coefficients between national MWTP estimates and SDG Index Scores and the Scores for all the 17 Underlying goals for all ecosystems and the three ecosystem services categories, respectively. Data for the SDG Scores were obtained from SDSN. Figure 10 presents the SDG Scores for all countries, by SDG.

[8] https://eu-dashboards.sdgindex.org/profiles

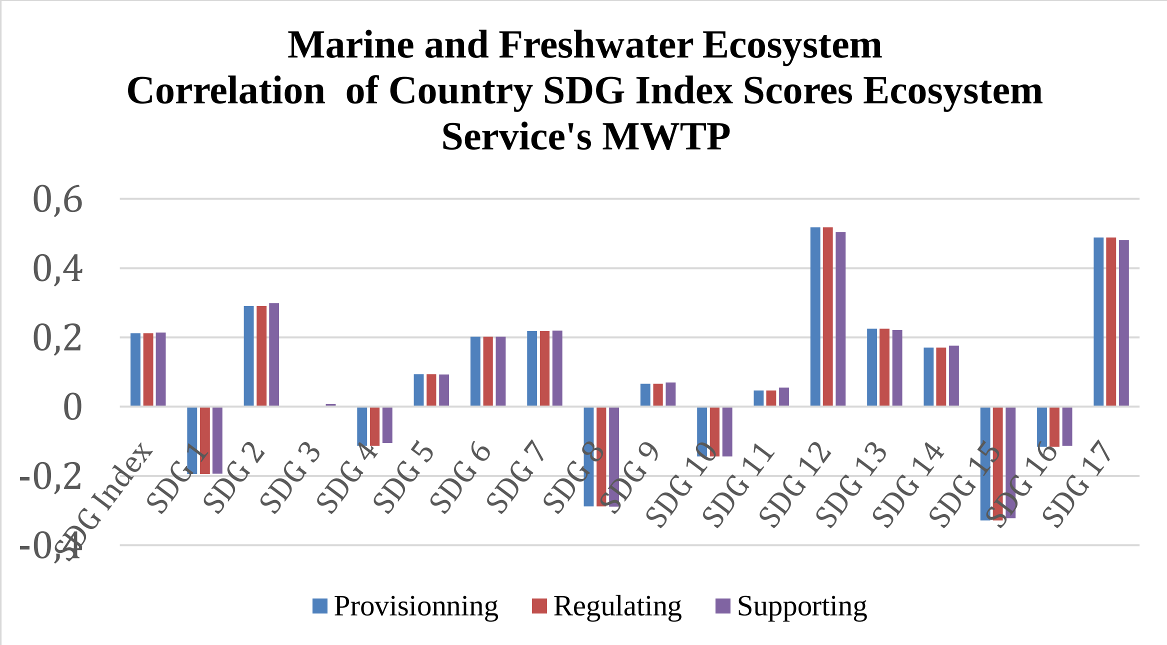

Figure 9: Cross Sectional Correlation of UNSDSN Index Scores and Ecosystem Service's MWTP, by SDG. Source: Authors' calculations

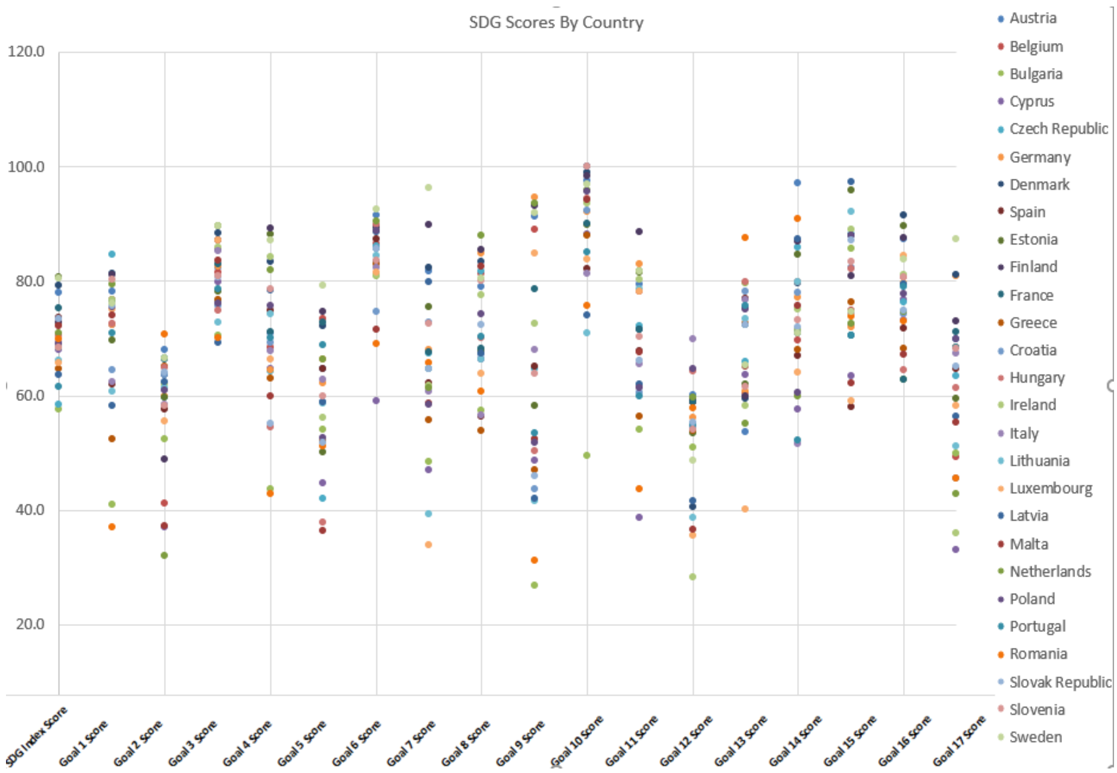

Figure 10: UNSDSN Index Scores by SDG. Source: Authors' calculations

Results indicate that Marine and Freshwater Ecosystems are mainly positively correlated to SDGs 2, 12, 13 and 17 and negatively correlated to 8 and 15. The positive correlation reported with SDG 14 is non-negligible, however less than 0.2 (Figure 9). A positive correlation implies that the WTP is high for a transformation that is needed. Goals 12,13 and 14 are closely intertwined, underscoring the global efforts towards a model of economic growth which does not accelerate the deterioration of environmental resources. The positive association with the ES valuation enshrined in the WTP metrics, albeit indicative at this level of analysis, underscores the relationship between ecosystems valuation and action towards SDG implementation. A plausible explanation is that, in societies where ecosystems are considered more valuable and where ES are appreciated by the public, resources are mobilized towards making progress on SDG targets. Keeping in mind that promoting and monitoring policies associated with sustainable development is a participatory process, societal attitudes vis-à-vis environmental resources and their provisions is of material importance.

Focusing on SDG 14, we perform the same analysis by breaking down the SDG scores into the correlations with the individual indicators, that is:

i. Mean area that is protected in marine sites important to biodiversity (%)[9]
ii. Ocean Health Index: Clean Waters score (worst 0-100 best)[10]
iii. Fish caught from overexploited or collapsed stocks (% of total catch)[11]
iv. Fish caught by trawling or dredging (%)[12]
v. Fish caught that are then discarded (%)[13]
vi. Marine biodiversity threats embodied in imports (per million population)[14]

Figure 11 presents the correlations between the Marine and Freshwater Ecosystem Service's Annual Marginal Willingness to pay estimates and the SDG Scores for all the individual SDG14 indicators. Interestingly the positive correlation corresponds mainly to fish caught from overexploited or collapsed stocks and Fish caught that are then discarded (%) Indicators.

[9] Sdg14_cpma
[10] Sdg14_cleanwat
[11] Sdg14_fishstocks
[12] Sdg14_trawl
[13] Sdg14_discard
[14] Sdg14_biomar

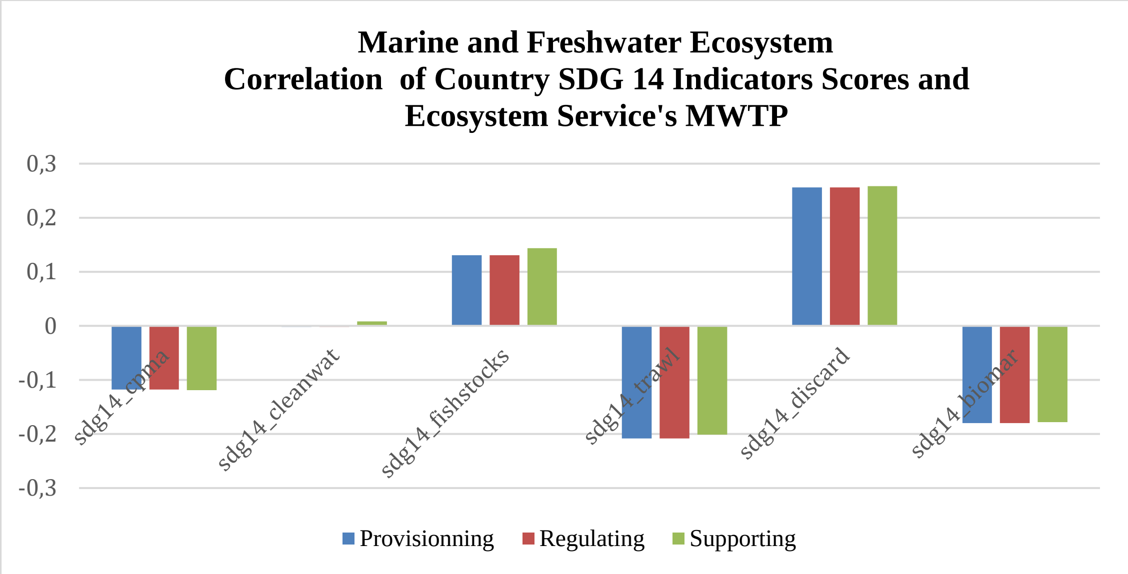

Figure 11: Cross Sectional Correlation of UNSDSN SDG14 Indicators Scores and Ecosystem Service's MWTP

Conclusion

This study refers to the valuation of European Ecosystems and Ecosystem Services stemming from Marine and Freshwater ecosystems, as well as 3 types of Ecosystem Services, that is Regulating, Supporting and Provisioning respectively, with a special focus to the relationship between valuation of Marine and Freshwater Ecosystems and progress on SDG 14. Ecosystem Services valuation based on scientific knowledge and through an interdisciplinary approach is materially linked to the progress on SDGs as per the Agenda 2030. Attribution of value to marine and freshwater ecosystems matters for designing, implementing, and monitoring policies towards improving life underwater as envisioned by SDG 14.

Results based on meta-regression analysis of 212 empirical papers from the EVRI database indicate that Mean Willingness to Pay (MWTP) per household is ranked high for the regulating services of marine and freshwater ecosystem while in terms of biogeographical regions, we find that in the Alpine region, the MWTP is greater than the other regions. Another important conclusion is that in almost 63% of European countries (17 out of 27), the willingness to pay for the improvement of the marine & freshwater ecosystems is high and exceeds estimates for terrestrial ecosystems. Across the EU there are signs of relatively high valuation of marine and freshwater resources.

In terms of valuing ecosystem services and link them to the Sustainable Development Goals, we find that marine and freshwater ecosystems are mainly positively correlated to SDGs 2,12, 13 and 17 and negatively correlated to 8 and 15. A modest positive association is revealed between ES valuation and SDG 14. The results combined indicate that societies with higher documented ES valuation (as expressed by their WTP) perform better in the environmental-related SDGs. Breaking further to specific SDG14 individual indicators, we uncover a higher MWTP for fish caught from overexploited or collapsed stocks and fish caught that are then discarded (%) indicators.

.

References

Chan, K. M., Satterfield, T., & Goldstein, J. (2012). Rethinking ecosystem services to better address and navigate cultural values. Ecological economics, 74, 8-18.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., & van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. Nature, 387(6630), 253–260. https://doi.org/10.1038/387253a0

Daily, G. C. (1997). Introduction: What Are Ecosystem Services? In Daily, G.C., Ed., Nature's Services: Societal Dependence on Natural Ecosystems (pp. 1–10). Island Press.

Dasgupta, P. (2021), The Economics of Biodiversity: The Dasgupta Review. Abridged Version. (London: HM Treasury).

DEFRA (2007), An introductory guide to valuing ecosystem services, https://ec.europa.eu/environment/nature/biodiversity/economics/pdf/valuing_ecosystems.pdf

Farber, S. C., Costanza, R., & Wilson, M. A. (2002). Economic and ecological concepts for valuing ecosystem services. *Ecological Economics*, *41*(3), 375–392. https://doi.org/10.1016/S0921-8009(02)00088-5

HM Treasury (2020), Final Report of the 2020 Green Book Review, 25 November 2020, ISBN 978-1-5286-2229-5, PU3051

Johnson, J. A., S. K. Jones, S. L. R. Wood, R. Chaplin-Kramer, P. L. Hawthorne, M. Mulligan, D. Pennington, and F. A. DeClerck, (2019). Mapping Ecosystem Services to Human Well-being: a toolkit to support integrated landscape management for the SDGs. Ecological Applications 29(8)

Koundouri, P., Giannouli, A. (2015). Blue growth and economics, Frontiers in Marine Science, 2, https://doi.org/10.3389/fmars.2015.00094.

Koundouri, P., Apostolaki, S., Akinsete, E. and Samartzis,P. (2019). Freshwater: The importance of freshwater for providing ecosystem services, DEOS Working Papers 1905, Athens University of Economics and Business.

MA (2005). Millennium Ecosystem Assessment (Program), Ecosystems and human well-being. Washington, D.C: Island Press.

MAES (2015), Typology for ecosystem classification (European ecosystem assessment-concept, data and implementation, EEA Technical Report, No 6/2015).

McCartney, M., Finlayson, M., de Silva, S., Amerasinghe, P., & Smakhtin, V. (2014). Sustainable development and ecosystem services (No. 612-2016-40661).

Remoundou, K., Koundouri, P., Kontogianni, A., Nunes, P., A.L.D., Skourtos, M. (2009), Valuation of natural marine ecosystems: an economic perspective, Environmental Science and Policy, Vol. 12, Issue 7, pp. 1040 – 1051.

Sachs J., Koundouri P. Becchetti L., Brunnhuber S., Chioatto E., Cordella M., Devves S., Halkos G., Hansmeyer C., Landis C. Morone P., Patel K., Plataniotis A., Romani I., Spani R., Stavridis C., Tessari F., Theodossiou N., Wetzel D., Zachariadis T. (2022). Financing the Joint Implementation of Agenda 2030 and the European Green Deal. Report of the UN Sustainable Development Solutions Network. https://resources.unsdsn.org/financing-the-joint-implementation-of-agenda-2030-and-the-european-green-deal

TEEB (2010) The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.

UNEP-WCMC (2011), Marine and coastal ecosystem services - valuation methods and their practical application, biodiversity series no. 33.

Vassilopoulos, A., Koundouri, P. (2017), Valuation of Marine Ecosystems, Oxford Research Encyclopedia of Environmental Science.

Vörösmarty, C. J., Osuna, V. R., Cak, A. D., Bhaduri, A., Bunn, S. E., Corsi, F., ... & Uhlenbrook, S. (2018). Ecosystem-based water security and the Sustainable Development Goals (SDGs). Ecohydrology & Hydrobiology, 18(4), 317-333.