Promote financial instruments for liability on environment (LIFE PROFILE)

Action B.2: Economic evaluation of environmental damage and especially on biodiversity

Deliverable B.2.1. Benefit transfer analysis of the international experience to the Greek setting

life profile

PROmote Financial Instruments for Liabilty on Environment

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ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CPI	Consumer Price Index
ELD	Environmental Liability Directive
EPA	Environmental Protection Agency
ESVD	Ecosystem Services Valuation Database
EVRI	Environmental Valuation Reference Inventory
EU	European Union
GEVAD	Greek Environmental Valuation Database
HEA	Habitat Equivalency Analysis HEA
IUCN	International Union for Conservation of Nature
MORA	Modelo de Valoración del Riesgo para el Medio Ambiente y la Salud (translates to: Risk Assessment Model for the Environment and Health)
NbS	Nature based Solutions
OPA	Oil Pollution Act
PPPI	Purchasing Power Parity Index
TEEB	The Economics of Ecosystems and Biodiversity
UNEP	United Nations Environment Programme
WCMC	World Conservation Monitoring Centre

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Executive Summary

The objective of this report is to contribute to the economic assessment of environmental damage, specifically focusing on the cost of biodiversity, by employing a "benefit (cost) transfer" methodology. The aim is to adapt the cost estimates of selected damage cases, representing different risk categories, to the Greek context. The initial step involves identifying the methodologies used by various countries to estimate the financial impact of environmental damages, including the costs associated with their remediation and compensation. Additionally, the report will examine the tools employed to assess these costs. Next, a benefit (cost) transfer method is applied. This method enables the application of existing valuation estimates to assess the economic implications of environmental factors in different settings, making the valuation process more efficient and cost-effective. Based on a review analysis (regarding valuation studies which are focusing on the environmental cost of accidents/damages), it became evident that the characteristics and features of the existing studies hinder the effective implementation of the conventional cost-transfer approach in the context of Greek conditions.

Therefore, instead of relying solely on a conventional cost-transfer approach based on research related to environmental accidents, a novel and innovative methodology has been developed to evaluate the monetary value of environmental damages. This approach goes beyond traditional methods by disaggregating natural capital losses resulting from potential pollution incidents into value losses in three key areas: soils, water resources, and biodiversity/ecosystem services.

Specifically, the methodology takes into account valuable insights gained from previous analyses, including international practices in assigning monetary values to soils, water resources, and biodiversity. It also considers the actual dynamics and physiological aspects of environmental damages in the real world. In this context, the total costs associated with a damage extend beyond the expenses incurred for remediation actions and encompass the social welfare that is foregone due to the occurrence of the damage.

By adopting this new methodology, a more comprehensive assessment of environmental damages can be achieved, incorporating both tangible and intangible factors. Furthermore, this new methodology offers a more holistic understanding of the economic implications (costs and values) associated with environmental damages, moving beyond the mere consideration of remediation costs.

Περίληψη του παραδοτέου

Ο στόχος αυτού του παραδοτέου είναι να συμβάλει στην οικονομική εκτίμηση της περιβαλλοντικής ζημίας, εστιάζοντας συγκεκριμένα στο κόστος της βιοποικιλότητας, μέσω της εφαρμογής της μεθόδου της «μεταφοράς οφέλους (κόστους)» (Benefit-cost transfer). Συγκεκριμένα επιδιώκεται η δυνατότητα εκτίμησης του κόστους για επιλεγμένες περιπτώσεις περιβαλλοντικών ζημιών/ατυχημάτων, που αντιπροσωπεύουν διαφορετικές κατηγορίες κινδύνου, στο ελληνικό πλαίσιο. Το αρχικό στάδιο αυτής της διαδικασίας περιλαμβάνει τον προσδιορισμό των σημαντικότερων μεθόδων που

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χρησιμοποιούνται από διάφορες χώρες για την εκτίμηση των οικονομικών επιπτώσεων των περιβαλλοντικών ζημιών, συμπεριλαμβανομένων των δαπανών που συνδέονται με δράσεις αποκατάστασης και αποζημίωσης. Στη συνέχεια εξετάζονται τα εργαλεία που χρησιμοποιούνται για την αξιολόγηση αυτού του κόστους. Ακολουθεί η εφαρμογή της μεθόδου μεταφοράς οφέλους (κόστους), η οποία στόχευε αρχικά στην χρήση υφιστάμενων μελετών/έρευνών αποτίμησης του κόστους των οικονομικών επιπτώσεων των περιβαλλοντικών ατυχημάτων/ζημιών σε διαφορετικές περιοχές/οικοσυστήματα. Ωστόσο με βάση τη βιβλιογραφική ανασκόπηση που πραγματοποιήθηκε (σχετικά με μελέτες αποτίμησης που εστιάζουν στο περιβαλλοντικό κόστος ατυχημάτων/ζημιών), κατέστη προφανές ότι ο μικρός αριθμός αλλά και τα χαρακτηριστικά των υφιστάμενων μελετών καθιστούν πολύ δύσκολη, μάλλον αδύνατη, μια αποτελεσματική εφαρμογή της συμβατικής προσέγγισης «μεταφοράς κόστους» στο πλαίσιο της ελληνικής συνθήκες.

Επομένως, αντί να βασιστούμε αποκλειστικά σε μια συμβατική προσέγγιση μεταφοράς κόστους που θα διερευνά αποκλειστικά μελέτες αποτίμησης του κόστους των περιβαλλοντικών ατυχημάτων, αναπτύχθηκε μια νέα και καινοτόμος μεθοδολογία για την αξιολόγηση της χρηματικής αξίας των περιβαλλοντικών ζημιών. Αυτή η νέα προσέγγιση υπερβαίνει τις παραδοσιακές μεθόδους μεταφοράς κόστους, αναλύοντας ξεχωριστά (και διαφορετικά) τις απώλειες φυσικού κεφαλαίου που προκύπτουν από πιθανά περιστατικά ρύπανσης σε απώλειες αξίας για: το έδαφος εδάφη, τους υδατικούς πόρους και τις οικοσυστημικές υπηρεσίες ή αλλιώς τη βιοποικιλότητα.

Συγκεκριμένα, η μεθοδολογία αυτή λαμβάνει υπόψη τις πολύτιμες γνώσεις που αποκτήθηκαν από την βιβλιογραφική ανασκόπηση και ανάλυση, συμπεριλαμβανομένων των διεθνών πρακτικών για την απόδοση χρηματικής αξίας (κόστους) στο έδαφος, τους υδατικούς πόρους και τη βιοποικιλότητα. Λαμβάνει επίσης υπόψη την οικονομική διάσταση του ίδιου του φυσικού αντικειμένου που εξετάζει και τα ιδιαίτερα χαρακτηριστικά των περιβαλλοντικών ζημιών/επιπτώσεων κάθε δυνητικού ατυχήματος στον φυσικό περιβάλλον (δίνοντας βαρύτητα στα υφιστάμενα χαρακτηριστικά/στην ποιότητα του κάθε οικοσυστήματος σε κάθε δεδομένη χρονική στιγμή)(. Σε αυτό το πλαίσιο, το συνολικό κόστος που σχετίζεται με μια ζημιά/ατύχημα δεν περιορίζεται στην εκτίμηση των δαπανών που πραγματοποιήθηκαν (ή θα πρέπει πραγματοποιηθούν) για δράσεις αποκατάστασης αλλά περιλαμβάνει το σύνολο της κοινωνικής ευημερίας που χάνεται λόγω της πρόκλησης της ζημίας.

Με την υιοθέτηση αυτής της νέας μεθοδολογίας, μπορεί λοιπόν να επιτευχθεί μια πιο ολοκληρωμένη εκτίμηση του κόστους των περιβαλλοντικών ατυχημάτων/ζημιών, ενσωματώνοντας τόσο υλικούς όσο και άυλους παράγοντες. Επιπλέον, αυτή η νέα μεθοδολογία προσφέρει μια πιο ολιστική κατανόηση των οικονομικών επιπτώσεων (κόστος και αξία) που σχετίζονται με τις περιβαλλοντικές ζημίες, πηγαίνοντας ένα βήμα παραπέρα από την απλή εξέταση του κόστους αποκατάστασης.

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1. Introduction

The aim of this report is to contribute to the economic appraisal of the environmental damage (and especially on the cost on biodiversity)[1] based on a "benefit (cost) transfer" methodological framework, which will be able to adjust the cost of selected damage cases (i.e. selected risk categories) to the Greek setting. This method should make use of all the available international and Greek experience by reviewing the relevant literature (peer reviewed publications as well as grey literature and official reports). The first step aims at identifying the methodologies followed by various countries to estimate the financial impact of environmental damages with regard to their remediation and compensation costs, as well as the tools used in order to assess these costs according to the type of damage that was occurred (directly or indirectly), its magnitude and its severity. Greater emphasis is given to studies/cases with characteristics that are similar to the Greek environment and setting.

Originally, the benefit (or cost) transfer method refers to the transfer of economic values/benefits (costs) of a particular environmental or non-market resource - estimated in previous studies - to a different location or context (Carson and Mitchell, 1993). It operates under the assumption that the economic value of a resource or environmental attribute can be applied to other settings, provided that certain conditions and characteristics remain similar (Freeman, 1993). It relies on the availability of previous (primary valuation) studies that have already assessed the economic value of the resource or the economic cost of an incident (environmental damage). These studies can include stated preference methods (e.g., contingent valuation, choice experiments) and/or revealed preference methods (e.g., hedonic pricing, travel cost method) in order to provide the basis for transferring values to the target location (Johnston and Rosenberger, 2010). The validity and reliability of this methodological approach depend on the quality and comparability of the primary valuation studies used for the benefit (cost) transfer. It is therefore very important to critically assess and select the appropriate/relevant studies to ensure valid results.

Hence, such a cost-transfer approach necessitates the application of statistical analysis of the existing experience with monetary valuation regarding the impacts of events that have already occurred. In this framework the existing published studies should be reviewed. However, the findings of this review analysis, as it is going to be presented in the following section (Section 2), indicate that the characteristics and the properties of the existing studies do not permit an effective implementation of the conventional cost-transfer approach to the Greek conditions (originally described as Step 2 of the Action B2). In this context, a novel methodological cost-transfer framework was developed that takes

[1] The methodology of action B2 should be able to deal with both ex-ante and ex-post evaluation. Namely, it should assess in monetary terms the impact of accidents already occurred, as well as of potential accidents (i.e., future/potential events). Such a methodological framework should be based in the field of environmental economics, which systematically deal with the monetary valuation of the environment and natural resources. At the same time the methodology should address the requirements of the Environmental Liability Directive (ELD) implementation by public authorities and financial security (insurance) industry.

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into account the actual physiology of environmental damages in the real world. This method is presented in Section 3.

2. Methodologies and tools used for the Implementation of the ELD

2.1 Methodologies and tools used in EU countries and in USA

2.1.1 Methodologies

The Environmental Liability Directive (ELD) provides a framework for preventing and remedying environmental damage. While the ELD sets out the general principles and requirements, the specific methodology for assessing environmental damage costs is likely to vary among the European Union (EU) member states based on national legislation, available data, and the guidance provided by regulatory agencies or competent authorities responsible for implementing the ELD within each country. In 2019, the work on improving the evidence base resulted in the establishment of 28 Member State fiches on the implementation of the ELD in each country (legal framework, administrative structure, facts and figures on ELD cases). Since May 2020, country fiches have been established on financial security for environmental liabilities. From these reports, it is possible to extract some basic information related to the range of environmental damage costs (highest and lowest values) as estimated in several countries. Figures 1a and 1b present these values for all countries where the lowest and/or highest cost estimates were publicly available[2].

Figure 1a. Lowest cost of environmental damage per country (based on 2020 State fiches)

[2] Among the EU countries, lowest and/or highest cost estimates are publicly available for Belgium, Bulgaria, Finland, Greece, Italy, Ireland, Lithuania, Romania, Slovakia and Spain. Average cost estimates were also available for Hungary and Sweden.

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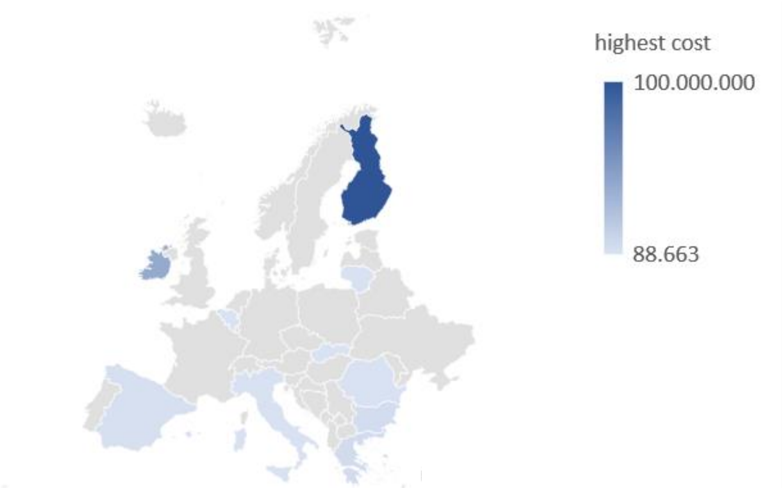

Figure 1b. Highest cost of environmental damage per country (based on 2020 State fiches)

Among the EU countries, three countries seem to have advanced a little further than most others in developing their own distinct methodologies for assessing environmental damage costs under the ELD: Italy, Spain and the Netherlands.

The implementation of the ELD in Italy, Netherlands, and Spain involves various calculating tools and methodologies to determine the extent of the environmental damages caused by the polluter, i.e., to ensure that polluters are held accountable for the environmental damages they cause. These countries have invested efforts in developing methodologies that align with the requirements of the ELD in: (a) restoring the damaged ecosystem to its pre-incident condition, (b) compensating for any lost ecosystem services, and (c) mitigating any adverse effects on human health and well-being. Their methods and tools include (among others):

1. Risk assessment models: Risk assessment models are used to assess the likelihood and severity of environmental damage caused by a particular activity or process. These models take into account factors such as the type of pollutant, the sensitivity of the affected ecosystem, and the potential impact on human health.
2. Environmental impact assessments: Environmental impact assessments are used to assess the potential environmental impacts of a proposed project or activity. They take into account factors such as the location of the project, the type of activity, and the potential impact on local ecosystems.
3. Damage assessment methodologies: Damage assessment methodologies are used to determine the extent of the environmental damages caused by a polluter. These methodologies take into account factors such as the cost of restoring the damaged ecosystem, the loss of ecosystem services, and the potential impact on human health.

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In Italy, the Ministry of the Environment has developed a methodology for assessing the cost of damage to natural resources, which includes the cost of remediation and restoration. The methodology takes into account the cost of restoring the damaged ecosystem to its pre-incident condition, including the cost of removing pollutants, restoring the affected habitat, and mitigating any adverse effects on ecosystem services. The methodology also considers the potential economic losses resulting from the damage, such as losses in tourism revenues or decreased agricultural productivity.

In the Netherlands, the Ministry of Infrastructure and Water Management has developed a methodology for calculating the cost of remediation and restoration, which takes into account the cost of removing pollutants, restoring the affected ecosystem, and compensating for any lost ecosystem services. The methodology also considers the potential economic losses resulting from the damage, such as losses in recreational activities or decreased property values.

In Spain, the Ministry for Ecological Transition and the Demographic Challenge has developed a methodology for assessing the cost of damage to protected species and habitats, which includes the cost of remediation and restoration. The methodology takes into account the cost of removing pollutants, restoring the affected habitat, and mitigating any adverse effects on biodiversity. The methodology also considers the potential economic losses resulting from the damage, such as losses in the value of ecosystem services or decreased opportunities for sustainable use.

Of particular importance in all three countries' methodology are the (economic) damages to biodiversity. Biodiversity is a critical component of healthy ecosystems, and any damage to it may have significant impacts on the overall health and functioning of an ecosystem. By quantifying the economic losses incurred due to biodiversity damage, polluters can be held accountable for the full range of environmental harm they cause, leading to more effective enforcement and incentivizing responsible environmental practices. They aim to capture the direct and indirect economic costs associated with the degradation or destruction of biodiversity, including the impacts on ecosystem services, ecological functions, and the potential long-term consequences for human well-being.

For example, in Italy, the methodology for assessing the cost of damage to natural resources considers the impact of the damage on biodiversity by including the loss of species and habitats. Namely, the methodology considers the cost of restoring the affected habitat and mitigating any adverse effects on biodiversity, as well as the potential economic losses resulting from the damage. The Dutch methodology takes into account the cost of restoring the affected ecosystem and compensating for any loss of ecosystem services, as well as for the potential economic losses resulting from the environmental damage. Finally, in Spain, the methodology for assessing the cost (damage) on biodiversity considers the cost of restoring the affected habitat and mitigating any adverse effects on biodiversity, as well as the potential economic losses resulting from the damage. The methodologies followed by all three countries are quite comprehensive, but there are some limitations and challenges that could affect the accuracy of their estimates. Some of their most important limitations are the following:

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1. Lack of data: One of the challenges in estimating the cost of biodiversity damage is the limited availability of reliable data on the value of ecosystem services and the cost of restoring damaged ecosystems. This can make it difficult to accurately estimate the true cost of environmental damages and the potential economic losses resulting from the damage.
2. Difficulty in valuing non-market goods: Many of the benefits provided by ecosystems, such as clean air and water, recreation, and cultural values, are difficult to value in economic terms. As a result, the methodologies used for estimating the cost of biodiversity damage may not fully capture the value of these non-market goods.
3. Difficulty in predicting long-term impacts: The long-term impacts of environmental damage on biodiversity are often difficult to predict, as they may take years or even decades to fully manifest. As a result, the methodologies used for estimating the cost of biodiversity damage may not fully capture the full extent of the long-term impacts of environmental damage.
4. Challenges in measuring ecosystem services: Ecosystem services are often difficult to measure and quantify, which can make it challenging to accurately estimate the cost of environmental damages and the potential economic losses resulting from the damage.

It should be mentioned that in United States, the methodologies used to calculate environmental damage costs are guided by a range of federal and state laws, regulations, and policies and are quite different from those used in Europe. One important law that guides the calculation of environmental damage costs in the US is the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as the Superfund law. CERCLA provides a framework for the cleanup of hazardous waste sites and requires that those responsible for the contamination of a site be held liable for the costs of cleanup and any resulting environmental damage[3].

The US government has developed a range of methodologies for the calculation of environmental damage costs under CERCLA, which are based on the restoration of natural resources that have been damaged or lost due to environmental contamination. These methodologies may include approaches such as the Replacement Cost Method[4], which estimates the cost of replacing the lost natural resources with equivalent resources, and the Habitat Equivalency Analysis (HEA) method, which estimates the value of lost natural resources based on the cost of restoring equivalent habitats or

[3] In addition to CERCLA, other federal laws such as the Oil Pollution Act of 1990 (OPA) and the Endangered Species Act (ESA) also provide guidance on the calculation of environmental damage costs in specific contexts, such as oil spills and harm to endangered species.
[4] For example, if a wetland has been contaminated and lost due to hazardous waste, the RCM would estimate the cost of constructing a new wetland in a different location to replace the lost wetland.

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ecosystem services[5]. The latter is commonly used for the assessment of natural resource damages under the Oil Pollution Act of 1990 (OPA), which applies to oil spills.

2.1.2 Tools

To better design an appropriate tool for estimating the environmental damage costs we relied on two existing and well tested tools: (a) the Habitat Equivalency Analysis (HEA) and (b) the Spanish Risk Assessment Model for the Environment and Health (MORA).

The Habitat Equivalency Analysis (HEA) method identifies as a key tool for many countries (but mainly use in the US) in estimating the environmental damage[6]. It is a comprehensive approach that can be used to estimate the cost of environmental damages and to determine the amount of restoration or compensation required to restore the damaged ecosystem to its pre-damage condition. It should be noticed that HEA focuses on complete, in-kind replacement of services lost between the time of impact and when the restored or created habitat becomes fully functional (See Figure 2).

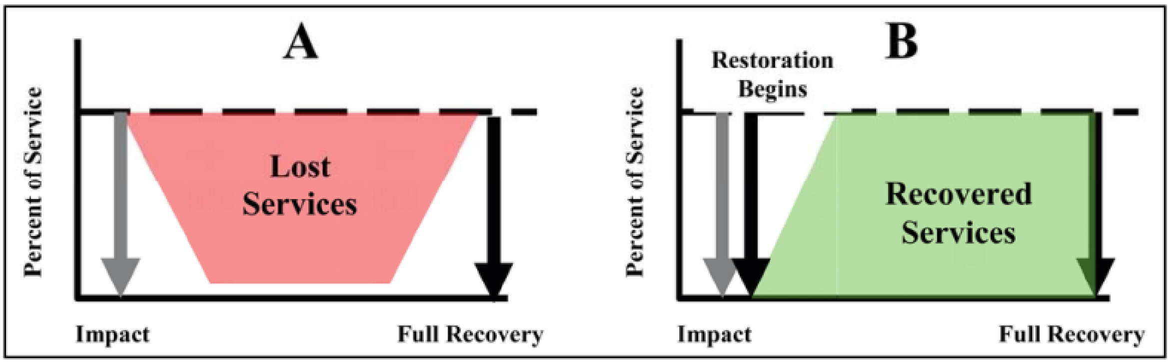

Figure 2. Estimation of (a) lost services and (b)recovered services (King, 1997; Ray, 2008)

Conceptually, the method proceeds in the following steps:

1. Determine the extent and severity of the damage: The first step is to assess the extent and severity of the damage to the ecosystem. This might involve collecting data on the size and location of the damaged area, the types of habitats and species affected, and the degree of contamination or physical damage.

2. Identify the baseline condition: The next step is to establish a baseline condition for the ecosystem, which represents the state of the ecosystem before the damage occurred. This might

[5] For example, if a river has been contaminated and lost due to hazardous waste, the HEA would estimate the value of restoring the river to its previous condition.
[6] Habitat Equivalency Analysis (HEA) is a method developed by the National Oceanographic and Atmospheric Administration (NOAA) to scale compensation for habitat damage resulting from oil spills and other contaminant-related impacts (NOAA 1997).

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involve collecting data on the types of habitats and species present, the ecological functions and services provided by the ecosystem, and the cultural and economic values associated with the ecosystem.

3. Estimate the value of the damage: The HEA method involves estimating the value of the damage in monetary terms, which includes the cost of restoring the ecosystem and compensating for any lost ecological functions or services. The value of the damage might be estimated using a combination of approaches, such as the resource-to-resource method, contingent valuation, or expert elicitation.

4. Determine the amount of restoration or compensation required: Once the value of the damage has been estimated, the next step is to determine the amount of restoration or compensation required to restore the damaged ecosystem to its pre-damage condition. This might involve identifying specific restoration activities, such as habitat restoration, species reintroduction, or pollution cleanup, and estimating the cost of these activities.

5. Determine the appropriate restoration timeline: The final step is to determine the appropriate timeline for restoration or compensation. This might involve considering factors such as the rate of recovery of the ecosystem, the ecological and cultural values at stake, and the practical constraints on implementing restoration activities.

Another comprehensive model (methodology and computer application), which is designed to estimate the replacement costs of environmental damage caused by various pollutants is the Spanish MORA model. The MORA model stands for “Modelo de Valoración del Riesgo para el Medio Ambiente y la Salud”, which translates to Risk Assessment Model for the Environment and Health. This methodology and the computer application facilitate the choice of the best available techniques considered necessary to return natural resources and the services they provide to their original condition after environmental damage.

The MORA model takes into account a range of factors, including the volume and type of pollutants, the characteristics of the affected ecosystem, and the potential impact on human health. The model also considers the costs of both short-term and long-term remediation and restoration measures, such as cleanup operations, monitoring, and habitat restoration.

The MORA model is designed to be flexible and adaptable to different types of accidents and environmental conditions. Hence it can be used to estimate the costs of environmental damage in different types of ecosystems, such as coastal areas, estuaries, and open seas. This (voluntary and not legally binding) tool enables operators, on the one hand, to know if they are required to provide a financial security, and calculate its amount; and on the other, to evaluate the potential damage associated with their risk scenarios, allowing them to manage their own environmental risk[7].

[7] https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/responsabilidad-mediambiental/guidancedocumentforthedevelopmentofera_tcm30-535234.pdf

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There are some limitations of the MORA model that should be considered when using it to estimate the costs of environmental damage. Some of these limitations include:

1. Data availability: The accuracy of the estimates generated by the MORA model depends on the availability of accurate and reliable data. Obtaining comprehensive and up-to-date data on pollutant concentrations, exposure pathways, and population characteristics can be challenging If data is incomplete or inaccurate, this can lead to inaccuracies in the estimates.
2. Uncertainty: The MORA model uses a probabilistic approach to estimate the costs of environmental damage (especially those related to health effects), which means that there is always some degree of uncertainty associated with the estimates. This uncertainty can be difficult to quantify and can lead to difficulties in decision-making.
3. Complexity: The MORA model is a complex and technical methodology that requires a high level of expertise to use effectively. This can make it difficult for non-experts to understand and use the results generated by the model.
4. Assumptions: The MORA model relies on a number of assumptions about the behavior of pollutants and the response of ecosystems to environmental damage (for example, it doesn't take into consideration the cumulative effects of various pollutants as it typically assesses the risk of individual pollutants independently). If these assumptions are incorrect, this can lead to inaccuracies in the estimates.
5. Limited scope: The MORA model is primarily designed to estimate the costs of environmental damage caused by chemical pollution. It may not be applicable in other contexts or for estimating the costs of damage caused by other types of environmental incidents (e.g. radiation, fire, etc).

It is worth mentioning that the MORA model offers significant input, for the Greek methodology as it directly aspires the implementation the ELD.

2.2 Methodologies and tools used in Greece

In Greece, the methodology for calculating environmental damage costs is grounded in the precautionary principle, which emphasizes the need to take preventive actions to avoid harm to the environment, even in situations where scientific evidence may be uncertain or incomplete. This principle serves as a guiding framework, ensuring that protective measures are implemented to safeguard the environment and mitigate potential risks. Additionally, Greece follows the polluter-pays principle, which holds those responsible for causing environmental damage accountable for the costs associated with remediation and restoration efforts. By incorporating the precautionary principle and the polluter-pays principle, Greece's methodology for calculating environmental damage costs emphasizes proactive measures to protect the environment and assigns responsibility to those who

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cause harm. This approach ensures that the potential impacts of uncertain or incomplete scientific evidence are taken into consideration while holding polluters accountable for their actions.

Furthermore, the methodology used in Greece for the calculation of environmental damage costs is based on the principles of valuation and restoration, which is commonly used in other European countries. This methodology involves the assessment of the environmental damage caused by an accident or incident, followed by the calculation of the cost of remediation and restoration (by considering the expenses required to mitigate and repair the damage caused).

Table 1. Aggregated facts and figures on costs of incidents of environmental damage in Greece based on the country's fiche (2019)

Average cost of environmental damage	Highest/lowest cost of environmental damage	No. of cases where liability was identified and attributed to private operator (PPP)	Average cost borne by liable parties	Average cost of preventive measures	Average cost of remediating the damage
€ 60,000 for the reporting period 2007-2013	The case of remediation of a recycling facility after a fire incident in 2015, has been estimated at 5 million euros (remediation measures are ongoing) In 2014 it was submitted the implementation of a pilot project for underground water remediation in Asopos river basin. The project was approved in 2016. Still on going, with a reported cost up to now 2 million euros	Not publicly available	Not publicly available	€ 60,000 one average per case	€60,000 on average per case. Exceptionally, the cost of remedies in one case exceeded the amount of €1,000,000[8]

[8] Commission Staff Working Document Refit, Evaluation of the Environmental Liability Directive, Brussels, 14.4.2016, p. 34.

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Concerning the latter (the methodology used for the calculation of environmental damage costs), it is typically based on a resource-to-resource approach. This approach involves identifying the natural resources that have been damaged or lost due to an environmental incident and estimating the value of those resources in monetary terms. The cost of remediation and restoration is then calculated based on the estimated value of the damaged or lost resources similar so other EU countries and the US.

It is also worth mentioning that so far, all Greek events have been assigned with a cost defined exclusively on administrative ground and based on the significant experience of Greek authorities. These costs are mainly reflecting the mitigation cost (i.e., the cost of effective clean-up operations that are able to prevent damage extension), plus the primary remediation costs. However, remediation costs are usually ignoring the actual costs of environmental externalities related to the various effects to biodiversity, habitats and water resources. Table 1 Presents the aggregated facts and figures on costs of incidents of environmental damage in Greece based on the country's fiche (2019) – an overview of the implementation of the ELD in all Member States[9].

3. Benefit (cost) transfer method

A benefit (cost) transfer method is employed when conducting original economic valuation studies may be impractical, costly, or time-consuming. Instead, researchers select this method and utilize existing studies that have already estimated the economic value (or cost) of a particular environmental good/service (or damage) and transfer those estimates to a new context.

The first step of a benefit (cost) transfer method is to identify existing studies or values that can be used for the transfer. In this case, the researcher would look for studies that value the (cost of) environmental damage (and especially the cost on biodiversity). It should be noted that the impacts (costs) of activities on the environment and natural resources are mainly impacts on non-market assets whose contribution to the (socio)economic welfare evades the context of existing exchangeable goods. According to the standard economics, those impacts are characterized as negative externalities of the industrial activities (or manmade disasters) whose management makes necessary their monetary valuation.

The second step is to decide whether the existing values (i.e., the results of the relevant valuation studies, as identified in step 1, are transferable). Existing values (or studies) would be evaluated based on several criteria (King et al., 2000), such as:

- Are the accidents (environmental damage) being valued comparable to all potential accidents that may occur in Greece?

[9] https://circabc.europa.eu/ui/group/cafdbfbb-a3b9-42d8-b3c9-05e8f2c6a6fe/library/82e90a00-fa70-4af6-bc4b-ab54207b1694?p=1&n=10&sort=modified_DESC

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- Some factors that determine comparability are similar types of sites (e.g., the same ecosystems/biomes), similar quality of sites (e.g., water quality, ecosystem services, soil quality, biodiversity)
- Are characteristics (e.g., demographics, socioeconomic characteristics) of the relevant population comparable? If not, are data available to make adjustments?

In order to answer these questions, the existing studies published were reviewed (see the relevant list in the Annex C: "Publications with valuation studies regarding disaster/accidents costs). Based on these finding, it can be concluded that, so far, there is no standard (peer reviewed) methodology linking the externalities caused by environmental accidents with their monetary value. The existing methodologies lead to estimates of the total cost that incorporate the operational costs of certain actions, prevention, and remediation, without reference to the degree of recovery, to the welfare losses, and to the remaining damages after remediation. On the other hand, a few studies are trying to estimate the damage cost based on the social welfare losses, without reference on operational, prevention and remediation costs. Stated (e.g., contingent valuation) and revealed preferences (e.g., hedonic pricing, travel cost method, etc.) non-market valuation methods are applied to evaluate the welfare losses due to the environmental damages/accidents.

Hence, the results of the comprehensive literature review concerning international industrial accidents and relevant pollution incidents suggest that the estimated costs are based on specific cases associated with a limited range of pollution/accident scenarios. The majority of these scenarios pertain to oil spills in coastal or marine environments, as well as pollution of surface and groundwater resources. Consequently, there are very few studies available that examine the costs related to biodiversity, soil resources, and the value of lost ecosystem services. Additionally, most existing studies do not distinguish or include the external costs associated with soil, water, and biodiversity, which makes it challenging to utilize these findings in line with the requirements of the ELD and the objectives of the Life-Profile project. Another issue encountered was the lack of specificity (dimensionality) in the estimated costs. In many cases, the costs were presented as totals rather than being broken down per action, making it impossible to directly determine the costs for specific actions using the cost transfer technique. Consequently, based on this review analysis (step 1), it is evident that the characteristics and features of the existing studies hinder the effective implementation of the conventional cost-transfer approach in the context of Greek conditions.

3.1 Development of a novel cost-transfer methodology in order to address the challenges arising from data/studies availability

The international experience, and particularly the Spanish free monetization tool for environmental damage (MORA), provides valuable insights that can inform the development of the Greek methodology, particularly in aligning with the goals of the ELD. However, these methodologies have raised significant methodological concerns. One major drawback is their underlying assumption that remediation actions can fully restore the environment and effectively "neutralize" the environmental

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damages. This assumption proves to be highly unrealistic, especially when it comes to impacts related to biodiversity. Biodiversity losses are often irreversible, and the restoration of ecosystems to their original state is challenging or even impossible in certain cases. Therefore, it is crucial to address this limitation and consider the long-term and irreversible nature of biodiversity impacts. The LIFE-Profile methodology should thus account for the ongoing and potentially permanent losses associated with biodiversity damages, as well as the limitations of remediation actions in fully restoring affected ecosystems. By doing so, it will be possible to provide a more realistic and comprehensive assessment of the true costs and damages incurred by environmental pollution incidents, including those affecting biodiversity.

The conventional cost-transfer method was initially considered the most suitable methodology for this purpose. However, the aforementioned findings (i.e., the dataset limitations) make necessary to deviate from the original description of the cost transfer methodology. Therefore, rather than employing a traditional cost-transfer approach relying on research (studies) related to environmental accidents, a new and innovative methodology has been devised to assess the monetary value of environmental damages. This approach differentiates (i.e disaggregates) natural capita losses (due to potential pollution incidents) into value losses (costs) in soils, water resources and biodiversity/ecosystem services.

This new methodology takes into account the insights gained from previous analysis - including the international experience in assigning monetary value to soils, water resources and biodiversity - also considering the actual dynamics (physiology) of environmental damages in the real world. In this context, the total costs associated with a damage should encompass not only the expenses incurred for remediation actions but also the social welfare that is forgone due to the occurrence of the damage. This approach accommodates cases where complete restoration of the environment is not achievable through remediation actions or where the time required for remediation is extensive, resulting in significant welfare losses. As a result, the forgone welfare accounts for the losses experienced until the environmental restoration is fully realized, as well as the ongoing destruction and irreversible damages. The main challenge of this methodology was to estimate the cost of environmental damage on biodiversity, while its main objective was to generate monetary values that can feed all the following methods, which were introduced by the ELD.

- resource to resource (restoration cost)
- service to service (restoration costs)

  } Linked to the restoration actions and costs

- value to value

  } Linked to the magnitude of the forgone utility[10]

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- value to costs

In particular, a “**resource to resource**” method will be applied for soil damages (taking into account the observable, in actual markets for soil, engineering costs)[11] and a “**service to service**” method will be applied for water-related damages, by using market costs (i.e. direct), and external costs (i.e. environmental and resource costs), following the Water Framework Directive recommendations regarding the full cost pricing of water resources)[12]. Since biodiversity is an integrated resource, focusing solely on the impacts to individual species is considered inadequate when addressing biodiversity damages. As a result, "resource to resource" and "service to service" approaches were deemed insufficient for accurately assessing the impacts on biodiversity. The multidimensional nature of biodiversity, stemming from complex interrelationships among habitats and species, necessitates an approximation of its impacts. These impacts are assessed by considering the society's foregone welfare or benefits, as well as the losses or impacts on various ecosystem services. Additionally, the location and natural environment surrounding the pollution incident are intertwined with biodiversity. As a consequence, a **“value to value”** and/or **“value to cost”** approach is designed and applied for the case of biodiversity damages, by combining benefit (cost) transfer and non-market valuation techniques. This procedure ultimately yields the evaluation of remaining impacts after restoration, encompassing both irreversible effects and the estimation of benefits forgone until the restoration process is finalized.

The conceptual framework of this methodology (i.e. the different estimates for soil, water and biodiversity) has been initially reflected in a simplified spreadsheet (Microsoft EXCEL) model which has been used in the meetings-workshops with stakeholders as shown in Annex A. Subsequently, an ongoing process has been followed in order to link the findings of Action B1 (impact model) of LIFE Profile with the Action B2, and particularly with the development of a novel cost-transfer approach. The objective of this ongoing procedure was to continuously enhance the original simplified model presented in Annex A, by taking into account:

- the Greek conditions and the characteristics of the Greek natural environment
- the implementation requirements of ELD
- the needs of the Greek stakeholders and the preferences of Greek citizens
- the available international experience

To achieve this goal, the following steps were undertaken: (a) multiple working meetings were conducted among the project partners, and (b) an expert consultation process was initiated. The involvement of six environmental inspectors and the environmental prosecutor proved to be particularly significant during meetings and interviews, enabling the adaptation of the methodology to comply with the requirements of Greek legislation.

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[10] Foregone utility defines a cost of the damage, which, when incurred by the “polluter” can be used to fund “value to value” and “value to cost” projects.
[11] Based on this approach, no foregone welfare is envisaged with regard to soil damages.
[12] These values can be extracted at the local/regional scale from the water management plans

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3.2 Resource to resource and service to service estimations for the case of soil and water resource pollution

Soil pollution refers to the presence of substances or organisms in the soil or subsoil that pose a significant risk to human health, either directly or indirectly. To assess the cost associated with soil pollution, our methodology relies on a "resource-to-resource" approach, which takes into account the observable, in actual markets for soil, engineering costs. This approach involves gathering data from various literature sources and databases. These databases can quantify the excavation, transport, disposal of soil (e.g. Table 2: database from the EPA of Ireland) or the cost of particular remediation techniques (e.g. Table 3: database used by the MORA tool in Spain). Additionally, specific cost information related to Greece is also considered. For instance, the estimated cost for excavating, collecting, packaging, and labeling contaminated soils (e.g., petroleum or asbestos-contaminated soils in Drepano, in the prefectural unit of Achaia) is approximately €50 per cubic meter, while the (cross-border) transport of contaminated soils was estimated to be equal to €500. This cost estimation serves as a reference (baseline) point for any future assessment, with future efforts focusing to obtain the most accurate soil cost approximations based on prevailing market conditions.

Table 2. Quantification and costing of plausible scenario from Ireland (EPA)

Description	Measurement Unit	Unit Rate (€)	Source of Unit Rates
Fire fighting	day	20,000	Fire Service
Excavation and construction of temporary fire water containment	unit	10,000	AB Contractor
Transport of fire water	tonne	50	Haulier Ltd
Disposal gate fee for fire water	tonne	25	WWTP Ltd
Excavation of contaminated soil (non-hazardous)	m^3	10	AB Contractor
Transport of contaminated soil (non-hazardous)	tonne	30	Haulier Ltd
Disposal gate fee for contaminated soil (non-hazardous)	tonne	50	Waste Co.
Consultancy costs	day	600	EC Environmental
Importation of topsoil	tonne	11	Landscaping Ltd
Landscaping	day	500	Landscaping Ltd
Decontamination of the building	day	1750	ABC Cleaners
Transport of decontamination wastes	tonne	30	Haulier Ltd
Disposal gate fee of decontamination waste	tonne	50	Waste Co.
Surface water monitoring	sample	130	EC Environmental
Groundwater monitoring	sample	150	EC Environmental

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Air monitoring	sample	200	EC Environmental
Ecological monitoring	sample	1000	EC Environmental
Waste monitoring	sample	200	EC Environmental

Table 3. Quantification and costing of soil remediation techniques (chemical damages) from Spain (MORA model)

Technique	Cost (€$_{2010}$/t)	Recovery time frame (years)
Biopiles	135.49	0.75
Enhanced bioremediation	52.11	2.00
Oxidation/Chemical reduction	343.95	0.25
Solidification	299.00	0.50
Landfarming	52.11	0.75
Natural recovery	0.00	3.00

As already mentioned, the "service to service" method will be employed to evaluate damages related to water, utilizing both market costs (direct water supply costs) and external costs (environmental and resource costs). This approach aligns with the recommendations of the Water Framework Directive, which advocate for the implementation of full cost pricing for water resources.

In order to evaluate the financial impact of water pollution, a comprehensive search was conducted in the database of the Ministry of Environment and Energy of Greece, specifically focusing on all water management plans across the country's water departments. The assessment of the full cost of water resources took into consideration variations at a smaller spatial scale, specifically the water basin level. Extensive data on water cost estimates, including monetary, environmental, and resource costs, were gathered for the entire country. This data was then used to create a database encompassing the total cost of irrigation water, as well as a separate database for the total cost of drinking water supply. These two databases (Figures 3a, 3b) serve as reference costs estimations for determining the value of a unit of water that may be compromised or lost due to any potential pollution incident.

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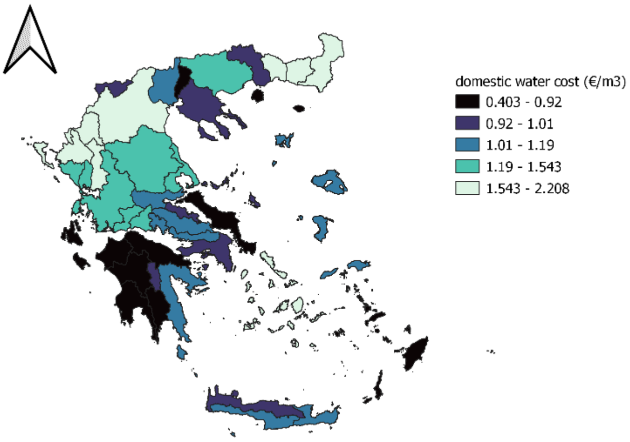

Figure 3a. Cost estimates of water resources - domestic use (full cost pricing per river basin)

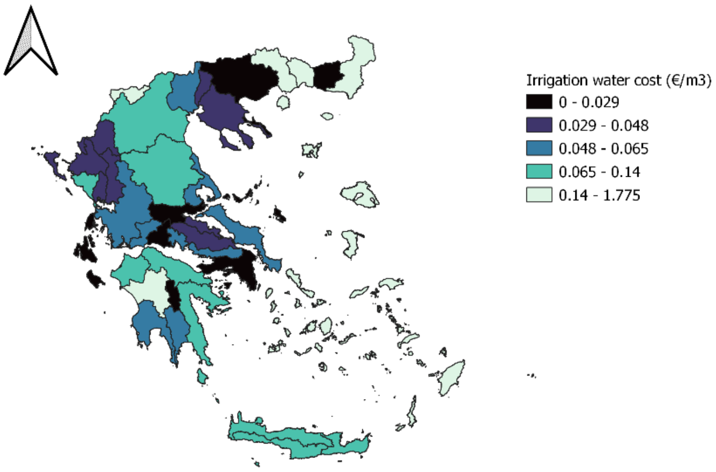

Figure 3b. Cost estimates of water resources - agricultural use (full cost pricing per river basin)

3.3 Value to value and value to cost estimations for the case of biodiversity and/or ecosystem services

The estimation of biodiversity costs involves employing a value-to-value (or value-to-cost) methodology. In order to do so, a benefit (cost) transfer method is followed, focusing on the foregone (social) value due to biodiversity loss and/or due to the decline of ecosystem services (i.e. due to the decline or impairment of the benefits that ecosystems provide to society).

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To achieve a desirable level of reliability in the benefit (cost) transfer, it was crucial to have access to a substantial number of original studies. In this regard, the availability of searchable environmental valuation databases could greatly facilitate the application of the benefit/cost transfer method in any future policy- and decision-making process. These databases can serve as valuable resources, streamlining the process of locating and retrieving relevant studies, ultimately enhancing the accuracy and effectiveness of benefit transfer.

In this report, the total value of biodiversity was approximated by using two international environmental valuation databases (benefit/cost transfer method). Specifically, the "Environmental Valuation Reference Inventory" (EVRI) and the "Ecosystem Services Valuation Database" (ESVD) were systematically searched, as they incorporate values for the majority of biodiversity resources, biomes and ecosystem services. Following this process, average per hectare values, which have already been estimated for a number of scenarios (differentiated with respect to the ecosystem affected by pollution incidents) will be used. Next, these values are going to be calibrated to the Greek conditions, aiming to take into account the characteristics of the Greek environment and people's preferences/values. The calibration to the Greek conditions will be achieved through a non-market valuation study.

In this context, a brief discussion should be made on the two international databases (EVRI and ESVD), which were used for the economic value of biodiversity/ecosystem services. First of all, the Ecosystem Services Valuation Database (ESVD) is a global database that compiles information on the economic value of ecosystem services (see Annex B1)[13], is publicly available (https://www.esvd.net) and can be used by researchers, policymakers, and other stakeholders: (a) to assess the economic value of ecosystem services in different regions and (b) to support decision-making on conservation and management. It should be noted that ecosystem services refer to the diverse range of benefits and resources that ecosystems provide to humans and the natural environment. These services can be categorized into four main types:

- Provisioning Services: including the tangible products obtained from ecosystems, such as food, water, timber, and raw materials.
- Regulating Services: involving the regulation and maintenance of essential ecological processes, including climate regulation, water purification, pollination, and flood control.
- Cultural Services: encompassing the non-material benefits that ecosystems offer, such as aesthetic and recreational values, cultural heritage, spiritual enrichment, and educational opportunities.
- Supporting Services: These services are the underlying ecological processes that sustain all other ecosystem services (e.g. nutrient cycling, soil formation, and habitat creation).

[13] The ESVD is maintained by the United Nations Environment Programme (UNEP) and the World Conservation Monitoring Centre (WCMC).

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The ESVD database contains information on the economic value of ecosystem services in different regions and ecosystems around the world. The database includes a number of studies that have estimated the value of ecosystem services using a range of valuation methods, such as market-based valuation, stated preference surveys, and cost-based approaches. However, it's worth noting that the ESVD has some limitations. For example, not all ecosystem services have been valued, and there can be variations in the methods and assumptions used to estimate the economic value of ecosystem services.

The Environmental Valuation Reference Inventory (EVRI) EVRI database, which is also publicly available (https://www.evri.ca/en) is quite similar to the ESVD. It is actually a searchable storehouse of empirical studies on the economic value of environmental assets and human health effects. It covers various environmental resources and ecosystem services, including but not limited to water resources, forests, biodiversity, air quality, and cultural heritage.

It is worth mentioning that apart from the above two databases, there are several other databases that provide information on the economic value of ecosystem services. Here are some examples:

- The Economics of Ecosystems and Biodiversity (TEEB) database: This is a global initiative that aims to provide a comprehensive assessment of the economic value of ecosystem services. The TEEB database includes case studies and other information on the economic value of ecosystem services in different regions and ecosystems around the world.
- The GEVAD (Greek Environmental Valuation Database) database: GEVAD serves as an on-line environmental valuation database developed by the National Technical University of Athens (http://www.gevad.minetech.metal.ntua.gr/home.php). This database provides necessary data to value environmental impacts of industrial activities in Greece and other European countries by means of the Benefit transfer method, in compliance with the institutional and research context of the international scientific community.
- The International Union for Conservation of Nature (IUCN): IUCN maintains several databases related to biodiversity conservation, but they do not focus specifically on the valuation of ecosystem services. However, the IUCN does provide guidance and tools for assessing the economic value of ecosystem services, such as their Guidelines for Applying IUCN’s Global Standard for Nature based Solutions (NbS). The IUCN's Global Standard for NbS provides guidance on how to assess the economic value of ecosystem services.

All economic data used in this report came from the ESVD and EVRI databases. A total of 1531 records (studies) have been evaluated, cost transferred and used in our analysis. Annex C includes both an indicative and analytical compilation of these valuation studies (i.e. a set of 200 studies pertaining to the values of environment and/or ecosystem services). In all these records, a damage/accident that may occur in each study area/ecosystem is actually considered as a foregone value. By categorizing the existing valuation studies based on the specific type of biome in which the study areas are situated, it becomes feasible to calculate the average value of each ecosystem service within each respective

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biome. Consequently, a value transfer approach is employed, which involves transferring a measure of central tendency, typically the mean value, from multiple study sites. This allows for the estimation of the value (cost) associated with the degradation of ecosystem services in a specific location by utilizing data and findings from similar sites (biomes).

To account for variations in price levels and time, adjustments need to be made to the unit values obtained from the selected studies. Specifically, two types of adjustments are necessary: spatial adjustment and temporal adjustment. For spatial adjustment, it is essential to consider the differences in purchasing power and monetary units between Greece (policy site of interest) and the country where the original study was conducted. The literature suggests that a reliable measure for international price comparisons is the Purchasing Power Parity Index (PPPI), which is calculated as the ratio of the weighted average price of a basket of goods between two countries, with expenditure shares used as the price weights. This index was used in this report aiming to eliminate the differences in price levels between different countries and so permit value comparisons. Regarding the temporal adjustment, the time difference between the primary study and the current (policy) period needs to be addressed. This adjustment is achieved using the Consumer Price Index (CPI), which reflects the inflation rate. By making these spatial and temporal adjustments, the ecosystem service values obtained from the selected studies (for each biome) were appropriately modified to ensure consistency and comparability. The final outcome of this procedure is depicted in Table 4.

Table 4. Benefit transfer value estimates of ecosystem services, in Greek 2023 euros

	Type of biome					
Ecosystem services	Coastal systems (included wetlands)	Inland wetlands	Temperate forests	High mountain systems	Cultivated areas	Urban Green and Blue Infrastructure
Food	1,639	3,637	5	3,742	318	
Water	11,015	1,563		94	39	
Raw materials	605	1,006	34	621	100	668
Genetic resources	10	102				
Ornamental resources				7		
Air quality regulation	1,156	2,286	1,340		2,542	11,470
Climate regulation	212	169	425	31	40	1584
Moderation of extreme events	17,923	45,823	36	654	13	
Regulation of water flows	85	2,115	60			570
Waste treatment	1,418	1,272			126	
Erosion prevention	230	6,663				
Maintenance of soil fertility	11,370	5,782			7	
Pollination					1,218	

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Biological control		155			1,294	
Maintenance of life cycles	192,675	4,378				
Maintenance of genetic diversity	1,015	799			22	

It should be noted that apart from this benefit (cost) transfer procedure, an extended valuation study of the Greek biodiversity has been also designed. This study focuses on protected areas with significant biodiversity characteristics (e.g., Natura 2000 sites) and is based on the contingent valuation method, untertaking a "Willingness to Accept" approach. A relevant and novel questionnaire has been developed and its pre-test phase (with more than 40 answers) has been completed. Apart from these answers, during the pre-test phase, a consultation process with experts on biodiversity (which was once again part of the Step 4) was followed (by means of a round-table discussion in the 13th conference of the Hellenic Association of Bioscientists – Thessaloniki 9-11/12/2022)[14].

The results of this (Greek) valuation study are aiming to:

- calibrate the international values to the Greek conditions
- define the range of values for the most important Greek biodiversity areas, considering the characteristics of the natural habitats and some important indicators of biodiversity
- compare and incorporate values estimated by different methods which can be used for comprehensive valuations of Greek biodiversity.

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Annex A: "Preliminary tool for estimating the cost of environmental damage"

Όνομα σεναρίου	Scenario 1	
Είδος δραστηριότητας	1. Εγκαταστάσεις ανάκτησης υλικών από μη επικίνδυνα σύμμεικτα ανακυκλώσιμα απόβλητα μέσω μηχανικής ή/και χειρωνακτικής διαλογής (ΚΔΑΥ) (εργασίες R12)	
		Υπόμνημα
Περιφέρεια	Ανατολική Μακεδονία και Θράκη	Δηλώνει λίστα
		Δηλώνει κελί εισαγωγής
Είναι η περιοχή προστατευόμενη;	ΟΧΙ	
Έκταση καταστροφής σε Ha	10 Ha	
% Ολικής καταστροφής	50%	
% Μερικής καταστροφής	50%	
How much is some		Καταστροφές σε:
Βλαβεροί παράγοντες:	☑ Υλικοί ☑ Φωτιά ☑ Χημικοί ☑ Βιολογικοί	☑ Έδαφος ☑ Νερό ☑ Οικοσύστημα ☑ Ενδοχώρα ☑ Παράκτια
Απόβλητα σε νερό	ΝΑΙ	
Τί ποσότητα νερού έχει επηρεαστεί σε m3	100 m3	
Τί ποσότητα εδάφους έχει επηρεαστεί σε t	10 t	
Είναι η καταστροφή αναστρέψιμη;	☐ Αναστρέψιμη	20 years
Έχουν επηρεαστεί τουριστικές περιοχές;	ΝΑΙ	
Παρέχει πρόσβαση σε δρόμο	ΟΧΙ	
Δρόμος που απαιτείται σε km	0 km	
Περίοδος από την καταστροφή μέχρι την έναρξη δράσης	12 μήνας/ες	
Χρόνος Δράσης αποκατάστασης	12 μήνας/ες	
Επιπλέον κόστη	☐ Παροχή συμβουλευτικών υπηρεσιών ☐ ### ☐ ###	

Go to Calculation →

Βασικά χαρακτηριστικά σεναρίου

Έκταση καταστροφής σε Ha	10 Ha
% Ολικής καταστροφής	50%
% Μερικής καταστροφής	50%
Είναι η περιοχή προστατευόμενη;	ΟΧΙ
Σε τι % είναι προστατευόμενη;	0%
Είναι η καταστροφή αναστρέψιμη;	ΟΧΙ
Μέθοδος αποκατάστασης	TBA
Περιφέρεια σεναρίου:	Ανατολική Μακεδονία και Θράκη
Δραστηριότητα	1. Εγκαταστάσεις ανάκτησης υλικών από μη επικίνδυνα σύμμεικτα ανακυκλώσιμα απόβλητα μέσω μηχανικής ή/και
Έχουν επηρεαστεί τουριστικές περιοχές;	ΝΑΙ
Προεξοφλητικό επιτόκιο (ή επιτόκιο ανατοκισμού)	4%

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Annex B: "International environmental databases for the evaluation of ecosystem services"

1. ***Ecosystem Services Valuation Database (ESVD):*** https://www.esvd.net/

ESVD aims to gather information on economic welfare values related to ecosystem services measured in monetary units. These values can be used to internalize the importance of Nature in decision making. ESVD currently contains over 8,600 value records from over 1100 studies distributed across all biomes, ecosystem services and geographic regions.

Filters

Get valuations Clear Filters

Intensive land use biome ✕

Country

Continent

Protection Status

TEEB services classification

CICES services classification

SEEA services classification

Valuation Method

Valuations: 46 row (s)

Database Version: MAR2023V1

Biomes	Ecozones	Ecosystems	TEEB services	CICES services	SEEA services	Value 2020
Intensive land use biome	Perennial monoculture	Plantations	Climate regulation	Regulation of chemical comp...	Global climate regulation serv...	102.546
Intensive land use biome	Sown pastures and fields		Raw materials	Fibres and other materials fro...	Crop provisioning services	2765.8934
Intensive land use biome	Perennial monoculture	Plantations	Air quality regulation	Filtration/sequestration/storag...	Air filtration services	2241.7694
Intensive land use biome	Sown pastures and fields		Climate regulation	Regulation of chemical comp...	Global climate regulation serv...	149.5462
Intensive land use biome	Rice paddies; Freshwater aq...	Temporary inundated rice pad...	Maintenance of soil fertility	Decomposition and fixing pro...	Biomass provisioning services	1365.4974
Intensive land use biome	Rice paddies; Freshwater aq...	Temporary inundated rice pad...	Climate regulation	Regulation of chemical comp...		5104.0338
Intensive land use biome	Rice paddies; Freshwater aq...	Temporary inundated rice pad...	Opportunities for recreation a...	Characteristics of living syste...	Recreation-related services	1238.7805
Intensive land use biome	Rice paddies; Freshwater aq...	Temporary inundated rice pad...	Climate regulation; Biological ...		Global climate regulation serv...	919.0203
Intensive land use biome	Rice paddies; Freshwater aq...	Temporary inundated rice pad...	Air quality regulation		Air filtration services	1568.8639
Intensive land use biome	Rice paddies; Freshwater aq...	Temporary inundated rice pad...	Climate regulation	Regulation of chemical comp...	Local (micro and meso) clima...	22178.0422
Intensive land use biome	Rice paddies; Freshwater aq...	Temporary inundated rice pad...	Food	Animals reared by in-situ aqu...	Aquaculture provisioning serv...	19936.6237
Intensive land use biome	Rice paddies; Freshwater aq...	Temporary inundated rice pad...	Erosion prevention	Weathering processes and th...	Soil erosion control services	13635.8764
Intensive land use biome	Annual cropland; Sown pastu...	Intensive annual cropland	Opportunities for recreation a...	Characteristics of living syste...	Recreation-related services; ...	5.8671

Figure B1. Example of the ESVD's filters and results

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2. ***Environmental Valuation Reference Inventory (EVRI):*** https://www.evri.ca/en

The Environmental Valuation Reference Inventory is a searchable storehouse of empirical studies on the economic value of environmental assets and human health effects.

Figure B2. Example of using the EVRI (for identifying studies related to the economic valuation of biodiversity

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Annex C: "Lists of publications with monetary valuation"

Publications with valuation studies regarding disaster/accidents costs:

1. Alvarez, S., Larkin, S. L., Whitehead, J. C., & Haab, T. (2014). A revealed preference approach to valuing non-market recreational fishing losses from the Deepwater Horizon oil spill. Journal of environmental management, 145, 199-209.
2. Carson, R. T., Mitchell, R. C., Hanemann, M., Kopp, R. J., Presser, S., & Ruud, P. A. (2003). Contingent valuation and lost passive use: damages from the Exxon Valdez oil spill. Environmental and resource economics, 25, 257-286.
3. Chalk Point Natural Resource Trustees, 2002. Final Restoration Plan and Environmental Assessment for the April 7, 2000 Oil Spill at Chalk Point on the Patuxent River, Maryland
4. Fonseca, M.S., Julius, B.E. and Kenworthy, W.J., 2000. Integrating biology and economics in seagrass restoration: How much is enough and why?. Ecological Engineering, 15(3-4), pp.227-237.
5. Kirsch, K. D., Barry, K. A., Fonseca, M. S., Whitfield, P. E., Meehan, S. R., Kenworthy, W. J., & Julius, B. E. (2005). The Mini-312 Program—an expedited damage assessment and restoration process for seagrasses in the Florida Keys National Marine Sanctuary. Journal of coastal Research, 109-119.
6. Lauta, K. C. (2016). What's the price of a polar bear? Compensating environmental damages in the Arctic. In Responsibilities and Liabilities for Commercial Activity in the Arctic (pp. 193-216). Routledge.
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9. Thébaud, O., Bailly, D., Hay, J., & Pérez, J. (2005). The cost of oil pollution at sea: an analysis of the process of damage valuation and compensation following oil spills. Economic, social and environmental effects of the Prestige Oil Spill de Compostella, Santiago, 187-219.
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Publications with valuation studies regarding environmental/ecosystem values (a damage/accident on these areas/ecosystems can be considered as a foregone value)

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