

A Critical Appraisal of the Role of Benefit Transfer in Valuing Environmental Degradation Within the ISEW Framework

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Abstract

The Index of Sustainable Economic Welfare (ISEW) aims to provide a more accurate representation of societal well-being by adjusting traditional economic indicators to reflect environmental and social costs. A critical component of the ISEW is the valuation of environmental degradation, which is frequently conducted through benefit transfer (BT) methods due to constraints on data and resources. This paper examines the role of benefit transfer in estimating environmental costs within the ISEW framework, evaluating its strengths, limitations and methodological implications. While BT allows for broader application and comparability across regions, it often raises concerns about context sensitivity, accuracy and transfer errors. The paper reviews current practices, highlights case examples and proposes improvements through meta-analytic techniques and context-specific adjustments. Ultimately, it argues that while benefit transfer is a pragmatic tool, its application in ISEW requires rigorous methodological standards to ensure transparency, relevance and policy usefulness in measuring sustainable economic welfare.

Keywords: Index of Sustainable Economic Welfare (ISEW); benefit transfer; environmental valuation; sustainable welfare indicators; non-market environmental costs

1. Introduction

Traditional economic indicators, such as Gross Domestic Product (GDP), have long been criticized for their inability to reflect the true state of societal well-being and sustainability (Eisner, 1988; Daly & Cobb, 1989; Ayres, 1996; England, 1997; Lawn, 2003). In response, alternative indicators have been developed to provide a more comprehensive assessment of economic performance by accounting for social and environmental factors. One such measure is the Index of Sustainable Economic Welfare (ISEW), which adjusts personal consumption to account for income distribution, public services and the costs of environmental degradation and resource depletion. Unlike GDP, the ISEW aims to measure *sustainable welfare*, the extent to which current economic activity contributes to net long-term human well-being (Tsara et al., 2024; Sachan et al., 2025).

A key feature of the ISEW is the integration of environmental costs, such as air and water pollution, climate change and the loss of ecosystem services. Including these costs is essential for reflecting the trade-offs between economic growth and ecological sustainability. However, quantifying environmental degradation in monetary



Academic Editor: Castiel
Chen Zhuang

Received: 18 June 2026

Revised: 8 July 2026

Accepted: 15 July 2026

Published: 2 August 2026

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terms presents significant methodological challenges, especially when market prices are unavailable or incomplete.

Benefit transfer (BT) has emerged as a widely used method for estimating these non-market environmental costs (Johnston et al., 2015). By transferring existing economic values from previously conducted studies to new contexts, BT offers a cost-effective and practical solution, particularly for national accounting exercises like the ISEW. It allows for the consistent inclusion of environmental values across countries and time periods, where primary valuation studies may be infeasible due to resource constraints.

This paper critically evaluates the use of benefit transfer in the environmental component of the ISEW. It explores its practical advantages, theoretical assumptions and methodological limitations, with particular emphasis on the accuracy, contextual relevance and transparency of transferred values. By reviewing existing applications and proposing improvements, the paper aims to inform best practices for incorporating environmental valuation into sustainability indicators such as the ISEW (A. Menegaki, 2018). To illustrate these methodological principles, the paper uses the case of water pollution in Greece as a representative application of benefit transfer in the absence of primary valuation data.

Theoretical Origins

In welfare economics, the valuation of non-market goods through methods such as benefit transfer is consistent with a utilitarian framework in which social welfare is inferred from the aggregation of individual preferences, and willingness to pay (WTP) is used as a monetary measure of welfare change associated with environmental improvements or losses (Johansson, 1993; Freeman et al., 2014). This logic underpins much of environmental valuation and cost-benefit analysis, allowing non-market environmental costs and benefits to be incorporated into broader welfare assessments and composite indicators such as the ISEW (Boardman et al., 2018). However, critiques from ecological economics stress that WTP-based measures may systematically undervalue critical ecological functions because they are constrained by ability to pay, shaped by income inequality, and often unable to represent adequately intrinsic values, ecological thresholds, or non-substitutable ecosystem services (Costanza et al., 1997; Daly & Farley, 2011; Spash, 2008). For this reason, the use of benefit transfer in the present study is understood as a pragmatic rather than exhaustive valuation strategy: it draws on the policy relevance and operational usefulness of welfare-economic tools while recognizing the need for complementary physical, ecological, and non-monetary assessments to address the broader sustainability objectives embedded in the ISEW.

The rest of this chapter is organized as follows: After the introduction (Section 1) follows background knowledge in Section 2 and the concept of benefit transfer (Section 3); Section 4 presents a critical evaluation of BT in the ISEW, Section 5 explains the improvement of BT for the ISEW, Section 6 hosts four case studies for critical values in the environmental component of the ISEW and Section 7 offers the conclusion.

2. Background Knowledge

2.1. The ISEW Framework

The Index of Sustainable Economic Welfare (ISEW) was first proposed in the late 1980s by Daly and Cobb as a response to the growing concern that Gross Domestic Product (GDP) fails to capture the true well-being of economies and societies (Daly & Cobb, 1989). While GDP measures economic activity, it does not account for social inequalities, environmental degradation, or the depletion of natural resources. The ISEW was developed to address these shortcomings by providing a more holistic measure of economic welfare, adjusted for sustainability considerations (Tsara et al., 2024).

The ISEW begins with personal consumption expenditures, as in GDP, but it then introduces several critical adjustments. These include deductions for income inequality, which reduce the welfare score in societies with high disparity, and additions for non-market benefits, such as unpaid household labor and public expenditures on health and education (Daly & Cobb, 1989; Costanza et al., 2014). Most importantly for environmental economics, the ISEW subtracts the costs of environmental degradation, including air and water pollution, carbon emissions, and the loss of ecosystem services.

These adjustments are designed to reflect the depletion of natural capital and the long-term consequences of economic growth patterns that are environmentally unsustainable (Cobb & Cobb, 1994; Niccolucci et al., 2007).

Since its inception, the ISEW has been applied in numerous countries and regions (Diefenbacher, 1994; Jackson & Stymne, 1996; Stockhammer et al., 1997; Rosenberg & Oegema, 1995), often with modifications to fit local or regional conditions (Pulselli et al., 2006; Gigliarano et al., 2014; A. N. Menegaki & Tsagarakis, 2015; A. Menegaki, 2018). It has also influenced the development of other well-being indicators, such as the Genuine Progress Indicator (GPI), which builds upon the ISEW methodology (Lawn & Sanders, 1999).

More recent empirical work has extended the application of ISEW and GPI-type indicators beyond national-level analyses to regional, sub-national, and urban contexts, as well as to developing and emerging economies. For example, Posner and Costanza (2011) summarize ISEW and GPI studies at multiple scales and provide new estimates for Baltimore City, Baltimore County, and the State of Maryland, demonstrating the usefulness of welfare-adjusted indicators at urban and regional levels. Likewise, Hayashi (2015) applies the GPI to examine rural–urban disparities in Japan, showing how welfare indicators can capture spatial differences that conventional output-based measures overlook. In the context of emerging economies, Long and Ji (2019) estimate the GPI for all 31 provinces in mainland China and show that environmental degradation, climate damages, and resource depletion substantially affect welfare outcomes, often producing trajectories that diverge from GDP growth. These studies reinforce the flexibility of the ISEW/GPI framework across different spatial and developmental contexts.

At the same time, this expanding empirical literature also underscores a persistent methodological challenge: the valuation of environmental degradation. This component remains one of the most complex elements of the ISEW, as it requires the monetization of non-market environmental goods and services. In many empirical applications—particularly in regional, urban, and developing-country contexts—this is achieved through benefit transfer methods due to the lack of primary valuation data. As a result, the robustness of benefit transfer becomes central to the credibility of the ISEW itself, which motivates the present paper’s focus on the methodological role of BT in sustainable welfare accounting.

2.2. The Environmental Component of the ISEW

The environmental component of the ISEW is essential for capturing the external costs that economic activities impose on the natural environment. This includes a wide range of pollution and degradation impacts, such as:

- (i) Air pollution (e.g., emissions of sulfur dioxide, nitrogen oxides, and particulate matter);
- (ii) Water pollution (e.g., nutrient loading, chemical contamination);
- (iii) Climate change (e.g., carbon dioxide and methane emissions);
- (iv) Loss of ecosystem services (e.g., deforestation, biodiversity loss, land degradation).

Monetizing these impacts is challenging, particularly because many environmental goods and services lack market prices. As a result, several valuation methods have been employed in the up-to-date literature. These include the following approaches:

- Damage cost approaches, which estimate the costs imposed on health, productivity, and ecosystems by pollutants (e.g., [Chen & Wu, 2018](#)).
- Abatement cost methods, which use the cost of pollution control or mitigation as a proxy for environmental value (e.g., [Oka, 2008](#)).
- Willingness-to-pay (WTP) and willingness-to-accept (WTA) measures derived from stated or revealed preference methods (e.g., [Cao et al., 2010](#)).
- Benefit transfer, which applies values from existing studies to new locations or policy scenarios ([Spash, 2000](#); [EPA, 2018a](#)).

Among these, benefit transfer has gained prominence in the context of the ISEW construction, as it enables inclusion of environmental costs without conducting costly and time-intensive primary valuation studies. However, its use raises important questions about validity, context sensitivity and methodological transparency, issues that are explored in the subsequent sections of the current paper.

2.3. Valuation Methods and the Role of WTP in ISEW

In this article, we mention four major categories of environmental degradation as they are commonly integrated into the ISEW framework and for which benefit transfer methods can be applied. These include:

- (1) Water pollution, primarily resulting from agricultural runoff and nutrient loading;
- (2) Soil degradation, with an emphasis on the loss of organic carbon and its effect on ecosystem services;
- (3) Loss of agricultural land, due to abandonment, urbanization, and unsustainable land-use practices;
- (4) Loss of cultural and ecological ecosystem services, such as aesthetic, recreational, and biodiversity-related functions, particularly those provided by grassland and natural landscapes.

Each of these environmental components is analyzed using benefit transfer techniques, and their corresponding monetary values are deducted from the ISEW as negative externalities impacting long-term sustainable welfare.

3. The Concept of Benefit Transfer

Benefit transfer (BT) is an economic valuation technique used to estimate the monetary value of environmental goods or services by transferring existing values from one context, namely the *study site*, to another, the *policy site* ([Johnston et al., 2015](#)). In the context of the ISEW, where comprehensive valuation is needed for multiple types of environmental degradation, BT offers a practical alternative to conducting new primary valuation studies for each case. Several such cases are given by [Pulselli et al. \(2006\)](#) and [Kubiszewski et al. \(2013\)](#). Based on the latter, an initial estimate of the value of ecosystem services in Bhutan was conducted using a simple benefit transfer methodology based on land use. This approach provided insights into the economic value of ecosystem services in Bhutan, which were then integrated into the ISEW framework. The study by [Pulselli et al. \(2006\)](#) calculated the ISEW for a local authority in Italy, incorporating adjustments for environmental factors such as water pollution. The research utilized benefit transfer methods to estimate the economic value of ecosystem services, including the costs associated with water pollution abatement. Another study by [Bleys \(2008\)](#) in Belgium applied benefit transfer to estimate the value of ecosystem services for the ISEW calculation. The study involved transferring values from existing literature to assess the economic contribution of ecosystem services at the national level.

3.1. Methodological Framework of Benefit Transfer

Benefit Transfer (BT) is a methodological approach in environmental economics that estimates the economic value of non-market environmental goods and services by transferring existing valuation information from previously conducted studies (study sites) to new policy contexts (policy sites) where primary valuation data are unavailable (Rosenberger & Loomis, 2001; Johnston et al., 2015). The approach has become one of the most widely applied techniques in environmental valuation because it substantially reduces the financial costs and time requirements associated with conducting original valuation studies while still allowing environmental externalities to be incorporated into policy analysis and environmental accounting.

The fundamental premise of BT is that environmental values estimated under one set of conditions can provide a reasonable approximation for another location, provided that sufficient similarity exists between the study and policy sites. Such similarity may concern ecological characteristics, environmental quality, socio-economic conditions, population preferences, institutional settings, and the nature of the environmental change being valued. Consequently, the validity of BT depends largely on the degree of correspondence between the original valuation context and the new application (Brouwer, 2000; Johnston et al., 2015).

Within the context of the Index of Sustainable Economic Welfare (ISEW), Benefit Transfer plays a particularly important role because the construction of the indicator requires the monetary valuation of multiple environmental degradation components, including water pollution, air pollution, climate change, soil degradation, biodiversity loss, and ecosystem service deterioration (Tsara & Menegaki, 2026). Conducting separate primary valuation studies for each environmental component would be prohibitively expensive and would considerably reduce the operational applicability of the ISEW. Benefit Transfer therefore provides a pragmatic mechanism for incorporating environmental costs into welfare accounting while maintaining consistency across different environmental categories and geographical contexts.

Three principal Benefit Transfer approaches have been developed in the environmental valuation literature, differing in both methodological complexity and data requirements.

The simplest approach is unit value transfer, whereby a monetary estimate (for example, willingness-to-pay per household or damage cost per unit of pollution) obtained from an existing valuation study is directly transferred to the policy site. In most applications, this transferred value is subsequently adjusted to account for differences in inflation, exchange rates, purchasing power parity (PPP), and income levels between the original and recipient populations. Owing to its simplicity and limited data requirements, unit value transfer remains the most frequently applied BT approach in practical environmental accounting despite its relatively high susceptibility to transfer error (Rosenberger & Loomis, 2001).

A more advanced alternative is function transfer, in which the original valuation function rather than a single monetary estimate is transferred. This approach incorporates explanatory variables describing the environmental good and the characteristics of the affected population, allowing transferred values to be adjusted according to local socio-economic and ecological conditions. Function transfer generally produces more context-sensitive estimates than simple unit value transfer but requires substantially greater data availability.

The most statistically sophisticated approach is meta-analytic function transfer, which estimates generalized valuation functions by synthesizing the results of a large number of primary valuation studies through meta-regression analysis (Brouwer, 2000; Johnston et al., 2015). Rather than relying on a single source study, meta-analysis exploits systematic

variation across numerous valuation studies to identify the principal determinants of willingness-to-pay and environmental values. This considerably improves the robustness, transferability, and predictive performance of transferred estimates while reducing dependence on any individual valuation study.

Although Benefit Transfer has become the standard approach for many environmental policy applications, its implementation requires several methodological assumptions. Among the most important are assumptions regarding the similarity between study and policy sites, the stability of individual preferences across populations, the transferability of willingness-to-pay estimates, income elasticity of environmental values, purchasing power parity adjustments, and aggregation procedures used to estimate total societal welfare effects. Each of these assumptions introduces potential sources of uncertainty that may influence the magnitude of transferred values and therefore requires explicit justification and transparent reporting (Johnston et al., 2015; OECD, 2018).

For these reasons, international guidelines increasingly recommend that Benefit Transfer should not be viewed as a simple substitution for primary valuation but rather as a structured methodological procedure requiring careful selection of source studies, appropriate contextual adjustments, uncertainty analysis, and transparent documentation of all transfer assumptions (EPA, 2018b; Johnston et al., 2015). The methodological workflow adopted in this paper follows these recommendations and is subsequently applied to the environmental valuation components incorporated within the ISEW framework.

3.2. Rationale for Using Benefit Transfer in the ISEW

The ISEW requires monetary estimates for a wide range of environmental impacts, including air and water pollution, greenhouse gas emissions, and natural resource depletion. Conducting original valuation studies for each of these categories across countries or years would be prohibitively expensive and time-consuming. Benefit transfer allows researchers to overcome these constraints by relying on a growing body of existing environmental valuation literature. It supports cross-country comparability and periodic updates of ISEW scores, which are critical for policy relevance and long-term tracking.

3.3. Types of Benefit Transfer

Benefit transfer (BT) methods vary in complexity and data requirements, and their suitability differs across the various environmental components of the Index of Sustainable Economic Welfare (ISEW), as shown in Table 1. Unit value transfer, the simplest and most commonly used approach, applies a fixed monetary value per unit of environmental damage (e.g., per ton of CO₂, per hectare of deforested land, or per kilogram of water pollutant).¹ This method is typically used for estimating climate change costs, air and water pollution damages or noise pollution cost, and even biodiversity loss by assigning average values to habitat destruction or ecosystem degradation. However, it lacks context sensitivity and may misrepresent local ecological values.

Table 1. Benefit transfer methods.

BT Method	Environmental Component	Data Needs	Strength	Limitation
Unit Value	CO ₂ , Water Pollution	Low	Simplicity	High transfer error
Function Transfer	Ecosystems, Soil Loss	Medium	Context adjustment	Needs detailed variables
Meta-Analytic	Cultural Services, Land Use	High	Low error, generalizable	Complex, data-intensive

Source: The authors.

Function transfer improves on this by incorporating variables such as income, population, or ecological quality into a valuation equation, allowing adjustments based on local conditions (UNEP, 2013). For instance, function transfer can be applied to water pollution by adjusting for recreational use intensity or to biodiversity loss by including species richness or conservation status.

Finally, meta-analytic function transfer offers the most statistically rigorous option by synthesizing multiple primary studies into generalized valuation functions (Rosenberger & Loomis, 2001). This method is especially powerful for complex and diverse environmental goods like biodiversity, where public willingness to pay may depend on factors such as rarity, ecological importance, or proximity to protected areas.² Meta-analytic functions are also increasingly used to value cultural ecosystem services, carbon sequestration, and soil fertility loss. While each method has trade-offs, aligning the choice of BT technique with the specific environmental component in the ISEW—such as carbon emissions, pollution, soil degradation, or biodiversity loss—can improve accuracy, relevance, and policy credibility.

3.4. Data Sources for Environmental Values

BT in the ISEW calculations draws from a range of published sources, including:

- (i) Peer-reviewed valuation studies (as in part 6 of this paper).
- (ii) Environmental databases such as EVRI (Environmental Valuation Reference Inventory) and ENVALUE; The Environmental Valuation Reference Inventory (EVRI) is a comprehensive database containing over 4000 valuation studies on environmental and health impacts. It serves as a valuable resource for applying benefit transfer techniques in research and policy analysis. ENVALUE is an Australian database that hosts over 400 environmental valuation studies, primarily focusing on Australian contexts. It is widely used for benefit transfer applications within Australia, despite some limitations in updates and maintenance.
- (iii) International reports and meta-analyses (e.g., by the OECD, IPCC, or the European Commission); The Organisation for Economic Co-operation and Development (OECD) has published reports that discuss the valuation of environmental damages and the role of benefit transfer in policy development. These reports provide guidance on applying benefit transfer methods in various contexts. The Intergovernmental Panel on Climate Change (IPCC) assesses the economic valuation of climate change impacts, including the application of benefit transfer techniques. Their reports discuss the use of benefit transfer in estimating the costs associated with climate change impacts on ecosystems and human health.
- (iv) National cost-of-damage estimates from ministries of environment or energy. Various national agencies, such as ministries of environment or energy, publish cost-of-damage estimates related to environmental degradation. These estimates are often used in conjunction with benefit transfer methods to assess the economic impacts of environmental changes (Pagiola et al., 2004).

These sources provide the necessary unit values for pollution types and ecosystem damages, enabling the construction of environmental accounts without bespoke data collection.

4. Critical Evaluation of Benefit Transfer in the ISEW

Before evaluating the role of Benefit Transfer (BT) within the Index of Sustainable Economic Welfare (ISEW), a structured qualitative assessment of the available evidence was undertaken. The analysis drew upon peer-reviewed environmental valuation studies, methodological contributions on Benefit Transfer, international guidance documents (e.g., OECD, EPA, and IPCC reports), environmental valuation databases such as the

Environmental Valuation Reference Inventory (EVRI) and ENVALUE, and published applications of the ISEW framework. These sources were comparatively reviewed with particular attention to recurring methodological issues, reported transfer errors, contextual limitations, practical implementation challenges, and recommended best practices. Through this comparative synthesis, the evidence was organized into two broad thematic categories, namely the strengths and limitations of Benefit Transfer. These themes represent the most consistently reported advantages and methodological concerns identified across the literature and provide the analytical basis for the critical discussion presented in the following subsections.

Benefit transfer (BT) has played a pivotal role in operationalizing the environmental component of the ISEW, allowing for the inclusion of non-market environmental values in a cost-effective and scalable manner. However, its use is not without controversy. While BT offers practical advantages, it also introduces a series of methodological and conceptual challenges that can compromise the accuracy and relevance of the resulting welfare estimates.

4.1. Strengths of Benefit Transfer

- (i) **Practicality and cost-efficiency:** BT eliminates the need for time- and resource-intensive primary valuation studies, which are often infeasible for comprehensive welfare indices like the ISEW, especially when applied across multiple years or countries.
- (ii) **Data accessibility:** The growing availability of environmental valuation studies and databases has made BT increasingly feasible and defensible. This is especially true for high-profile externalities such as carbon emissions and air pollutants, where consensus damage cost estimates exist.
- (iii) **Comparability and consistency:** Using standardized transferred values facilitates cross-national comparisons and time-series analyses. BT can help maintain a uniform methodology across different case studies, improving the comparability of ISEW scores.
- (iv) **Policy relevance:** BT allows for the rapid integration of the latest scientific estimates into policy tools. For example, updated social cost of carbon figures can be easily incorporated into ISEW calculations to reflect new climate science and economic modeling.

4.2. Limitations of Benefit Transfer

- (i) **Context sensitivity:** One of the primary criticisms of BT is its lack of site-specific sensitivity. Environmental values are often dependent on local ecological, economic, and social conditions. Transferring values without proper adjustment can lead to inaccurate or misleading estimates.
- (ii) **Transfer errors:** Empirical studies have shown that transfer errors, the difference between values obtained through transfer and those obtained from original site-specific studies, can be large. These errors may stem from differences in population income levels, environmental quality, cultural preferences, or regulatory context.
- (iii) **Over-simplification:** Many ISEW applications rely on unit value transfer, which assumes a uniform cost per unit of environmental damage. This method often fails to account for non-linearities, thresholds, or spatial heterogeneity in damage functions, potentially distorting welfare estimates.
- (iv) **Obsolescence of source studies:** Some ISEW studies rely on outdated valuation research, which may not reflect current scientific understanding, damage functions, or economic conditions. This is particularly problematic in fast-evolving fields such as climate change.
- (v) **Risk of double counting or omissions:** When multiple environmental impacts are valued separately and aggregated, there is a risk of either double counting (e.g.,

including both the cost of deforestation and the lost ecosystem services it causes) or omitting interrelated effects due to incomplete data.

- (vi) Lack of transparency and replicability: BT in ISEW is often applied with limited documentation, making it difficult to assess the credibility or replicability of the estimates used. Without detailed reporting of source studies, adjustment factors, and valuation methods, the robustness of ISEW's environmental component remains uncertain.

5. Improving Benefit Transfer in the ISEW

Given the practical importance of benefit transfer (BT) in the construction of the ISEW and the limitations discussed in the previous section, enhancing the reliability and methodological rigor of BT is essential. This section outlines several strategies to improve the quality, accuracy, and transparency of benefit transfer practices in ISEW applications.

5.1. Use of Meta-Analytic Benefit Transfer

One of the most promising advances in environmental valuation is the meta-analytic function transfer approach. Instead of using a single study's value, meta-analysis aggregates results from numerous primary valuation studies to estimate a generalized valuation function. This function can incorporate key explanatory variables, such as income, population density, or ecosystem characteristics, allowing for more context-sensitive adjustments. Applying such meta-functions to ISEW can significantly reduce transfer errors compared to simpler unit value transfers.

To illustrate the difference between unit value transfer and meta-analytic function transfer, consider the valuation of carbon emissions. A **unit value transfer** might directly apply a published social cost of carbon, for example, €50 per tonne of CO₂, adjusted for inflation and PPP. By contrast, a **meta-analytic function transfer** uses a regression model derived from multiple primary valuation studies, with predictors such as GDP per capita, population density, and environmental policy stringency. Applying such a model might yield an estimate of €46 per tonne of CO₂, reflecting contextual factors that differ from the original study sites. While the numerical difference in this example is modest (8%), it illustrates how meta-analytic transfer can adjust for systematic variation across study contexts, potentially improving the accuracy of environmental valuations in the ISEW. While the difference in this example (8%) is relatively modest, meta-analytic transfer provides a more context-specific estimate by incorporating explanatory variables from a large body of primary studies, potentially reducing transfer error when valuing environmental components of the ISEW.

5.2. Contextual Adjustments

Where the unit value transfer is used, contextual adjustments should be systematically applied. Such common adjustments include:

- (i) Income scaling (e.g., using purchasing power parity or income elasticity. Purchasing Power Parity (PPP) is used in benefit transfer to adjust WTP values across countries in a way that reflects differences in local purchasing power, ensuring that the monetary estimates reflect comparable economic effort rather than nominal currency values).
- (ii) Price-level corrections (e.g., inflation indexing or local cost of living).
- (iii) Ecological relevance checks, ensuring the transferred value is ecologically appropriate for the policy site.

Incorporating these adjustments helps to tailor transferred values more closely to the socio-economic and environmental conditions of the recipient context (see Appendix A at the end of this paper).

5.3. Improved Data Transparency and Documentation

Evidence from previous Benefit Transfer applications suggests that inadequate documentation of transfer procedures remains one of the principal sources of uncertainty affecting the credibility and reproducibility of transferred environmental values. Although international guidelines recommend transparent reporting of study selection, adjustment procedures, transfer assumptions, and sources of uncertainty, published applications often provide only limited information regarding the rationale for selecting source studies, the magnitude of contextual adjustments, or the assumptions underlying aggregation procedures (Johnston et al., 2015; OECD, 2018; EPA, 2018b). As a consequence, independent researchers may find it difficult to reproduce the calculations or evaluate the suitability of transferred values for alternative policy contexts.

The same concern applies to applications of the ISEW, where environmental cost estimates are frequently derived from multiple secondary valuation studies that differ in geographical scope, valuation methods, and underlying assumptions. In several cases, insufficient reporting of data sources, transfer parameters, inflation adjustments, purchasing power corrections, or uncertainty analyses limits the transparency of the resulting environmental accounts and complicates comparisons across studies. Environmental valuation databases such as the Environmental Valuation Reference Inventory (EVRI) have therefore emphasized standardized documentation of valuation studies to facilitate consistent and transparent Benefit Transfer applications (EVRI, 2026).

To address these challenges and improve the credibility and replicability of ISEW estimates, all Benefit Transfer applications should fully document the sources of transferred values, including the original study location, valuation method, year of data collection, justification for study selection, and all contextual adjustments applied (e.g., inflation, purchasing power parity, income elasticity, and ecological similarity). Establishing a standardized reporting framework for BT within the ISEW would substantially improve transparency, facilitate peer review, and enhance the reproducibility of future welfare assessments.

5.4. Integration with Physical Indicators

To address the risk of over-reliance on monetary values, BT can be complemented with physical indicators (e.g., tons of CO₂, hectares of lost forest). This dual approach helps validate the plausibility of monetary estimates and ensures that environmental pressures remain visible even when valuation is uncertain or contested.

5.5. Incorporating Uncertainty Analysis

BT values are inherently uncertain, especially when transferred across different contexts. Including uncertainty bounds or using Monte Carlo simulations in ISEW estimates can provide a range of possible welfare impacts rather than a single deterministic value (EcoShape, 2025). This approach encourages more cautious interpretation and policy design. In the uncertainty bounds, for each transferred value, one can calculate a lower bound and an upper bound based on possible variations. For example, if the original WTP for an environmental good is \$100, but there is uncertainty around this estimate due to variations in income levels, the lower bound might be \$80, and the upper bound could be \$120. In the Monte Carlo simulation, for each uncertain parameter, we assign a probability distribution. For example, if the WTP estimate is normally distributed, we might assume a mean of \$100 and a standard deviation of \$10. In essence we present the results in a way that reflects the uncertainty, such as by showing the probability distribution of the welfare impacts or the range of possible outcomes.

5.6. Dynamic Updating of Values

Environmental damage costs, especially for climate change, biodiversity loss and air pollution, are continuously updated in the literature. The ISEW calculations should establish procedures for regularly updating transferred values in line with the latest research and policy guidance (e.g., IPCC reports, EU cost-of-carbon estimates).

5.7. Methodological Assumptions Underlying the Transfer Procedure

The application of Benefit Transfer (BT) inevitably requires a number of methodological assumptions that facilitate the transfer of environmental values from the original study site to the policy site. While these assumptions are commonly adopted in the environmental valuation literature, they introduce uncertainty into the transferred estimates and therefore require explicit justification and transparent reporting. The present study follows internationally accepted BT practice while acknowledging the limitations associated with each assumption, as shown in Figure 1 (Johnston et al., 2015; OECD, 2018).

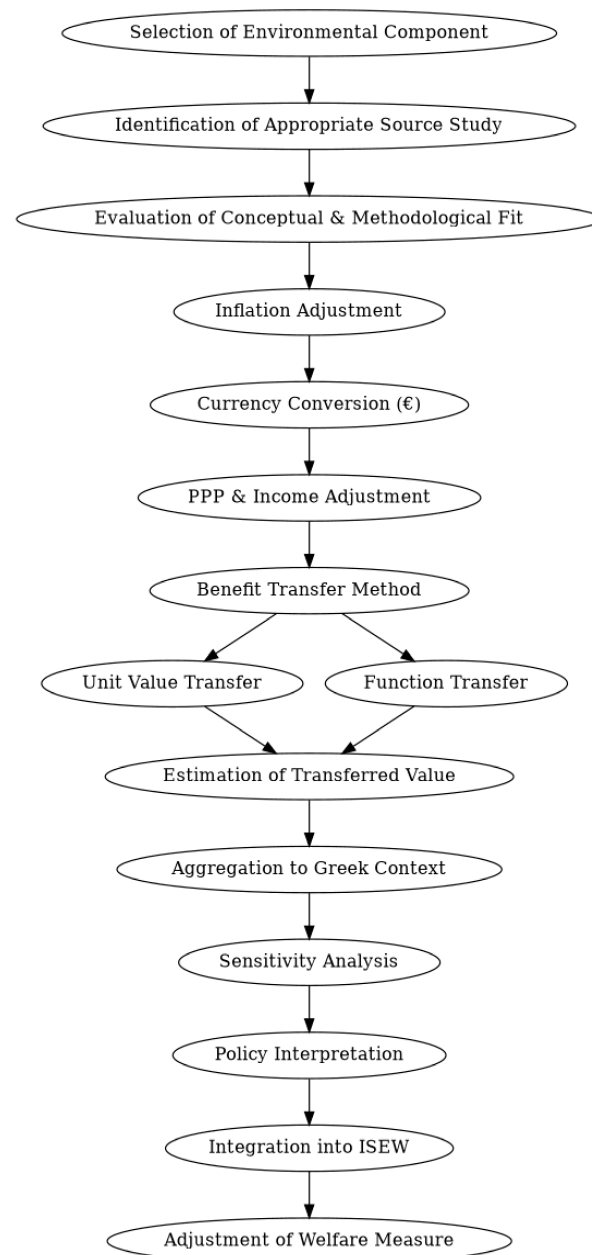


Figure 1. Integration of Benefit Transfer into the ISEW Framework.

A first assumption concerns income elasticity of willingness to pay (WTP). Since environmental values generally increase with income, transferring values across countries requires adjustment for differences in purchasing power and living standards. In this study, a unit income elasticity ($\epsilon = 1$) is adopted, implying that willingness to pay changes proportionally with income. This assumption is widely used in international benefit transfer applications when reliable country-specific elasticity estimates are unavailable and provides a transparent and conservative basis for transferring environmental values between countries with different income levels (OECD, 2018). Nevertheless, empirical studies have reported elasticity values ranging from below one to above one depending on the environmental good, implying that the transferred estimates should be interpreted as approximations rather than precise welfare measures.

A second methodological assumption relates to the use of Purchasing Power Parity (PPP) adjustments. PPP corrections are applied to account for differences in purchasing power between countries, allowing transferred monetary values to reflect comparable levels of economic welfare rather than nominal exchange rate differences. Compared with simple currency conversion, PPP adjustment is generally regarded as a more appropriate procedure in international benefit transfer because it better reflects differences in household purchasing capacity and cost-of-living conditions (OECD, 2018).

The transfer procedure further assumes that population scaling and aggregation provide a reasonable approximation of national environmental values. After adjusting individual or household willingness-to-pay estimates, values are aggregated using the relevant population or household totals in Greece. This proportional scaling approach is widely applied in environmental valuation because it enables local valuation estimates to be translated into national welfare measures. However, aggregation implicitly assumes that transferred values are representative of the recipient population and that average willingness to pay remains relatively homogeneous across households. In practice, regional differences in environmental preferences, income distribution, demographic characteristics, and environmental conditions may influence aggregate estimates.

Finally, all benefit transfer applications are subject to transfer uncertainty, arising from differences between the study site and the policy site that cannot be fully captured through income adjustments or scaling procedures. Such uncertainty may reflect ecological differences, institutional characteristics, environmental quality, cultural preferences, or methodological differences among the original valuation studies. To acknowledge this uncertainty, the present study complements deterministic benefit transfer calculations with Monte Carlo simulations, providing an indication of the potential variability surrounding the transferred estimates rather than relying exclusively on single-point values. Consequently, the resulting estimates should be interpreted as policy-oriented approximations intended to demonstrate the application of the Benefit Transfer methodology within the ISEW framework rather than as precise measures of environmental damages. Explicit recognition of these assumptions enhances the transparency, reproducibility, and methodological robustness of the proposed valuation procedure.

6. Case Study: Applying Benefit Transfer for the Calculation of the Environmental Component of the ISEW in Greece

The primary objective of the case studies presented in this section is not to derive official environmental damage estimates for Greece, but rather to demonstrate how a transparent and methodologically consistent Benefit Transfer (BT) procedure can be integrated into the environmental component of the Index of Sustainable Economic Welfare (ISEW). The applications therefore serve as illustrative methodological examples that show the sequence of adjustments required when transferring environmental values from existing

valuation studies to a new policy context. By explicitly documenting each step—including inflation adjustment, currency conversion, purchasing power parity (PPP) correction, income adjustment, aggregation procedures, and uncertainty analysis—the proposed framework provides a replicable protocol that can be adapted for other environmental components and geographical settings.

Greece was selected as the policy site because it represents a country where the construction of comprehensive welfare indicators is constrained by the limited availability of primary environmental valuation studies covering all components required by the ISEW. As in many countries, national environmental accounting frequently relies on secondary valuation evidence due to financial, temporal, and data limitations. Consequently, Greece provides an appropriate example for illustrating how Benefit Transfer can support environmental valuation in situations where primary valuation is either unavailable or impractical.

River water pollution was selected as the first application because it represents one of the environmental components most frequently valued in the international Benefit Transfer literature and one for which willingness-to-pay estimates are relatively abundant and conceptually compatible with the environmental adjustment required by the ISEW. Furthermore, water quality is of particular policy relevance in Greece, where pressures arising from agriculture, urban wastewater discharges, industrial activities, and tourism affect the ecological status of many river basins and ultimately influence coastal ecosystems protected under the European Union Water Framework Directive. For these reasons, river water pollution provides an appropriate example for demonstrating the complete transfer procedure.

Other environmental components, such as air pollution, biodiversity loss, soil degradation, and ecosystem services, are equally important within the ISEW framework and are also examined in the following subsections. However, river water pollution was intentionally selected as the introductory application because it allows the methodological steps of Benefit Transfer to be presented in a relatively transparent and easily reproducible manner before extending the procedure to environmental goods that are often characterized by greater ecological complexity and valuation uncertainty.

The originality of the present study does not lie in proposing a new valuation model or producing official national environmental accounts for Greece. Rather, its contribution lies in developing and demonstrating a structured Benefit Transfer protocol that combines internationally accepted adjustment procedures with explicit documentation of methodological assumptions and uncertainty analysis. In doing so, the paper contributes a practical framework that may improve the consistency, transparency, and reproducibility of future ISEW applications in Greece and elsewhere.

6.1. Monetary Valuation of Water Pollution in Greece Through Benefit Transfer

This application should be interpreted as an illustrative methodological demonstration of the Benefit Transfer procedure rather than as an official estimate of the environmental cost of river water pollution in Greece. Its purpose is to demonstrate the sequence of methodological adjustments required to transfer environmental values from an existing valuation study to the Greek context in a transparent and reproducible manner. Producing nationally validated estimates would require Greece-specific primary valuation studies, detailed environmental monitoring data, and comprehensive sensitivity analyses that are beyond the scope of the present study.

The source study focuses on the Mayur River in Bangladesh, a heavily polluted urban river, and applies the contingent valuation method (CVM) using a double-bounded dichotomous choice model. Based on a sample of 198 respondents residing near the river,

the authors estimate a mean WTP of approximately BDT 312 (USD 2.57) per household per month for a water quality improvement program.

This valuation captures both use and non-use values associated with improved water quality, including health benefits, ecosystem restoration, recreational use, and broader environmental improvements. As such, it provides a direct estimate of the social value of reducing river water pollution, making it conceptually suitable for integration into the environmental component of the Index of Sustainable Economic Welfare (ISEW).

For the purposes of this study, the estimated WTP is interpreted as a proxy for the marginal social cost of river water pollution. However, as the original study is conducted in a developing country context, adjustments are required to ensure comparability with Greece. The following subsections describe the steps taken to adapt this value through currency conversion, income adjustment, aggregation, and scaling.

The steps we take for benefit transfer in this case are as follows:

6.1.1. Inflation Adjustment

The original mean willingness to pay (WTP) is reported as BDT 312 per household per month. To ensure temporal comparability, the value is first adjusted for inflation from the base year of the study (2025) to the reference year of the analysis. Given the negligible inflation difference for a same-year adjustment, the nominal value is retained without modification:

$$WTP_{real} = WTP_{base}$$

Thus, the inflation-adjusted value remains: 312 BDT per household per month.

6.1.2. Currency Conversion

The inflation-adjusted value is converted into a common currency (EUR) to ensure consistency with the ISEW framework. Using the conversion provided in the study

$$\text{BDT } 312 \approx \text{USD } 2.57$$

and an approximate exchange rate of 1 USD = 0.93 EUR (ECB, 2024b), we obtain

$$2.57 \times 0.93 = 2.39 \text{ EUR per household per month.}$$

$$\text{Annualizing : } 2.39 \times 12 = 28.68 \text{ EUR per household per year}$$

This represents the baseline monetary value prior to income adjustment.

6.1.3. Income Adjustment Using PPP and Elasticity

To account for differences in income levels between Bangladesh and Greece, an income adjustment is applied using Purchasing Power Parity (PPP) and an income elasticity of WTP. Assuming GDP per capita (PPP) for Bangladesh $\approx$ €6000 and GDP per capita (PPP) for Greece $\approx$ €25,000 (World Bank, 2024), the income ratio is

$$\frac{25,000}{6000} \approx 4.17$$

Assuming unit income elasticity ($\epsilon = 1$), the adjusted WTP is

$$WTP_{adj} = 28.68 \times 4.17 = 119.6 \text{ EUR per household per year}$$

This adjusted value reflects differences in purchasing power and ability to pay between the two countries.

6.1.4. Aggregation for the Greek Population

The adjusted WTP is aggregated across households to estimate the total national cost of river water pollution.

Assuming the number of households in Greece $\approx$ 4.1 million (ELSTAT, 2024) and the total annual value is

$$119.6 \times 4.1 \text{ million} = 490.36 \text{ million EUR}$$

Thus, the estimated aggregate cost of river water pollution in Greece is approximately 490 million EUR per year.

6.1.5. Monte Carlo Simulation

In addition to the deterministic benefit transfer approach, a Monte Carlo simulation was conducted in order to account for the uncertainty associated with the estimated willingness to pay (WTP) for river water quality improvement.

The simulation was based on the mean willingness-to-pay (WTP) estimate reported by Mim and Haider (2025), which amounted to approximately 312 BDT per household per month for river water quality improvement. The simulation assumed a normal probability distribution with a mean equal to 312 BDT and a standard deviation of approximately 450 BDT. The standard deviation was derived from the standard error reported in the original study using the relationship $SD = SE \times \sqrt{n}$, where n denotes the sample size. A total of 10,000 iterations were generated in order to ensure convergence and stability of the simulated results.

The resulting distribution exhibits the expected bell-shaped form of the normal distribution, with the majority of simulated values concentrated around the mean estimate (Figure 2). This suggests that most simulated outcomes remain relatively close to the original valuation reported in the source study.

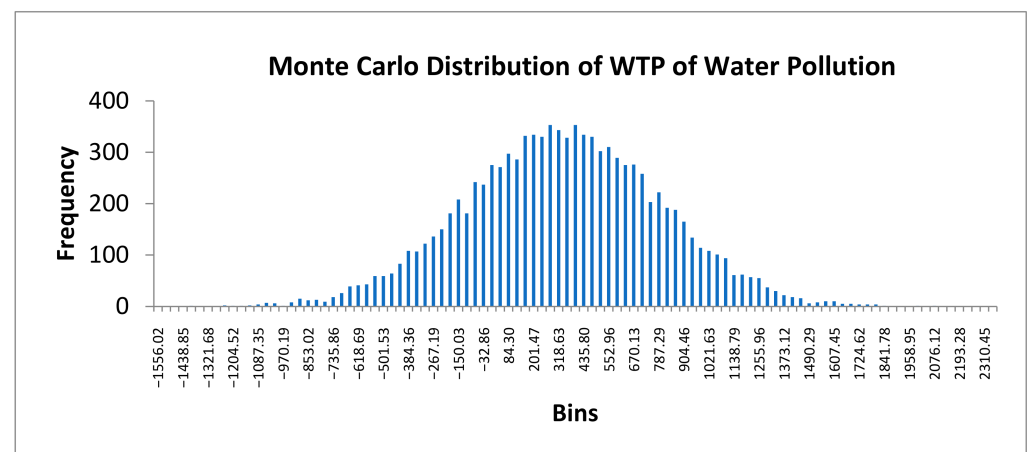


Figure 2. Monte Carlo simulation of WTP estimates for river water pollution valuation.

6.2. Monetary Valuation of Soil Degradation in Greece Through Benefit Transfer

To estimate the environmental cost associated with soil degradation, this study employs benefit transfer using evidence from Franceschinis et al. (2023), which provides a comprehensive valuation of soil functions within the soil security framework.

The source study applies a discrete choice experiment to approximately 3000 respondents in two regions (Veneto, Italy and New South Wales, Australia), estimating willingness to pay (WTP) for improvements in key soil functions, including carbon sequestration, water infiltration, biodiversity (earthworm density), and groundwater quality.

Unlike studies focusing on a single environmental attribute, this approach captures the multidimensional nature of soil degradation, which affects multiple ecosystem services simultaneously. Therefore, it provides a more comprehensive valuation framework consistent with the concept of soil security.

The results show that individuals are willing to pay for improvements in soil functions, with positive marginal WTP values across all attributes. Importantly, the study aggregates these values to the population level, estimating a total willingness to pay of approximately \$244 million for the Veneto region.

For the purposes of this study, this aggregate value is interpreted as a proxy for the social cost of soil degradation, under the assumption that preventing degradation requires similar levels of investment as restoring soil functions.

6.2.1. Currency Conversion and Inflation Adjustment

The aggregated value for the Veneto region is reported as: 244 million USD. Assuming approximate conversion: 1 USD = 0.93 EUR (ECB, 2024b), we obtain

$$244 \times 0.93 = 226.9 \text{ million EUR.}$$

The estimate was subsequently updated to 2025 price levels using the ECB staff inflation projections for the euro area, which foresee HICP inflation of 2.3% in 2024 and 2.0% in 2025 (ECB, 2024a):

$$226.9 \times 1.023 \times 1.020 \approx 236.70 \text{ million EUR}$$

6.2.2. Transfer to the Greek Context (Scaling by Population)

To transfer the value to Greece, a population scaling approach is applied.

From the study: Veneto population $\approx$ 4.9 million

Thus

$$\frac{236.70 \text{ million}}{4.9 \text{ million}} \approx 48.3 \text{ EUR per capita}$$

6.2.3. Adjustment for Greece

Assuming similar socio-economic conditions between Italy and Greece, no strong income adjustment is applied. Thus, the per capita value is directly transferred:

$$48.3 \text{ EUR per capita}$$

6.2.4. Aggregation for Greece and Final Estimate

Assuming the Population of Greece $\approx$ 10.4 million (ELSTAT, 2024), we obtain

$$48.3 \times 10.4 \text{ million} \approx 502.3 \text{ million EUR}$$

6.2.5. Monte Carlo Simulation

To account for uncertainty associated with the WTP estimates, Monte Carlo simulations were conducted for the four principal soil functions examined in the source study:

- Carbon sequestration (Figure 3);
- Earthworm density (Figure 4);
- Rainfall infiltration (Figure 5);
- Nitrate concentration in groundwater (Figure 6).

The simulations were based on normal probability distributions using the marginal willingness-to-pay estimates reported in Appendix A of Franceschinis et al. (2023). The means and standard deviations derived from the Mixed Logit model in WTP space were used as input parameters.

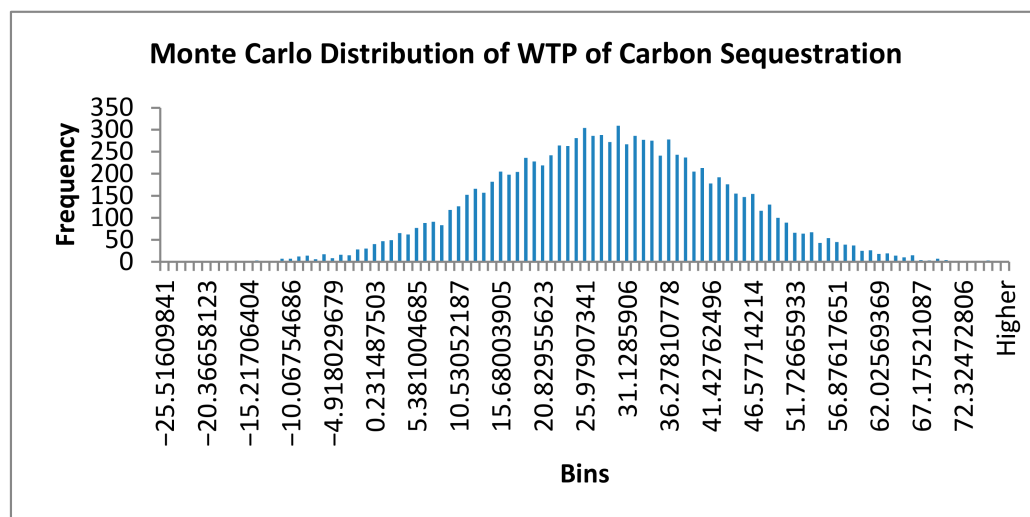


Figure 3. Monte Carlo simulation of WTP estimates for carbon sequestration.

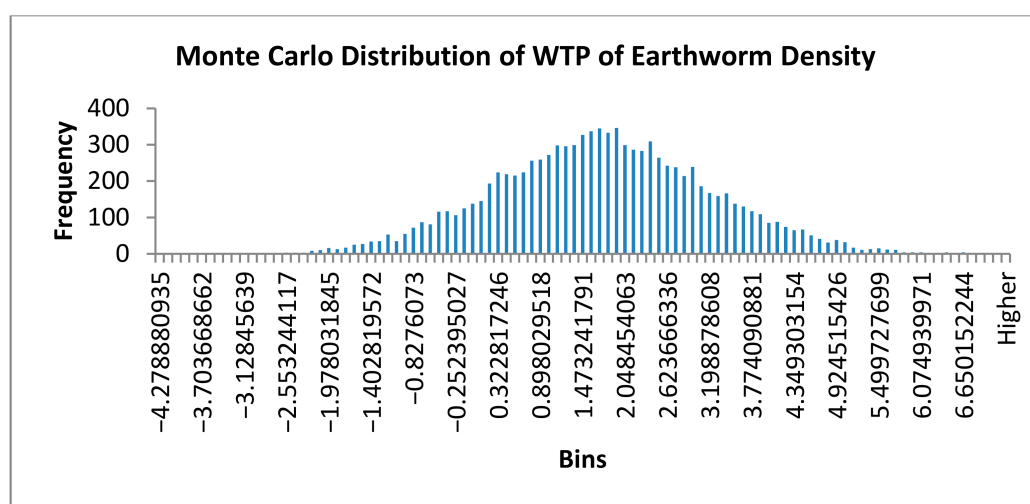


Figure 4. Monte Carlo simulation of WTP estimates for earthworm density.

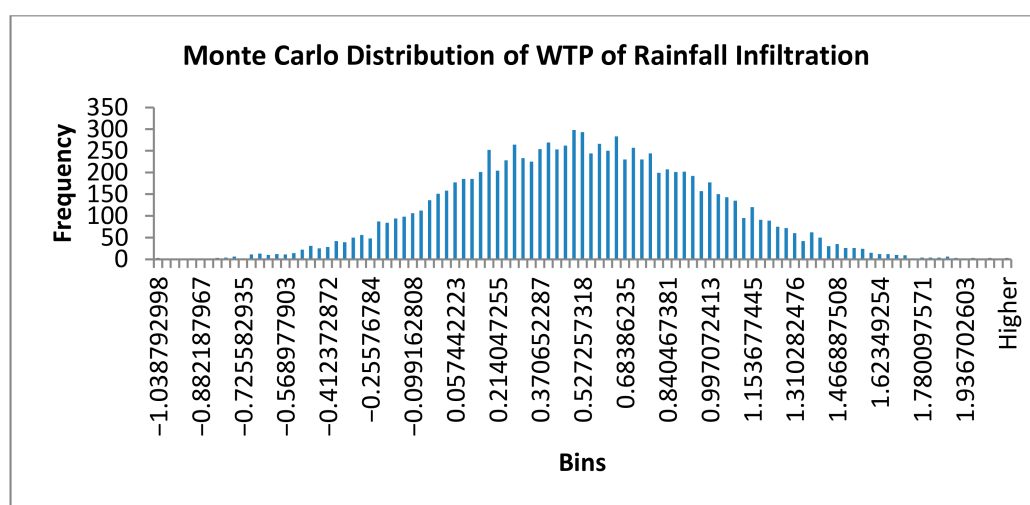


Figure 5. Monte Carlo simulation of WTP estimates for rainfall infiltration.

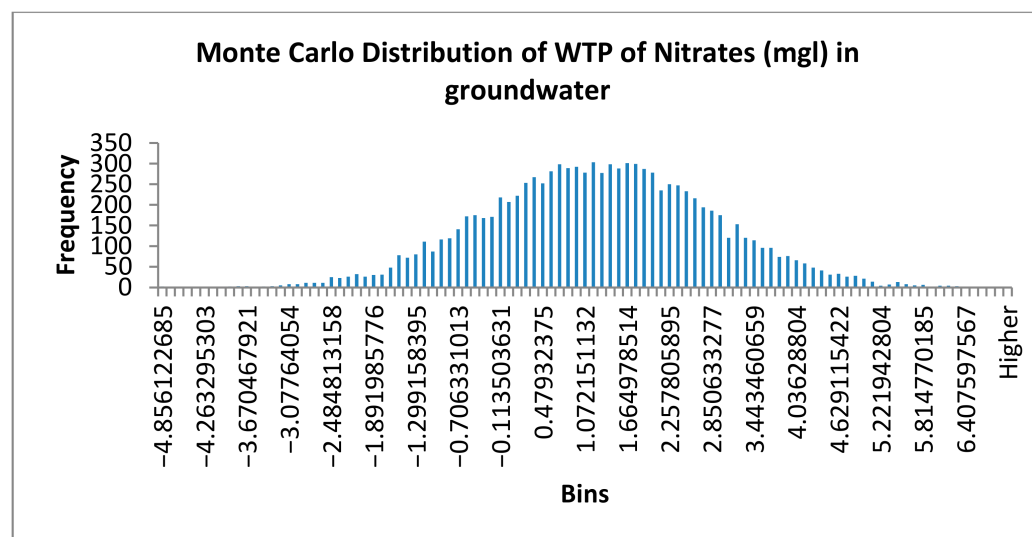


Figure 6. Monte Carlo simulation of WTP estimates for nitrates in groundwater.

For each environmental attribute, 10,000 iterations were generated in order to estimate the probability distribution of potential WTP outcomes. The resulting distributions indicate that simulated values remain concentrated around the central estimates, while still reflecting substantial variability associated with respondents' preferences. Although dispersion differs across soil functions, the simulations consistently demonstrate that uncertainty does not substantially alter the overall magnitude of the estimated environmental costs.

6.3. Estimating the Cost of Agricultural Land Degradation Through Benefit Transfer

To estimate the environmental cost associated with agricultural land degradation, this study applies benefit transfer using evidence from [Sen Chakraborty et al. \(2023\)](#), who examine the economic value of soil erosion control investments on agricultural lands in Nigeria through a hedonic pricing model.

The source study uses household-level self-reported agricultural land values from the Nigeria Living Standards Measurement Survey and estimates the capitalization of soil erosion control measures into land prices. The analysis finds that plots with erosion control investments have significantly higher land values than plots without such measures. In the preferred specification, the estimated coefficient for erosion control is 0.234, implying that land with erosion control facilities is approximately 26.36% more valuable than comparable land without erosion control. The corresponding marginal implicit price (MIP) is estimated at approximately USD 686.73.

Unlike studies that value agricultural landscapes or land preservation in general terms, this paper provides a more direct estimate of the economic value of avoiding land degradation through soil erosion control. For the purposes of the present study, this implicit price is interpreted as a proxy for the avoided cost of agricultural land degradation, particularly where soil erosion reduces long-term land productivity and asset value.

The relevance of this approach for the ISEW lies in the fact that soil erosion is one of the most important forms of agricultural land degradation, affecting both the productive and capital value of land. Therefore, the estimated gain associated with erosion control may be used, with caution, as an approximation of the economic loss avoided when land degradation is prevented.

However, important caveats remain. The original study is conducted in Nigeria, in a predominantly rain-fed agricultural setting with different climatic, institutional, and land market conditions from those of Greece. Moreover, the estimate reflects the private capitalization of erosion control into land values rather than a full social valuation of all

ecosystem losses associated with land degradation. Accordingly, the transfer should be interpreted as an indicative benchmark rather than a precise damage cost estimate.

6.3.1. Currency Conversion and Inflation Adjustment

The marginal implicit price is reported as

$$MIP_{real} = 686.73 \text{ USD}$$

To ensure consistency with the ISEW framework, the value is converted into euros.

Assuming $1 \text{ USD} = 0.93 \text{ EUR}$ (ECB, 2024b), we obtain $686.73 \times 0.93 = 638.66 \text{ EUR}$. Thus, the implicit value of erosion control is

$$638.66 \text{ EUR per hectare (approx.)}$$

Applying inflation adjustments for 2024 and 2025,

$$638.66 \times 1.023 \times 1.020 \approx 666.4 \text{ EUR}$$

Thus, the adjusted estimate becomes

$$666.4 \text{ EUR per hectare}$$

6.3.2. Income Adjustment Using PPP and Elasticity

As the source study is based on Nigeria, an income adjustment is required to transfer values to the Greek context. Using GDP per capita in purchasing power parity (PPP): Nigeria $\approx$ €6000, Greece $\approx$ €25,000 (World Bank, 2024), the income ratio is

$$\frac{25,000}{6000} \approx 4.17$$

Assuming unit income elasticity ($\epsilon = 1$), the adjusted value becomes

$$666.4 \times 4.17 = 2778.9 \text{ EUR per hectare}$$

This adjusted value reflects the higher economic valuation of land quality and environmental protection in a higher-income country. It should be noted that the assumption of unit elasticity is standard in benefit transfer applications but introduces uncertainty, particularly when transferring values derived from hedonic models.

6.3.3. Aggregation for the Greek Agricultural Land

To estimate the total cost of agricultural land degradation, the adjusted value is aggregated across the agricultural land area exposed to soil erosion in Greece. Assuming Total agricultural land in Greece $\approx$ **3.3 million hectares** (Eurostat, 2023) and the share significantly affected by erosion $\approx$ **30%**, we obtain $3.3 \times 0.30 = 0.99$ million hectares.

Thus, the total cost is

$$2778.9 \times 0.99 \text{ million} \approx 2.75 \text{ billion EUR}$$

6.3.4. Monte Carlo Simulation

To account for uncertainty associated with the transferred valuation estimate, a Monte Carlo simulation was conducted using the marginal implicit price reported in Sen Chakraborty et al. (2023).

The simulation was based on a normal probability distribution centered around the adjusted estimate of EUR 2778.9 per hectare. In the absence of an explicitly reported

standard deviation in the source study, uncertainty was introduced using a coefficient-of-variation approach, assuming a central coefficient of variation equal to 30%.

A total of 10,000 iterations were generated in order to estimate the range of plausible environmental cost outcomes associated with agricultural land degradation.

The simulation results indicate that most observations remain concentrated around the mean estimate, while still allowing for substantial variability associated with uncertainty in land valuation, PPP adjustments, and erosion exposure assumptions (Figure 7).

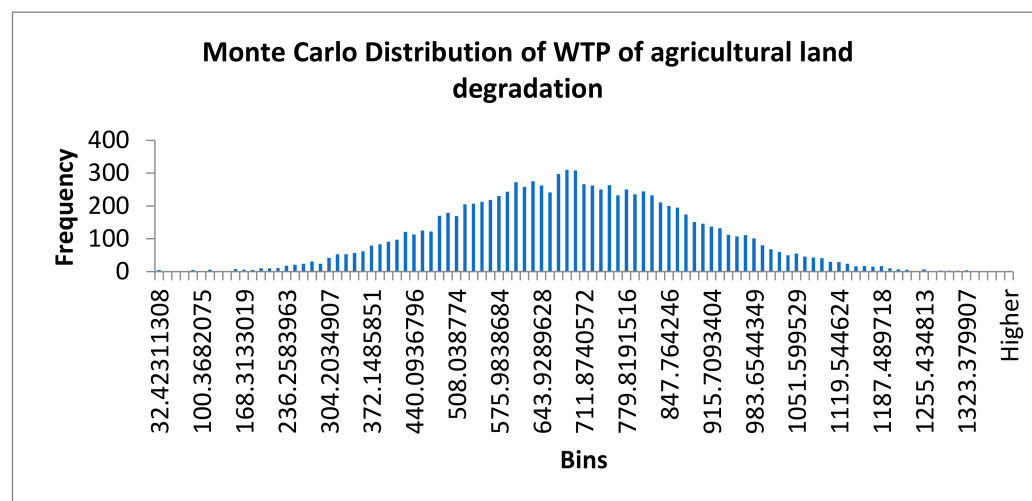


Figure 7. Monte Carlo simulation of WTP estimates for agricultural land degradation.

6.4. Monetary Valuation of Ecosystem Services Through Benefit Transfer

To estimate the value of ecosystem services within the ISEW framework, this study applies benefit transfer using evidence from [Obeng and Aguilar \(2018\)](#), which provides a stated preference valuation of willingness to pay (WTP) for ecosystem service improvements under a payment for ecosystem services (PES) scheme.

The source study examines public willingness to financially support the restoration of a degraded forest watershed ecosystem in the United States. The valuation is based on a contingent valuation framework embedded within a Value–Belief–Norm (VBN) behavioral model, allowing for the integration of socio-economic and attitudinal determinants of environmental preferences.

The ecosystem services considered include improvements in water quality through pollution reduction, enhanced habitats for plant and animal species, and increased landscape aesthetics. These services represent a bundled set of regulating, supporting, and cultural ecosystem functions, reflecting the multidimensional nature of ecosystem service provision. The study reports a mean willingness to pay of approximately USD 66.14 per household per year for the restoration of these ecosystem services. For the purposes of this study, this value is interpreted as a proxy for the social value of ecosystem service improvements and is used to approximate the cost of ecosystem degradation within the ISEW framework.

6.4.1. Inflation Adjustment

The reported WTP value refers to approximately 2016 price levels. To express the value in current terms, an inflation adjustment is applied. Assuming cumulative inflation of approximately 20% ([BLS, 2024](#)), $66.14 \times 1.20 = 79.37$ USD per household per year.

Thus, the inflation-adjusted value is

$$79.37 \text{ USD/year}$$

6.4.2. Currency Conversion

To ensure consistency with the ISEW framework, the value is converted into euros. Assuming $1 \text{ USD} = 0.93 \text{ EUR}$ (ECB, 2024b), we obtain

$$79.37 \times 0.93 = 73.81 \text{ EUR per household per year}$$

6.4.3. Income Adjustment Using PPP and Elasticity

To transfer the value from the United States to Greece, an income adjustment is applied. Using PPP GDP per capita: USA $\approx$ €65,000, Greece $\approx$ €25,000 (World Bank, 2024),

$$\frac{25,000}{65,000} \approx 0.38$$

Assuming income elasticity $\varepsilon = 1$,

$$73.81 \times 0.38 = 28.05 \text{ EUR per household per year}$$

6.4.4. Aggregation for the Greek Population

To estimate the total value of ecosystem services, the adjusted WTP is aggregated across households. Assuming that there are 4.1 million households in Greece (ELSTAT, 2024)

$$28.05 \times 4.1 \text{ million} \approx 115 \text{ million EUR}$$

6.4.5. Monte Carlo Simulation

Because the original study reports only the mean WTP value and does not provide standard deviation estimates, uncertainty was incorporated using a coefficient-of-variation approach.

A central coefficient of variation equal to 30% was assumed, while sensitivity analysis was conducted using alternative coefficients of variation of 20% and 50%.

Using the adjusted WTP estimate as the mean parameter, 10,000 Monte Carlo iterations were generated assuming a normal probability distribution.

The resulting histogram exhibits an approximately normal distribution centered around the mean WTP estimate, indicating relative stability in the simulated results. Most observations remain concentrated near the central estimate, while extreme values occur with relatively low frequency (Figure 8).

It is important to note that all transferred values are subject to uncertainty stemming from differences in context, valuation methods, and purchasing power adjustments; therefore, sensitivity bounds should be considered when interpreting these estimates.

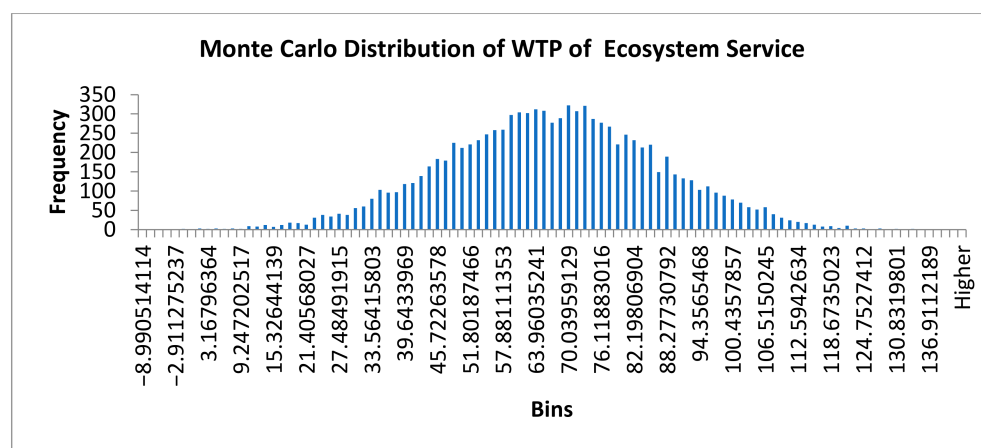


Figure 8. Monte Carlo simulation of WTP estimates for ecosystem service valuation.

Uncertainty and sensitivity

To address uncertainty in the revised benefit transfer applications, we no longer refer to a single adjusted WTP estimate, but instead acknowledge that each case study is subject to transfer uncertainty arising from differences in context, valuation method, scale, and adjustment procedures. In addition to the Monte Carlo simulations presented in the case studies, we adopt a pragmatic sensitivity approach by applying a $\pm 15\%$ range around the central transferred estimate in each case study, where appropriate. This range is intended to provide an illustrative uncertainty band rather than a formal confidence interval, and reflects common practice in the benefit transfer literature for dealing with residual transfer error and contextual mismatch (e.g., Johnston et al., 2015). The purpose is not to claim precision, but to show how sensitive the resulting ISEW environmental values may be to plausible variation in transferred parameters.

Table 2 presents illustrative sensitivity ranges around the central transferred estimates. For water pollution and ecosystem services, the ranges reflect alternative assumptions regarding income elasticity and contextual transferability. For soil and land degradation, they reflect uncertainty related to contextual adjustment and the extent of land affected. These are not formal confidence intervals but indicative robustness checks.

Table 2. Illustrative sensitivity of the case-study estimates to key assumptions.

Case Study	Baseline Estimate (€ Million/Year)	Key Assumption Tested	Low Scenario	High Scenario
6.1 River water pollution	490.4	Income elasticity of WTP ($\epsilon = 1.0$)	240.1 ($\epsilon = 0.5$)	653.1 ($\epsilon = 1.2$)
6.2 Soil degradation	502.3	Contextual transfer uncertainty	427.0 (-15%)	577.7 ($+15\%$)
6.3 Agricultural land degradation	2750.0	Share of land affected (30%)	1815.0 (20%)	3630.0 (40%)
6.4 Ecosystem services	115.0	Public awareness/cultural factors	97.8 (-15%)	132.3 ($+15\%$)

The numerical values presented throughout this section are intended to demonstrate the implementation of the Benefit Transfer methodology within the ISEW framework. They should therefore be interpreted as illustrative methodological applications rather than official estimates of the environmental costs for Greece. Producing nationally validated estimates would require country-specific primary valuation studies, detailed environmental monitoring data, and comprehensive uncertainty analyses beyond the scope of the present study.

The four applications presented in this section illustrate how Benefit Transfer can be systematically incorporated into different environmental components of the ISEW. Although the numerical estimates should not be interpreted as official national environmental accounts, they demonstrate a transparent and reproducible methodological framework that can be adapted to alternative environmental goods and policy contexts. Future applications based on Greece-specific primary valuation studies would further improve the precision and policy relevance of the resulting welfare estimates.

7. Conclusions

The Index of Sustainable Economic Welfare (ISEW) represents a significant advancement in measuring economic progress by explicitly incorporating social and environmental dimensions of well-being. A key component of this index is the valuation of environmental degradation, which often relies on benefit transfer (BT) methods due to practical constraints in conducting original valuation studies. This paper has examined the rationale, application and limitations of BT within the environmental component of the ISEW.

Benefit transfer offers several strengths, including cost-effectiveness, consistency, and the ability to draw on a growing international literature. It enables the regular and scalable inclusion of environmental costs, especially for widely studied impacts such as carbon emissions or air pollution. However, BT also suffers from well-known limitations, including context sensitivity, transfer errors, and methodological opacity. Without proper adjustments or documentation, transferred values may distort true welfare estimates or obscure important local variations.

To address these concerns, the paper recommends the use of meta-analytic functions, contextual adjustments, uncertainty analysis and transparent documentation. Greek case studies as illustrative examples, such as the one presented for carbon emissions, demonstrate both the practical value and the methodological caution required when using BT. Ultimately, while benefit transfer is an imperfect tool, it remains indispensable for the operationalization of sustainability indicators like the ISEW, provided it is applied with rigor, transparency, and a critical understanding of its assumptions.

Author Contributions: I.T. wrote the manuscript. A.N.M. and D.I.V. supervised the research. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were generated or analyzed in this study. All numerical examples used are publicly available in the cited papers from which they were obtained.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

This appendix illustrates a comprehensive way of handling benefit transfer in order to calculate and adapt values for the environmental component of the ISEW that we are working on for Greece. We are facing the challenge of systematically adapting WTP values through time and different economies with varying inflation rates and currency exchange rates.

Table A1. A suggested systemized approach to benefit transfer.

Steps in Benefit Transfer	Tools	Important Caveats
(1) Identify the original value and source	Contingent valuation studies, choice experiments, or other sources where environmental goods, services, or impacts were valued.	Geography, context and methodology of the original study.
(2) Adjust for time (inflation adjustment)	Obtain an inflation index for the country of the original study (for example, the Consumer Price Index (CPI) or GDP deflator).	Determine the base year of the original study and the year to which we are adjusting with Equation (A1).
(3) Adjust for currency differences	Obtain the exchange rate between the original currency and the target currency for the year of the original study.	Convert the original value into the target currency using the historical exchange rate for the year the study was conducted as in Equation (A2).
(4) Adjust for differences in economic conditions (income differences)	We use purchasing power parity (PPP) as a tool for adjusting the value to reflect differences in local economic conditions.	We use the income elasticity of WTP to scale the values up or down as in Equation (A3). This is difficult to obtain and we suggest alternative ways in part 2 of the appendix.
(5) Adjust for regional or contextual differences	Examine studies or literature from the target region that may provide insights into local preferences or differences in WTP. This may help refine adjustments related to local/regional conditions.	We use a multiplier based on regional factors (e.g., differences in environmental quality, awareness, or the importance of a specific service).

Source: The authors, Note: Numbering of Equations starts from Equation (A1) in Appendix A.

Appendix A.1. Justification of the Table

1. Identify the original value and source

We start by identifying the original WTP estimates or other economic values that one is transferring. These could be from contingent valuation studies, choice experiments, or other sources where environmental goods, services, or impacts were valued. Then, we make sure you know the geography, context and methodology of the original study (e.g., was it based on a specific region, demographic group, or economic conditions).

2. Adjust for time (inflation adjustment)

Inflation affects the purchasing power of money over time, so the value in the original study needs to be adjusted to the year one is working in. In this step, we obtain an inflation index for the country of the original study (for example, the Consumer Price Index (CPI) or GDP deflator). These can be found from national statistical agencies or international organizations like the World Bank or OECD (OECD, 2024, n.d.; World Bank, n.d.) Afterwards, we determine the base year of the original study and the year to which you are adjusting. For example, if the original study is from 2000 and you are adjusting it to 2023, use the CPI from 2000 and 2023. Last, we use the following formula for inflation adjustment as in Equation (A1).

$$\text{Adjusted value} = \text{Original value} \times \frac{\text{CPI in target year}}{\text{CPI in original year}} \quad (\text{A1})$$

This formula adjusts the original value to account for the changes in purchasing power due to inflation. Last, if inflation data is unavailable, you can often use GDP deflators for similar countries or economic sectors to adjust the value. One should ensure that the chosen deflator is relevant to the value being transferred (e.g., consumer goods vs. environmental goods).

3. Adjust for currency differences

When transferring values across economies with different currencies, it is essential to convert the original value into the currency of the target economy. We obtain the exchange rate between the original currency and the target currency for the year of the original study. Historical exchange rate data can be found from sources such as the International Monetary Fund (IMF) or World Bank. Then, we convert the original value into the target currency using the historical exchange rate for the year the study was conducted as in Equation (A2).

$$\text{Converted Value} = \text{Original Value} * \text{Exchange Rate (Original to target currency)} \quad (\text{A2})$$

Last, if we need to adjust the value for inflation in the target country as well, we repeat the inflation adjustment process described above, but for the target currency.

4. Adjust for differences in economic conditions (income differences)

Economic conditions, such as income levels, purchasing power, and consumer preferences, may differ significantly between regions or countries. Therefore, simply adjusting for inflation and currency may not always be sufficient. We use purchasing power parity (PPP) as a tool for adjusting the value to reflect differences in local economic conditions. PPP accounts for how much a unit of currency can purchase in different countries. If income levels vary between the original and target region, adjust the WTP

based on income differences. One can use the income elasticity of WTP to scale the values up or down as shown in Equation (A3).

$$\text{Adjusted value} = \text{Original value} * \left(\frac{\text{Income in target economy}}{\text{Income in original economy}} \right)^{\text{Income elasticity}} \quad (\text{A3})$$

Income Elasticity is a factor that describes how WTP changes with income levels. If no specific elasticity is available, you can use general values based on existing literature or assume an elasticity of around 0.4 to 0.6 for non-market goods (Drupp et al., 2023; Barbier et al., 2017).

5. Adjust for regional or contextual differences

Local preferences, environmental conditions and the specific context of the study region may significantly impact the value of a good or service. For instance, WTP for wetland preservation may differ in rural versus urban areas or in countries with different environmental awareness levels. We examine studies or literature from the target region that may provide insights into local preferences or differences in WTP. This could help refine adjustments related to local conditions. Then, we use a multiplier based on regional factors (e.g., differences in environmental quality, awareness, or the importance of a specific service). For instance, if residents in the target region are known to have higher environmental consciousness or greater income, we may be able to adjust WTP upwards.

6. Sensitivity analysis

It is critical to test how sensitive the results are to our assumptions, particularly when transferring values across regions and time. We can conduct sensitivity analysis by testing different inflation rates, exchange rates and income elasticity values to determine how robust the transferred values are. For example, if transferring a WTP value for wetland conservation from the U.S. to a developing country, we can explore how varying the inflation rate or exchange rate assumptions affect the final WTP value. This ensures that our final estimates are not overly dependent on a single assumption. Last but not least, we need to pay attention to documentation and transparency. We thoroughly document all steps, assumptions, and data sources used in the transfer process. Transparency is crucial, especially when results are used for policy decisions. We clearly outline the adjustments made for inflation, exchange rates, income differences and contextual variations, so that stakeholders can understand and replicate your methodology.

Appendix A.2. Alternatives to the WTP Elasticity of Income

Given that income elasticity of WTP (E_{WTP})³ is difficult to obtain, there are alternative approaches to scale the values up or down to adjust for differences in income levels, regional economic conditions, and other local factors. We provide a few methods we could consider for scaling values:

1. Use of Purchasing Power Parity (PPP) for scaling

The Purchasing Power Parity (PPP) is a measure that allows for comparison of income levels between different countries or regions by adjusting for differences in the cost of living and inflation rates. PPP adjusts the value of money based on how much it can purchase in each region. By using PPP, we can make the value of WTP from one economy more comparable to another by adjusting for local purchasing power. So, to begin, we can find the PPP conversion factor for the countries or regions involved. This information is typically accessible from sources such as the World Bank, OECD, or the International Monetary Fund (IMF). Once the conversion factor is identified, we adjust the original Willingness to Pay (WTP) value by applying the PPP conversion factor, ensuring the WTP

value is appropriately scaled to reflect the differences in purchasing power between the regions. This process allows for more accurate comparisons across economies with differing costs of living and inflation rates as in Equation (A4):

$$\text{Adjusted value} = \text{Original value} * \frac{\text{PPP of target region}}{\text{PPP of original region}} \quad (\text{A4})$$

This adjustment accounts for differences in the cost of living and allows for the translation of values across different economies, even if income data is not directly comparable.

2. Use of average income ratio (simple scaling)

Alternatively, we can use the income ratio between the original study region and the target region as a simpler way to adjust the WTP value. We find the average income or GDP per capita of the original study region and the target region (we can use GDP per capita from sources like the World Bank or OECD). We calculate the income ratio as in Equation (A5):

$$\text{Income ratio} = \frac{\text{Average income in target region}}{\text{Average income in original region}} \quad (\text{A5})$$

Last, we multiply the original WTP by the income ratio as in Equation (A6):

$$\text{Adjusted value} = \text{Original value} * \text{Income ratio} \quad (\text{A6})$$

In this approach we assume that people's WTP for environmental goods is proportional to their income. While this assumption is less precise than using income elasticity, it provides a simple, practical way to scale values based on income differences.

3. Use of proxy variables for regional preferences

Another approach in this context is using proxy variables that are indicative of regional economic conditions, social values, and environmental priorities. Examples of such variables include first the environmental awareness. Regions with higher environmental awareness may place more value on ecosystem services, so we could use environmental policy ratings, participation in environmental initiatives, or the presence of green organizations as proxies for higher WTP. Second, the economic development through development indices (e.g., Human Development Index (HDI) or Environmental Performance Index (EPI)) as proxies for economic and environmental conditions. A more developed region might have higher WTP due to greater financial capacity and better environmental awareness. Third, urban vs. rural differences; Urban regions may value services like air quality and green spaces more than rural areas, while rural areas may have a higher valuation for agricultural land or forest preservation. Adjusting WTP based on urbanization or rural development can be another approach.

4. Adjusting based on previous studies and expert opinion

When detailed data is not available, experts in environmental economics or local contexts may provide valuable insights into scaling values. If similar studies or regional reports provide estimates of WTP or income elasticity in similar regions, these values can be used as benchmarks to adjust the values. First, we identify studies or reports that focus on Willingness to Pay (WTP) for similar services in economies or regions that are comparable to your target area. Next, we adjust the values based on expert insights or known regional differences, such as variations in environmental preferences, income levels, and social contexts. Finally, we use qualitative reasoning or conduct expert interviews to further refine

the adjustments, accounting for specific regional conditions or cultural factors that may influence people's willingness to pay for the service in question. This approach ensures that the values are tailored to the local context, making them more relevant and accurate (Perepolkin, 2022).

5. Use of aggregate adjustments based on GDP growth or economic indicators

If we have data on economic growth, we can apply the growth rate of GDP or GDP per capita over time or across regions to adjust the original WTP estimate. This method assumes that as a country's economy grows, so does the public's ability to pay for environmental goods. Thus, we identify the GDP growth rate over a certain period for both the original and target regions. We can get this figure from the World Bank, IMF, or national statistics agencies and then we adjust the original WTP value based on the economic growth rates as in Equation (A7):

$$\text{Adjusted value} = \text{Original value} * \left(\frac{1 + \text{GDP Growth in Target Region}}{100} \right) \quad (\text{A7})$$

This method is simple and relies on the assumption that economic growth leads to proportional increases in WTP, although it does not account for non-linear effects or changes in consumer preferences.

Notes

- ¹ Unit value transfer refers to the direct application of a value (e.g., WTP per household) from one study context to another, adjusted for income and purchasing power.
- ² Meta-analytic function transfer relies on a statistical model derived from multiple studies, allowing predictions based on site- or population-specific variables.
- ³ Income elasticity of WTP describes how sensitive willingness to pay is to changes in income; for example, an elasticity of 0.5 suggests that a 10% rise in income increases WTP by 5%.

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