Guidance Manual on Value Transfer Methods for Ecosystem Services

UNEP

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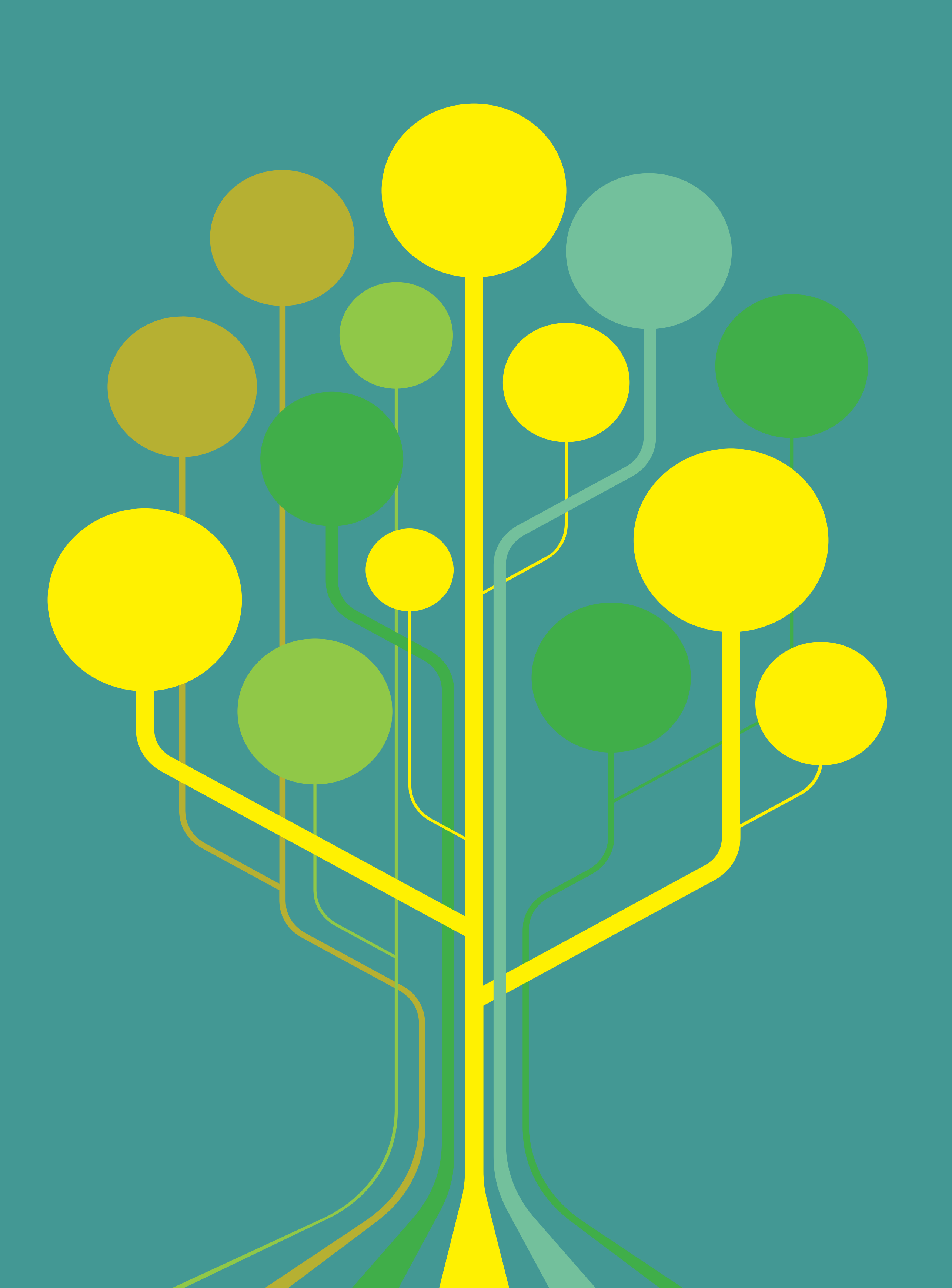

Foreword

In recent years, there have been growing global interest and efforts in integrating the value of ecosystem services into national development frameworks. The outcome of the United Nations Conference on Sustainable Development (UNCSD) in Rio de Janeiro in 2012 (Rio+20) 'The Future We Want' highlights the importance of Green Economy in the context of sustainable development and poverty eradication, and the need for broader measures of progress to complement conventional indices such as gross domestic product (GDP). Furthermore, Aichi Biodiversity Target 2 agreed under the Convention on Biological Diversity (CBD) as part of the Strategic Plan for Biodiversity 2011-2020 states that biodiversity values should be integrated into national and local development programs, poverty reduction strategies and planning processes, and be incorporated into national accounting and reporting systems. To achieve these targets and objectives, the role of economic valuation of ecosystem services is critical.

Within this global context, UNEP has been implementing 'The Economics of Ecosystems and Biodiversity' (TEEB) program, which has contributed to generating international attention to the economic contribution of ecosystems and biodiversity. Furthermore, the recently launched UNEP initiative -Valuation and Accounting of Natural Capital for Green Economy (VANTAGE) brings accounting and valuation into the larger goals of sustainable and inclusive Green Economy.

However, although the importance of ecosystem services valuation has been increasingly recognized by the international community, undertaking valuation requires considerable resources in terms of money, time and skills, especially if the estimates are to be obtained from primary valuation studies. At the same time, the demand for using existing information on the value of ecosystem services for environmental decision-making is strong and growing.

It is in response to this need that UNEP is pleased to present a practical guide on value transfer methods for ecosystem services valuation, which estimate the value of ecosystem goods and services based on already existing primary valuation studies. Such methods deliver on this objective by transferring values from 'study sites' to 'policy sites'. The manual lays down the steps involved in empirical application of the methods and provides a lucid guidance on precautions the analyst should observe in the process. The manual will greatly contribute to capacity development for effective use of ecosystem assessment in developing countries on how value transfer can be used to support environmental decision-making.

Achim Steiner
UN Under-Secretary General and Executive Director,
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Executive Summary

- The purpose of this guidance manual is to show how the **value of ecosystem services** can be estimated and incorporated into decision making. Specifically, it is designed to help a broad audience of conservation managers, government officials, private sector managers, NGOs, and statisticians to understand the available information on the values of ecosystem services and how this information can be transferred to inform the decisions that they make.
- Ecosystem services are often not traded in markets and so there are no market prices that reflect their value. As a result we tend not to take the value of ecosystem services into consideration when we make decisions that affect the natural world. **Economic valuation** is simply a means to reveal how valuable the natural world is to us.
- Economists have developed a variety of **'primary' valuation methods** for estimating the value of ecosystem services that are not traded in markets. These methods attempt to address the range of challenges involved in valuing non-marketed services that generally have the characteristics of public goods and complex linkages with the natural environment.
- Decision making often requires information quickly and at low cost. New 'primary' valuation research, however, is generally time consuming and expensive and may not always be a suitable approach. For this reason, while recognising the importance of 'primary' valuation methods, there is interest in using information from existing primary valuation studies to inform current decisions regarding impacts on ecosystems. This transfer of **value information** from one context to another is called value transfer (or benefit transfer).
- **Value transfer** is the procedure of estimating the value of an ecosystem service of current policy interest (at a "policy site") by assigning an existing valuation estimate for a similar ecosystem elsewhere (at a "study site").
- **Value transfer methods** can be divided into three main types:
  - **Unit value transfer** uses values for ecosystem services at a study site, expressed as a value per unit (usually per unit of area or per beneficiary), combined with information on the quantity of units at the policy site to estimate policy site values. Unit values can be adjusted to reflect differences between the study and policy sites (e.g. income and price levels).
  - **Value function transfer** uses a value function estimated for an individual study site in conjunction with information on policy site characteristics to calculate the unit value of an ecosystem service at the policy site. A value function is an equation that relates the value of an ecosystem service to the characteristics of the ecosystem and the beneficiaries of the ecosystem service.
  - **Meta-analytic function transfer** uses a value function estimated from the results of multiple primary studies representing multiple study sites in conjunction with information on policy site characteristics to calculate the unit value of an ecosystem service at the policy site. Since the value function is estimated from the results of multiple studies it is able to represent and control for greater variation in the characteristics of ecosystems, beneficiaries and other contextual characteristics.
- The key challenge of conducting accurate and credible value transfers is to **account for important differences** in the characteristics of the study and policy sites. Differences

in the characteristics of ecosystems, services, their beneficiaries and bio-physical surroundings can potentially result in very large differences in the provision and value of ecosystem services. It is therefore necessary to make adjustments to transferred values to reflect the important determinants of those values.

- For a number of reasons the valuation of ecosystem services using value transfer cannot be conducted with complete certainty. It is therefore necessary to measure and communicate the level of **uncertainty** regarding a transferred value. The acceptable level of accuracy is dependent on the decision making context.
- The purpose of conducting economic valuation of ecosystem services is to inform and improve decision making regarding the management of the environment. So any value transfer application should be designed to provide information that is directly useful and understandable to the decision makers involved. This requires **stakeholder engagement** in the value transfer process and clear communication of results.
- **Stakeholder engagement** in a value transfer application may take several forms and occur at different stages of the process. Most importantly, engagement at the initial stage should be used to frame the value transfer in terms of the type of information required, relevance of different ecosystem services, geographic scope and identification of beneficiaries.
- Making the results of a value transfer accessible to the different stakeholders that use the information requires different types of **communications strategies**, different messages and different ways of presenting information. The main steps that should be part of a communication plan are identifying the audience(s), formulating the main message(s) and developing the communication tools.

Résumé à l'intention des décideurs

- Ce guide a pour objectif de montrer comment la valeur des services écosystémiques peut être estimée et prise en compte dans les mécanismes décisionnels. Plus précisément, il est conçu pour aider un large groupe de responsables de la conservation, de fonctionnaires gouvernementaux, de dirigeants du secteur privé, d'ONG et de statisticiens à comprendre les informations disponibles sur les valeurs des services écosystémiques et la façon dont ces informations peuvent être transférées pour étayer les décisions qu'ils prennent.
- Souvent, les services écosystémiques ne font pas l'objet d'échanges commerciaux, de sorte qu'il n'a pas de prix de marché reflétant leur valeur. Nous avons donc tendance à ne pas prendre en considération la valeur de ces services lorsque nous prenons des décisions qui ont des effets sur le milieu naturel. L'évaluation économique est simplement un moyen de montrer combien le milieu naturel nous est précieux.
- Les économistes ont mis au point diverses méthodes d'évaluation 'primaire' pour estimer la valeur des services écosystémiques qui ne sont pas échangés sur les marchés. Ces méthodes visent à répondre à l'ensemble des difficultés associées à la valorisation de services non marchands qui ont généralement les caractéristiques de biens publics et dont les liens avec l'environnement naturel sont complexes.
- La prise de décisions nécessite souvent de disposer d'informations rapidement et à faible coût. Or, la réalisation d'une nouvelle évaluation 'primaire' est en général longue et coûteuse et peut ne pas être toujours l'approche appropriée. Dans ces conditions, tout en reconnaissant l'importance des méthodes d'évaluation 'primaire', il est intéressant d'utiliser les informations recueillies dans le cadre d'évaluations 'primaires' existantes pour servir de base aux décisions courantes concernant des incidences sur les écosystèmes. Ce transfert d'informations sur les valeurs d'un contexte vers un autre est appelé transfert de valeurs (ou transfert d'avantages).
- Le transfert de valeurs est la procédure d'estimation de la valeur d'un service écosystémique présentant au moment considéré un intérêt pour les décideurs (sur un « site d'application ») en attribuant à ce service une estimation de la valeur établie ailleurs (sur « site d'étude ») pour un écosystème similaire.
- On distingue trois types principaux de méthodes de transfert de valeurs :
  - Le transfert de valeurs unitaires, qui repose sur les valeurs des services écosystémiques établies sur un site d'étude, exprimées sous forme de valeurs unitaires (généralement par unité de surface ou par bénéficiaire), auxquelles sont conjuguées des informations sur la quantité d'unités sur le site d'application de façon à estimer les valeurs unitaires sur ce site. Les valeurs unitaires peuvent être ajustées pour refléter les différences entre le site d'étude et le site d'application (par exemple, dans les niveaux de revenus et de prix).
  - Le transfert de fonctions, qui utilise une fonction de valeur estimée pour un site d'étude particulier, associée à des informations concernant les caractéristiques du site d'application, pour calculer la valeur unitaire d'un service écosystémique sur le site d'application. Une fonction de valeur est une équation qui relie la valeur d'un service écosystémique aux caractéristiques de l'écosystème et aux bénéficiaires du service en question.
  - Le transfert de fonctions de méta-analyse, lesquelles sont estimées à partir des résultats d'évaluations primaires multiples réalisées par plusieurs sites d'étude. Pour le transfert

sont prises en compte également des informations concernant les caractéristiques du site d'application afin de calculer la valeur unitaire d'un service écosystémique sur ce site. Les fonctions de méta-analyse, qui sont estimées à partir des résultats de plusieurs études, permettent de représenter et de contrôler une plus large éventail de caractéristiques des écosystèmes, de bénéficiaires et d'autres aspects contextuels.

- La difficulté majeure rencontrée pour procéder à des transferts de valeurs précis et crédibles réside dans la prise compte des différences importantes existant entre le site d'étude et le site d'application pour ce qui est des caractéristiques des écosystèmes, des services, de leurs bénéficiaires et des milieux biophysiques, qui risquent de conduire à des divergences très marquées dans la fourniture et la valeur des services écosystémiques. Il est donc nécessaire d'ajuster les valeurs transférées pour tenir compte des déterminants importants de ces valeurs.
- Pour plusieurs raisons, l'évaluation des services écosystémiques fondée sur le transfert de valeurs ne peut être réalisée avec une certitude absolue. Il y a donc lieu de mesurer le niveau d'incertitude quant à la valeur transférée et de le faire connaître. Le niveau de précision acceptable dépend du contexte dans lequel la décision doit être prise.
- L'objectif de l'évaluation économique des services écosystémiques est d'étayer le mécanisme décisionnel intéressant la gestion de l'environnement, et de l'améliorer. Ainsi, toute demande de transfert de valeurs devrait être conçue de manière à fournir des informations qui sont directement utiles et compréhensibles pour les décideurs concernés. Cela suppose l'implication des parties prenantes dans le processus de transfert de valeurs et une communication claire des résultats.
- L'implication des parties prenantes dans une demande de transfert de valeurs peut revêtir plusieurs formes et intervenir à différents stades du processus. Il importe surtout que l'implication au stade initial soit mise à profit pour bien cadrer le transfert, eu égard au type de renseignements nécessaires, à la pertinence des différents services écosystémiques, au champ d'application géographique et aux bénéficiaires identifiés.
- Rendre les résultats d'un transfert de valeurs accessibles aux différents acteurs utilisant les renseignements visés exige différents types de stratégies de communication, différents messages et différents modes de présentation de l'information. Les principales étapes d'un plan de communication sont l'identification de la (des) cible(s), la formulation du (des) messages principal(aux) et la mise au point des outils de communication.

Resumen

- La finalidad del presente manual de orientación es demostrar la manera en que se puede calcular el valor de los servicios de los ecosistemas para incorporarlo en la adopción de decisiones. La intención concreta es ayudar al gran número de administradores de la conservación, funcionarios públicos, gerentes del sector privado, ONG y estadísticos a interpretar la información disponible acerca de los valores de los servicios de los ecosistemas y a conocer la manera en que se puede transferir esa información para fundamentar las decisiones que adopten.
- A menudo, los servicios de los ecosistemas no son objeto de compra y venta en los mercados y, por esa razón, no hay precios de mercado que reflejen su valor. De ahí que exista la tendencia a no tomar en consideración el valor de los servicios de los ecosistemas a la hora de adoptar decisiones que afectan al mundo natural. La valoración económica es simplemente un medio de revelar cuán valioso es el mundo natural para nosotros.
- Los economistas han creado diversos métodos de valoración 'primaria' para calcular el valor de los servicios de los ecosistemas que no se comercian en los mercados. Estos métodos tratan de abordar la diversidad de problemas implícitos en la valoración de servicios no comercializados que, por regla general, tienen la característica de bienes públicos y mantienen vínculos complejos con el medio natural.
- Con frecuencia, los responsables de adoptar decisiones necesitan obtener información con rapidez y a bajo costo. Sin embargo, las nuevas investigaciones de la valoración 'primaria' son costosas y suelen demorar bastante, además posiblemente no siempre sean el método idóneo. Por esa razón, aunque se reconozca la importancia de los métodos de valoración 'primaria', hay interés en utilizar la información que figura en los estudios de valoración primaria ya realizados para fundamentar las decisiones que se están adoptando respecto de los efectos en los ecosistemas. Esta transferencia de información sobre el valor de un contexto a otro se denomina transferencia de valor (o transferencia de beneficios).
- La transferencia de valor es un procedimiento mediante el cual se calcula el valor de un servicio del ecosistema de interés normativo actual (en una "zona de aplicación de la norma") asignándole una valoración estimada existente hecha en relación con un ecosistema análogo de otro lugar (en una "zona objeto de estudio").
- Los métodos de transferencia de valor se pueden dividir en tres tipos fundamentales:
  - La transferencia de valor unitario utiliza los valores correspondientes a los servicios de los ecosistemas en una zona objeto de estudio, expresados como valor por unidad (usualmente por unidad de superficie o por beneficiario), combinados con la información sobre la cantidad de unidades en la zona de aplicación de la norma para calcular los valores de esta última. Los valores unitarios se pueden ajustar para reflejar las diferencias entre la zona de estudio y las zonas de aplicación de la norma (por ejemplo, niveles de ingresos y de precios).
  - La transferencia de la función del valor utiliza una función del valor calculado para una zona objeto de estudio particular, conjuntamente con la información sobre las características de la zona de aplicación de la norma a los efectos de calcular el valor unitario de un servicio del ecosistema en esta última. La función del valor es una ecuación que relaciona el valor de un servicio del ecosistema con las características del ecosistema y los beneficiarios de ese servicio.

  - La transferencia de la función metaanalítica utiliza una función del valor calculado a partir de los resultados de múltiples estudios primarios que representan a múltiples zonas objeto de estudio, conjuntamente con la información sobre las características de la zona de aplicación de la norma para calcular el valor unitario de un servicio del ecosistema en esta última. Dado que la función del valor se calcula a partir de los resultados de estudios múltiples, es capaz de representar y controlar una mayor variación de las características de los ecosistemas, los beneficiarios y otras características contextuales.
- La principal dificultad para realizar transferencias de valor exactas y fiables está en tomar en consideración diferencias importantes en las características de las zonas objeto de estudio y las zonas de aplicación de la norma. Las diferencias en las características de los ecosistemas, los servicios, sus beneficiarios y el entorno biofísico posiblemente den lugar a diferencias muy grandes en la prestación de servicios de los ecosistemas y en su valor. Por consiguiente, es necesario introducir ajustes en los valores transferidos para reflejar factores determinantes importantes de esos valores.
- Por distintas razones, la valoración de los servicios de los ecosistemas no se puede determinar con total certidumbre utilizando la transferencia de valor. Por eso, es indispensable medir y comunicar el grado de incertidumbre respecto de un valor transferido. El grado de exactitud admisible depende del contexto en que se adoptan las decisiones.
- La valoración económica de los servicios de los ecosistemas tiene como finalidad fundamentar y mejorar la adopción de decisiones en lo que atañe a la gestión del medio ambiente. Por eso, cualquier aplicación de la transferencia de valor se deberá proyectar de manera tal que proporcione información directamente útil y comprensible para los responsables de adoptar decisiones de que se trate, para lo cual es indispensable la participación de los interesados en el proceso de transferencia de valor y una clara comunicación de los resultados.
- La participación de los interesados en la aplicación de la transferencia de valor podrá adoptar diversas formas y tener lugar en diferentes etapas del proceso. Lo más importante es que esa participación se utilice en la etapa inicial para estructurar la transferencia de valor en lo que se refiere al tipo de información requerida, la importancia de los diferentes servicios de los ecosistemas, el alcance geográfico y la determinación de los beneficiarios.
- Para que los diferentes interesados que utilizan la información tengan acceso a los resultados de la transferencia de valor hacen falta diferentes tipos de estrategias de comunicación, diferentes mensajes y diferentes maneras de presentar la información. El plan de comunicación deberá constar de las siguientes partes fundamentales: determinación del destinatario o los destinatarios, formulación del mensaje o los mensajes y establecimiento de los instrumentos de comunicación.

Contents

1. Introduction: the purpose of this guidance manual

1.1 The purpose of this guidance manual

The purpose of this guidance manual is to show how the value of ecosystem services (ES) can be estimated and incorporated into decision making. Specifically, it is designed to help a broad audience of conservation managers, government officials, private sector managers, NGOs, and statisticians to understand the available information on the values of ecosystem services and how this information can be transferred to inform the decisions that they make.

The broad objective of this guidance manual is to provide an understanding of how information on the value of ecosystem services can be used to support decision making regarding the use and management of ecosystems. The specific objective of the manual is to explain how the method of value transfer can be used to provide such information. To this end, the manual provides:

1. A non-technical introduction to the alternative approaches to value transfer, their applicability to different contexts, and strengths and weaknesses.
2. An explanation of the limitations of value transfer and potential uncertainties.
3. An overview of the available resources for conducting value transfer, including databases of ecosystem service values.
4. Illustrative applications of the use of value transfer for different scales, decision making contexts, and ecosystems (with a special focus on forests and wetlands).

1.2 Who should use this guidance manual

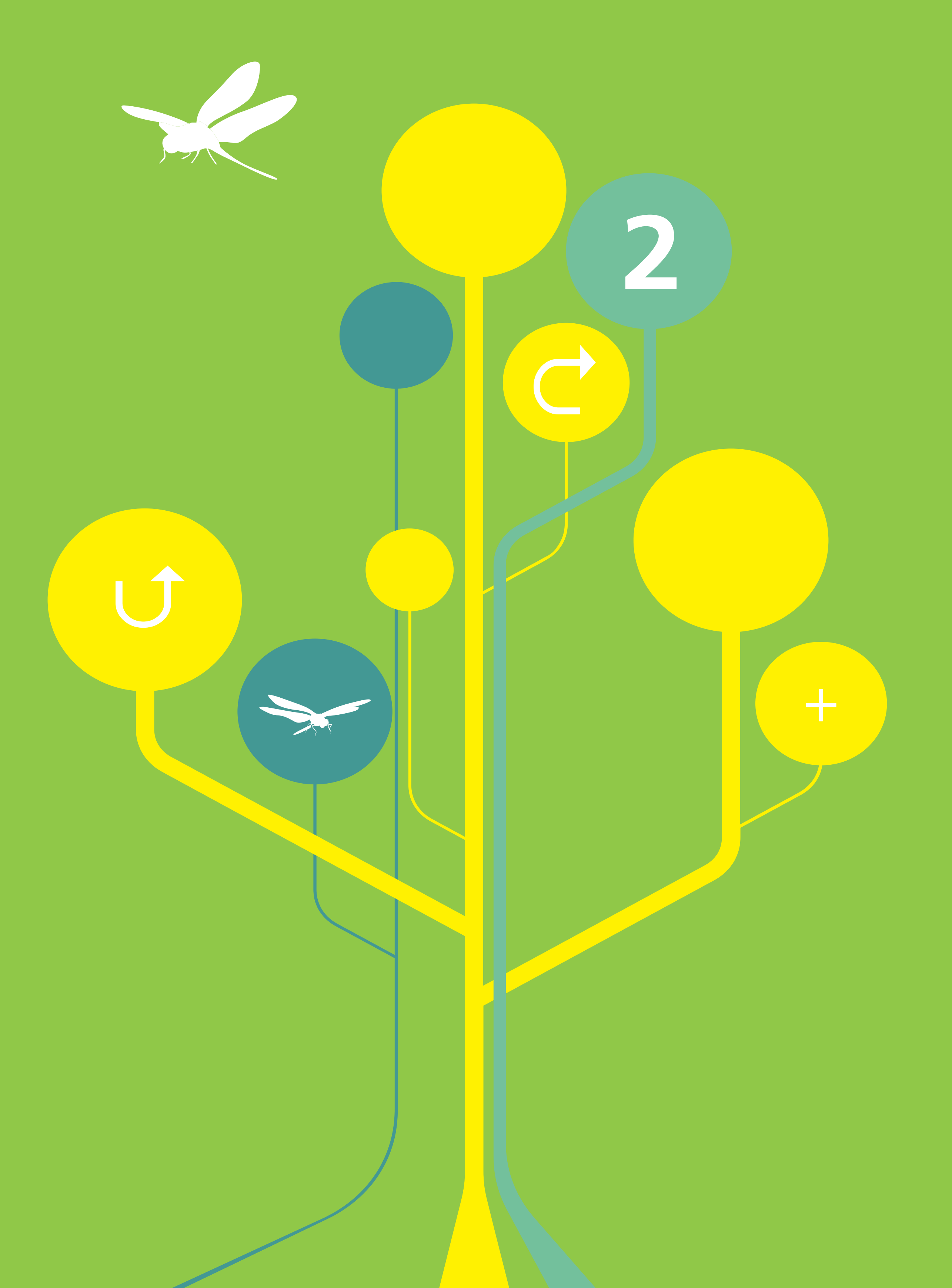
The manual has been designed to help anyone involved in conducting economic assessments of ecosystem services to understand and take account of the key methodological and practical issues involved in using value transfer. Potential users include:

- Senior/middle level conservation managers. Value transfer is potentially a useful source of information for demonstrating the benefits of conservation or for appraisal of alternative conservation measures.
- Policy makers in sector ministries (e.g. environment, forestry, agriculture). Value transfer may be used in policy appraisal, damage assessment, and the design of incentive and market based mechanisms for ecosystem services.
- Private sector. There is an increasing interest in understanding the value of ecosystem services from the perspective of private enterprises, either as inputs into production or as outputs (external costs and benefits) to society. Value transfer is potentially useful as a source of information for full cost accounting, Triple Bottom Line analysis, and calculating environmental profit and loss.
- NGOs. Economic valuation, and value transfer, can be used to communicate the importance of ecosystems and biodiversity to society. The use of economic language can be more effective in communicating this message to some stakeholders and decision makers.
- Statisticians and accountants. Several international initiatives are underway to incorporate ecosystem service values into national accounts and reporting systems (e.g. under the Convention on Biological Diversity Aichi Target 2). Value transfer provides a means to do this at the relevant scale and allows consistency in the methodology used.

1.3 How to use this guidance manual

To be able to use the manual, a basic understanding and experience of applied environmental economics and economic valuation, including statistics and econometrics, is useful but not necessary. The aim is to provide a practical handbook to guide the use of value transfer. This manual can be used alongside other economic valuation manuals such as those listed in section 7.

The manual is organised as follows. Section 2 explains the role of information on the economic value of ecosystem services in decision making regarding the environment. It makes the case for economic valuation of ecosystem services, introduces economic valuation methods and the concept of value transfer. Section 3 provides a detailed explanation of alternative methods for transferring values, with step-by-step guidelines and example applications. Section 4 explains the need to make adjustments to transferred values to account for differences in the characteristics and contexts of ecosystems and beneficiaries. Section 5 discusses the issue of uncertainty in value transfer estimates and how to assess and communicate uncertainties. Section 6 addresses the communication of results and the need for stakeholder engagement to enable the use of value information in decision making. Section 7 describes the resources that are available for supporting value transfer, including databases of value estimates and specialised guidelines.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2. Role of economic valuation in decision making regarding the environment

2.1 The case for economic valuation of ecosystem services

Economic valuation is simply a means to reveal how valuable the natural world is to us. Estimating an economic value for the natural environment begins with an understanding of the many different services that the environment can provide and the contribution these services make to the wellbeing of beneficiaries. The concept of ecosystem services provides a framework for identifying and quantifying the variety of benefits that we obtain from the environment (see Definition Box 1).

Often, decisions to support economic development affect the functioning or quality of ecosystems. Although such decisions are intended to enhance development, they can also reduce the supply of ecosystem services that are critical to human well-being and sustainable development. Every time we make a decision that affects the way in which the natural environment functions we are implicitly putting a value on the environment. If we choose to clear a forest for agricultural development, then a trade-off is made between the ecosystem services provided by the forest that we will forgo and the benefits that will accrue under the new development. Economic valuation of affected ecosystem services makes that trade-off explicit and allows the alternatives to be directly compared using the same units (i.e. money). Valuation reveals very clearly to decision makers what will be lost or gained by making a decision.

For most goods or services that we buy, we make decisions based on the price of those items. The price of a good or service is determined by the cost of supply and our demand for it and reflects our gain in welfare from producing and consuming one additional unit. The price of a good or service therefore reflects its 'marginal value' to society (see Appendix I for an explanation of economic concepts of value). For ecosystem services and the natural environment, there are often no prices that reflect their value, since the services that are provided are not traded in markets (e.g. clean air, flood water retention, biodiversity). As a result we tend not to take the value of ecosystem services into consideration when we make decisions that affect the natural world. When we investigate the implications of projects, such as constructing roads, logging forests, or draining wetlands for agriculture, we need to fully understand the environmental as well as the financial implications of this decision. Economic valuation puts a price on ecosystem services and hence reveals clearly the trade-offs that have to be made.

Under pressure to respond to immediate problems, but hampered by a lack of high quality information and analysis, decision makers often have to make quick decisions without full knowledge of the long term implications of their decisions. Having access to reliable information that describes the costs, values, and risks of environmental change facilitates more objective, more transparent and better informed decision-making. Such information should reduce the pressure on decision makers by giving them a fuller and more balanced understanding of the economic gains from environmentally sustainable policies, projects and decisions, and the potential losses from unsustainable ones.

Economic valuation of ecosystem services does not provide the 'correct' answer to questions on environmental conservation and management, but it does provide information to facilitate more objective decision-making. It provides a means of measuring the implications of decisions on the provision of ecosystem services, not just to the immediate stakeholders, but also to people impacted by environmental change further afield (e.g. downstream) and to future generations.

Alternative approaches to economic valuation are available for quantifying and communicating information on impacts on ecosystem services. For example, bio-physical indicators for ecosystem services may also be used to convey impacts directly to decision makers. The advantage of economic valuation is that impacts are expressed in common units (i.e. money) that can be directly compared and reflect impacts in terms of human welfare.

There are many contexts in which the economic valuation of ecosystem services may be useful, including:

- Raise **awareness** of the value of the environment
- Reveal the **distribution** of costs and benefits of a project among winners and losers
- Design the most effective tools for environmental **management**
- Design appropriate **fees** for use of ecosystem services
- Calculate potential **returns on investment** for projects that impact the environment
- Compare **costs and benefits** of different uses of the environment
- Calculate values for ecosystem services and natural capital for input into **green accounts**
- Calculate environmental **damages** and set **compensation**

Because economic valuation is done for a variety of reasons in a variety of contexts, it is difficult to present a uniform framework for the economic valuation of ecosystem services. In other words, each new assessment may require a slightly different approach from other studies.

It should also be noted that economic valuation is just one element in a decision process, along with a number of other steps that require expertise beyond the economic domain. A general description of a decision process that involves impacts on the environment includes the following steps: problem identification, determination of policy or investment options, identification of impacts, bio-physical assessment, valuation, policy evaluation and decision support. These steps might require inputs from policy analysts, engineers, hydrologists, ecologists, economists and experts in decision support. Although the emphasis of this manual is on economic valuation, and on value transfer in particular, these other crucial elements in the decision process should not be ignored.

Definition Box 1: Ecosystem Services

A number of different definitions of ecosystem services have been developed through different initiatives. These include:

Ecosystem services are the benefits that ecosystems provide for people (Millennium Ecosystem Assessment – MA, 2005).

Ecosystem services are the direct and indirect contributions of ecosystems to human well-being (The Economics of Ecosystems and Biodiversity – TEEB, 2010)

Ecosystem services refer to those contributions of the natural world that are used to produce goods which people value (UK National Ecosystem Assessment – UKNEA, 2011).

Ecosystem services are the contributions that ecosystems make to human well-being (Common International Classification of Ecosystem Services – CICES, 2012).

Similarly there are a number of different classification systems for ecosystem services including those developed by the Millennium Ecosystem Assessment, The Economics of Ecosystems and Biodiversity, and the Common International Classification of Ecosystem Services. All classifications make a distinction between "provisioning", "regulating" and "cultural" services. The Millennium Ecosystem Assessment classification also includes the category "supporting" services.

Provisioning services are the "products obtained from ecosystems". Examples include food, timber and fuel.

Regulating services are the "benefits obtained from the regulation of ecosystem processes". Examples include water flow regulation, carbon sequestration and protection from storms.

Cultural services are the "non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences".

Supporting services "are necessary for the production of all other ecosystem services". Examples include nutrient cycling, soil formation and primary production.

The distinction between supporting services and other ecosystem services is related to the distinction between "intermediate" and "final" ecosystem services.

Final ecosystem services are the last item in the chain of natural processes that provide inputs to the generation of products (goods and services) that are used by humans. Some ecosystem services are used as inputs in the production of manufactured products (e.g. trees used to make timber) whereas others are consumed directly (e.g. a natural area used for recreation) (UKNEA, 2011).

Intermediate ecosystem services are natural processes that contribute to other ecosystem functions, but do not directly input into the production of goods consumed by humans (UKNEA, 2011)

2.2 Methods for valuing ecosystem services

Economists have developed a variety of methods for estimating the value of ecosystem services. These valuation methods are designed to span the range of valuation challenges raised by the application of economic analyses to the complexity of the natural environment. The selection of appropriate valuation methods is in part determined by the type of ecosystem service being valued. Appendix II provides an overview of primary valuation methods, typical applications, limitations and indicates which primary valuation methods can be used to value which ecosystem service. The term 'primary valuation' refers to methods and studies that produce a new or original value estimate for a specific ecosystem. The term is used to make a distinction from studies that use existing value information (i.e. value transfer). Specialised guidelines on primary valuation methods are listed in section 7.

An important distinction to be aware of between primary valuation methods is the difference between revealed preference methods (those that observe actual behaviour of the use of ecosystem services to elicit values) and stated preference methods (those that use public surveys to ask beneficiaries to state their preferences for, generally hypothetical, changes in the provision of ecosystem services). Revealed preference methods may be favoured since they reflect actual behaviour but are limited in their applicability to some ecosystem services. Stated preference methods on the other hand rely on responses recorded in surveys or experiments but are more flexible in their application.

It is necessary to understand that different primary valuation methods produce different measures of economic value that are not equivalent and cannot necessarily be directly compared. Accordingly, when transferring values from primary valuation studies it is important to understand the methods used and the type of values that are produced. Appendix I provides an explanation of different concepts and measures of economic value.

2.3 Transferring values for ecosystem services

Decision making often requires information quickly and at low cost. New 'primary' valuation research, however, is generally time consuming and expensive. For this reason there is interest in using information from existing primary valuation studies to inform decisions regarding impacts on ecosystems that are of current interest. This transfer of value information from one context to another is called value transfer (see Definition Box 2).

In addition to the need for quick and inexpensive information, there is often a need for information on the value of ecosystem services at a different geographic scale from that at which primary valuation studies have been conducted. So even in cases where some primary valuation research is available for the ecosystem of interest, it is often necessary to extrapolate or scale-up this information to a larger area or to multiple ecosystems in the region or country. Primary valuation studies tend to be conducted for specific ecosystems at a local scale whereas the information required for decision making is often needed at a regional or national scale. Value transfer therefore provides a means to obtain information for the scale that is required.

The number of primary studies on the value of ecosystem services is substantial and is growing rapidly. This means that there is a growing body of evidence to draw on for the purposes of transferring values to inform decision making (see section 7.2 for an overview of databases that compile existing valuation studies). With an expanding information base, the potential for using value transfer is improved. For this reason, interest in using value transfer as a means of providing information has developed.

Value transfer can potentially be used to estimate values for any ecosystem service, provided that there are primary valuations of that ecosystem service from which to transfer values. Value transfer methods have been employed widely in national and global ecosystem assessments (e.g. the UK NEA, 2011; EEA, 2010; COPI, 2008; TEEB QA, 2011), value mapping applications (see Schaegner et al., 2013) and policy appraisals (e.g. World Bank, 2002). The use of value transfer is widespread but requires careful application. The alternative methods of conducting value transfer are described in the next section.

Definition Box 2: Value Transfer

Value transfer involves estimating the value of ecosystem services through the use of value data and information from other similar ecosystems and populations of beneficiaries. It involves transferring the results of existing primary valuation studies for other ecosystems ("study sites") to ecosystems that are of current policy interest ("policy sites").

Value transfer is also known as **benefit transfer** but since the values that are transferred may be costs as well as benefits, the term value transfer is more generally applicable.

3. Value transfer methods

This section provides an explanation of the alternative methods for conducting value transfer; setting out the key steps and strengths and weaknesses of each method.

As explained in the previous section, value transfer is the procedure of estimating the value of an ecosystem service of current policy interest (at a "policy site") by assigning an existing valuation estimate for a similar ecosystem elsewhere (at a "study site"). The transfer of information from one site to another is represented in Figure 1. The figure shows two similar watersheds, both with upstream forests that provide the service of regulating the flow of water downstream. In the case that we have existing information about the value of this ecosystem service for the first watershed (study site), it is possible to use this information to estimate the value of the ecosystem service in the second watershed (policy site). The values of the ecosystem service at each site may be assumed to be similar given that the two sites are similar in terms of the area of upstream forest, the amount of rainfall and the number of beneficiaries living downstream

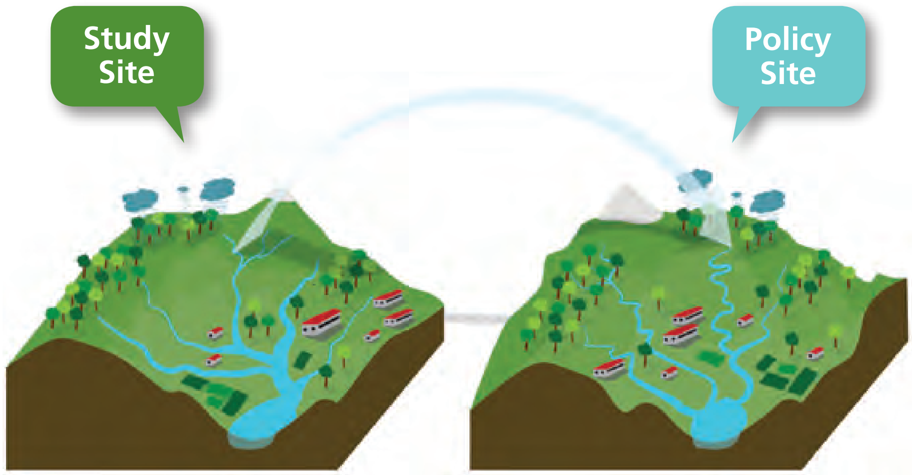


Figure 1. Value transfer is the procedure of estimating the value of an ecosystem service of current policy interest ("policy site") by assigning an existing valuation estimate for a similar ecosystem elsewhere ("study site").

A range of methods have been developed for transferring information from a study site and adjusting that information to reflect the characteristics of the policy site. Value transfer methods can be divided into three main types: unit value transfer, value function transfer and meta-analytic function transfer. These are described in detail in sections 3.3, 3.4 and 3.5 respectively (see also Definition Box 3).

Definition Box 3: Value transfer methods

Unit value transfer uses values for ecosystem services at a study site, expressed as a value per unit (usually per unit of area or per beneficiary), combined with information on the quantity of units at the policy site to estimate policy site values. Unit values from the study site are multiplied by the number of units at the policy site. Unit values can be adjusted to reflect differences between the study and policy sites (e.g. income and price levels).

Value function transfer uses a value function estimated for an individual study site in conjunction with information on parameter values for the policy site to calculate the value of an ecosystem service at the policy site. A value function is an equation that relates the value of an ecosystem service to the characteristics of the ecosystem and the beneficiaries of the ecosystem service. Value functions can be estimated from a number of primary valuation methods including hedonic pricing, travel cost, production function, contingent valuation and choice experiments.

Meta-analytic function transfer uses a value function estimated from the results of multiple primary studies representing multiple study sites in conjunction with information on parameter values for the policy site to calculate the value of an ecosystem service at the policy site. A value function is an equation that relates the value of an ecosystem service to the characteristics of the ecosystem and the beneficiaries of the ecosystem service. Since the value function is estimated from the results of multiple studies it is able to represent and control for greater variation in the characteristics of ecosystems, beneficiaries and other contextual characteristics.

Before elaborating on each value transfer method in detail, the next two sections describe in general the steps involved in conducting a value transfer study and the important choice of units in which to transfer values.

3.1 Steps in conducting value transfer

Irrespective of the specific value transfer method used, there are a number of general steps in conducting value transfer that should be followed. These are outlined in Figure 2 and described in more detail below.

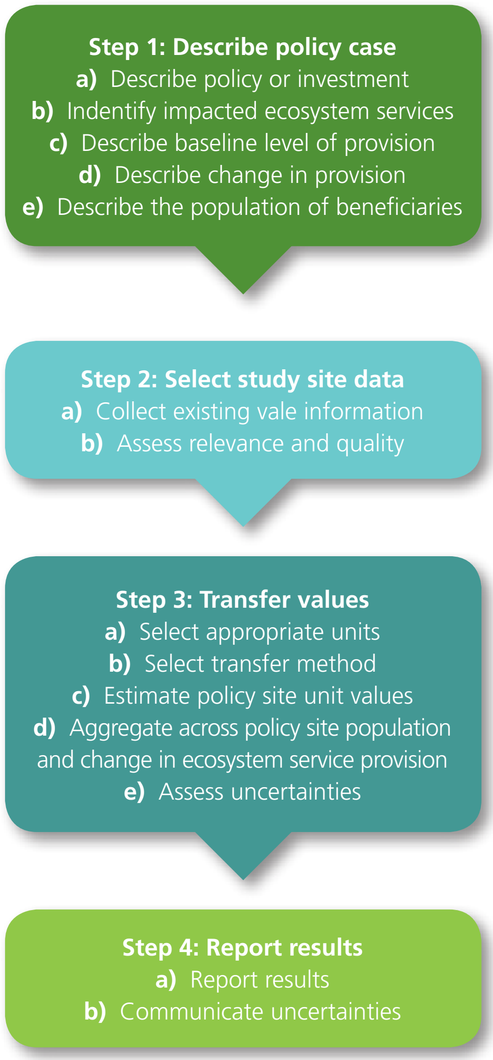


Figure 2. The main steps in conducting value transfer

Step 1 **Describe the policy case**. This is done to clearly frame the information that is required.

a) Describe the policy change, conservation measure, investment, development etc. that is under consideration.
b) Identify the ecosystem service(s) that are relevant to the decision context. This may involve input from stakeholders or experts on what are considered to be the ecosystem services of greatest economic importance (i.e., highest value) or those most affected by the policy change. The use of a classification scheme for ecosystem services, such as those identified in Definition Box 1, may be useful for identifying relevant ecosystem services. To avoid potential double counting it is necessary to identify only final ecosystem services.
c) Describe the baseline level of ecosystem service provision in physical terms. For example, the description of flood control might be in terms of the return period and duration of flood events; the description of recreation might be in terms of the annual number of visitors; the description of water quality might be in terms of concentrations of pollutants. This step is likely to involve input from experts in other disciplines (e.g. ecologists, hydrologists), technical reports and/or stakeholders (see section 6.1). A baseline should describe both the current and future level of provision in the absence of the policy or investment under consideration.
d) Describe the extent of change in ecosystem service provision in physical terms. This step is also likely to involve input from experts in other disciplines (e.g. ecologists, hydrologists), technical reports and/or stakeholders. The change in provision of ecosystem services may occur over a period of time, in which case it is necessary to describe the temporal profile of the change. This involves determining the time horizon over which changes occur and the degree of change that occurs in each intermediate year.
e) Describe the population of beneficiaries that are affected (number, household size, income, age). The affected population can be described as the market or economic constituency for the ecosystem service. Note that the population of affected beneficiaries is likely to be different for each ecosystem service considered in the assessment. Beneficiaries of provisioning services may be local, whereas beneficiaries of regulating services and non-users may be distant from the ecosystem itself. It is important to accurately identify the populations of beneficiaries for each ecosystem service in order to correctly adjust values for population characteristics (see section 4.1 and 4.6) and compute aggregate values for the change in ecosystem service provision (see step 3c and section 4.8).

Step 2 **Select relevant study site data**. This is done to obtain existing values that correspond to or can be adjusted to represent the policy site.

a) Obtain existing value information for study sites that are similar to the policy case in terms of the ecosystem service, baseline level of provision, extent of change in provision and characteristics of beneficiaries. Value information, including value functions, may be obtained from published primary studies, meta-analyses or databases (see sections 7.2 and 7.3 for an overview of available databases and a list of published meta-analyses on forest and wetland ecosystem service values respectively).

b) Review case studies for relevance and quality. Relevance relates to the similarity of the study and policy sites in terms of the ecosystem service, baseline provision, extent of change, population of affected beneficiaries, and availability of substitutes. Quality relates to the valuation methods that are used (whether they estimate reliable measures of welfare), how well they are applied (follow recommended approaches), the data that is used (sampling procedure, representativeness, and sample size), and the statistical significance of the value estimates or functions[1]. Select value information that is relevant and of high quality.

Step 3 **Transfer values**.

a) Determine the units in which to transfer values (see section 3.2).
b) Select the value transfer method to be applied. The available methods are unit value transfer, value function transfer and meta-analytic function transfer, which are defined in Definition Box 3 and described in detail in sections 3.4-3.6 respectively. The choice of which method to use is dependent on the availability of study site value data, the similarity of study and policy sites, and the number and variety of policy sites to be assessed. In general, unit value transfer is preferred when study and policy sites are closely similar; and value function transfer and meta-analytic function transfer are preferred when there are important differences between study sites and policy sites.
c) Estimate unit values for ecosystem service(s) at the policy site, controlling for any important differences between the study site and policy site.
d) Aggregate values for the change in ecosystem service provision (i.e. multiply unit values by the extent of change at the policy site).
e) Assess uncertainties in the value transfer estimates through sensitivity analysis, confidence intervals, transfer errors and/or value ranges (see section 5.2).

Step 4 **Report results**.

a) Report the results of the value transfer in a way that is useful to the decision maker. The results should clearly correspond to the policy or investment choices that are being considered.
b) The presentation of value estimates should be accompanied with clear information about the uncertainty of the estimates. This can be communicated in a number of different ways (see section 5.2).

[1] The Swedish Environmental Protection Agency has developed guidance on assessing the quality of environmental valuation studies: http://www.naturvardsverket.se/Documents/publikationer/620-1252-5.pdf. Annex 2 of the Eftec (2010) guidelines for the use of value transfer in policy and project appraisal also provides guidance on assessing the quality of primary valuation studies: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/182367/vt-annex2.pdf

3.2 The choice of units: beneficiaries or ecosystems

Values for ecosystem services can be estimated and presented both in terms of the beneficiaries that enjoy those services and or in terms of the ecosystems that supply them. Accordingly, values can be transferred either in terms of beneficiaries (e.g. US$ per household) or ecosystems (e.g. US$ per hectare). The selection of appropriate units in which to transfer values is important and depends on the ecosystem service under consideration, the nature of the available value information from existing studies, and the available information for the policy site.

Some ecosystem service values may be expressed more straightforwardly and meaningfully in one set of units than another. For example, recreation values or non-use values may be directly estimated and expressed per person rather than per unit of ecosystem area. On the other hand, services such as support to commercial fisheries, pollination of crops and carbon sequestration are not straightforwardly expressed in per beneficiary terms but can be described per unit area of an ecosystem.

Similarly, the results of different valuation methods correspond with different types of units. Some methods produce estimates of willingness to pay (WTP) per beneficiary (e.g. contingent valuation, travel cost) whereas others produce estimates of values per physical or areal unit (e.g. production function and net factor income methods). The correspondence between valuation methods and units is not strict and many methods produce results that can be expressed in terms of both beneficiaries and physical/areal units of ecosystems.

The choice of the appropriate unit in which to transfer values is also determined by the type of information that is available for the policy site. If information is available on the number of beneficiaries at the policy site then values can be transferred in those terms. Equivalently, if information is available on the quantity of an ecosystem service or area of the ecosystem at the policy site then values can be transferred using those units. Ideally, any value transfer and aggregation of values would account for both the number of beneficiaries and the scale of the ecosystem.

It should be noted that values are also defined in terms of temporal units (e.g., value per day, month, year, or multiple years). Values for multiple years, for example a total value for an ecosystem service over the full time horizon for which a particular conservation investment is expected to have an impact, are often presented as present values.[2] It is important to determine the temporal units that are relevant to the policy context and recognise that primary valuation results may be expressed in different temporal units.

Examples of value transfers per hectare and per beneficiary are given in Example Application Boxes 2 and 3 respectively.

[2] The term present value indicates that a flow of values that occur over time have been discounted to reflect society's preference for consumption over time or the opportunity cost of capital.

3.3 Unit value transfer

Unit value transfer uses values for ecosystem services at a study site, expressed as a value per unit (usually per unit of area or per beneficiary), combined with information on the change in quantity of units at the policy site to estimate policy site values. Value per unit at the study site is multiplied by the relevant number of units at the policy site. Unit values can be adjusted to reflect differences between the study and policy sites (e.g. income and price levels). In this case the method is sometimes referred to as adjusted unit value transfer.

The step-by-step specific description of unit value transfer follows on from the general explanation of the steps in performing value transfer (i.e. the explanation here adds detail to Step 3b described above). The main steps in conducting a unit value transfer are:

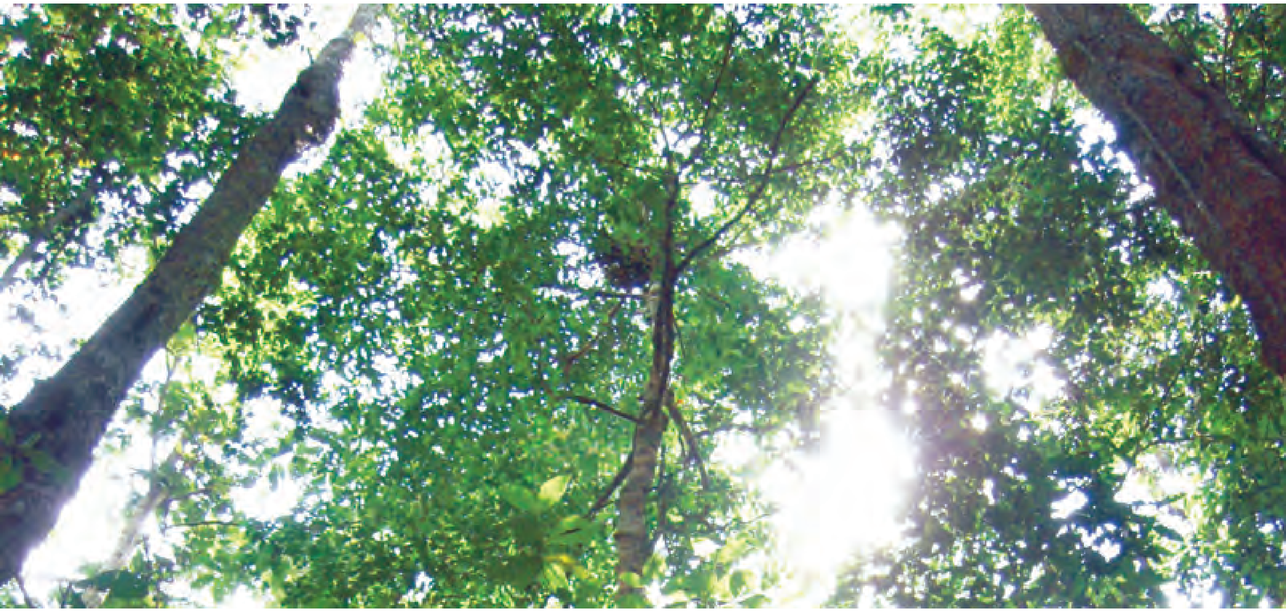
Step 1. From the selected study site valuation results, obtain or compute the value per unit (e.g. US$ per household, US$ per visit, US$ per hectare, US$ per cubic meter water). The unit value may be from a single study site valuation or the average unit value from multiple study sites.

Step 2. Where necessary and feasible, adjust the study site unit value to reflect any identified differences between the study site and the policy site. Common adjustments are for differences in incomes or price levels between the study and policy sites. Section 4 provides information on making adjustments for potentially important differences between study and policy sites.

Step 3. For the policy site, quantify the change in ecosystem service provision in the units in which the transfer is being made (e.g. visits, hectares, cubic meters of water).

Step 4. Multiply the unit value by the change units at the policy site to estimate the aggregate change in ecosystem service value.

In order for the unit value transfer approach to produce reliable information it is crucial that at least one primary valuation estimate is available for a study site that corresponds closely to the characteristics of the policy site. To some extent, unit values can be adjusted to reflect differences between study and policy sites but this is generally limited to a few characteristics. When no closely corresponding study site values are available, the unit value transfer approach becomes unreliable.



Example Application Box 1: Unit value transfer

This example application illustrates the use of the unit value transfer approach to estimate the value to residents of an improvement in coastal water clarity for the island of St. Thomas in the US Virgin Islands. The US Virgin Islands (USVI) are located at the eastern tip of the Greater Antilles in the Caribbean Sea, approximately 65 km east of Puerto Rico.

The policy question addressed by this case study is: what is the welfare gain to local residents from improving the clarity of coastal waters? Water clarity is an issue of concern due to the construction of residential buildings resulting in sedimentation of coastal waters. The ecosystem services affected by coastal water clarity are recreational uses (swimming, diving, snorkeling and fishing) and the aesthetic enjoyment of the marine environment. The environmental change under consideration is an improvement from current 'medium' clarity to 'high' clarity.

Regarding the selection of relevant and high quality study site value data, a choice experiment valuation study of the marine environment, including water clarity, had been conducted for the neighbouring US Virgin Island of St. Croix. This was selected as the most suitable study site since the islands of St Thomas and St Croix have similar marine environments and populations, removing any necessity of adjusting unit values. The study site unit value, expressed in WTP/household/year in US$ at 2010 price levels, for an improvement from 'medium' to 'high' water clarity is US$ 20.51 with a 95% confidence interval of US$ 13.48 - 45.07.

Multiplying this study site unit value by the number of households at the policy site (19,938 – obtained from the US census) gives an aggregate estimate of the welfare improvement for an improvement in water clarity from 'medium' to 'high' of US$ 408,926 per year.

This case study is based on information provided in van Beukering et al. (2011)

3.4 Value function transfer

The value function transfer approach uses a value function estimated for an individual study site in conjunction with information on the characteristics of the policy site to calculate the value of an ecosystem service at the policy site. A value function is an equation that relates the value of an ecosystem service to the characteristics of the ecosystem and the beneficiaries of the ecosystem service. Value functions can be estimated using a number of primary valuation methods including hedonic pricing, travel cost, production function, contingent valuation and choice experiments. In all cases, the value function is estimated using a regression analysis. A regression analysis is a statistical approach to empirically modelling the relationship between a dependent variable (e.g. WTP per household) and one or more explanatory variables (e.g. household income, distance to ecosystem, frequency of visits, number of substitute ecosystems).

The step-by-step description of value function transfer follows on from the general explanation of the steps in performing value transfer (i.e. the explanation here adds detail to Step 3b described above). The main steps in conducting a value function transfer are:

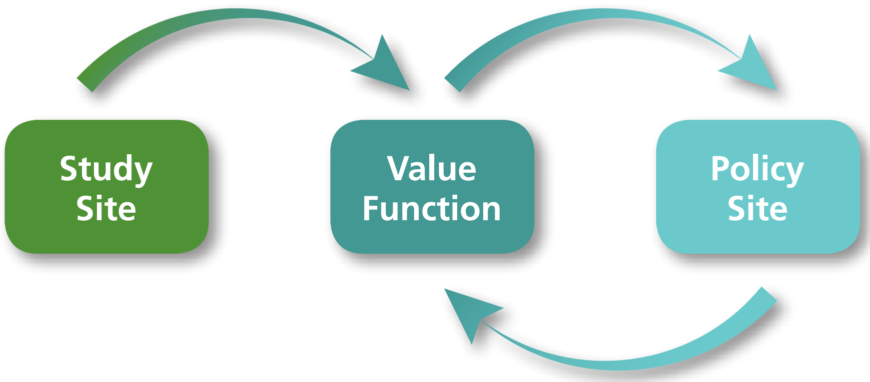


Figure 2. The value function transfer approach uses a value function estimated for an individual study site in conjunction with information on parameter values for the policy site to calculate the value of an ecosystem service at the policy site.

Step 1. From the available primary valuation studies, select an estimated value function that relates the value of ecosystem service to the characteristics of the ecosystem and its beneficiaries. Value functions will often be reported in the form of a regression output table, in which the dependent (or explained) variable is the value of ecosystem service and the explanatory variables include measures of ecosystem and beneficiary characteristics. The dependent variable of the value function is almost always defined as a value per unit (e.g. US$ per household, US$ per hectare).

Step 2. Collect information for the policy site on each of the explanatory variables in the value function and for the change in the quantity of units in which the dependent variable is defined (e.g. number of households, number of visits, hectares of ecosystem). Information on the explanatory variables at the policy site (e.g. household income, distance to ecosystem, frequency of visits, number of substitute ecosystems) can be obtained from a variety of sources, including public statistics, surveys, technical reports and GIS data.

Step 3. Input the policy site data on the explanatory variables into the value function to estimate a unit value for the ecosystem service at the policy site. This involves multiplying the policy site data for each explanatory variable by the estimated coefficient for each explanatory variable reported in the value function and then summing across explanatory variables to obtain an estimate of the dependent variable at the policy site (i.e. the unit value). It is practical to use a spreadsheet to perform this step (see worked example).

Step 4. Multiply the estimated unit value by the change in number of units at the policy site to compute the aggregate change in value of the ecosystem service.

Example Application Box 2: Value function transfer

This example application illustrates the use of the value function transfer approach to estimate the unit value of water quality improvements in a Danish river. The ecosystem services affected by changes in surface water quality include the cultural ecosystem services (recreation, aesthetic enjoyment and non-use values for good ecological conditions).

The policy question addressed in this case study is: what is the welfare gain to local residents from improving the quality of water in the river? The environmental change under consideration is a 'small' improvement from the status quo defined by a combination of chemical, physical, flora and fauna characteristics as well as use characteristics (i.e. what the water can safely be used for).

Regarding the selection of relevant and high quality study site value data, a choice experiment valuation study of water quality improvements in Denmark and four other European countries was identified from the literature (Bateman et al., 2011). This was selected as the most suitable primary valuation study since it includes Denmark and directly addresses changes in surface water quality. The study estimates a value function for changes in water quality, which is summarized in Table 1. The dependent variable is defined as WTP per household per year in purchasing power parity adjusted Euros at 2008 price levels (and converted to a natural logarithm). The explanatory variables in the value function include a measure of the scale of improvement, distance between the improved water body and residents, distance between nearest substitute water body and residents, and household income. The estimated coefficients in the value function (column 2) measure the direction and magnitude of the effect of each explanatory variable on WTP for an improvement in water quality.

The characteristics of the policy site river are summarized in column 3. The improvement in water quality is small (therefore the policy site value for the dummy variable indicating a large improvement is set to 0 instead of 1); the average distance between the river and residents that use it is 6 km; the average distance between the identified population of beneficiaries and their nearest substitute water body is 10 km; average annual household income is EUR 34,854.

These policy site characteristics are multiplied by the coefficients in the value function (column 4). The sum of column 4 gives the natural logarithm of the estimated policy site WTP (2.43). Taking the exponential (i.e. reversing the natural log transformation) of this value gives the unit value of the improvement in water quality: 11.39 EUR/household/year at 2008 price levels.

Table 1. Example application of value function transfer

Value function variables	*Value function coefficients*	*Policy site characteristics*	*Coefficients x Policy site characteristics*
Constant	1.74	1	1.74
Large improvement (dummy variable)	0.201	0	0
Average distance from improved water body to residence (km)	-0.009	6	-0.054
Distance to nearest substitute (km)	0.005	10	0.05
Household income (EUR per year)	0.00002	34,854	0.70
Policy site WTP (ln)			2.43
Policy site WTP			11.39

3.5 Meta-analytical function transfer

Meta-analytical function transfer is similar to the value function approach but the value function in this case is estimated from the results of multiple primary valuation studies representing multiple study sites. The meta-analytic value function is used in conjunction with information on parameter values for the policy site to calculate the value of an ecosystem service at the policy site. Since a meta-analytic value function is estimated from the results of multiple studies it is able to represent and control for greater variation in the characteristics of ecosystems, beneficiaries and also methodological aspects of the primary valuation studies.

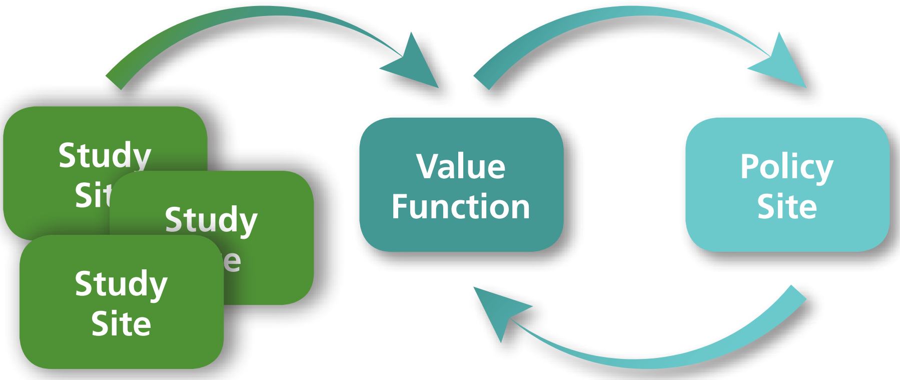


Figure 3. Meta-analytic function transfer uses a value function estimated from the results of multiple primary valuation studies in conjunction with information on parameter values for the policy site to calculate the value of an ecosystem service at the policy site.

The step-by-step description of the meta-analytic value transfer approach follows on from the general explanation of the steps in performing value transfer (i.e. the explanation here adds detail to Step 3b described in section 3.1).

Step 1. Obtain or estimate a meta-analytic value function for the ecosystem service of interest. There are numerous published meta-analyses in the economic valuation literature for different ecosystems and ecosystem services from which value functions can be obtained. A list of existing meta-analyses for forest and wetland values is provided in Section 7.3. Alternatively, a new meta-analysis for the ecosystem service of interest can be conducted. The main steps in conducting a meta-analysis of primary valuation results in order to estimate a value function are:

a) From the available primary valuation studies, construct a database containing information on the value of the ecosystem service of interest.
b) Value information presented in the primary valuation literature may be reported in different physical and temporal units. Values should be standardised into the same set of units (e.g. US$ per household per month, US$ per hectare per year) so that they can be directly compared and analysed. Similarly, value estimates are

likely to be reported in different currencies and for different years and price levels. Values should therefore be standardised to the same currency, year of value/price level (see Section 4 for further details). In addition, value estimates produced using different primary valuation methods may estimate different concepts of value and may therefore not be directly comparable. If there is a sufficiently large number of primary value estimates available, it is preferable to only use estimates produced by the same valuation method. If this is not possible, variables should be included in the meta-analysis regression model to control for methodological differences between value estimates.

c) For each primary value estimate included in the database, include information on the valuation method used, type of ecosystem service valued, base level of provision, change in provision, characteristics of the ecosystem (e.g., size, quality), and the characteristics of beneficiaries (e.g., number, household size, income, age).

d) In addition to information obtained directly from each primary study, information on each study site can be added using secondary data sources including spatially defined data using GIS. Examples of such additional data include population density, income, abundance of other ecosystems in the vicinity of the study site, landscape fragmentation, and distance to population centres.

e) Estimate a multiple regression equation with the standardised value as the dependent variable and measures of study, ecosystem and beneficiary characteristics as explanatory variables.

Step 2. Collect information for the policy site on each of the parameters (explanatory variables) in the meta-analytic value function and for the quantity of units in which the dependent variable is defined (e.g. number of households, hectares of ecosystem).

Step 3. Input the policy site parameter values into the meta-analytic value function to estimate a unit value of the ecosystem service at the policy site.

Step 4. Multiply the estimated unit value by the number of units to compute the value of the ecosystem service at the policy site.

Example Application Box 3: Meta-analytic function transfer

This example application illustrates the use of the meta-analytic function transfer approach to estimate the unit value of a freshwater wetland in England, the United Kingdom.

A meta-analytic function for wetland ecosystem service values is obtained from a published meta-analysis (Brander et al., 2012). The meta-analytic function is summarized in Table 2. The dependent variable in the meta-regression function is the value of wetland ecosystem services in US$/ha/year at the 2003 price level. The coefficients in the function (column 2) measure the direction and magnitude of the effect of each explanatory variable on the unit value of wetland ecosystem services.

The characteristics of the policy site wetland are summarized in column 3. The wetland is an inland marsh and has an area of 327 ha; the GDP per capita in the UK in the year of assessment (2050) is projected to be US$ 48,440; the population within a 50 km radius of the wetland is 1,264,494; and the wetland area within a 50 km radius of the wetland is 8,412 ha.

These policy site characteristics are multiplied by the coefficients in the meta-analytic function (column 4). Note that several of the variables are expressed as natural logarithms (ln) and so policy site variable values first need to be converted to natural logarithms before multiplication with the coefficients. The sum of column 4 gives the natural logarithm of the estimated unit value of wetland ecosystem services (8.730). Taking the exponent of this value gives the unit value of wetland ecosystem services: 6,188 US$/ha/year at 2003 price level.

The use of this meta-analytic function therefore produces a unit value estimate for the wetland that takes into account several important characteristics, including type, size, income of beneficiaries, population, and the abundance of other wetlands in the area.

Table 2. Example application of meta-analytic function transfer

Meta-analytic function variables	*Meta-analytic function coefficients*	*Policy site characteristics*	*Coefficients x Policy site characteristics*
Dependent: US$/ha/year (ln)			
Constant	-1.251	1	-1.251
Marginal value (dummy variable)	0.828	1	0.828
Inland marsh (dummy variable)	-0.161	1	-0.161
Peatbog (dummy variable)	-0.122	0	0.000
Salt marsh (dummy variable)	0.012	0	0.000
Intertidal mudflat (dummy variable)	-0.029	0	0.000
Wetland size, ha (ln)	-0.218	327	-1.262
GDP per capita, US$ (ln)	0.430	48,440	4.639
Population in 50 km radius (ln)	0.503	1,264,494	7.067
Wetland area in 50 km radius, ha (ln)	-0.125	8,412	-1.130
Policy site value, US$/ha/year (ln)			8.730
Policy site value, US$/ha/year			6,188

3.6 Summary of value transfer methods

The unit, value function and meta-analytic function transfer methods are summarised in Table 3 together with their respective strengths and weaknesses. The choice of which value transfer method to use to provide information for a specific policy context is largely dependent on the availability of primary valuation estimates and the degree of similarity between the study and policy sites. In cases where value information is available for a highly similar study site, unit value transfer may provide the most straightforward and reliable means of conducting value transfer. On the other hand, when study sites and policy sites are different, value function or meta-analytic function transfer offers a means to systematically adjust transferred values to reflect those differences. Similarly, in the case that value information is required for multiple different policy sites, value function or meta-analytic function transfer may be a more accurate and practical means for transferring values.

Table 3. Value transfer methods: strengths and weaknesses

	Approach	*Strengths*	*Weaknesses*
Unit value transfer	Select appropriate values from existing primary valuation studies for similar ecosystems and socio-economic contexts. Adjust unit values to reflect differences between study and policy sites (usually for income and price levels)	Simple	Unlikely to be able to account for all factors that determine differences in values between study and policy sites. Value information for highly similar sites is rarely available
Value function transfer	Use a value function derived from a primary valuation study to estimate ES values at policy site(s)	Allows differences between study and policy sites to be controlled for (e.g. differences in population characteristics)	Requires detailed information on the characteristics of policy site(s)
Meta-analytic function transfer	Use a value function estimated from the results of multiple primary studies to estimate ES values at policy site(s)	Allows differences between study and policy sites to be controlled for (e.g. differences in population characteristics, area of ecosystem, abundance of substitutes etc.). Practical for consistently valuing large numbers of policy sites.	Requires detailed information on the characteristics of policy site(s). Analytically complex

4. Adjusting values for different contexts

The key challenge of conducting accurate and credible value transfers is to account for important differences in the characteristics of the study and policy sites. Differences in the characteristics of ecosystems, services, their beneficiaries and bio-physical surroundings can potentially result in very large differences in the provision and value of ecosystem services. This section provides an explanation of some of the key characteristics that need to be controlled for in conducting a value transfer.

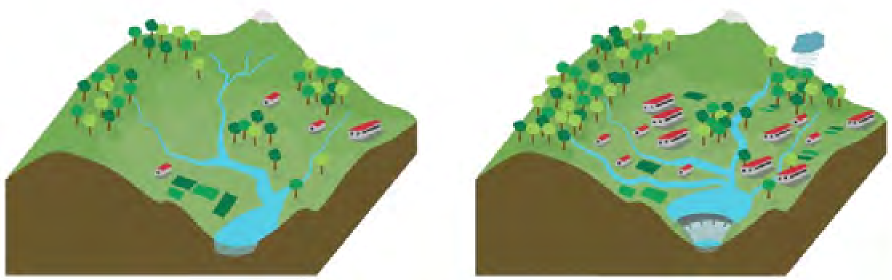


Figure 4. Important differences between study sites and policy sites, such as the size of the ecosystem and number of beneficiaries, need to be controlled for when transferring values.

4.1 Income

The demand for most goods and services, including ecosystem services, changes with income. Generally, as incomes rise, the demand and value of normal goods and services also increases. It is therefore necessary, when transferring values for ecosystem services across populations with different incomes (or over time for populations experiencing rising incomes), to account for the effect of income on the demand and value of ecosystem services.[3]

Adjustments for differences in income between study sites and policy sites can be made using information on the responsiveness of willingness-to-pay (WTP) for the ecosystem service in question with respect to income. The economic term for this is the "income elasticity of WTP". This is a measure of how much the WTP for an ecosystem service changes with income, and is generally expressed as the percentage change in WTP for a one percentage point change in income. Estimates of the income elasticity of WTP for different ecosystem services are available from primary valuation studies and meta-analyses that include income as an explanatory variable in estimated value functions. For example, estimates of the income elasticity of WTP for wetland ecosystem services from recent meta-analyses are in the range 0.295-1.16.

Value transfers using value functions that include income as an explanatory variable therefore provide a means of controlling for differences in income between the study and policy sites.

[3] See Brander et al. (2006) and Ghermandi et al. (2010).

In the case of the unit value transfer method, adjustments to unit values can be made using secondary information on the income elasticity of WTP (e.g. from value functions estimated in primary valuation studies or meta-analyses).

The formula for this adjustment is:

$$WTP_p = WTP_s \, (Y_p / Y_s)^E$$ **Equation 1**

where:

WTP_p	=	willingness to pay at the policy site
WTP_s	=	willingness to pay at the study site
Y_p	=	income per capita at the policy site
Y_s	=	income per capita at the study site
E	=	income elasticity of willingness to pay

Ideally such adjustments to transferred values should use measures of individual or household income. In cases where information on the income of beneficiaries is not available, it is possible to use information on Gross Domestic Product (GDP) per capita as a proxy for income. This may, however, introduce a degree of error into the value transfer in cases where the income of the specific beneficiaries of the ecosystem services in question is substantially different from the national GDP per capita.

Example Application Box 4: Adjusting unit values for differences in income

This example application builds on the case study for the US Virgin Islands introduced in Example Application Box 1. It illustrates how to adjust unit values to reflect differences in income between study and policy sites.

The study site (St Croix) has a higher average household income than the policy site (St Thomas). This is expected to affect willingness to pay for improvements in environmental quality. From a survey of households on the two islands the average household income is found to be US$ 36,240 in St. Thomas and US$ 48,750 in St. Croix.

An estimate of the price elasticity of WTP with respect to income is obtained from a published meta-analysis of wetland values (Brander et al., 2012). This estimate is 0.43, which indicates that WTP increases with income but at a less than proportional rate (i.e. for every 1% increase in income, WTP increases by 0.43%).

Using equation 1, the unit value adjusted for the difference in average household incomes between the study and policy sites can be calculated as:

US$ $18.05 = 20.51 \times (36{,}240 / 48{,}750)^{0.43}$

The adjustment for the difference in income therefore results in a 12% lower unit value.

4.2 Year of value and general price levels

Value estimates from primary valuation studies are reported at the general price level for a particular year, usually (but not always) the year in which the study was conducted. For example, a valuation study conducted in 1995 is likely to report values in the price level in that year. Inflation, however, causes general price levels in a country to rise over time so that any given amount of money is worth less, in terms of the goods and services that it can purchase, over time.

When transferring study site values that were estimated in previous years to inform a current policy decision (and to compare transferred ecosystem service values with other values that are relevant to the policy decision), it is necessary to adjust values to account for inflation. All values should be adjusted to ensure that they represent the general price level of the same year. This can be done using available domestic price indices or GDP deflators that measure the annual rate of price change in an economy. GDP deflators are available from the World Bank World Development Indicators.[4]

The formula for this adjustment is:

$$WTP_P = WTP_S (D_P / D_S) \qquad \textbf{Equation 2}$$

where:

WTP_P = willingness to pay at the policy site

WTP_S = willingness to pay at the study site

D_P = GDP deflator index for the year of the policy site assessment

D_S = GDP deflator index for the year of the study site valuation

[4] http://data.worldbank.org/data-catalog/world-development-indicators

Example Application Box 5: Adjusting unit values for changes in general price levels over time

This example application builds on the case study for the US Virgin Islands introduced in Example Application Box 1. It illustrates how to adjust unit values to account for differences in general prices levels between the year in which the study site estimate is reported and the year in which the policy site assessment is made.

The study site valuation on the island of St Croix was conducted in 2010 and the estimated ecosystem services values are reported for the general price level of that year. The policy site assessment for the island of St. Thomas, however, was conducted in 2012. Study site values therefore need to be adjusted to reflect the change in the general price level between 2010 and 2012.

GDP deflator index values for the United States for the years 2010 and 2012 are obtained from the World Bank World Development Indicators. These are 111 and 116 respectively.

Using equation 2, the unit value adjusted for the change in general price levels between the study year and policy year can be calculated as:

US$ 21.44 = 20.51 x (116 / 111)

The adjustment for the change in the general price level therefore results in a 5% higher unit value.

4.3 Purchasing power and currency

General prices for goods and services vary across different countries and even within countries (as well as over time) reflecting localised differences in the costs of production and demand. Prices for goods and services will tend to be higher where the cost of production and/or demand is higher.

Differences in the general level of prices across countries are measured using price indices, which compare prices for a representative basket of consumer goods in each country. When comparing across countries with different price levels, a given amount of money income will be able to purchase more goods and services in a country with a lower general price level than in a country with a higher general price level. For example, someone earning US$ 750 in Turkey would need to earn US$ 1000 in the United States to be able to buy the same quantity of goods and services because prices are generally 33% higher in the United States. In other words, the purchasing power of money, in terms of the goods and services that it can buy, differs across countries.

Differences in purchasing power have implications for transferring values for ecosystem services from one country to another. Differences in purchasing power mean that a dollar in one country is not equivalent, in terms of the goods and services that it represents, to a dollar in another country (different currencies are considered in the next paragraph but for the moment we stick with the same currency). A dollar is effectively worth less in a country with a high general price level than in a country with a low price level. This means that it is not valid to directly transfer values between countries with different price levels – since the same amount of money represents a different quantity of goods and services (and therefore utility for the consumer). It is therefore necessary to make adjustments to values when transferring from one country to another.

Controlling for differences in price levels between countries can be thought of as equivalent to controlling for changes in price level in a single country due to inflation (see Section 4.2). Transferring values from a study site in one country to a policy site in another country is slightly more complicated, however, since most countries have their own currencies, and so values need to be converted to the appropriate currency as well as price level.

Values for ecosystem services may be reported in any currency. Primary valuation studies generally report values in the currency of the country in which the study site is located and often also in US dollars if the results are intended for an international audience.

To transfer values between countries involves using purchasing power parity adjusted exchange rates, which are also available for all countries in the World Bank World Development Indicators.

The formula for this adjustment is:

$$WTP_P = WTP_S \times E \qquad \textbf{Equation 3}$$

where:

WTP_P = willingness to pay in currency of the policy site

WTP_S = willingness to pay in the currency of the study site

E = purchasing power parity adjusted exchange rate between policy and study site currencies

In cases where the study site value estimate is reported in a second currency (often US$) that has been calculated using a standard market exchange rate, it is necessary to adjust this reported value to reflect differences in price level. This involves converting the value reported in US$ into the local currency using the market exchange rate (ideally the rate that was used by the analyst for the primary study) and then converting it into the desired currency (possibly US$) using a PPP adjusted exchange rate. [5]

[5] If the standard market exchange rate is not reported in the primary study, market exchange rates are available from in the World Bank World Development Indicators or websites such as http://www.oanda.com/currency/converter/

Example Application Box 6: Adjusting unit values for currency and purchasing power

This example application builds on the case study for the US Virgin Islands introduced in Example Application Box 1. It illustrates how to convert study site unit values to the relevant currency at policy site and adjust for differences in purchasing power between countries.

In this example application we now consider the case in which the policy site is in a different country from the study site. We now want to estimate the welfare impact of improving water clarity in coastal waters for Antigua and Barbuda, also in the Caribbean Sea.

The purchasing power parity adjusted exchange rate between the US dollar and the East Caribbean dollar (XCD – the currency used in Antigua and Barbuda) for the year 2010 is 2.07 (obtained from the World Bank World Development Indicators). For comparison the standard market exchange rate is 2.67, which indicates that the general price level is lower in Antigua and Barbuda than in the United States. Instead of needing XCD 2.67 to buy US$ 1 worth of goods, it is only necessary to have XCD 2.07.

Using equation 3, the unit value converted to the local currency and accounting for the difference in price level can be calculated as:

XCD 42.46 = US$ 20.51 x 2.07

Using the standard exchange rate would have produced a unit value of XCD 54.76, i.e. 29% too high.

4.4 Time profiles

When making an economic assessment of the impact of a policy or investment on the provision of ecosystem services it is important to recognise that any impact has a temporal dimension and that the flow of ecosystem services many be affected over a number of years. In order to properly assess such impacts it is necessary to describe this temporal profile, i.e. what is the effect on ecosystem services in each year and what is the time horizon of the assessment when impacts cease or no longer enter the assessment. Describing the temporal profile of impacts on the provision of ecosystem services largely falls in the domain of bio-physical sciences but there is also a need to take account of the time profile of impacts in conducting value transfer.

The values of ecosystem services are not fixed over time but can vary due to changes in a number of determinants (income, population, preferences, availability of substitutes etc.). In many parts of the world the populations of beneficiaries of ecosystem services are changing rapidly and dramatically. It is therefore not valid to assume that the value of ecosystem services will remain constant over time. When using value transfer to estimate the value of ecosystem services provided in future time periods, it is necessary to account for the determinants of values in each relevant future year. This requires future projections of the relevant determinants of ecosystem service value. Similarly, when aggregating transferred values for a population of beneficiaries, it is necessary to use future projections of that population.

Information on how important variables might change over time is available from a variety of sources. Projections of how national incomes and populations are likely to change are available from government reports and international organisations.[6] Inputs for developing scenarios of the future can also be obtained from experts and stakeholders (see section 6.1).

A further aspect of valuing impacts that occur over time is the practice of discounting future costs and benefits to reflect their present values. Discounting is the process of calculating the present value of a stream of future values in order to reflect individuals' or society's time preference and/or the productive use of capital.

The formula for discounting or calculating present value is:

$$PV = FV / (1+r)^n \qquad \textbf{Equation 4}$$

where:

PV	=	present value
FV	=	future value
r	=	discount rate
n	=	the number of years in the future in which the cost or benefit occurs.

[6] For example, the OECD publishes projections of economic activity (http://www.oecd.org/eco/outlook/lookingto2060.htm) and the UN Population Information Network publishes projections of population (http://www.un.org/popin/)

4.5 Culture and preferences

It should be recognised that different people and cultures can have very different perceptions, preferences and values for ecosystem services (and many other things). For example, patterns of outdoor recreational activities in natural areas are observed to be very different across countries. More fundamentally, ecosystems can have strong cultural significance in some societies and not in others. Transferring ecosystem service values from one cultural context to another can therefore be problematic. Cultural considerations should be reflected in the selection of relevant primary valuation studies from which values are transferred. In cases of specific cultural significance and customs related to ecosystems, however, the scope for using value transfer may be limited and primary research is the only valid valuation approach.

4.6 Scarcity, substitutes and complements

It is generally the case that as a good or service becomes scarce, its price or marginal value increases (think of the difference in the price of Beluga caviar which is extremely scarce, and bread which is not at all scarce). The local scarcity or abundance of an ecosystem service is therefore a potentially important determinant of its value. For example, the value of water supplied by a wetland is likely to be considerably higher in an environment with low water availability than one in which water is abundant (setting aside other factors). It is therefore necessary to consider and, where necessary, adjust for differences in the relative scarcity of the resource or ecosystem service being valued.

Similarly, differences in the availability of substitute or complementary resources should be controlled for. Substitute ecosystems are alternative sources of the same service. For example, parks and greens spaces within a city can be used for recreation activities and may be direct substitutes (a recreationist could easily decide to use one and not another). In localities with a large number of ecosystems that provide similar services, the value of each individual site might be lower than in localities with few substitutes. The consequence of disregarding substitutes is generally an overestimation of WTP, as the sum of the value of ecosystem services measured individually is higher than the value measured for all ecosystem services at once.

Complementary ecosystems are those that combine to provide a greater quantity or quality of an ecosystem service. For example, systems of coastal and marine ecosystems that include mangroves, seagrass and coral reefs support commercially important fish species that depend on each habitat at different stages in their life cycle. The presence of complementary ecosystems in a locality may enhance the value of an ecosystem service, and this should be reflected in transferred values. Disregarding complementary sites is likely to result in underestimation of WTP.

Controlling for such factors in a value transfer application is challenging. Meta-analytic value functions that include explanatory variables for scarcity, substitutes and complements provide a means to account for these factors.

Example Application Box 7: Adjusting values to account for scarcity of other ecosystems

This example application builds on the case study presented in Example Application Box 3 to illustrate how transferred values can be adjusted to reflect variation in the scarcity of other ecosystems.

The meta-analytic function for wetland ecosystem service values includes an explanatory variable for the area of other wetlands in the vicinity of the policy site, measured as the number of hectares of other wetland within a 50 km radius of the wetland. The estimated coefficient on this explanatory variable is negative (-0.125) indicating that as the abundance of other wetlands increases the unit value of the policy site wetland will decline; or conversely that as the scarcity of other wetlands increases the value of the policy site wetland will increase.

For the purposes of illustration, we consider the case that wetlands become scarce in the vicinity of our policy site wetland (described in Example Application Box 3). The area of other wetlands within a 50 km radius declines from 8,412 ha to only 1,000 ha. Substituting this new policy site characteristic into the meta-analytic function results in the estimated unit value increasing from 6,188 US$/ha/year to 8,076 US$/ha/year.

4.7 Aggregation and total demand

One of the key steps in any value transfer application is to aggregate transferred unit values for the ecosystem service (e.g. US$ per household, US$ per hectare) across the relevant number of those units at the policy site to obtain a total value for the change in ecosystem service provision. Much of the focus of the preceding section has been on obtaining valid unit values but identifying the appropriate number of units for the aggregation is of at least equal importance.

For value transfers that use values per beneficiary, this involves identifying the appropriate populations of beneficiaries, 'market size' or 'economic constituency' for the ecosystem service in question. In other words, how many individuals or households hold values for the ecosystem service and are affected by the change in provision. Defining the relevant market size for an ecosystem service at a policy site can be challenging and may require further analysis of the policy site and its surrounding population. Often the market size used in value transfer applications is identified as a political jurisdiction or census district for which population data is readily available. This approach is convenient but unlikely to be valid since there is no obvious correspondence between political jurisdiction and the use of ecosystem services. For some ecosystem services, such as recreational use of ecosystems, it may be possible to use existing information on visitation rates to natural areas to estimate the number of beneficiaries to a specific policy site given information on distances to population centres and the availability of substitute sites (see Example Application Box 3).

For value transfers that use values per unit of ecosystem area, it is important to identify the relevant area over which to aggregate unit values. For example, this might be the area of a forest converted to agricultural land or the area of restored wetland in a floodplain. Generally most policy decisions will result in relatively small or marginal changes to the area of ecosystems. Very rarely will a policy decision consider the total loss of an ecosystem. It is therefore necessary, and more useful to the decision maker, to identify and value the specific area that is impacted by the policy decision. This information may be obtained from technical reports, inputs from experts, or through stakeholder consultation.

Example Application Box 8: Estimating the number of ecosystem service beneficiaries

The use of ecosystems for outdoor recreation is one of the major leisure activities in the United Kingdom. As part of the UK National Ecosystem Assessment, this study developed a methodology for predicting outdoor recreation visits and values for different ecosystems. To predict the number of recreational visits to different ecosystems, data on the origin and destination characteristics of recreation sites are combined with survey information from over 40,000 households to estimate a trip generation function. A meta-analysis of relevant recreation valuation studies is used to estimate a value function for recreation visits. The trip generation function and meta-analysis are then used in combination to predict the number of recreational visits to ecosystem and their value.

For illustrative purposes the study considers the conversion of 100 ha of agricultural land near the town of Northampton into open access woodland. The increase in the number of predicted visits to the new woodland is approximately 215,000 per annum for which the meta-analytic value function predicts an ecosystem-specific average value of £3.34 per visitor per trip, yielding a gain in recreation value of roughly £0.71 million per annum. However, the new site draws nearly 32,000 visits away from other local sites, most of which are a mix of urban fringe farmland, floodplain and grasslands for which we estimate an average value of £2.91 per trip. Adjusting for this decrease in the use of substitute ecosystems suggests that the new woodland generates a net increase in recreational value of approximately £0.62 million per annum.

This case study is based on the analysis presented in Sen et al. (2013).

4.8 Scaling up values across large geographic areas

The currently available information on the value of ecosystem services is mostly for relatively small spatial scales (e.g. individual ecosystems). Assessments of changes in ecosystem service provision at larger geographic scales, e.g. national level reporting of ecosystem services, require the “scaling-up” of value information. The term “scaling up” is used to describe the transfer and aggregation of values that have been estimated for localised changes in individual ecosystem sites to assess the value of simultaneous changes in multiple ecosystem sites within a large geographic area (e.g. country or region). Scaling-up ecosystem service values is relevant for their incorporation into national accounts.

At the level of individual ecosystem sites, marginal unit values for ecosystem services are likely to vary with the characteristics of the ecosystem site (area, integrity, and type of ecosystem), beneficiaries (number, income, preferences), and context (availability of substitute and complementary sites and services). As described in the preceding sections, the transfer of values to an individual ecosystem site needs to account for variation in these characteristics between study sites and the policy site. Localised changes in the extent of an individual ecosystem may be adequately evaluated in isolation from the rest of the stock of the resource, which is effectively assumed to be constant.

When valuing simultaneous changes in multiple ecosystem sites within a region, however, it is not sufficient to estimate the value of individual ecosystem sites and aggregate them without accounting for the changes that are occurring across the stock of the resource. As an environmental resource becomes scarcer, its marginal value will tend to increase. This means that multiplying a constant marginal value by the change in area of an ecosystem site, as is often done in scaling up exercises, is likely to underestimate the value of the change. Brander et al. (2012) provide a methodology to specifically address the challenge of scaling up ecosystem service values.

4.9 Value mapping

The economic value of an ecosystem service is, as with any good or service, determined by its supply and demand. The supply side of an ecosystem service is largely determined by ecological processes and characteristics (e.g., functioning, fragmentation, productivity, resilience or climate) that may be influenced by human activities, either deliberately or inadvertently. The demand side is largely determined by the characteristics of human beneficiaries of the ecosystem services (population, preferences, distance to the ecosystem etc.). It should be recognised that the determinants of both the supply and demand of ecosystem services are spatially variable, which makes the assessment of ecosystem service values inherently spatial. Value mapping addresses this spatial dimension of ecosystem service valuation. Ecosystem service value mapping can be defined as the valuation of ecosystem services in monetary terms across a relatively large geographical area that includes the examination of how values vary across space. It therefore includes not only studies that produce graphical value maps but also analyses that explicitly address spatial variability in values.

Value mapping thereby reveals additional information as compared to conventional site-specific ecosystem service valuation, which is potentially useful for designing effective policies and institutions for maintaining ecosystem service supply. Besides communication and visualisation, value mapping makes site specific ecosystem service values available on a large spatial scale. Thereby, spatially explicit ecosystem service value maps have specific advantages for several policy applications including green accounting, land use policy evaluation, conservation planning and payments for ecosystem services.

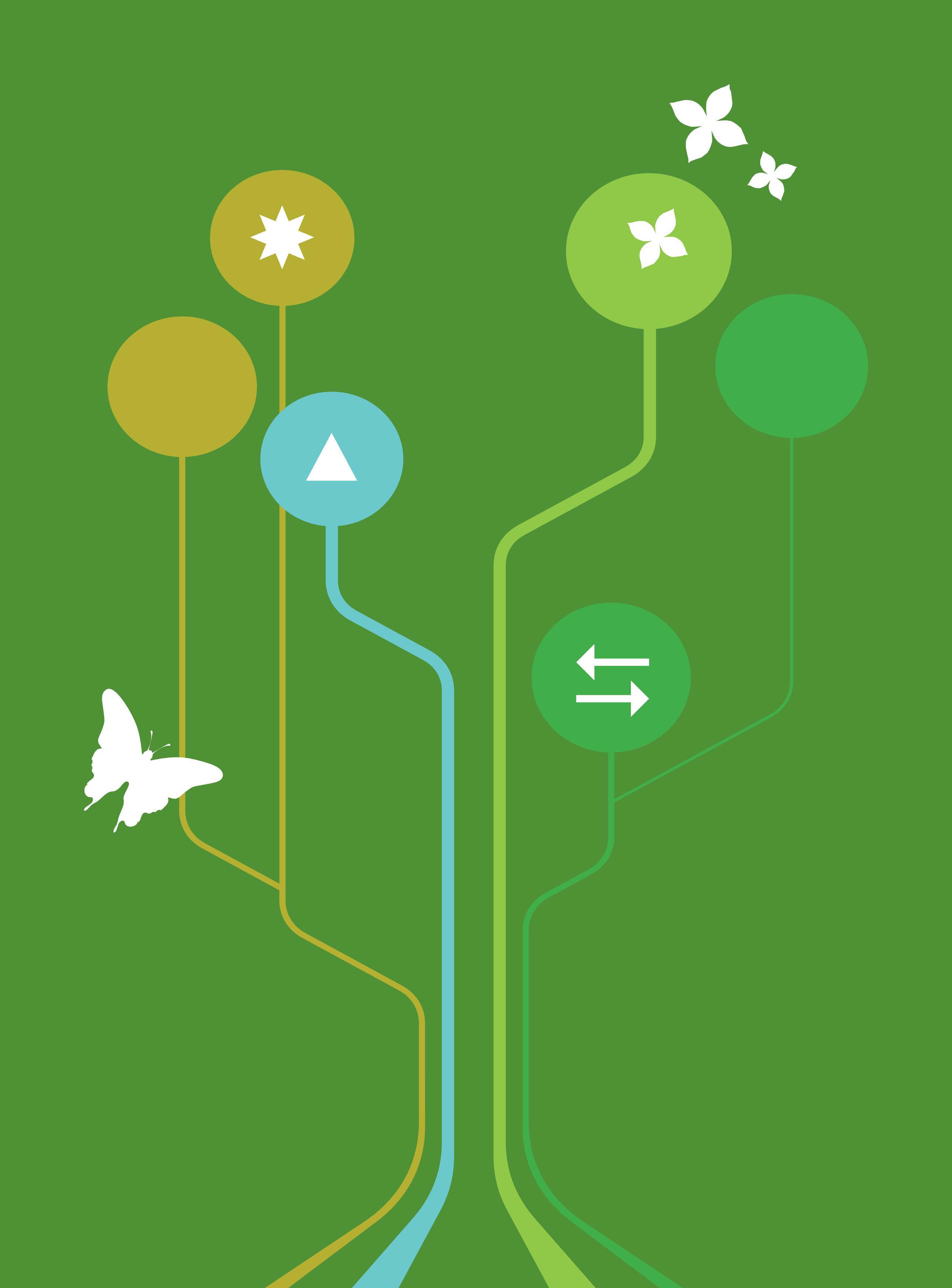
Mapping ecosystem service values involves two dimensions: a biophysical assessment of ecosystem service supply; and a socioeconomic assessment of the value per unit of ecosystem service. A value mapping application can map spatial variations of ecosystem service supply, value per unit of ecosystem service, or a combination of both dimensions.

Methodologies used for mapping ecosystem service supply can be divided into five main categories: (1) one-dimensional proxies for ecosystem services, such as land cover or land use, (2) non-validated models: ecological production functions (or models) based on likely causal combinations of explanatory variables, which are grounded on researcher or expert

assumptions, (3) validated models: ecological production functions, which are calibrated based on primary or secondary data on ecosystem service supply, (4) representative samples of the study area: data on ecosystem service supply that is collected for the specific study area, and (5) implicit modelling of ecosystem service supply within a value transfer function, i.e. the quantity of ecosystem service supply is modelled within the valuation of the ecosystem service.

Methodologies for mapping spatial variation in ecosystem service values are the value transfer methods described in detail in Section 3.

The technical implementation of value mapping is complex and beyond the scope of this manual but references to specialised guidelines are provided in Section 7.1.



5. Dealing with uncertainty

For a number of reasons the valuation of ecosystem services using value transfer cannot be conducted with complete certainty. This section explains the sources of uncertainty in value transfer, how to assess and communicate uncertainty, and discusses to what extent uncertain valuation estimates are useful for decision making.

5.1 Sources of uncertainty in value transfer

For a number of reasons, ecosystem service values estimated using value transfer methods may be inaccurate. In other words, transferred values may differ significantly from the actual value of the ecosystem service under consideration. The sources of uncertainty in the values estimated using value transfer are:

1. Primary value estimates used in value transfer are themselves uncertain. Inaccuracies in primary valuation estimates may result from weak methodologies, unreliable data, analyst errors, and the whole range of biases and inaccuracies associated with primary valuation methods.

2. The available stock of information on ecosystem service values may be unrepresentative due to the processes through which primary valuation study sites are selected and results are disseminated, which can be biased towards certain locations, services, methods and findings.

3. The number of reliable primary valuation results may be limited, particularly for certain services, ecosystems and regions. As the number and breadth of high quality primary valuations increases, the scope for reliable value transfer also increases. For some ecosystem services and regions there are now many good quality value estimates available whereas for others there are still relatively few.

4. The process of transferring study site values to policy sites can also potentially result in inaccurate value estimates. So-called 'generalisation error' occurs when values for study sites are transferred to policy sites that are different without fully accounting for those differences. Such differences may be in terms of beneficiary characteristics (income, culture, demographics, education etc.) or biophysical characteristics (quantity and/or quality of the ecosystem service, availability of substitutes, accessibility etc.). The availability of study sites that are closely similar to policy site and/or the value transfer methods used to control for differences will determine the magnitude of generalisation error.

5. There may also be a temporal source of generalisation error since preferences and values for ecosystem services may not remain constant over time. A value function that is able to predict current values well may not perform as well in predicting future values.

5.2 Assessing and communicating uncertainty

The magnitude of uncertainties needs to be quantified and communicated in order to provide an understanding of the robustness of the value information provided. Decision makers can then assess whether the information is sufficiently precise to be considered in making the decision. A balance has to be struck between presenting too little information on the level of uncertainty (e.g. giving the impression of high certainty for a central estimate) and too much information that cannot be taken in (e.g. a table of results for an extensive sensitivity analysis).

Alternative ways to quantify and communicate uncertainties in value transfer include:

1. **Ranges of values**. In cases where multiple primary value estimates are available for the ecosystem service under consideration, the range of values can be presented to give an impression of the variability of unit value estimates.

2. **Distribution of values**. In order to give a more complete picture of the distribution of value estimates, information on the average, median and standard error of the average value can be presented (in addition to information on the range of values). Minimum and maximum values may be 'outliers' and not necessarily representative of the likely values of the ecosystem service.

3. **Confidence intervals**. A confidence interval is an estimated range of values which is likely to include the actual value. The estimated range is calculated from the set of sample data on the ecosystem service value under consideration. Confidence intervals are usually expressed as a range of values within which the actual value lies with a given confidence level or probability.

4. **Sensitivity analysis**. A sensitivity analysis can be used to show how estimated ecosystem service values change as value function parameters, data inputs and assumptions change. A sensitivity analysis involves systematically varying (within plausible ranges) the uncertain inputs to a model to assess how sensitive the results are to those changes. Joint sensitivity analysis (varying more than one parameter at a time) is sometimes also useful if possible changes in parameters are not independent of each other. In this case, scenarios can be developed that describe how multiple parameters might change in combination.

5. **Transfer errors**. The percentage difference between the actual value and the transferred value is called the 'transfer error'.
   The formula for calculating transfer error is:

   Transfer error = (predicted value - observed value) / observed value **Equation 5**

For example, a transfer error of 50% means that the predicted value is 50% higher or lower than the observed value at the policy site). Assessments of transfer errors show the difference between the transferred value and the actual value of the ES. Since in most cases the actual value is unknown, it is generally not possible to compute transfer errors (indeed if we knew the actual value we wouldn't need to use value transfer). Nevertheless, studies that do examine transfer errors (i.e. compare primary and transferred values) provide an indication of how accurate value transfer is in general.

5.3 Acceptable levels of uncertainty for decision making

It is evident that in almost all cases the value of ecosystem services will not be estimated with complete certainty. The question therefore becomes, how much uncertainty is too much? Assessments of the 'size' of uncertainty are important but require careful interpretation and are not comparable across contexts. Arguably the simplest and most general answer to this question is that the degree of uncertainty becomes unacceptable when a valuation estimate no longer provides information that enables better decisions to be made. For example, if the level of uncertainty is such that the analyst or decision maker can still tell whether, say, benefits (with uncertainty) are still clearly larger or smaller than costs, then that information helps the decision and the level of uncertainty is acceptable.

Different decision making contexts may require different levels of certainty regarding the information that they use. For example, the use of value information for raising general awareness of the importance of ecosystem services arguably does not need to be as accurate as valuation information used in litigation for compensation of damages to ecosystems. A general ordering of decision contexts with respect to their required level of accuracy for value information is represented in Figure 4.

The uncertainty of value transfers and the accuracy requirement of each decision making context should be assessed to determine whether value transfer can provide sufficiently accurate information. In the case that value transfer is judged to be insufficiently accurate, it is advisable to conduct primary valuations of ecosystem services, if resources (data, time, expertise, knowledge) are available.

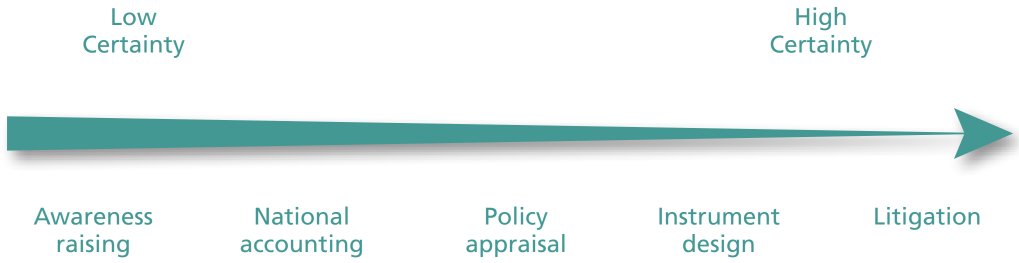


Figure 4. Value certainty requirements for different applications of value information (adapted from Eftec, 2009)

6. Communication of results and policy influence

The purpose of conducting economic valuation of ecosystem services is to inform and improve decision making regarding the management of the environment. So any value transfer application should be designed to provide value information that is directly useful and understandable to the decision makers involved. In a review of economic valuations of coastal resources in the Caribbean, the World Resources Institute identify the following key contextual, procedural, and methodological conditions that determine policy influence (Kushner et al., 2012)[7]:

- Local demand for information on economic values
- A clear policy question
- Strong local partnerships
- Access to decision-makers
- Good governance with high transparency
- Study areas with a high dependence on environmental resources

Not all of these factors can be controlled in the process of conducting a value transfer study. This section provides guidance on enabling policy influence through stakeholder engagement and communication of results.

6.1 Stakeholder engagement

Best practice in economic valuation of ecosystem services encourages the identification and engagement of stakeholders. Stakeholders are people, groups or institutions that are affected by or can affect a project or decision. The first step in engaging stakeholders is

[7] http://www.wri.org/publication/influence-of-coastal-economic-valuations-in-caribbean

to identify who they are by considering which groups are directly involved in a particular decision and which groups are likely to be affected. Identifying relevant stakeholders can be an iterative process and additional groups can be involved as the study progresses. Given limited resources and time, which are typical characteristics of a value transfer application, it is unlikely to be possible to engage all stakeholders so it is necessary to identify key representative groups that can provide inputs and use the information produced.

Stakeholder engagement in a value transfer application may take several forms and occur at different stages of the process. Engagement at the initial stage can be useful to frame the value transfer (e.g., type of information required, relevance of different ecosystem services, geographic scope, identification of beneficiaries) and build interest in the results. Stakeholders may also be useful during the analysis stage regarding information sources for the policy site, assessing the distribution of values, and validating results. Finally, the clear communication of results to stakeholders is crucial for the information to be accepted and taken up in decision making.

6.2 Communication of results

Making the results of a value transfer accessible to the different stakeholders that use the information requires different types of communications strategies, different messages and different ways of presenting information. The main steps that should be part of a communication plan are:

Step 1. Identify the **audience**(s) for the information produced and determine what is of interest to them. What is the "hook" for the audience? The stakeholder engagement process is useful for this. Different audiences may have different interests and be receptive to different messages and information formats/channels.

Step 2. Identify and formulate the **main message** that you want to convey. Keep it simple and do not try to be too comprehensive in reporting all results from an analysis. It is better to get across one message that sticks than five messages that are lost. It is important to recognise that the main message is generally in the interpretation or implication of the valuation, not the value estimate itself. Value estimates are the evidence that help support a particular case or argument.

Step 3. Select the **tools** to communicate the message to the audience. This includes the choice of statistics, indicators and visual representation (e.g. maps, illustrations, diagrams, pictures, charts, graphs, tables) and the materials for communication (e.g., reports, policy briefs, films, media coverage). It is generally useful to communicate results through multiple avenues. Technical reports are necessary to ensure that all sources and analyses are well documented but are generally not widely read. Executive summaries, synthesis reports and policy briefs that distil the main results and message into one or two pages are more accessible and effective in disseminating information. For such communication materials it is important to use suitable language and avoid using jargon of technical terminology.

7. Available resources

Value transfer requires information from existing studies on the economic value of ecosystem services. There are a number of useful resources and databases that summarise existing value information that can be used as a basis for conducting value transfer. This section provides an overview of specialised guidelines and manuals on valuation of ecosystem services; databases of value estimates; and published meta-analyses on ecosystem service values for forests and wetlands.

7.1 Specialised guidelines and manuals

There are a number of useful publications and manuals that provide guidance on specific topics and methods that are of relevance to value transfer for the economic assessment of ecosystem services. A selection of these resources is listed below according to the topic that they address.

Value transfer

- *Measuring the Economic Benefits of Water Quality Improvement with Benefit Transfer: An Introduction for Non-Economists*. (2005). By Dumas, C.F., Schuhmann, P.W., and Whitehead J.C. American Fisheries Society Symposium. www.appstate.edu/~whiteheadjc/eco3660/dumas.pdf

- *Practical tools for value transfer in Denmark – guidelines and an example*. (2007). By Navrud, S. Working Report No. 28, Danish Environmental Protection Agency, Copenhagen. www2.mst.dk/udgiv/publications/2007/978-87-7052-656-2/pdf/978-87-7052-657-9.pdf

- *Environmental value transfer: issues and methods* (2007). By Navrud, S. and Ready, R. Dordrecht, Springer.

- *Valuing Environmental Impacts: Practical Guidelines for the Use of Value Transfer in Policy and Project Appraisal* (2010). By Economics for the Environment Consultancy (Eftec) for Department for Environment, Food and Rural Affairs, London. www.gov.uk/government/uploads/system/uploads/attachment_data/file/182376/vt-guidelines.pdf

- *Scaling up ecosystem benefits* (2010). By European Environment Agency. EEA Technical Report 4/2010, Copenhagen. www.eea.europa.eu/publications/scaling-up-ecosystem-benefits-a/download

- *Improving the use of environmental valuation in policy appraisal: A Value Transfer Strategy* (2010). Department for Environment, Food and Rural Affairs; Environment Agency; Natural England; and Forestry Commission. http://archive.defra.gov.uk/environment/policy/natural-environ/documents/value-transfer-strategy.pdf

- *Benefit transfer of outdoor recreation use values* (2001). Rosenberger, R. S. and Loomis,
  J.B. U.S. Department of Agriculture Forest Service.
  http://coastalsocioeconomics.noaa.gov/core/bibsbt/benefits_transfer_guide.pdf

Primary valuation

- *Economic Valuation with Stated Preference Techniques Summary Guide* (2002).
  By Pearce, D. et al. for Department of Transport, Local
  Government and Regions, London.

- *The Measurement of Environmental and Resource Values* (2003).
  By Freeman, A.M.I.; Resources for the Future, Washington D.C.

- *Economic Valuation of Wetlands: A Guide for Policy Makers and Planners* (1997).
  By Barbier, E., Acreman, M., and Knowler, D.; Ramsar Convention Bureau,
  Gland, Switzerland. http://www.ramsar.org/pdf/lib/lib_valuation_e.pdf

- *Economic Valuation of Environmental and Resource Costs and Benefits in the Water Framework Directive: Technical Guidelines for Practitioners* (2009).
  By Brouwer, R. et al.; AquaMoney.

- *Handbook on Biodiversity Valuation* (2002).
  Organisation for Economic Cooperation and Development, Paris.
  http://earthmind.net/rivers/docs/oecd-handbook-biodiversity-valuation.pdf

- *Guidance for policy and decision makers on using an ecosystems approach and valuing ecosystem services*. www.gov.uk/ecosystems-services

- *An introductory guide to valuing ecosystem services* (2007).
  Department for Environment, Food and Rural Affairs (Defra).
  www.gov.uk/government/uploads/system/uploads/attachment_
  data/file/69192/pb12852-eco-valuing-071205.pdf

- *An instrument for assessing the quality of environmental valuation studies* (2006).
  Swedish Environmental Protection Agency.
  www.naturvardsverket.se/Documents/publikationer/620-1252-5.pdf

- *The Economic Valuation of Mangroves: A Manual for Researchers* (2003)
  By Bann, C. Environmental Economics Programme for South East Asia (EEPSEA).
  http://network.idrc.ca/uploads/user-S/10305674900acf30c.html

- *The Economic Valuation of Tropical Forest Land Use Options: A Manual for Researchers* (2002) By Bann, C.; Environmental Economics Programme for South East Asia (EEPSEA). www.idrc.ca/uploads/user-S/10916232241spcbann1.pdf

Mapping and biophysical assessment

- *Mapping and Assessment of Ecosystems and their Services* (2013). Maes, J., et al.; European Union. http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/MAESWorkingPaper2013.pdf

- *Integrated Valuation of Ecosystem Services and Tradeoffs* – InVEST. Natural Capital Project. www.naturalcapitalproject.org/InVEST.html

- *Artificial Intelligence for Ecosystem Services* – ARIES. http://www.ariesonline.org/

7.2 Value databases

There are a number of good databases of primary valuation studies available online. These are listed in the table below together with an indication of the region that they cover and the web address.

Table 4. Databases of primary valuation estimates

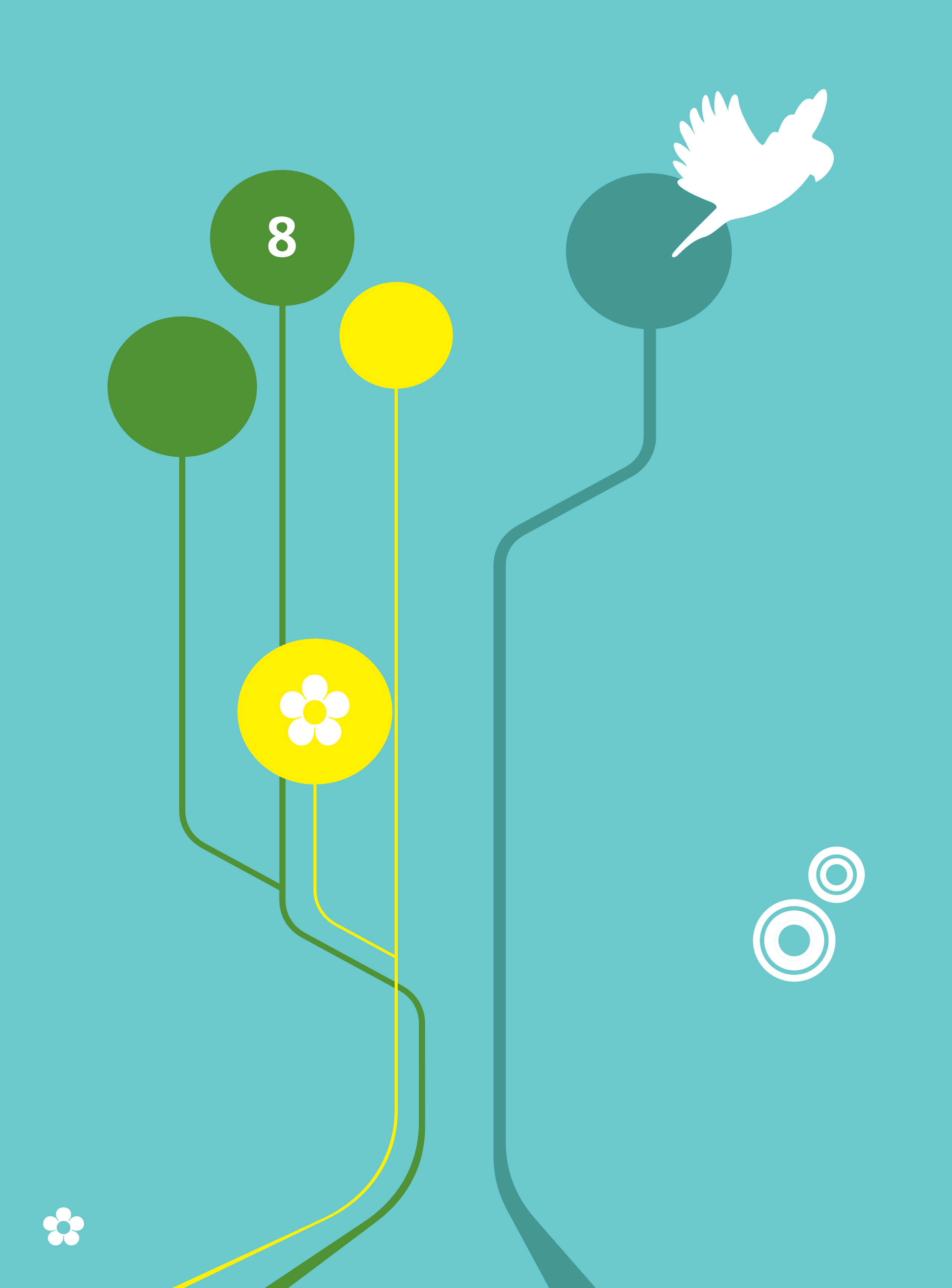
Database	*Region*	*Website*
ASEAN TEEB Valuation Database	Southeast Asia	http://lukebrander.com/
CaseBase	All	www.fsd.nl/naturevaluation/73766/5/0/30
ConsValMap	All	www.consvalmap.org
Ecosystem Service Valuation Database (ESVD)	All	www.es-partnership.org/esp/80763/5/0/50
Ecosystem Services Project Database	All	www.naturalcapitalproject.org/database.html
Ecosystem Valuation Toolkit	All	www.esvaluation.org/gap_analysis.php
Envalue	US and Australia	www.environment.nsw.gov.au/envalueapp/
Environmental Valuation Reference Inventory (EVRI)	All	www.evri.ca/Global/Splash.aspx
Marine Ecosystem Services Partnership Library	All	www.marineecosystemservices.org/explore
National Ocean Economics Program (NOEP)	All	www.oceaneconomics.org/nonmarket/NMsearch2.asp
Non-market Valuation Database	New Zealand	www2.lincoln.ac.nz/nonmarketvaluation/
ValueBaseSwe	Sweden	www.beijer.kva.se/valuebase.htm

7.3 Meta-analyses of forest and wetland values

Published meta-analyses of ecosystem service values for forests and wetlands are listed in Table 5.

Table 5. Meta-analyses of ecosystem service values for forests and wetlands.

Reference	*Ecosystem*	*Ecosystem service*
Barrio and Loureiro (2010)	Forests	All
Chiabai et al. (2011)	Forests	Recreation, non-use values
Lindhjem and Navrud (2007)	Forests	Non-timber benefits
Ojea et al. (2010)	Forests	Provisioning, regulating, cultural
Zandersen and Tol (2009)	Forests	Recreation
Brander et al. (2012)	Mangroves	Coastal protection, fisheries
Salem and Mercer (2012)	Mangroves	Fisheries, forestry, recreation
Brander et al. (2006)	Wetlands	All
Brander et al. (2012)	Wetlands	All
Brander et al. (2013)	Wetlands	Regulating services
Brouwer et al. (1999)	Wetlands	All
Ghermandi et al. (2010)	Wetlands	All
Woodward and Wui (2001)	Wetlands	All
Bateman and Jones (2003)	Woodland	Recreation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8. References

Bann, C. (2002). ***The economic valuation of tropical forest land use options: A manual for researchers.*** Environmental Economics Programme for South East Asia (EEPSEA).

Bann, C. (2003). ***The economic valuation of mangroves: A manual for researchers***. Environmental Economics Programme for South East Asia (EEPSEA).

Barbier, E., Acreman, M., and Knowler, D. (1997). ***Economic valuation of wetlands: A guide for policy makers and planners***. Ramsar Convention Bureau, Gland, Switzerland.

Barrio, M. and Loureiro, M.L. (2010). ***A meta-analysis of contingent valuation forest studies***. Ecological Economics 69: 1023-1030.

Bateman, I.J. and Jones, A.P. (2003). ***Contrasting conventional with multi-level modeling approaches to meta-analysis: expectation consistency in U.K. woodland recreation values***. Land Economics 79: 235–258.

Bateman, I.J., Brouwer, R., Ferrini, S., Schaafsma, M., Barton, D.N., Dubgaard, A., Hasler, B., Hime, S., Liekens, I., Navrud, S., De Nocker, L., Sceponaviciute, R., and Semeniene, D. (2011). ***Making benefit transfers work: Deriving and testing principles for value transfers for similar and dissimilar sites using a case study of the non-market benefits of water quality improvements across Europe***. Environmental and Resource Economics. DOI: 10.1007/s10640 -011-9476-8.

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Brander, L.M., Florax, J.G.M. & Vermaat, J.E. (2006). ***The empirics of wetland valuation: A comprehensive summary and meta-analysis of the literature***. Environmental and Resource Economics, 33 (2), 223-250.

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EEA (2010). ***Scaling up ecosystem benefits – Assessing large-scale ecosystem services with primary data*** – EEA Technical Report 2010, Copenhagen.

Eftec (2009). ***Valuing environmental impacts: Practical guidelines for the use of value transfer in policy and project appraisal***. Department for Environment, Food and Rural Affairs, London.

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Freeman, A.M.I. (2003). ***The measurement of environmental and resource values***. Resources For The Future, Washington D.C.

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Lindhjem, H. (2007). ***20 years of stated preference valuation of non-timber benefits from Fennoscandian forests: A meta-analysis***. Journal of Forest Economics, 12: 251–277. doi:10.1016/j.jfe.2006.09.003.

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Zanderson M. and Tol R.S.J. (2009). ***A meta-analysis of forest recreation values in Europe***. Journal of Forest Economics 15: 109-130.

9. Glossary of terms

Adjusted unit transfer: The transfer of a unit value for an ecosystem service at a study site that is adjusted to account for some factor (or factors) to estimate the value of at a policy site.

Baseline: The starting point from which the impact of a policy or investment is assessed. In the context of ecosystem service valuation, the baseline is a description of the level of ecosystem service provision in the absence of the policy or investment under consideration. The baseline describes both the current and future provision in the absence of the policy.

Benefits transfer: see 'Value Transfer'.

Beneficiary: A person that benefits from the provision of ecosystem system services.

Choice Experiment: A stated preference valuation method in which values are inferred from the hypothetical choices or trade-offs that people make between different combinations of attributes of a good.

Choice Modelling: see 'Choice Experiment'.

Consumer Surplus: The difference between what consumers are willing to pay for a good and its price. A measure of the benefit that consumers derive from consumption of a good at a given quantity and price.

Contingent Valuation (CV): A stated preference valuation technique that elicits respondents' willingness-to-pay for specified changes in the quantity or quality of an ecosystem service, in the hypothetical situation that it would be available for purchase or sale.

Cost-Benefit Analysis (CBA): An evaluation method which assesses the economic efficiency of policies, projects or investments by comparing their costs and benefits.

Cost-Effectiveness Analysis (CEA): An evaluation method that assesses the desirability of alternative policies, projects or investments by computing the cost of attaining a specified objective.

Damage cost avoided valuation method: A cost based valuation technique that estimates the value of an ecosystem by calculating the damage that is avoided to infrastructure, property and people by the presence of ecosystems.

Dependent variable: In a statistical equation, the dependent variable is explained by variation in a set of independent or explanatory variables.

Direct use value: The value derived from direct use of an ecosystem, including provisioning and recreational ecosystem services.

Discounting: The process of calculating the present value of a future stream of benefits or costs. Discounting reflects individuals' or society's time preference and/or the productive use of capital. The formula for discounting or calculating present value is: present value = future value/(1+r)n, where r is the discount rate and n is the number of years in the future in which the cost or benefit occurs.

Discount rate: The rate used to determine the present value of a future stream of costs and benefits.

Economic value: The monetary measure of the wellbeing associated with the consumption of an ecosystem service. For market goods this is ordinarily measured by market price; for non-market goods this ordinarily measured by willingness to pay (WTP) or willingness to accept (WTA).

Ecosystem: An ecosystem is a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

Ecosystem services (ES): The benefits that ecosystems provide to people.

Ecosystem service approach: A framework for analysing how human welfare is affected by the condition of the natural environment.

Evaluation: An ex ante or ex post assessment of the overall impact of a policy or investment.

Existence value: The value that people attach to the continued existence of an ecosystem, unrelated to any current or potential future use.

GDP deflator: A measure of general inflation in the domestic economy.

GDP deflator: A measure of general inflation in the domestic economy. Inflation is a rise in general prices over time.

Generalisation error: The inaccuracy of value transfer estimates that occurs when values for study sites are transferred to policy sites that are different without fully accounting for those differences.

Geographic Information Systems (GIS): An information system that captures, stores, manages, analyses and presents data that is linked to a geographic location.

Green accounting: The inclusion of information on environmental goods and services and/or natural capital in national accounts.

Hedonic Pricing: A revealed preference valuation method that values ecosystem services as attributes of other marketed goods and services, for example residential property.

Indirect use value: The value of ecosystems services that contribute to human welfare without direct contact with the elements of the ecosystem, for example regulating services.

Inflation: A general rise in prices of goods and services; and consequentially the decline in purchasing power.

Marginal Cost: The change in cost associated with producing one additional unit of a good or service.

Marginal Value: The change in value resulting from an incremental change (one additional unit) in the quantity of an ecosystem service produced or consumed.

Market Price valuation method: A valuation method that uses the market price of ecosystem services.

Meta-analysis: Meta-analysis is a statistical method of combining valuation estimates from multiple studies that allows the analyst to systematically explore variation in existing value estimates and its determinants.

Multi-criteria analysis: An evaluation method that standardises and weights different types of monetary and non-monetary information.

Net factor income valuation method: Estimates the value of an ecosystem input in the production of a marketed good as the total surplus between revenues and the cost of other inputs in production.

Net Present Value (NPV): A measure of project desirability or economic efficiency. It is computed as the difference between the present value of benefits and the present value of costs.

Non-use value: The value that people gain from an ecosystem that is not based on the direct or indirect human use of the resource. Non-use values may include existence values, bequest values and altruistic values.

Opportunity Cost: The value to the economy of a good, service or resource in its next best alternative use.

Option values: The premium placed on maintaining environmental or natural resources for possible future uses, over and above the direct or indirect value of these uses.

Primary valuation: Valuation methods and studies that produce a new or original value estimate for a specific ecosystem.

Production function valuation method: Estimates the value of a non-marketed ecosystem product or service by assessing its contribution as an input into the production process of a commercially marketed good.

Purchasing power parity (PPP): An indicator of price level differences across countries.

Purchasing power parity adjusted exchange rate: An exchange rate that equalizes the purchasing power of two currencies in their home countries for a given basket of goods.

Public Good: A good or service for which consumption is non-rival and non-excludable. The consumption of the good by one individual does not reduce the availability of the good for consumption by others, and that no one can be effectively excluded from using the good.

Regression analysis: A statistical method to empirically estimate the relationship between a dependent variable and specified independent (explanatory) variables.

Regulating services: A category of ecosystem services that refers to the benefits obtained from the regulation of ecosystem processes. Examples include water flow regulation, carbon sequestration and protection from storms.

Replacement Cost valuation method: A valuation method that estimates ecosystem values by determining the cost of replacing its services with man-made alternatives.

Revealed preference valuation methods: A group of economic valuation methods that estimate the value of non-market goods and services using data on observed behaviour is related markets. Revealed preference methods include the travel cost and hedonic pricing methods.

Scenario: A description of the future that might potentially arise under certain assumptions and conditions.

Stakeholder: A person, group or institution that is affected by or can affect a project or a decision.

Stakeholder analysis: The process of identifying and engaging stakeholders and assessing the impacts of a policy or project on them.

Stakeholder engagement: Methods used to involve stakeholders in a deliberative or consultative process regarding a policy or project.

Stated Preference methods: A group of valuation techniques that involve asking individuals to state their value or preference for specific ecosystem services through public surveys.

Supporting services: A category of ecosystem services that are necessary for the production of all other ecosystem services. Examples include nutrient cycling, soil formation and primary production.

Total Economic Value (TEV): The sum of all marketed and non-marketed benefits associated with an ecosystem, including direct, indirect, option and non-use values.

Travel Cost valuation method: A revealed preference valuation technique that uses data on the travel costs that people incur to visit an ecosystem to estimate the consumer surplus that they attain from accessing it (usually for recreational purposes).

Transfer error: A measure of the accuracy of value transfer. It is computed as the percentage difference between the actual value of an ecosystem service and the transferred value (e.g., a transfer error of 50% means that the transferred value is 50% higher or lower than the actual value at the policy site).

Triple bottom line: In conventional business accounting, the "bottom line" refers to the sum of financial revenues minus financial costs, i.e. profit. Triple bottom line accounting includes measures of environmental and social benefits and costs.

Unit value transfer: An approach to value transfer that involves taking the unit value (e.g. US$ per person, US$ per hectare) for a study site and multiplying it by the number of relevant units at the policy site.

Use value: Economic value derived from the human use of an ecosystem. It is the sum of direct use, indirect use and option values.

Valuation: The process or practice of estimating monetary values for ecosystem services.

Value transfer: The estimation of economic values for ecosystem services by transferring value information from existing studies for one location (the study site) to another (the policy site). This is also called 'benefit transfer'.

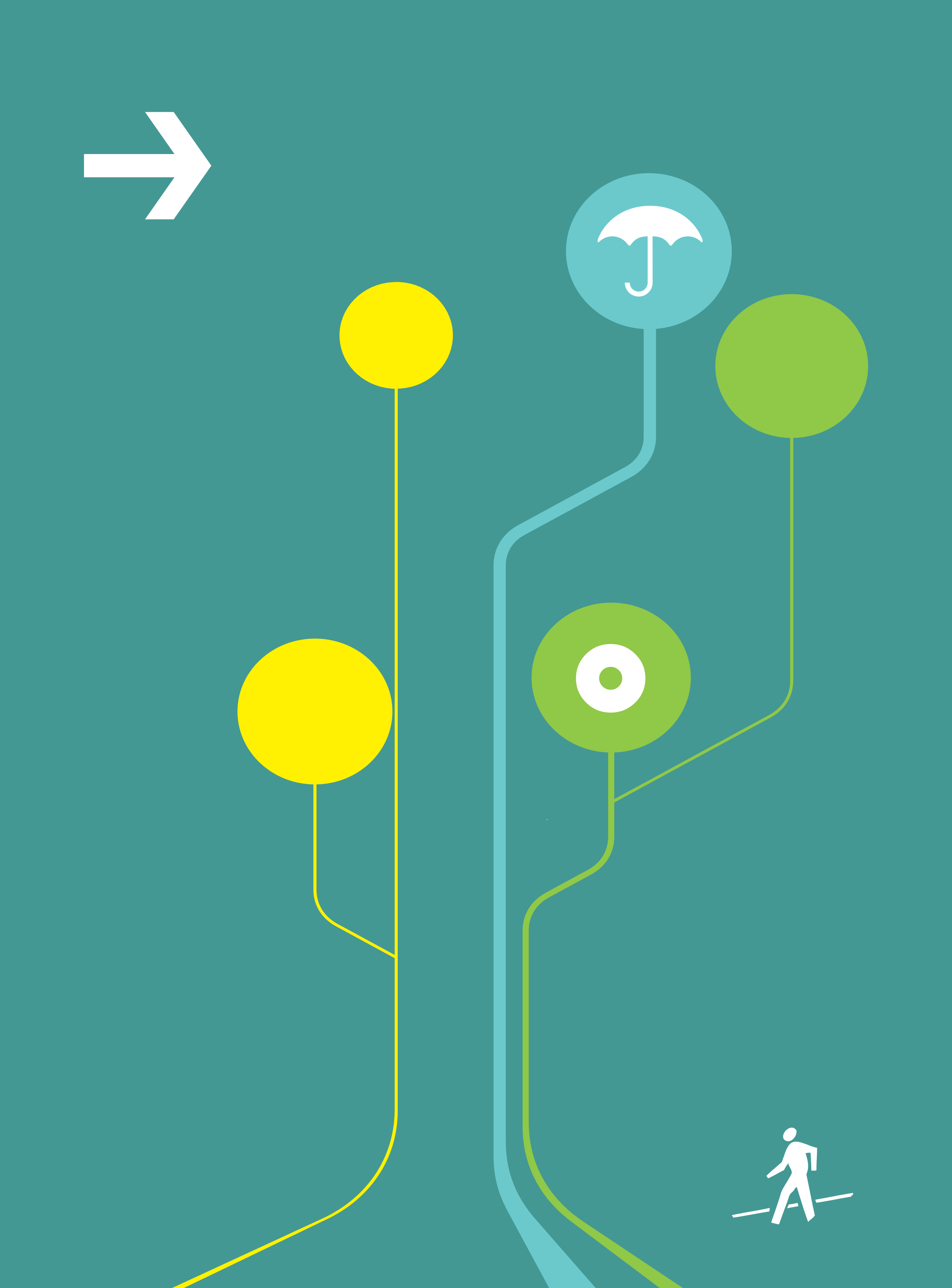
Value function: An equation that relates the value of an ecosystem service to the characteristics of the ecosystem and the beneficiaries of the ecosystem service. Value functions can be estimated using a number of primary valuation methods (including hedonic pricing, travel cost, production function, contingent valuation and choice experiments) and through meta-analyses of valuation studies.

Value function transfer approach: An approach to value transfer that uses a value function estimated for an individual study site in conjunction with information on parameter values for the policy site to calculate the value of an ecosystem service at the policy site.

Welfare: A measure of human satisfaction or utility generated from the consumption of an ecosystem service.

Willingness to accept (WTA): The minimum amount of money an individual requires as compensation in order to forego a good or service.

Willingness to pay (WTP): The maximum amount of money an individual would pay in order to obtain a good or service.



Appendix I: Definitions of economic value

This appendix provides definitions of the various concepts of economic value that may be encountered when conducting economic valuation and value transfer studies.

In neo-classical welfare economics, the economic value of a good or service is the monetary measure of the wellbeing associated with its production and consumption. The economic value of a good or service is determined by the demand for and supply of that good or service in a perfectly functioning market. This is illustrated in Figure A1. This figure shows a demand and a supply curve for a good traded in a market at quantity ‘Q’ and at price ‘P’. The demand and supply curves are assumed to be linear for the purpose of this illustration, but this will not normally be the case in practice.

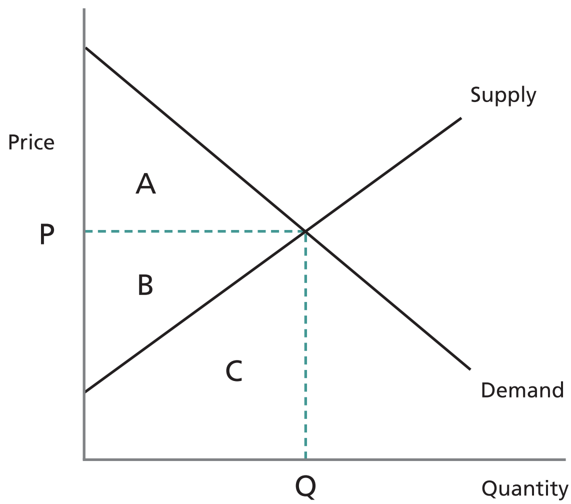


Figure A1. Producer and consumer surplus

In Figure A1, area ‘A’ represents the **consumer surplus**, which is the gain obtained by consumers because they are able to purchase a product at a market price that is less than the highest price they would be willing to pay, which is represented by the demand curve. The **producer surplus**, depicted by ‘B’, is the amount that producers benefit by selling at a market price that is higher than the lowest price that they would be willing to sell for, which is related to their production costs and represented by the supply curve. The area ‘C’ represents production costs, which differ among producers and/or over the scale of production. The sum of areas A and B is labelled the ‘surplus’. The surplus can be seen as the net economic gain resulting from production and consumption with a volume of Q at price P. This corresponds to the definition of **welfare value**.

The market price (P) reflects consumers’ marginal **willingness to pay (WTP)** for one additional unit of the product at the market equilibrium quantity of services Q, or conversely the marginal **willingness to accept (WTA)** one unit fewer. In the case of ecosystem services not traded in a market, alternative approaches to establish a price or marginal willingness to pay for the ecosystem service need to be used (see Appendix II).

The **marginal value** of an ecosystem service is the contribution to wellbeing of one additional unit of the service. It is equivalent to the price of the service in a perfectly functioning market.

The **average value** of an ecosystem service can be calculated as its total value divided by the total quantity of the service provided and consumed.

Using value estimates that are reported in the primary valuation literature we face the challenge of distinguishing between average and marginal values, both of which can be expressed as a monetary value per unit (e.g., US$ per hectare, US$ per cubic meter of water, US$ per visit). Expressing ecosystem service values in terms of a monetary value per unit gives the impression that each unit (whether it is a hectare, cubic meter of water, visit etc.) is equally valuable, i.e., that the ecosystem exhibits constant returns to scale or equivalently that the marginal value and average values are equal and do not vary with quantity . This, however, is unlikely to be the case since both the supply and demand for most services varies with the amount that is provided (represented by the upward sloping supply curve and downward sloping demand curve in figure A1). For example, considering figure A1, when Q units of an ecosystem service are used, the average value is equal to (A+B+C)/Q and is larger than the marginal value (by the amount A/Q).

Small changes in ecosystem service provision should be valued using marginal changes. Average values may be useful for comparing the aggregate value of an ecosystem service relative to the scale of provision (defined in terms of units of provision, area of ecosystem, or number of beneficiaries).

A further distinction within the concept of willingness to pay can be made between two types of welfare measures based on two different points of reference: the **compensating surplus** and the **equivalent surplus**. The former equals the money income adjustment necessary to keep an individual at his initial welfare level before the change in the provision level of the good, while the latter equals the money income adjustment necessary to maintain an individual at his new welfare level after the change in the provision level of the good. Four relevant welfare measures associated with welfare gains and losses can be distinguished:

Willingness to pay to secure a welfare gain (CSWTP)

Willingness to accept to forego a welfare gain (ESWTA)

Willingness to pay to prevent a welfare loss (ESWTP)

Willingness to accept to tolerate a welfare loss (CSWTA)

The WTP measures have become the most frequently applied in economic valuation studies and have been given peer review endorsement, especially because they are constrained by income whereas WTA is not.

The concept of **Total Economic Value (TEV)** of an ecosystem is used to describe the sum of the components of utilitarian value derived from that ecosystem. This concept is useful for identifying the different types of value that may be derived from an ecosystem. TEV comprises of use values and non-use values. Use values are the benefits that are derived from some physical use of the resource. Direct use values may derive from on-site extraction of resources (e.g. fuel wood) or non-consumptive activities (e.g. recreation). Indirect use values are derived from off-site services that are related to the resource (e.g. downstream flood control, climate regulation). Option value is the value that people place on maintaining the option to use an ecosystem resource in the future. Non-use values are derived from the knowledge that an ecosystem is maintained without regard to any current or future personal use. Non-use values may be related to altruism (maintaining an ecosystem for others), bequest (for future generations) and existence (preservation unrelated to any use) motivations. The constituent values of TEV are represented in figure A2. It is important to understand that the "total" in Total Economic Value refers to the aggregation of different sources of value rather than the sum of all value derived from a resource. Accordingly, many estimates of TEV are for marginal changes in the provision of ecosystem services but "total" in the sense that they take a comprehensive view of sources of value.

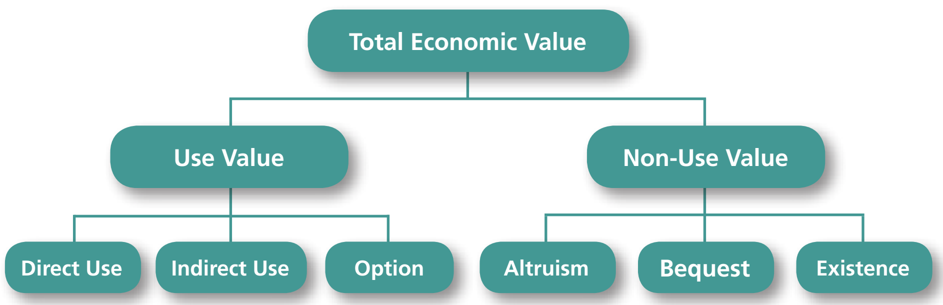


Figure A2. The components of Total Economic Value

The classification of different types of economic value within the concept of TEV is complementary to the classification of ecosystem services (described in definition box 1). Table A1 sets out the correspondence between categories of ecosystem service and components of TEV.

Table A1. Correspondence between ecosystem services and components of Total Economic Value

	Total Economic Value			
	Direct use	*Indirect use*	*Option value*	*Non-use*
Ecosystem service				
Provisioning	X		X	
Regulating		X	X	
Cultural	X		X	X

The concept of welfare value is used in most assessments of ecosystem service but it is not used in the system of national accounts (SNA) that is used to calculate gross domestic product (GDP) and other economic statistics. The SNA uses the concept **exchange value**, which is a measure of producer surplus plus the costs of production (i.e., areas B and C in figure A1, or equivalently P times Q). Under this concept of exchange value, the total outlays by consumers and the total revenue of the producers are equal. For national accounting purposes, this approach to valuation enables a consistent and convenient recording of transactions between economic units since the values for supply and use of products are the same. In the context of comparing the values of ecosystem services with values in the system of national accounts, it is therefore necessary to value the total quantity of ecosystem services at the market prices that would have occurred if the services had been freely traded and exchanged. In other words, it is necessary to measure exchange value and not welfare value.

The differences between the concepts of welfare value and exchange value are the inclusion of consumer surplus (A) in the former and the inclusion of production costs in the latter (C). The concept of welfare value corresponds to a theoretically valid measure of welfare in the sense that a change in value represents a change in welfare for the producers and/or consumers of the product(s) under consideration. The concept of exchange value does not correspond to a theoretically valid measure of welfare in the sense that a change in value does not necessarily represent a change in welfare for either producers or consumers.

Appendix II: Primary valuation methods

This appendix provides a brief explanation of each primary economic valuation method, setting out the approach, applicability to different ecosystem services, example applications, and limitations.

It is important to note that different valuation methods produce different measures of economic value that are not equivalent and cannot necessarily be directly compared. The valuation method, and the measure of economic value that it estimates, will have a substantial bearing on the magnitude of the value estimated. It is therefore important to understand what each measure is and to select a measure that is relevant to the case in hand. Accordingly, when transferring values from primary valuation studies it is important to understand the methods used and the type of values that are produced.

Table A2. Primary valuation methods, typical applications, examples and limitations

Valuation method	*Approach*	*Applications*	*Example ecosystem service*	*Limitations*
Market prices	Use prices that are directly observed in markets	ES that are traded directly in markets	Timber and fuel wood from forests; clean water from wetlands	Market prices can be distorted e.g. by subsidies. Most ES not traded in markets
Public pricing	Use public expenditure or monetary incentives (taxes/subsidies) for ES as an indicator of value	ES for which there are public expenditures	Watershed protection to provide drinking water; Purchase of land for protected area	No direct link to preferences of beneficiaries
Replacement cost	Estimate the cost of replacing an ES with a man-made service	ES that have a man-made equivalent that could be used and provides similar benefits to the ecosystem service.	Coastal protection by dunes; water storage and filtration by wetlands	No direct relation to ES benefits. Over-estimates value if society is not prepared to pay for man-made replacement. Under-estimates value if man-made replacement does not provide all of the benefits of the original ecosystem.
Restoration cost	Estimate cost of restoring degraded ecosystems to ensure provision of ES	Any ES that can be provided by restored ecosystems	Coastal protection by dunes; water storage and filtration by wetlands	No direct relation to ES benefits. Over-estimates value if society is not prepared to pay for restoration. Under-estimates value if restoration does not provide all of the benefits of the original ecosystem.

Valuation method	*Approach*	*Applications*	*Example ecosystem service*	*Limitations*
Net factor income	Revenue from sales of environment-related good minus cost of other inputs	Ecosystems that provide an input in the production of a marketed good	Filtration of water by wetlands; commercial fisheries supported by coastal wetlands	Tendency to over-estimate values since method attributes all normal profit to the ES
Production function	Estimate value of ES as input in production of marketed good	Ecosystems that provide an input in the production of a marketed good	Soil quality or water quality as an input to agricultural production	Technically difficult. High data requirements
Hedonic pricing	Estimate influence of environmental characteristics on price of marketed goods	Environmental characteristics that vary across goods (usually houses)	Urban open space; air quality	Technically difficult. High data requirements. Limited to ES that are spatially related to property locations.
Travel cost	Use data on travel costs and visit rates to estimate demand for recreation sites	Recreation sites	Outdoor open access recreation	Technically difficult. High data requirements. Limited to valuation of recreation. Complicated for trips with multiple purposes or to multiple sites.
Contingent valuation	Ask people to state their willingness to pay for an ES through surveys	All ecosystem services	Species loss; natural areas; air quality; water quality landscape aesthetics	Expensive and technically difficult to implement. Prone to biases in design and analysis
Choice modelling	Ask people to make trade-offs between ES and other goods to elicit willingness to pay	All ecosystem services	Species loss; natural areas; air quality; water quality; landscape aesthetics	Expensive and technically difficult to implement. Prone to biases in design and analysis
Group / participatory valuation	Ask groups of stakeholders to state their willingness to pay for an ES through group discussion	All ecosystem services	Species loss; natural areas; air quality; water quality; landscape aesthetics	Prone to biases due to group dynamics

This manual provides guidance on how to estimate the economic value of ecosystem services using value transfer methods. It explains why you would undertake a study, who should be involved, how to implement the study and how to use the results.

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