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Valuation Methods in Ecosystem Services: A Meta-analysis

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Abstract

Ecosystem services are the benefits people obtain from ecosystems, including provisioning, regulating, supporting, and cultural services. The Meta-analysis of this seminar was reviewed to identify, describe, and choose an appropriate ecosystem valuation method. Four major and nine sub-ecosystem services valuation methods were reviewed from scientific literature sources. Direct market-valuation methods are used to estimate ecosystem services via the use of direct market prices and production functions, indirect market valuation methods are used to estimate when direct markets for many ecosystem goods and services do not exist, direct market prices are missing, and stated preference valuation methods are used when no market prices are available, indirect market valuation methods are not possible, and the change in ecosystem services is hypothetical. The indirect market valuation methods can be used to estimate economic values for all types of ecosystem services. Ecosystem service modeling is used in integrating all the spatial and temporal dynamics of ecosystem services. The strength and limitations of each ecosystem services valuations method are summarized to know and choose appropriate valuation methods. The analysis shows different valuation methods exist and have been applied to estimate the values of different ecosystem services, but their appropriateness under specific conditions or limitations is not uniform. Thus, further study on the pros and cons of valuation methods will be needed to choose appropriate ecosystem valuation methods.

Key Words: Classification, Ecosystem services, Methods, Modeling, Monetary, Valuation

Introduction

Ecosystem services are natural systems outputs, conditions, or processes that directly or indirectly benefit humans or enhance the livelihoods of human beings [1-4]. The four main types of ecosystem services include a provision (e.g. food, fuel, fibers), regulation (e.g. climate regulation by carbon sequestration, pollination, sediment regulation), cultural (e.g. recreation), and supportive (e.g. habitat quality, nutrient cycling) [3, 4]. Recently, the importance of biodiversity for underpinning the delivery of ecosystem services and the possible effects of biodiversity loss is well recognized [5]. To protect ecosystems, politicians should ensure that human activities are sustainable and resources are distributed fair and efficiently [1]. Assessing the ecosystem service is vital to understanding the benefits of ecosystem services in improving human wellbeing and sustainable management of all ecosystems [6]. Ecosystem service assessments have been found useful in extending biodiversity conservation beyond the extent of protected areas [7].

The need for conservation of natural resources, mitigation, and adaptation of climate change and degradation of ecosystems services are the current challenge of global issues. Though the concept of ecosystem services has become important but the services it provide are little understood in economic markets and by government policies [3]. Recently the assessment of ecosystem service focus values in space and time have been receiving considerable attention. There are increasing worldwide efforts to incorporate information on ecosystem services into public and private decisions to overcome the challenges. Assessing and being aware of the benefits of ecosystem service is essential to understanding the importance of ecosystem services for improving and continuing human wellbeing and for sustainable management of the ecosystem [6]. Furthermore, information on ecosystem services is important for decision-makers to understand the dependency of local communities on ecosystem services, incorporate stakeholders' perceptions, and come up with better land-use policies [8]. Assessment of ecosystem services is a tool for decision-makers, which helps choose between alternative management options or multiple goals [9]. It is a system that links ecology to the economy, which is why economic methods should be used for the assessment of components of ecological systems [10].

Though methodologies for classification, quantification, and

valuation of ecosystem services are many and improving, identification of the most methodology is still not clear or restricted to researcher preferences. Ecosystem services valuation of different ecosystems (Forest, Grass land, Deseret, Wetland etc) is a concern because much of the disputes in the methodologies, type of service valued (limited to specific service and function), and not comprehensive across the world [1, 6, 11, 12]. Even though there is neither a commonly accepted methodology nor statistical standards for ecosystem service assessment [13-15]. The number of published articles dedicated to ecosystem services and, in particular, to the assessment of ecosystem services is increasing [16, 17]. Furthermore, the number of studies devoted to the assessment of forest ecosystem services has gradually increased in recent years [14, 18].

There are numerous methods used by researchers to evaluate ecosystem services. Especially, monetary valuation can be carried out using a variety of different approaches. Increasing interest in measuring, modeling, and valuing ecosystem services, the benefits that ecosystems provide to people, has resulted in the development of an array of ecosystem services assessment tools in recent years. Selecting an appropriate tool for measuring and modeling ecosystem services can be challenging. Therefore, this study systematically reviews and synthesizes the valuation methods of ecosystem services to identify, describe valuation methods and choose appropriate tools to use.

Methods

This study was based on a systematic analysis/review of data from journals through Web of Science, Google Scholar, and Scopus databases, to understand and choose appropriate methods of ecosystem services. A review collects all possible studies related to a given topic with keywords that either alone or in combination: ecosystem services, modeling ecosystem services, ecosystem function, ecosystem process, ecosystem value, ecosystem services valuation methods, and ecosystem benefits. Initial information was extracted from 250 articles that cover the types of methods, quantification of ecosystem services, ecosystem concepts, pros, and cons of ecosystem services. The first screening was made based on the publication year and reduced the initial documents to 150. Further screening was made by reading the abstracts and reducing the number of papers to 75 for the detailed investigation. The data from the final list of selected articles were summarized to review in detail the common ecosystems assessment method, classification system, and concept, and the pros and cons of different methods of ecosystem valuation. Only papers directly related to the topic and those focusing on the valuation methods of ecosystem services were chosen. The systematic review also captures the state of the study for scientific research needed in the future from various disciplines.

Classification of Ecosystem Services

Categorization of ecosystem services is a precondition for any attempt to measure, map, or value ecosystem services and to communicate the findings transparently [19]. Several frameworks have been developed for the analysis of ecosystem services but, each author classifies ecosystem services in his or her way. Thus, data on ecosystem services were analyzed differently. Therefore, a consistence and detailed assessment of ecosystem function, goods, and services standardized frameworks are crucial.

The most commonly used classification, provided by the Millennium Ecosystem Assessment, is based on four categories: provisioning, regulating, supporting, and cultural services [3]. Provisioning services include goods extracted from ecosystems such as timber, fuelwood, food, and fibers. Regulating services help maintain the regulation of ecosystem processes including carbon sequestration and climate regulation, pest and disease control, and waste decomposition. Supporting services support the provision of all the other categories including soil formation and retention, production of oxygen, nutrient cycling, water cycling, and provisioning of habitat whereas cultural services contribute to spiritual welfare such as recreational, spiritual, religious, and esthetic experiences) [4, 20, 21].

The second commonly used classification is the Economics of Ecosystems and Biodiversity (TEEB) study applies a similar classification approach as proposed by MEA, distinguishing provisioning, regulating, and cultural services, while the fourth category labeled habitat or supporting service cover sites for species and maintenance of genetic diversity i.e. an alternative classification replacing the category of supporting services with habitat services including nursery and gene pool functions (De Groot et al., 2010). And more recently, the Common International Classification of Ecosystem Services (CICES) provided standardization in the way ecosystem services are described to overcome a translation problem between different classification systems, which are not always comparable due to different perspectives or definitions of the categories (www.cices.eu). The CICES is hierarchically organized and it applies the three major sections of services provisioning, regulating, and cultural, defined basically in the same way as in the MEA and TEEB classification and then splits them further into divisions, groups and classes. The hierarchical structure allows users to go down to the most appropriate level of detail required by their application as well as combine results when making comparisons or more generalized reports, and cultural ecosystem services [22, 23].

Ecosystem Services Valuation Methods

There are three different ways to assess the value of ecosystem services: qualitative analysis, quantitative analysis, and monetary analysis [24]. According to Kettunen et al. (2012), the qualitative analysis focuses on non-numerical indicators of the value such as benefits to mental and physical health, and social benefits from recreation. The quantitative analysis focuses on numerical data such as the quantity of sequestered carbon, quality of water, etc. The monetary analysis focuses on translating the qualitative and quantitative aspects into a particular currency. Monetary valuation of ecosystem services is the most widely applied approach, as it is often deemed to be the most pragmatic language when it comes to communication with political and business institutions [25, 26]. Ecosystem service valuation utilizes various methods and approaches to estimate the value of ecosystem services [9]. These methods include direct market valuation methods (market price–based method, cost-based valuation methods, and production function), indirect market valuation methods or revealed preferences (travel cost method & hedonic pricing method), and Non–market valuation methods or

stated preference (contingent valuation methods, Choice modeling methods, and group deliberation) [27].

Direct Market Valuation Method

The method uses data from existing markets as a basis for the ecosystem services valuation process. That means this method operates with prices for goods and services that exist in real markets. Direct market valuation methods are divided into three main approaches (a) market price-based methods, (b) cost-based methods, and (c) production functions methods.

Market Price-Based Method

Market-price methods utilize directly observed prices from actual markets related to the provision of an environmental good or service [28]. This method estimates the economic value of ecosystem products or services that are bought and sold in commercial markets. It can be used to value changes in either the quantity or quality of a good or service. It uses standard economic techniques for measuring the economic benefits of marketed goods, based on the quantity people purchase at different prices, and the quantity supplied at different prices [25, 27, 28]. It has the advantages of reflecting an individual's willingness to pay for the costs and benefits of goods that are bought and sold in markets, price, quantity, and cost data are relatively easy to obtain for established markets. The methods also allowed to use of standard, accepted economic techniques and uses observed data of actual consumer preferences. Some of the limitations of the market price based method are data may only be available for a limited number of goods and services and, the true economic value of goods or services may not be fully reflected in market transactions, due to market imperfections and/or policy failures, it requires seasonal variations must be considered, it cannot be easily used to measure the value of larger-scale changes that are likely to affect the supply of or demand for a good or service, does not deduct the market value of other resources used to bring ecosystem products to market and thus may overstate benefits, the value of goods and services can be underestimated due to market imperfections and the value of natural resources valued estimated, considering the inability to capture non-use values.

Cost-Based Method

The cost-based method assumes that the value of ecosystem services can be defined at least as the costs that are avoided because ecosystem services exist. It is based on estimations of the costs that would be incurred if ecosystem service benefits needed to be recreated through artificial means (Garrod and Willis, 1999). Different techniques exist, including, (a) the avoided cost method, which defines the value of ecosystem services as the costs associated with the hypothetical damage that was avoided due to the existence of these ecosystem services or which relates to the costs that would have been incurred in the absence of ecosystem services, (b) the replacement cost method, which estimates the costs incurred by replacing ecosystem services with artificial technologies, (For example, if the forest stand has to be harvested due to construction work, the value of the forest stand will be equal to at least the costs of establishing a new forest stand by planting new trees) and (c) mitigation or restoration cost method, which refers to the cost of mitigating the effects caused by to the loss of ecosystem services or the cost of getting those services restored. It assumes that the cost of ecosystem services is equal to the expenses incurred from the mitigation of the negative effects caused by the degradation of the ecosystem [15, 27].

Production Function-Based Method

The method estimates how much a given ecosystem service contributes to the delivery of another service or commodity which is traded on an existing market. It is used to estimate the economic value of ecosystem products or services that contribute to the production of commercially marketed goods. It is applied in cases where the products or services of an ecosystem are used, along with other inputs, to produce a marketed good [29, 30]. (For example, water quality affects the productivity of irrigated crops or the costs of purifying municipal drinking water. Thus, the economic benefits of improved water quality can be measured by the increased revenues from greater agricultural productivity or the decreased costs of providing clean drinking water. The idea thus is that any resulting improvements in the resource base or environmental quality as a result of enhanced ecosystem services, lower costs and prices, and increase the quantities of marketed goods, lead to increases in consumers and perhaps producers' surpluses (Freeman 2003). It generally consists of the following two-step procedure (Barbier, 1994). The first step is to determine the physical effects of changes in a biological resource or ecosystem service on economic activity. In the second step, the impact of these changes is valued in terms of the corresponding change in the marketed output of the traded activity. A distinction should be made then between the gross value of output and the value of the marginal product of the input. Hence, the method generally uses scientific knowledge on cause-effect relationships between the ecosystem service(s) being valued and the output level of marketed commodities. It relates to objective measurements of biophysical parameters [31, 32]. As note, for many habitats where there is sufficient scientific knowledge of how these link to specific ecological services that support or protect economic activities, it is possible to employ the production function approach to value these services. The advantages of the production function-based method include: straightforward, data requirements are limited, and the relevant data may be readily available, so the method can be relatively inexpensive to apply. Some of its limitations are: the method is limited to valuing those resources that can be used as inputs in the production of marketed goods; not all services will be related to the production of marketed goods during ecosystem value resulting to understate its true value to society, information is needed on the scientific relationships between actions to improve the quality or quantity of the resource and the actual outcomes of those actions, methods become much more complicated if the changes in the natural resource affect the market price of the final good or the prices of any other production inputs. Its limitation also production function-based methods rely on the knowledge of the effects of ecosystem services on the production of traded goods [33]. The existing knowledge on the cause-effect links between ecosystem services and the production of marketed commodities is still in the early stages of development. The production function approach has the additional problem that adequate data on and understanding of the cause-effect linkages between the ecosystem service being valued and the marketed commodity are often lacking [34]. In other words, the production functions

of ecosystem services are rarely understood well enough to quantify how much of a service is produced, or how changes in ecosystem condition or function will translate into changes in the ecosystem services delivered. Furthermore, the interconnectivity and interdependencies of ecosystem services may increase the likelihood of double-counting ecosystem services.

Indirect Market Valuation/ Revealed Preference Methods

The revealed-preferences method involves determining the value that consumers hold for an environmental good by observing their purchase of goods in the market that directly (or indirectly) relate to environmental quality. It assumes that ecosystem services values can be revealed through observable consumer behaviors or activities in relevant markets [35]. For example, the purchase of air fresheners, noise-reducing materials, and water-purification systems reveals the minimum amount individuals would be willing to pay for improved air and water quality. It is also used to determine the value of clean air and clean water through differences in home prices between pristine and polluted areas. Revealed-preference methods use the observed behavior of an individual in the markets that relate to the ecosystem services in question. These revealed-preference methods also have some limitations. Generally, if the market of the commodities associated with the ecosystem services of interest is imperfect, the estimated values of these ecosystem services will be biased. In addition, because they rely on observed information, these methods cannot estimate the non-use values of ecosystem services. And also, methods require large data, and complex statistical analysis to determine the relationship between environmental goods and the associated market goods. Consequently, conducting these methods is costly and time-consuming [36].

The revealed preference method is based on the observation of individual choices in existing markets that are related to the ecosystem service that is subject to valuation. The concept of well-being based on revealed preferences is very problematic and has been criticized over the last years [37]. Preferences are context-dependent, change with time, and are flexible [38]. Moreover, people have cognitive biases that are not anomalies but common to human reasoning and judgmental processes. Because of these findings, the method in the current form seems not to be a good indicator of well-being [39, 40]. The two and probably most commonly used revealed-preference methods of ecosystem valuation are the travel-cost and hedonic pricing methods. In revealed preferences methods, market imperfections and policy failures can distort the estimated monetary value of ecosystem services. Scientists need good quality data on each transaction, large data sets, and complex statistical analysis. As a result, revealed preference approaches are expensive and time-consuming. Generally, these methods have the appeal of relying on actual/observed behavior but their main drawbacks are the inability to estimate non-use values and the dependence of the estimated values on the technical assumptions made on the relationship between the environmental good and the surrogate market good [24, 31].

Travel Cost Method

The travel cost method is used to estimate economic use values associated with ecosystems or sites that are used for recreation. The method can be used to estimate the economic benefits or costs resulting from changes in access costs for a recreational site, elimination of an existing recreational site, the addition of a new recreational site, and changes in environmental quality at a recreational site. The value of a change in the quality or quantity of a recreational site (resulting from changes in biodiversity) can be inferred by estimating the demand function for visiting the site that is being studied [41-44]. The travel-cost model mostly involves estimating tourism or recreation values of ecosystem services placed in recreation areas. It assumes that the demand for ecosystem services requires travel to recreation areas. Therefore, the travel costs (can be accrued for the value of the ecosystem services. For example, as described by, recreation areas attract distant visitors whose value placed on that area must be at least what they were willing to pay to travel to it [45].

The basic premise of the travel cost method is that the time and travel cost expenses that people incur to visit a site represent the price of access to the site. Thus, people's willingness to pay to visit the site can be estimated based on the number of trips that they make at different travel costs. The Travel Cost Method is applied to the valuation of components of the natural environment (forests, national parks, nature reserves), whose consumption is associated with the necessity of incurring expenses determined by market prices. For example, a visit to a national park embracing forest areas is associated with expenses for travel, the cost of which implicitly attests to the quality of tourist/recreational value of the destination. The turnout of stays and the number of travel expenditures are, therefore, an indirect indicator of the attractiveness of the forest/national park that constitutes its value to the consumer. The method allows estimating values related to the quality of the environment and tourist attractions (admiring the views, trekking, recreation, etc [40, 46]. The method is the more conventional empirical technique used by economists to estimate economic values based on market prices and it is based on the actual behavior of what people do rather than a stated willingness to pay what people say. It provides opportunities for large sample sizes, as visitors tend to be interested in participating, and easy to interpret and explain the results as compared to other ecosystem valuation methods [47].

Some of the limitations to the travel cost method are people perceive and respond to changes in travel costs the same way that they would respond to changes in admission prices, the methods assume that individuals take a trip for a single purpose to visit a specific recreational site, for instance, if a trip has more than one purpose, the value of the site may be overestimated. It can be difficult to apportion the travel costs among the various purposes. No appropriate model to measure the availability of substitute's site, the opportunity cost of time, time spent, recreational quality, and relating recreational quality to environmental quality. The travel cost method is limited in its scope of application because it requires user participation. It cannot be used to assign values to on-site environmental features and functions that users of the site do not find valuable. It cannot be used to value off-site values supported by the site. Most importantly, it cannot be used to measure non-use values. Thus, sites that have unique qualities

that are valued by non-users will be undervalued [47-49].

The method requires complex statistical analysis, and large and complex data sets, hence expensive and time-consuming and it is likely to estimate the value of one factor because difficult to separate the effect of different factors.

The Hedonic Pricing Method

The hedonic pricing method is used to estimate economic values for ecosystem or environmental services that directly affect market prices. It is most commonly applied to variations in housing prices that reflect the value of local environmental attributes. It can be used to estimate economic benefits or costs associated with environmental quality, including air pollution, water pollution, or noise and environmental amenities, such as aesthetic views or proximity to recreational sites. It is mostly used to value environmental amenities that affect the price of residential properties [40, 50]. The hedonic pricing method uses the valuation of a property, depending on its location in the natural environment. The basic premise for using the hedonic pricing method is the fact that the prices of market goods depend on the existence of non-market (natural) goods, such as proximity to the forest, clean air, uncontaminated water, or low noise. As components of the natural environment highly influence real estate prices, it is possible to ultimately estimate the value of services provided by most forest ecosystems based on property prices. A new variant of the hedonic pricing method is the so-called happiness approach [51]. Turner 2010, in other words: the evaluation of human happiness or life satisfaction, for which experimental measures were worked out. In terms of a declared part of income, the method enables the valuation of natural assets that affect an individual sense of happiness (Welsch and Kuhling 2008). The main idea is that there is a direct relationship between the location of real estate and its price. The closer the house to ecosystem services, the higher the price of the house. For example, the difference between the price of a house located near a lake and a house located in the same area but farther from the lake can be interpreted as the value of ecosystem services provided by the lake.

The hedonic pricing method (also known as attribute pricing) estimates the values of ecosystem services based on the assumption that the demand for these ecosystem services may be reflected in the prices of marketed commodities associated with them. For example, housing prices are relevant to amenity attributes, including ecosystem services, such as house prices at beaches being usually higher than those that are located inland. The method's main strength is that it can be used to estimate values based on actual choices, it can be a good indication of value and reliability. Another strength of the method is data on property sales and characteristics are readily available through many sources and can be related to other secondary data sources to obtain descriptive variables for the analysis. It is useful and can be adapted to consider several possible interactions between market goods and environmental quality [52].

As described by Bateman et al., (2002) the limitation of the hedonic pricing method includes the scope of environmental benefits that can be measured is limited to things that are related to housing prices, the method will only capture people's willingness to pay for perceived differences in environmental attributes and their direct consequences, and the housing market may be affected by outside influences, like taxes, interest rates, or other factors, complex to implement and interpret, requiring a high degree of statistical expertise. The method required heavy model specification, large amounts of data must be gathered and manipulated and the time and expense to carry out an application depend on the availability and accessibility of data [53].

Non-Market Valuation/Stated Preference Methods

The method is a survey-based technique for establishing valuations and simulating a market and demand for ecosystem services using surveys on hypothetical (policy-induced) changes in the provision of ecosystem services. Stated preference methods can be used to estimate both use and non-use values of ecosystems and/or when no replacement market exists from which the value of ecosystems can be deduced [27]. The methods are the only ones that can value environmental goods in cases where there are no markets to provide information on the value of environmental goods i.e. this approach can be used when no market prices are available and it is not possible to apply methods particular to the revealed preference approach []. It involves developing hypothetical scenarios of the changes in ecosystem services and eliciting individuals' willingness to pay for an improvement or willingness to accept forgoing this improvement or the degradation/loss of ecosystem services in social surveys. The individuals' responses are then modeled to estimate the values of the changes in ecosystem service conditions [54].

One of the main problems that have been highlighted in the literature on stated preference methods is the divergence between willingness to pay and willingness to accept. From a theoretical perspective, willingness-to-pay and willingness-to-accept should be similar in perfectly competitive private markets. Another important problem is the embedding, part-whole bias, or insensitivity to scope problem [55, 56]. Furthermore, the application of stated preference methods to public goods that are complex and unfamiliar has been questioned because respondents cannot give accurate responses as their preferences are not fully defined [57]. Sometimes stated preference methods incorporate basic upfront information in questionnaires [58-60]. Argue that valuation workshops that provide respondents with opportunities to discuss and reflect on their preferences help to overcome some of the potential cognitive and knowledge constraints associated with stated preference methods. Typically, deliberative monetary valuation methods will provide upfront information to stakeholders as well. The bias in deliberative monetary valuation approaches is supposedly less than in individual CV studies [61]. Such methods may further reduce non-response rates and increase respondents' engagement. In general, the method allows for the estimation of values associated with use as well as non-use values, and its flexibility is seen as a pro and the cons of the methods are very related to the survey in which survey data are costly to acquire, high degree of technical knowledge needed for design and estimation, results may be subject to a variety of biases. The common types of stated-preference methods include the contingent valuation method, choice modeling, and group valuation method.

Contingent Valuation Method:

Contingent valuation refers to the method of valuation used in cost-benefit analysis and environmental accounting. It is conditional (contingent) on the construction of hypothetical markets, reflected in expressions of the willingness to pay for potential environmental benefits or the avoidance of their loss [62, 63]. Uses questionnaires to ask people how much they would be willing to pay to increase or enhance the provision of an ecosystem service, or how much they would be willing to accept for its loss or degradation. It is used to estimate economic values for all kinds of the ecosystem and environmental services. It can be used to estimate both use and non-use values, and it is the most widely used method for estimating non-use values. It is also the most controversial of the non-market valuation methods [62]. The method often involves rigorous construction of a scenario that offers a hypothetical environmental improvement and asks individuals to state their willingness to pay for the offer. For example, in a survey, individuals may be asked to express their willingness to pay for an environmental improvement project that prevents landslides, which is something that they might benefit from by avoiding damages caused by landslides [64].

Choice Modeling:

The choice model also makes use of social surveys to elicit individuals' expressions of their choices among alternative options that are defined by different levels of attributes of ecosystem services and the associated payment that would be required. This method models the responses of individuals regarding the levels of the attributes (i.e. the levels of the ecosystem services and payment) to estimate the value of the ecosystem services [54, 65]. The method recognizes that most environmental goods are composite goods, made up of a variety of attributes that can take on various levels. It allows estimation of the relative importance of multiple environmental attributes and their levels and generates large quantities of data in a single application. Table 1 below summarized the pros and cons of ecosystem valuation methods

Group Valuation

The method combines stated preference techniques with elements of deliberative processes from political science, and is being increasingly used as a way to capture value types that may escape individual based surveys, such as value pluralism, incommensurability, non-human values, or social justice [26, 33, 66]. Group valuation has recently been getting greater attention in the course of ecosystem service valuation. Rooted in social and political perspectives, this valuation method applies the principles of deliberative democracy and the assumption that decision-making relating to the public good should rely on open public debate rather than an aggregation of individual preferences [12]. This method is acknowledged for its ability to deal with the issue of social equity relating to the allocation of ecosystem services [67].

Although these methods have been widely used in non-market valuation, particularly in ecosystem service valuation, it is worth noting that they have been severely criticized. The criticism primarily relates to the validity and reliability of the results and various sources of errors and bias. The validity and reliability of the stated-preference studies are questioned because of their hypothetical nature.

Ecosystem Services Modeling

Models are simulations or representations of an ecological system. When direct and indirect data are unavailable, other ecological and socio-economic data and knowledge can be used as substitute data to estimate the provision and demand of ecosystem services. The advantage of using ecosystem services models is that the input data can be modified to simulate hypothetical scenarios of land management, land cover change, climate change, etc. to predict possible impacts on the provision of ecosystem services. Open-source computer models were created that can map and evaluate ecosystem services, currently used in many programs and initiatives for both scientific and planning purposes. These models include the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) [68, 69]. Which treats ecosystem services in both biophysical and economic terms; the Social Values for Ecosystem Services – SolVES, which evaluates and maps the social values of the ESs; the Artificial Intelligence for Ecosystem Services (ARIES), which aims to balance the user's need for clarity without renouncing at the same time the maintenance of the complexity of the space-time flows of the benefits provided to the community [70-75].

Table 1: A summary of the pros and cons of ecosystem valuation methods

Methods		Definition	Pros	Cons
Direct market valuation	Market Price methods (Christie et al., 2012; Ellis & Porter-Bolland, 2008)	Market-price methods utilize directly observed prices and/or costs from actual markets related to the provision of an environmental good or service as a proxy to the value of those goods.	Price data are easy; Market prices reflect the private willingness to pay;It relies on observed information that reflects actual individual preferences or costs; It uses standard economic techniques for measuring Price data are relatively easy to obtain.	The value of goods and services can be underestimated due to market imperfections. The value of the natural resource can be underestimated, considering the inability to capture non-use values It requires relying on observed data Data may only be available for a limited number of goods and services

	Cost-Based Method (Arias-Arévalo et al., 2018)	The replacement cost method measures the potential expenditures in replacing/restoring the function that is lost. The damage cost avoided method measures the costs that would be incurred if a specific environmental function were not present	Straightforward and time- and resource-saving nature, thus allowing for an application even in countries where resources and technical skills are limited.It is easier to measure the costs of producing benefits than the benefits themselves when goods, services, and benefits are nonmarked. Approaches are fewer data and resource-intensive.	The methodology relies on the quality of data available since inaccurate values can lead to a misleading appraisal of the natural resource. These second- best approaches assume that expenditure provides positive benefits and net benefits generated by expenditure match the original level of benefits. Even when these conditions are met, costs are usually not an accurate measure of benefits. So long as it's not clear whether it's worth it to replace a lost or damaged asset, the cost of doing so is an inadequate measure of damage
	Production Function-Based Method (Pascual et al., 2010a; Spash, 2000)	Estimates the value of a non-marketed resource or ecological function in terms of changes in economic activity by modeling the physical contribution of the resource or function to economic output.	The application of the approach is most straightforward in the case of a single system, data requirements are limited, and the relevant data may be readily available, so the method can be relatively inexpensive to apply.	Requires explicit modeling of the dose-response relationship between the resources and some economic output. It is more complicated with multiple use systems. Problems may arise from the multi-specification of the ecological-economic relationship or double counting. Adequate data on and understanding of the cause-effect linkages between the ecosystem service being valued and the marketed commodity is often lacking
Revealed preferences	Travel cost method (Provins & Powell, 2006; Graves, 2018)	The travel cost method is a survey-based technique that uses the cost incurred by individuals traveling to and gaining access to a recreation site as a proxy for the recreational value of that site."	It allows computing of the recreational value of any location and is quite easy to implement; The method is the more conventional empirical technique used by economists to estimate economic values based on market prices;It is based on the actual behavior of what people do rather than a stated willingness to pay for what people say. It provides opportunities for large sample sizes, as visitors tend to be interested in participating, and easy to interpret and explain the results as compared to others ecosystem valuation methods.	It tends to underestimate the recreational value of the site since it only considers the time and money spent on getting there. The method cannot be applied in the case of multifunctional trips, in which the visit to the site is not the only destination. It does not apply to studies in the poorest countries, where the majority of people cannot afford to travel. Data-intensive; restrictive assumptions about consumer behavior (e.g. multifunctional trips); results highly sensitive to statistical methods used to specify the demand relationship.

	Hedonic pricing (Arias-Arévalo et al., 2018; Abbasov, 2014)	Hedonic pricing attempts to (i) identify how much of a property differential is due to a particular environmental difference between properties and (ii) infer how muchpeople are willing to pay for an improvement in the environmental quality that they face and what the social value of the improvement is."	It can isolate the effects of ecosystem services on land value, under the assumption that those services are fully reflected in land prices. It is useful and can be adapted to consider several possible interactions between market goods and environmental quality Data on property sales and characteristics are readily available through many sourcesIt can be used to estimate values based on actual choices, It can be a good indication of value and reliable	It relies on a large amount of high-quality data on property prices. The approach may be limited where markets are distorted, choices are constrained by income, information about environmental conditions is not widespread and data are scarce. The scope of environmental benefits that can be measured is limited to things that are related to housing prices, It only captures people's willingness to pay for perceived differences in environmental attributes and their direct consequences, and The housing market may be affected by outside influences like taxes, interest rates, or other factors.
Stated preferences	Contingent valuation (Bateman et al., 2002; Chan et al., 2012; Ahlheim et al., 2006)	Environmental evaluations are obtained by using surveys to ask people directly their willingness to pay or willingness to accept a given gain or loss of a specified good."	It allows for a high degree of flexibility in the formulation of the questions, including the valuation of scenarios that are yet to happen. The only method that can measure option and existence values and provide a true measure of total economic value. The most widely accepted method for estimating total economic value The method allows for the estimation of values associated with use as well as non-use values, and The nature and the results of CVM studies are not difficult to analyze and describe	Respondents' valuation can be influenced by their prior knowledge and by what they are told in the questionnaire. Hence, bias issues in survey design might be happen It is based on hypothetical behavior Results are sensitive to numerous sources of bias in survey design and implementation. The method is complex and unfamiliar and has been questioned because respondents cannot give accurate responses WTA very significantly exceeds WTP
	Choice modeling (Christie et al., 2012)	The choice modeling technique estimates economic values by constructing a hypothetical the market for the non-market environmental good	Respondents select their preferred policy option, thus ruling out any sort of bias related to respondents' lack of knowledge about the monetary economy	It is more complex to analyze and explain to the respondents, who may not look at the policy characteristics as a bundle but focus only on one attribute.

Conclusion

This seminar has been organized through article review on the different valuation methods of ecosystem services. The review covers ecosystem services background, classification, common valuation methods such as direct market valuation method, revealed preference methods, stated preference methods and ecosystem services modeling. The ecosystem provides a range of functions mainly socio-cultural, economic, and ecological value that sustains human beings on earth. An ecosystem provides four main types of services such as provisioning, regulating, cultural and supportive. Previously, the services that an ecosystem provides are not well understood and recognized in economic markets and government policies due to its methodological sophistication i.e. the methods for obtaining the necessary information are often so different for each service, time consuming and need more cost. However, ecosystem service valuations focusing on the assessment of ecosystem service values in space and time have recently been receiving considerable attention worldwide in their policy development, public and private decisions to overcome the challenges of ecosystems services degradation.

The most commonly used classification of ecosystem services includes millennium ecosystem assessment classification (categories based on provisioning, regulating, supporting and cultural services), the economics of ecosystems and biodiversity (categories based on such as provisioning, regulating, cultural services and habitat service) and common international classification of ecosystem services (categorized based on the three major sections of services provisioning, regulating and cultural, and then splits them further into divisions, groups and classes). Various ecosystem valuation methods exist and have been applied to estimate the values of different ecosystem services. The most common ecosystem valuation methods reviewed for this assignment are direct market valuation methods (market price based, cost-based valuation and production function), indirect market valuation methods or revealed preferences (travel cost & hedonic pricing), and non-market valuation methods or stated preference (contingent valuation, choice modeling and group valuation). Provisioning services valued using direct market methods and regulation services can be valued through direct (cost-based valuation applied for all types of regulation services) or indirect market methods. However, when provisions services changes in quantity and/or quality non-market valuation methods (hedonic pricing) are more suitable. The hypothetical and potential future changes of regulation services are valued in most cases through non-market valuation methods. Non-market methods are most often used for valuing cultural services, due to cultural services are not traded on markets and supporting services are frequently valued through direct market methods, although the possibilities may vary strongly depending on the specific service. And also, non-market valuation methods (contingent valuation, choice modeling) are used to estimate all ecosystem services such as provisioning, regulating, cultural and supportive. Among the reviewed valuation methods contingent valuation, travel cost, hedonic pricing and cost-based methods were widely used methods by different authors.

The most recent methods of valuing and mapping the value of ecosystems were computer software programs that log and analyze land cover data and satellites to estimate ecosystem services provided by a given area of land. Because of the complex nature of many environmental goods and natural resources, more than one type of method may be necessary to gain an understanding of all the components of value. The pros and cons of each ecosystem services valuation methods were reviewed as summarized in the table 1 to know which methods are most accurate in specific situations. All the reviewed valuation methods have strengths and limitations, and a decision to choose appropriate ecosystem valuation method depends on type of ecosystem service to be valued, type of economic value to be estimated, the purpose of the valuation, data and information availability and accuracy of results required.

In general, in the process of compiling the range of different methods, a few flaws and gaps in the communication of methods were observed during the process. There is also a lack of consistency in the names of different methods was observed.

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