

Review

Valuing Forest Ecosystem Services. Why Is an Integrative Approach Needed?

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Abstract: Among the many types of terrestrial ecosystems, forests have some of the highest levels of biodiversity; they also have many interdependent economic, ecological and social functions and provide ecosystem services. They supply a range of tangible, marketable goods, as well as a variety of nonmarketable and intangible services derived from various forest functions. These translate into social, cultural, health and scientific benefits for people’s quality of life. However, because they cannot be traded on a market, nonmarketable and intangible services are often perceived as free, inexhaustible and, as a result, underestimated. The human–nature interaction has affected both nature (via resource consumption) and society (via development of human welfare and well-being). Decision-makers, both public and private, often manage natural capital for multiple aims. In recent years it has been found that the single, individual approach estimating the value for these goods and services is not able to provide information that generates and supports decisions and policies in complex areas of current relevance such as the constant loss of biodiversity, climate change and global warming in close connection with the need for social development and ensuring an acceptable level of well-being for the greatest part of humanity. An integrated assessment with advanced techniques and methods using a pluralist framework of a heterogeneous set of values is considered a better approach to the valuation of such complex nature of the ecosystem goods and services. This assessment should take into account both costs and benefits trade-off issues among the multiple uses of ecosystem goods and/or services, especially the relationships between them and how they influence or determine the economic, social and cultural development of society. It should also consider the estimation of the complex inverse effect, from society to nature, whose goods and services can be diminished to exhaustion by the extensive and intensive anthropization of natural ecosystems with major impact on the number and quality of goods and services provided by ecosystems. Research has shown that applying an integrative assessment approach that utilizes tools developed by sustainability sciences could be an important component of future environmental policy making.

Keywords: biodiversity; forests; valuing ecosystem services; climate change; policy making



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1. Introduction

The Earth’s population relies on the benefits provided by ecosystems, including ecosystem provisioning, regulation and cultural and support services [1]. Over time, humans have transformed ecosystems to meet their needs and desires. Nowadays, climate change and biodiversity loss are major challenges for both developed and developing countries. According to the Intergovernmental Panel on Climate Change (IPCC, 2018), if global warming

exceeds 1.5 °C, climate change will severely affect humanity and ecosystems. An analysis of how people's use and management of natural resources affects ecosystem resilience is necessary because people's daily choices will result in continued biodiversity loss and new social costs [2]. Forests, which cover one-third of Earth's land surface, are an immense and renewable source of ecosystem services (ESs) [3,4]. They represent an extraordinary opportunity to mitigate climate change through carbon sequestration [5,6], soil stabilization and natural disaster mitigation [5]; forest conservation efforts (e.g., establishing protected areas) do not contradict territorial and regional development objectives [3] since changes in land cover and land use are among the major drivers of forest area reduction, biodiversity loss and land and ecosystem degradation at the global, regional and local levels [7–12]. In this respect, all these aspects should be kept together, to establish correlation among services and their impact on communities' development. In addition, the emergence of states of necessity (e.g., economic crises and social, political and military conflicts) could potentially intensify the use of resources and ESs offered by forests [13]. There are a number of less visible services provided by forests that support local development through cultural services [14] or sustainable tourism services [3]. Depending on the goals of the valuation of the ESs, some services should be seen and evaluated in a strict correlation and an integrative manner. Many studies have addressed how cultural services can be integrated into spatial planning methods; they showed that using spatial mapping and integrating information on habitat types, landscape features and land-use methods with information on existing infrastructure, number of visitors to the area and proximity to local communities during stakeholder consultations often led to increased stakeholder involvement in the planning process [15].

Recent research has analyzed ESs in relation to bioeconomic strategy objectives. This trend reflects how ESs and bioeconomy strategy, two key concepts in sustainability science, must be addressed together, especially given the effects of bioeconomy strategies on ESs [16,17]. Recent sustainable development initiatives have embraced the concept of a circular economy; this paradigm challenges the current linear behavioral model of take–do–consume–throw, which produces excessive waste and inefficiently uses natural resources [18]. The new EU Forest Strategy (2021–2027) emphasizes the need to ensure that the multifunctional potential of EU forests and their vital ESs are managed sustainably.

However, when discussing natural capital (NC), ecosystems and ESs, it is important to integrate concepts and methods that give a perceptible expression of their value. Depending on the final purpose of the analysis and evaluation, at least one of the following types of value can be assigned to NC and then calculated or estimated: philosophical value, economic value, social value, aesthetic value, inheritance value (for future generations), altruistic value [19,20], egoistic value [19], biospheric value [19,21] or intangible and cultural value [22]. Previous research has shown that everything is valuable but in different ways. Art objects often have sentimental value, historical value or financial value [23]. Landscapes, mountains and forests can have economic value and recreational value. In addition, great works of art, as well as natural landscapes, possess a distinct noninstrumental and nonutilitarian value, which is a central concern when works of art or landscapes are evaluated. Though some may think the value of art and landscapes comes from their beauty, others may not consider them beautiful. As such, beauty is a particular case of aesthetic value [23,24]. Aesthetic value is defined as the value possessed by an object, event or state of affairs by virtue of its ability to cause pleasure (positive value) or dissatisfaction (negative value) [23]. It is often seen as more subjective than other types of value and is usually of low priority in policy debates [24]. An example of this is the complex relationship between human aesthetic experience and the development of ethical attitudes towards the environment [25,26]. For ESs, their value often reflects contributions to human welfare and well-being, and a distinction can be made between use value derived from direct or indirect use of ESs and nonuse value derived from the intrinsic value of ecosystems and their biodiversity [27]. Currently, macro-indicators such as GDP report the values of goods and services exchanged in the market, but they do not reflect the values of nonmarket ESs,

the deterioration of ESs or the loss of biodiversity. The inclusion of ES indicators in national accounts would allow for not only an economic assessment, but also an environmental and social assessment of a country's development [27,28]. Additionally, mapping ESs and establishing assessment indicators [29] is an important and current issue, with the EU Biodiversity Strategy explicitly calling for this action under Action 5 [26,30–32].

A holistic approach, using sustainability science methods and techniques developed for ES valuation, seems to be now the challenge for value pluralism of forest ecosystems, including well-known services and other indirect benefits such as health, education, equality and governance [17,32–34]. There are many complexities that have to be taken into account in order to value ESs. Their resources provide multifaceted benefits, and for some of them, it is difficult to quantify their value. Cost–benefit analysis allows the aggregation of the values of ESs on a single monetary scale of measurement [35]. However, public sector entities are deeply involved in such efforts. A plethora of multinational organizations are involved, including TEEB, WAVES (Wealth Accounting for the Value of Ecosystem Services, a World Bank program) and IGPBES. National governments are more involved in assessing ESs. The United Kingdom conducts an evaluation of national ecosystems that includes the assessment of several ESs. In the United States, all departments and agencies in the executive branch are now directed to “develop and institutionalize policies to promote the consideration of ecosystem services... and, where appropriate, monetary or non-monetary values for those services” [36] (p. 8/32). In Romania, the ES valuation process is at the beginning; up to now, several exploratory studies have been conducted related to the value of ESs in natural protected areas, and a case study on Piatra Craiului National Park has been conducted [37,38]. The studies revealed that even though the Piatra Craiului protected area generates significant ESs, very low economic values are mirrored in the earnings of the park administration. Thus, in-depth studies combining biodiversity aspects with economic evaluations of ESs will be a strong base for decision-makers for promoting sustainable development public policies in this area.

This paper aims to explore why an integrative approach for valuing and assessing forest ESs is needed, taking into account the many interdependent factors involving ESs and their associated values, as well as current challenges people face.

2. Evaluation of Ecosystem Services—Why Is It Necessary?

Natural resources associated with production (such as wood, food and energy resources), as well as services associated with protection (such as air quality), are assets that help increase the efficiency of services provided to people by NC [39]. The exploitation of NC produces social costs and benefits, referred to as externalities [39]. From an economic viewpoint, externalities occur when a variable (not the price) generated by an economic unit influences the production processes of other economic units or of the population. For example, the construction of a slaughterhouse could produce water, land or air pollution, all of which are negative externalities that affect other economic units and the local population. Due to the difficulty in measuring total benefits or already proven multiple benefits, decision-makers are often required to depend on cost-effectiveness analyses of different management options. More importantly, trade-offs of benefits and burden distribution happen between space, time and social groups, and in general, the perceived value of ecosystems has not been accounted for all of the services the ecosystems provide. One study assessed the monetary and nonmonetary values of forest ecosystems in eight Mediterranean countries and found that wood and wood fuel represent less than one-third of the total economic value (TEV) of forests in the countries under study. The other, nontimber services offered by the assessed ecosystems—recreational activities, fishing, protection provided by the river network and carbon sequestration—made up between 25 and 96% of the ecosystems' TEV.

Scientists have long reported the implications of biodiversity loss. In 1872, Yellowstone National Park became the first geographic area defined as a protected area due to the initiative of several scientists [40]. The economic view that people's survival depends on

natural resources, which are limited, has been held since the 18th century (Malthus 1888); the concept of ESs, or services offered by nature to people, was developed in the 1960s and 1970s [39–42]. Many natural processes improve human well-being [43] and welfare, but human activity negatively affects ecosystems through ecosystem conversion, habitat fragmentation, landscape alteration and the anthropization of the natural environment over time [26] and biodiversity loss, which ultimately harms human well-being [31,32,43].

Globally, the importance of protecting and sustainably managing forest ESs has been recognized through a series of UN-adopted documents. These include the ‘Rio Forest Principles’ from the 1992 United Nations Conference on Environment and Development [44]; the United Nations Framework Convention on Climate Change (UNFCCC) [45], which emphasizes the importance of forests in terms of the global greenhouse gas (GHG) balance; the Convention on Biological Diversity [46,47], which addresses forest biodiversity; the United Nations Forum on Forests (UNFF); the UN Convention to Combat Desertification (UNCCD) [36]; and the Paris Agreement [48], which calls for major reforms in order to fight global warming.

However, in recent years, ESs emerged as an important issue on the public agenda through discussions on topics such as biodiversity loss [2,40,41], land-use and spatial planning [7,9,10], climate change [42], circular economies [49,50] and bioeconomies [16,51] and public policies [36,52–54] and strategies [16]. To address all of these challenges requires sound decision-making [55]; the development of a tool for measuring TEV is necessary to support the political decision-making process and to inform both citizens and businesses about the benefits and costs inherent in projects, programs and policies [56]. There is a growing consensus that in spatial planning, land management and other decision-making contexts, the economic valuation of ESs is essential for the development of efficient public policies and strategies [57]. The value of ESs and biodiversity is assigned based on what societies are ready to offer in exchange for nature conservation [25,58] because the valuation of ESs can vary with time and spaces [59], ranging from simply raising awareness to analyzing various policy choices and scenarios in detail [60]. The estimated loss of ESs from 1997 to 2011 due to land-use change is \$4.3–20.2 trillion per year [19].

3. Ecosystem Services and Natural, Socioeconomic and Public Policy Challenges

In recent decades, the concept of nature and ESs as capital has gained visibility [61], as society can receive important goods and services, such as clean air and water, flood control and crop pollination, by conserving and restoring natural habitats [56]. These goods and services, if properly considered, may be valuable enough to justify the protection of forest ESs [62]. Public debates on ESs have hit a sensitive chord. For some, the concept of ESs presents an opportunity to include all of the environmental benefits that the market failed to account for in public and private decision-making. For others, the possibility of structuring payments for ESs that assign and respect property rights and bring the power of the market to a bearable level may seem just as attractive [36].

Addressing climate change requires mitigation and action to adapt to new conditions. Forests and the forestry sector play a significant role in mitigating climate change by capturing CO₂ and producing timber products, as well as by substituting materials whose processing requires high energy consumption [63–65]. They also provide services that can help people adapt to both current and future climate risks [42]. While ESs are part of the solution to climate change, they are also affected by climate change. Climate change will impact forests and may impair their ability to provide essential ecosystem services in the decades to come. Addressing this challenge requires adjustments to forest management strategies as of now, but it is still unclear to what extent this is already in progress [66]. An EFI study found that forests and the role of the forestry sector could be significantly enhanced through Climate-Smart Forestry [63]. This approach aims to increase the climate benefits of forests and the forestry sector in a way that creates synergies with other forest-related needs. It is based on three pillars: (1) reducing or eliminating GHG emissions to mitigate climate change, (2) adapting forest management to build resilient forests and

(3) actively managing forests in order to sustainably increase productivity and provide all of the benefits that forests can offer [62–64,67]. The European Environmental Bureau, an international nonprofit association that has assembled over 160 civil society organizations from more than 35 European countries, stated in 2021 that “the global material footprint is already beyond ecological limits, being over 100 billion tonnes per year and, if we continue ‘business as usual’, is expected to double in the next 40 years. The impact of excessive consumption is significant. In the European Green Deal, the European Commission states that ‘resource extraction and processing account for more than 90% of the global impact on biodiversity loss and water quality and about half of global climate change emissions’” [50].

In this context, sustainable development has become a global concept that transcends different sciences with environmental, social, cultural and economic dimensions. A bioeconomy is currently being promoted both for policymakers and businesses as a sustainable action plan for reconciling environmental, social and economic goals [16,68,69]. Human activity has led to the degradation of the natural environment, which has had a far-reaching impact on society and the economy and has created new conceptual frameworks for how people interact with and depend on the environment. A bioeconomy generally involves replacing fossil fuels with bio-based ones, so three main goals—involving resources, biotechnology and agroecology—are becoming more prevalent in the scientific literature [16]. In 2020, a review of 45 documents and articles showed that, although the publications were diverse and the approaches used were still quite new, eight topics were predominant: (a) the technical and economic feasibility of biomass extraction and use; (b) the potential and challenges of a bioeconomy; (c) frames and tools; (d) the sustainability of biology-based processes, products and services; (e) the ecological sustainability of a bioeconomy; (f) the governance of a bioeconomy; (g) biosecurity; and (h) bioremediation [16]. Though both the bioeconomy and NC combine economics and natural sciences and propose new interdisciplinary frameworks for environmental sustainability, the two concepts are rarely applied together [51]. A circular economy would positively impact ecological systems by not exhausting or overburdening them with technological and productive tasks. This is reflected in the environmental benefits of the circular economy. For example, a circular economy would emit less GHGs; the soil, air and water would remain unchanged; and natural reservations would be preserved [18,53]. Forest ecosystems provide services and products such as wood, pollination and clean drinking water. In a linear economy, these services will eventually be depleted by the constant extraction of products from ecosystems or will be affected by the release of toxins from technological processes [53,69]. If the products extracted from an ecosystem are used in a rational and intelligent technological and economic cycle, and the technological processes do not discharge toxic substances into the environment, then the soil, air and water will remain resistant and productive [52,69,70]. Understanding ESs and their economic applications offers a number of environmental and economic advantages because assessing NC and ES flows provides a powerful economic engine for nature conservation and nature-based solutions to current economic challenges, processes and industrial systems [49].

4. Ecosystem Valuation: Utilitarian vs. Nonutilitarian Approaches

The importance of ESs for human society has multiple dimensions: ecological, sociocultural and economic [71]. Over time, concerns related to ES valuation have led to the development of various methods for conducting these assessments, from mapping and modeling supply and demand for ESs to determine their market value (utilitarian approach) to social and environmental assessment techniques to assess their nonmarket value (nonutilitarian approach).

Utilitarian Approach

The utilitarian approach is intrinsically linked with cost–benefit analysis and welfare economics since they approach human well-being in terms of individual satisfaction based on the individual utility of goods and services. At the same time, environmental psychol-

ogy research confirms that the relevance of ESs for human well-being is more than the satisfaction of individual needs and consists of physical and psychological health, social integration and cultural identity (ACB). While market valuation is relatively simple to perform, challenges arise when estimating the nonmarket value of an ecosystem. From the seminal classification of Krutilla (1967), the utilitarian approach divides the TEV of ESs into two types of value: the use value, which relates to ESs associated with production and protection functions for which market prices usually exist, and the nonuse value, which reflects the satisfaction of knowing that biodiversity and ESs are preserved and that future generations will also benefit from them [58]. Both of these categories have subsequently been disaggregated into multiple components. Use value was broken up into direct use, indirect use, optional, quasi-optional and bequest values; nonuse value was split into existence or intrinsic, aesthetic, altruist, bequest, moral and religious values [21,40,58,59,72,73]. Direct use value is associated with the benefits of using ESs, such as raw materials. Indirect use value is associated with regulating services like water quality regulation. The optional and quasi-optional values are the values of ESs based on the option to use the services at a certain time in the future. Of the nonuse values, existence or intrinsic value is usually presented as the value attributed by an individual to the continued existence of a service or good, regardless of its current or possible uses [58]. Both use and nonuse values are associated with the utilitarian approach, which primarily aims to express the associated values of ESs in monetary terms and takes into account the utility of NC for humans and for the socioeconomic system [71]. This includes ecosystem resources that can be used or are used by the population and by economic units in their daily activities.

In a neoclassical economy, on which environmental economics and assessment methods are based, the nonuse values are defined and measured in monetary units based on a willingness to pay (WTP) or a willingness to accept (WTA) [19,39,58]. Nonuse values such as WTP are estimated by methods of preference declared in questionnaires or interviews, including both the contingent assessment method (CVM) and direct choice experiments (DCEs) [39]. Two assessment approaches are commonly used to estimate nonuse values. The first approach asks how many respondents would be willing to pay for ESs (or their attributes in the case of DCE) if they were absolutely certain they would never use them. In this case, the interviews would be based on nonusers. The second approach asks respondents, including users, to divide the total WTP for ESs into different categories, such as inheritance, existence and own use. Such statement decomposition approaches have been applied in many CVM-related ES applications and have been useful in understanding the relative quotas of value categories in WTP estimates [39,74] or in identifying warm glow effect in willingness to pay (WTP) responses [75]. In most cases, the proportions of nonuse values in WTP are considered to be quite substantial, representing between 40 and 90% of the total WTP [39,74]. Despite its popularity, the approach to decomposition stated in interviews has substantial shortcomings and is highly controversial, mainly due to the cognitive difficulty of addressing the components of an unfamiliar and inseparable value. An individual's total WTP for an ES is usually a consequence of different overlapping and correlated motivations that may be inseparable and, as such, inaccessible to the researcher [76]. In most cases, the ES assessment is completed when a choice must be made among different services.

Over time, the desire to conduct a comprehensive economic assessment of ESs has led to the identification and refinement of various measurement methods. The first significant economic assessment of ESs, including from a nonmonetary perspective, was made by Costanza in 1997 based on the fact that ecosystems provide benefits to populations through ecosystem functions and components (i.e., services). Ecosystems are unique and irreplaceable, which makes them invaluable. Based on this, the author grouped ESs into categories and calculated their unit values, using assessment techniques based mainly on people's WTP. The resulting values were then multiplied by the area occupied by all US ecosystems and totalled \$33 trillion per year, more than double the annual GDP, which was estimated at \$16 trillion [20]. Fourteen years later, the value of ESs globally was estimated

at \$18 billion per year, of which 19% came from ES climate regulation and 4% came from raw materials related to productive functions. ES contributions to recreation, protection against extreme phenomena, the water supply, erosion control, nutrient cycling, habitat, genetic resources and nonwood products represent the rest of the value [20].

Costanza's work can be considered pioneering. From other perspectives, however, the proposed methodology was both technically and ethically challenged because ecosystems, as a support for life, are constantly evolving and cannot be measured monetarily. There is skepticism about the association of ecology with the economy; many specialists consider a strong involvement in the economic sector for the conservation of ecosystems dangerous, which could lead to an increase in nature depreciation. For example, developing countries could request and receive financial compensation in accordance with the estimated value of the ESs they provide, as long as they preserve them. Costanza's approach produced much debate and criticism, but it is better to have debate and criticism among scientists, policy-makers and stakeholders than to have nothing. However, despite the interest in making monetary assessments of ESs, these are not the only possible value assessments. In 2010, TEEB, published by The Ecological and Economic Foundations, developed the concept of TEV and presented a classification of TEV components and assessment tools that can be used to assess various components of ESs. The authors hypothesized that the value of ESs and biodiversity is determined by what a society is willing to offer in exchange for nature conservation. Society and policy-makers need to understand that ecosystems are unique and limited resources and that depreciation or degradation involves costs to society. From an economic point of view, when a resource is limited, an opportunity cost exists, representing the value of the best of the sacrificed chances (i.e., the one that is given up when a choice is made). However, the difficulty of conducting a monetary assessment of ESs is due to the fact that the changes to ecosystems are irreversible or are reversible for a prohibitive cost. The estimated economic value is a cumulation of choices of the buyer, which includes a multitude of preferences for ecology, society, health, technology and expectations regarding the future [58]. The modification of any of the factors listed influences the estimated economic value [58,77] and could lead to different scenarios being planned [77].

The evaluation methods identified in the VET methodology fall into three categories: (a) direct market valuation approaches, such as the price-based method, cost-based method and production function-based method; (b) revealed preference approaches, including the travel cost method and hedonic pricing method; and (c) simulated valuation, such as the contingent valuation method, choice modeling and group valuation.

Price-based methods are most often used to calculate the value of provided goods and services. Because they are traded on the market, their value is relatively easy to calculate. Examples include the value of wood, honey or tourist services [58]. Cost-based methods [39] are based on several identified techniques, such as the avoided costs method, which assesses the costs that would have occurred in the absence of the ES. The replacement cost method estimates the costs of replacing ESs with artificial technologies, the restoration cost method assesses the costs of counteracting the effects of ecosystem loss or restoration and the production function-based method estimates how much of the nonmarket ESs contribute to other services or goods traded on the market, noting how much the services contribute to increasing the productivity or price of those goods or services.

The travel cost method is relevant mainly for determining the value of recreational services associated with biodiversity and ESs. The method is based on the principle that recreational experiences can be associated with a cost that consists of direct costs and opportunity costs. In the case of tourism, changing ecosystem biodiversity can influence the demand to visit that location. The hedonic pricing method is based on the added value that a landscape, or location near an ecosystem, can bring to a market, such as the real estate market. Changing the biodiversity of an ecosystem can change the market value of a property. The revealed preference approaches require a large amount of complex data and statistics and so are expensive and time-consuming. In addition, since these methods are

based on direct observation of clients, they can provide an image at a certain moment in time [58].

The contingent valuation method uses questionnaires through which respondents provide information on how they would be willing to pay to protect ESs and how much they would be willing to pay to accept ecosystem loss or degradation. The choice modeling method focuses on modeling human behavior in particular contexts; this method starts with the supposition that people must choose from two or more alternatives when making a decision, one of which is the price in money. The group valuation method combines the use of questionnaires with elements of the deliberative process from political science and is becoming a widespread method for collecting values such as the uniqueness of ecosystems and social justice, as well as altruism towards other people and towards future generations compared to the species that live in the ecosystem. These methods should be applied carefully, and their limitations should be considered, especially when evaluating the nonuse value of a service that does not have a corresponding price on the market [36,54].

Extensive research conducted in Europe through the study Operationalisation of Natural Capital and Ecosystem Services Integrated (OpenNESS) [78] classified the methods used for evaluating ESs into the following categories: (i) biophysical methods, which are used for mapping ESs and include matrix approaches, ecosystem modelling with InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs [79], E-Tree [80] or ESTIMAP [81,82]; (ii) integrated mapping-modelling approaches; (iii) land-use scoring [83]; (iv) participatory mapping; (v) sociocultural methods for understanding social preferences or values for ESs, such as deliberative assessment methods, preference prioritization methods, multicriteria analysis methods and photo-elicitation surveys; (vi) monetary methods for estimating the economic value of services, such as preference methods, revealed preference methods and travel cost methods [58] or hedonic pricing methods [58,84]; and (vii) integrative approaches [85]. The selection of a particular method for a specific case can depend on many factors, including the decision-making context; the strengths and limitations of each method; and pragmatic reasons such as available data, resources and expertise. Each method has specific features that inform its relevance or appropriateness to certain decisions or problems in the context of the study. The ability of a method to address a specific purpose may be the primary factor influencing method selection. Most methods are able to characterize the current state of ecosystem service demand or supply, but only a few are able to explore potential future service provision through modeling approaches and participatory scenario development (which was specifically designed to address this purpose). Some methods focus on specific ESs, such as biophysical models of soil erosion, or specific groups of services, such as photo-series analyses of cultural ESs. Other methods attempt to provide a more holistic or strategic overview of multiple ESs, which may be used to assess trade-offs [86] between the supply of different services (e.g., matrix-based approaches) or the demand for services by different stakeholders (e.g., PGIS, preference assessment methods, photo-elicitation or MCDA). The integration of ES assessment with life cycle assessment (LCA) is important for developing decision support tools for environmental sustainability. LCA methods have traditionally been employed as environmental management tools to assess the environmental impacts of production processes from ‘cradle to grave’ [87]. The method was developed in the 1960s in reaction to the ‘Limits to Growth’ discourse, which raised concerns about natural resource finiteness. The assessments were initially limited to energy efficiency and emissions and were information for internal use by companies.

After the 1980s, academia and governments began using LCA as well; methodological development progressed and was supported by formal attempts at international standardization [88]. LCA has since become a reference tool for the assessment of sustainability issues in the context of production–consumption systems, obviously bearing both strengths and weaknesses [89,90]. Despite emerging interest in the topic, additional work is needed for tackling the integration of ES issues in LCA approaches [91].

The nonutilitarian approach identifies four types of value: ecological value, sociocultural value, value with direct economic significance and intrinsic value [40,92].

The ecological value is determined by the integrity of the regulation and habitat functions of the ecosystem and by various ecosystem parameters such as complexity, diversity and scarcity (de Groot). The most appropriate methods to evaluate the ecological value are the biophysical methods mentioned above as well as integrated mapping–modeling approaches and land-use scoring [92]. Sociocultural value is mainly related to aspects such as physical and mental health, education, cultural diversity and identity (heritage value), freedom and spiritual values. The most used methods to evaluate it are participatory mapping and sociocultural methods described above [92].

As regards the economic value, the monetary methods, such as direct methods of valuation based on market prices or indirect valuation methods (e.g WTP, WTA, Replacement cost, travel cost, Hedonic pricing), are the most commonly identified. [92].

For determining intrinsic value, the most adequate methods could be preference prioritization methods, multicriteria analysis methods and photo-elicitation surveys, combined with biophysical methods such as ecological models.

In conclusion, the utilitarian approach is in line with the philosophy of environmental economists who are in favor of extension of monetary valuation methods to nonmarket ESs, while the nonutilitarian approach is aligned with the concepts of ecological economists who consider the substitutability and valuation of NC controversial. Boundaries between utilitarian and nonutilitarian approaches (Figure 1) are blurred, and they benefit from an abundant and expanding body of literature [2].

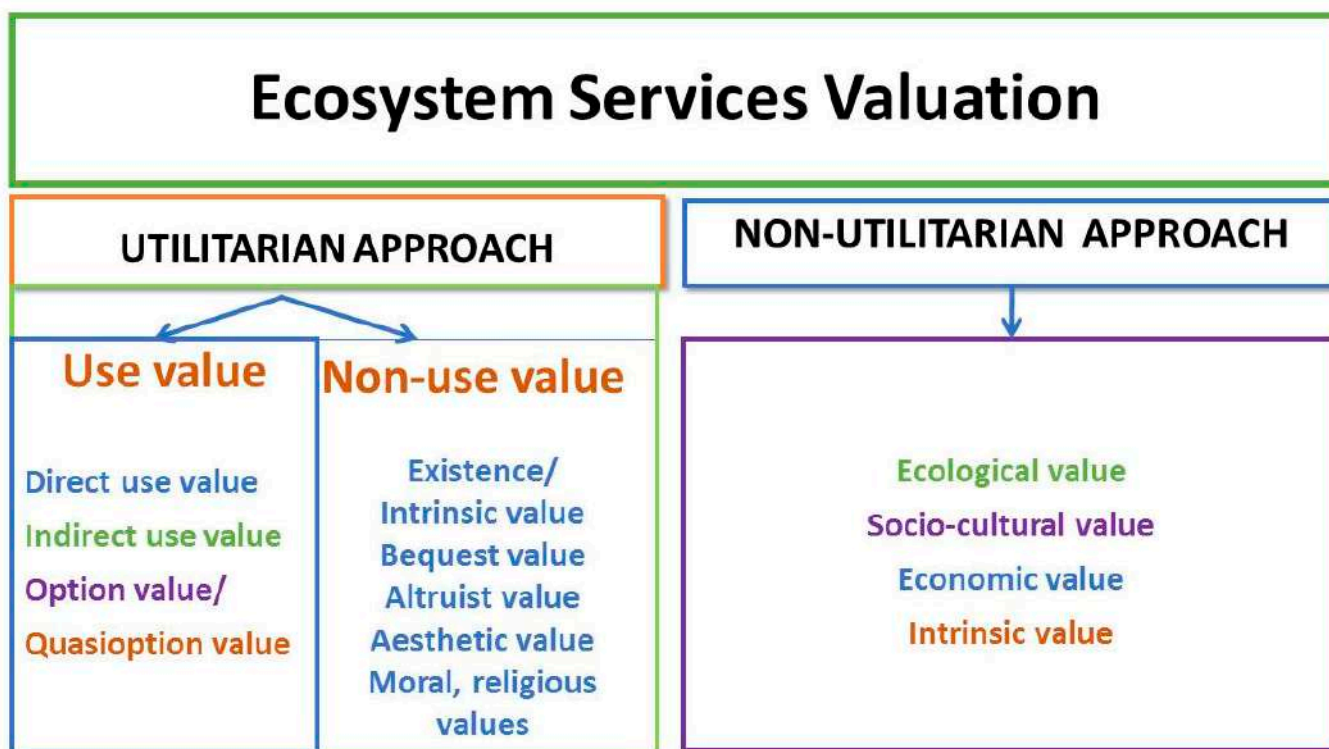


Figure 1. Utilitarian and nonutilitarian frameworks for valuing ESs. (adapted after TEEB).

The nonutilitarian approach is recognized as an important component of the ES valuation and an important motivation for increasing conservation efforts, but using monetary units to raise awareness of policymakers about their importance is a powerful tool [71].

5. Cost–Benefit Analysis of ES

Data on each ecosystem and each service highlighted the need to preserve ecosystems to ensure sustainable development. Even if ecosystems are subject to intensive and extensive exploitation, people must take care of them to ensure continuity. Therefore, in response to the exploitation of resources, plans must be made to conserve ecosystems. An environmental cost–benefit analysis (CBA) is best suited for this purpose [62]. First, because a CBA presents the territorial distribution of benefits and costs and compares this distribution with the distribution of biodiversity, it allows for the identification of important areas for both people and biodiversity (win–win areas), as well as the identification of areas of potential conflict and areas in need of compromises (negotiations). In these areas, the net economic benefits of ecosystem conservation are low, but biodiversity values are high, or vice versa. Second, a CBA highlights which areas have the highest unit cost benefits, thus indicating the most effective places for conservation efforts. Third, maps with ESs could help identify providers and consumers of ESs, enabling the identification of efficient and equitable payment mechanisms for financing conservation projects [62,93]. The core activity in an environmental CBA is estimating monetary values of the environment, especially the economic value of nonmarketable goods and services; the objective of the analysis is to estimate the TEV that arises from a policy proposal [94]. In 1970, CBAs were introduced for use on publicly financed projects with an environmental impact in the US. Since then, CBAs have been continuously adapted and applied to different methods and techniques, such as stated preference methods (which include the contingent valuation method, WTP, WTA, choice experiments, deliberative group valuation and health risk valuation) and revealed preference methods (which include the travel cost and hedonic price methods) [35]. At the same time, an important aspect that has to be taken into consideration when performing CBA is spatiotemporal frames, meaning that ESs are generated at different scales from short-term site level to long-term global level, and any slight change in the spatial or temporal frame approached in CBA can generate different consequences and stakeholders included in the CBA.

6. Ecosystem Service Valuation—What Is Next?

ES approaches and assessment efforts have changed the discourse on issues such as nature conservation, natural resource management and other areas of public policy. It is now accepted that in order to create a win–win situation rather than a compromise between environment and development, strategies for natural resource management and conservation through investment in the conservation, restoration [68] and sustainable use of ecosystems should be based on a combination of all values that occur when estimating the TEV [3,56,95,96] (Figure 2). Nonmarket assessments and methods used for cultural and environmental services have been criticized for their inability to provide values that represent or substantiate the total value of an ecosystem, but economists' efforts to involve interdisciplinary teams and incorporate a variety of methods and information into their research have demonstrated their flexibility, which reinforces the idea that they are effective in the process of diluting public policy decisions [13,57,76,97]. At the same time, actions have to be based on evidence, data and analysis to assess how public policies are beneficial for both people and nature [98], and the valuation methods have to be adapted to the local conditions and stakeholders involved [99]. The moving from conceptual frameworks and theory to practical integration of ESs into credible, replicable, scalable and sustainable public policies will require radical transformations [100] towards systematical integration of the ESs in decision-making at the individual, corporate or governmental level [101].

The ways in which ESs can be included in national accounts have generated a great deal of debate because it is, to some extent, a matter of choice [102,103]. In 2002, the UN's System of Environmental–Economic Accounting—Experimental Ecosystem Accounting (SEEA EEA) showed that the concept of valuation has made a significant difference in attempts to incorporate the generated ES values into national accounts [104,105]. Accounting ESs supposedly quantifies the amount of ESs provided by an ecosystem to socioeconomic

systems [25,106]. This can highlight ES contributions to the economy, social well-being, jobs and livelihoods.

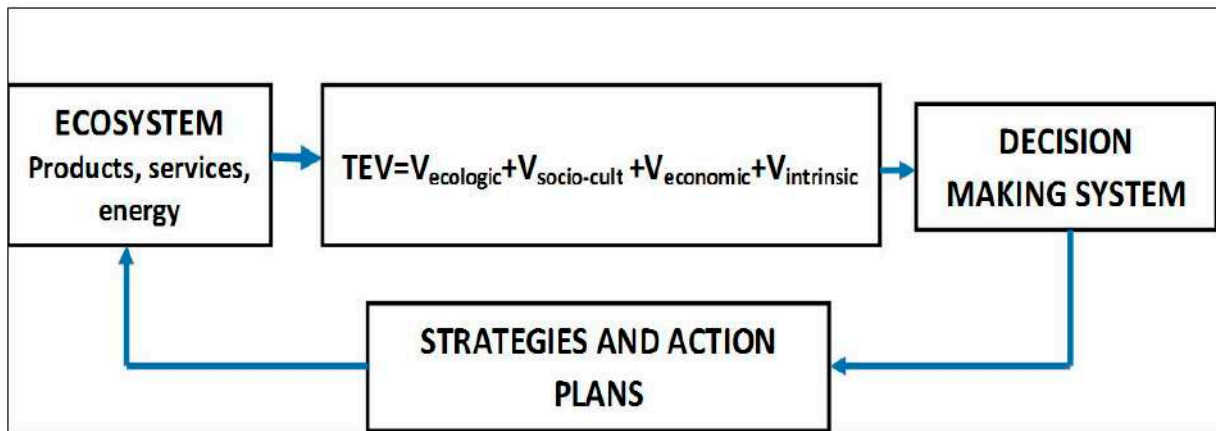


Figure 2. Integrative approach of valuing ESs.

SEEA methodology gave rise to the concept of the information pyramid (Figure 3), which combines basic economic, ecological and sociodemographic data. These data can be collected, centralized, processed and used for the development of analyses and studies that provide evidence for public policies and lead to the development of aggregate key indicators at the macro level.

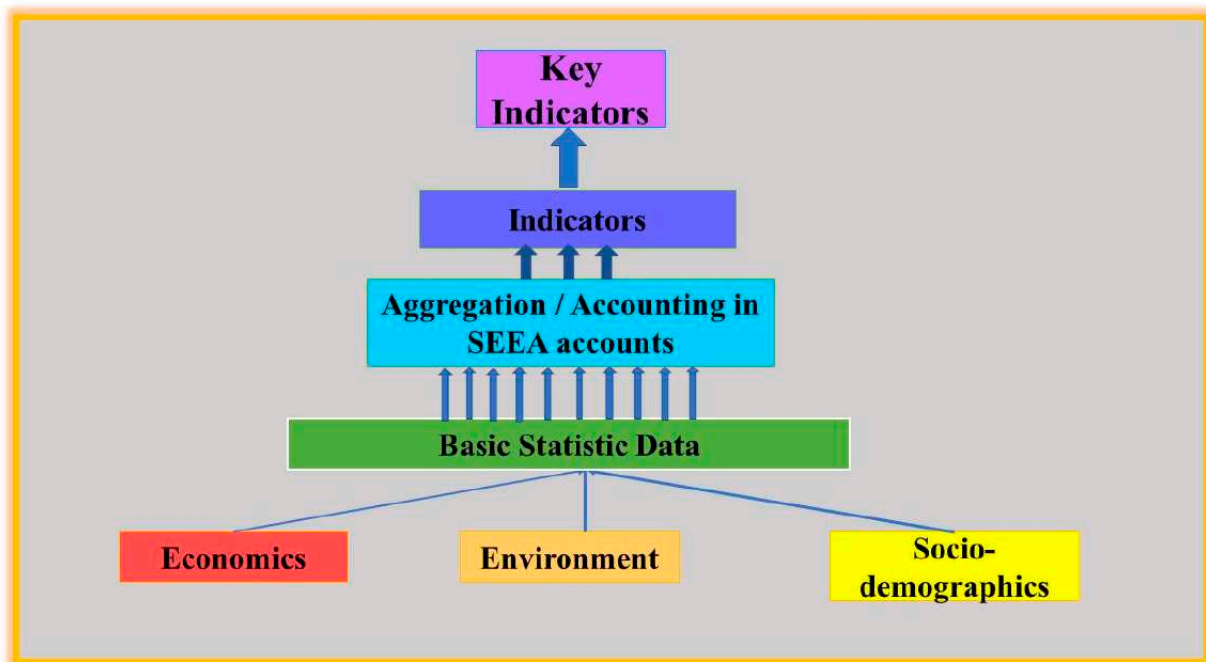


Figure 3. Information pyramid for ES key indicators (from SEEA).

However, creating such key indicators is a challenge. Using exchange value methods based on market techniques to quantify ESs [107] is easier because these are already compatible with the Systems on National Accounts; well-being value-based methods are difficult to translate into exchange value terms [106,108]. This shows that more effort should be put into the development of a pluralistic value-based approach able to capture both monetary and nonmonetary values [105].

In addition, the development of experimental ES accounts revealed the need to develop different indicators for separate ESs since each service has different characteristics. For forest ecosystems, the main indicators are related to timber production, biomass harvesting for energy, wild food provision, climate regulation, fire management, air quality regulation, noise reduction, water purification and recreational and aesthetic values. The accounts developed at the EU level [109] face many challenges, such as a lack of data and a lack of availability at the required spatial resolution [106], because natural, historical and cultural resources do not have an explicit monetary value. A different conclusion is reached if the cost of living with regard to the maintenance of nature in acceptable conditions is compared to conditions in which nature is allowed to degrade [20], showing that the single-value approaches are not an option anymore [110].

7. Conclusions

NC produces multiple ecosystem services with differences in values in human life and measurement requirements. The values vary between time and space. Valuation of an individual service or by a single method may result in the overestimation of values of some of them. At the same time, the exploitation of NC generates costs that translate into negative externalities or trade-offs for the environment and for society.

In real life, people do compromise between them. Policy and management decision-making requires information of different dimensions. Information from integrated valuation methods would provide information from different aspects and help policymakers to make informed and pragmatic decisions.

ES valuation does not aim to establish prices in order to capitalize on ESs through the market. Instead, it highlights how ESs contribute to human well-being and welfare and how they are an essential tool for developing efficient public policies and strategies based on scientific evidence. Utilitarian and nonutilitarian approaches to NC have developed multiple methods and techniques for assessing different types of value for ecosystems. However, there is still a significant lack of reliable evidence on nonuse values of ESs. Many approaches to ES assessment remain controversial because they raise concerns related to the availability and accuracy of data. Establishing accurate methods for calculating VET of ESs, as well as indicators and methods for their modeling and calculation, is a topic that requires further research. Using a pluralist framework composed of a set of decision-making instruments adapted to specific spatial and temporal scales involved, in which CBA is an important component, will allow identifying win–win areas and areas of potential conflicts, both for people and for the environment. Such techniques may be the best solution for supporting the public policy measures needed to mitigate current challenges. In recent years, there has been an increased focus on how climate change affects ecosystems, as well as on how ESs connect to sustainability science topics like environmental economies, bioeconomies and circular economies. Further research that utilizes an integrative approach to connect ES valuation to sustainability science is needed in order to support the decision-making process and public policies.

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