REVIEW ARTICLE

A review on the integrative approach for economic valuation of forest ecosystem services

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Abstract
Forests have the most biodiversity and provide vital ecosystem services. They offer numerous forest-related services, some of which can be commercialized. This improves social, cultural, health, and scientific life. Nonmarketable and intangible services are discounted because people think they're endless and free. Humans have changed the natural and social worlds through using resources and improving well-being. Public and private decision-makers often compete over natural capital. The loss of biodiversity, climate change, and global warming are interconnected with social development and ensuring an acceptable level of well-being for the majority of humanity, making it difficult for a single, individual approach to estimating the value of these goods and services to generate and support decisions and policies in these complex areas. The complexity of ecosystem products and services requires an integrated assessment with cutting-edge technologies and approaches using a pluralist framework of heterogeneous values. This evaluation should encompass costs and benefits of several ecosystem commodity and service applications. These usage' effects on economic, social, and cultural advancement are also crucial. The extensive and thorough enthronization of natural ecosystems can affect the amount and quality of ecosystem goods and services; thus, it is vital to quantify the complicated inverse effect from civilization to nature. Studies show that incorporating sustainability sciences approaches into an integrative assessment approach may be vital to environmental policy in the future.

Keywords: Forest; Ecosystem services; Economic valuation; Climate change; Policy

Introduction

Ecosystems perform several important functions for humanity, such as food production, climate regulation, and social and cultural support (Raihan et al., 2022a). Humans have altered ecosystems over time to better suit their wants and needs (Ali et al., 2022; Voumik et al., 2023). Both wealthy and developing nations face serious threats from climate change and biodiversity loss today (Raihan et al., 2022b; Isfat and Raihan, 2022; Raihan and Himu, 2023). If the world warms by more than 1.5 degrees Celsius, climate change will have disastrous effects on people and ecosystems, according to the Intergovernmental Panel on Climate Change (IPCC) (Raihan et al., 2022c). Because people's daily decisions will lead to continuous biodiversity loss and increased social costs, it is important to examine how human use and management of natural resources influences ecosystem resilience (Raihan, 2023a). A third of Earth's territory is covered by forests, and these forests provide a vast and renewable resource for ecosystem services (ESs) (Loomis et al., 2019; Raihan, 2023b). Since changes in land cover and land use are among the major drivers of forest area reduction, biodiversity loss, and land and water degradation, forests present an extraordinary opportunity to mitigate climate change through carbon sequestration, soil stabilization, and natural disaster mitigation (Begum et al., 2020; Raihan et al., 2022d); forest conservation efforts (e.g., establishing protected areas) do not contradict territorial and regional development objectives (Loomis et al., 2019; Raihan, 2023c). For this reason, it's important to have everything in one place so that we can see how various services affect one another and how those in turn affect the growth of local communities. The creation of states of necessity (such as economic crises and social, political, and military conflicts) could further increase demand for the resources and ESs provided by forests (Raihan et al., 2021a). Cultural services (Raihan et al., 2021b) and sustainable tourist services (Loomis et al., 2019; Raihan et al., 2022e) are two examples of the less obvious benefits that woods bring to local communities. Some services should be viewed and evaluated in a precise correlative and integrative manner, while others should be evaluated independently, depending on the goals of the valuation of the ESs. The incorporation of cultural services into spatial planning has been the subject of a number of studies, which have all found that increasing stakeholder participation in the planning process is possible through the use of spatial mapping and the integration of data on habitat types, landscape features, and land-use methods with data on existing infrastructure, visitor numbers, and proximity to local communities (Vasiljevic and Gavrilovic, 2019; Raihan et al., 2023a).

ESs have been the subject of analysis in the context of bioeconomic strategy goals in recent studies. Given the effects of bioeconomy initiatives on ESs, there is a growing recognition that the two concepts must be tackled in tandem (D'Amato et al., 2020). Recent sustainable development initiatives have embraced the concept of a circular economy, which poses a challenge to the dominant linear behavioral model of "take-do-consume-throw" (Aarikka-Stenroos et al., 2021; Raihan and Tuspekova, 2022a) that results in excessive waste and inefficient use of natural resources. The new EU Forest Strategy (2021-2027) highlights the importance of sustainably managing EU forests to maximize their multifunctional potential and essential ESs. Natural capital (NC), ecosystem services (ESs), and the like are often discussed; nonetheless, it is crucial to incorporate notions and methodologies that give a palpable manifestation of their value into these discussions. Philosophical value, economic value, social value, aesthetic value, inheritance value (for future generations), altruistic value, egoistic value, biospheric value, or intangible and cultural value can all be assigned to NC and then calculated or estimated, depending on the ultimate purpose of the analysis and evaluation (Kim and Stepchenkova, 2020).

Previous studies have demonstrated that all things are useful in their own unique ways. Values attached to works of art might be financial, emotional, or both (Robinson, 2014). There is monetary worth and recreational value in landscapes, mountains, and woods. Great works of art, like beautiful natural landscapes, also have a value that cannot be reduced to monetary terms or other purely instrumental measures. While some may attribute worth to the aesthetic qualities of works of art and natural settings, others may disagree. Therefore, aesthetic value includes attractiveness (Robinson, 2014). The aesthetic worth of something is its potential to elicit a favorable emotional response (positive aesthetic value) or a negative emotional response (negative aesthetic value). Policy debates rarely give it much weight since it is considered as more subjective than other types of value (Robinson, 2014). Consider the intricate web that holds human aesthetic experience and the growth of environmentally responsible values together. It is possible to separate the use value of ESs, which comes from humans' direct and indirect use of them, from the nonuse value, which comes from the intrinsic value of ecosystems and their biodiversity (Nevzati et al., 2023) to better understand the value of ESs and how it relates to humans' welfare and well-being. The values of nonmarket ESs, deteriorating ESs, and biodiversity loss are not reflected in current macro-indicators like GDP, which measure values of products and services exchanged in the market. If environmental and social (ES) indicators were included in national accounts, not only could the economic development of a country be evaluated, but so could its impact on the environment and the lives of its citizens (Nevzati et al., 2023). Action 5 of the EU Biodiversity Strategy specifically requests that ESs be mapped, and assessment indicators be established by the year 2020 (Czcz et al., 2020).

It appears that the problem for value pluralism in forest ecosystems, which includes both direct and indirect benefits like health, education, equality, and governance, requires a holistic approach that makes use of the tools and techniques created for ES valuation in the field of sustainability science (Raihan, 2023d). There are a lot of moving parts that need to be considered when assigning a monetary value to ESs. The worth of some of the many advantages provided by their resources is hard to put a price tag on. Values of ESs can be aggregated onto a single monetary scale through the use of cost-benefit analysis (Raihan and Said, 2022). But organizations from the public sector are heavily engaged in these activities. The World Bank's Wealth Accounting for the Value of Ecosystem Services (WAVES) is also a participant, as is the International Group for the Promotion of Biodiversity and Ecosystem Services (TEEB). The evaluation of ESs has gained the attention of national governments. The United Kingdom assesses multiple ESs as part of its national ecological review. "Develop and institutionalize policies to promote the consideration of ecosystem services... and, where appropriate, monetary or non-monetary values for those services" is the new directive for all executive branch departments and agencies in the United States (Raihan, 2023e). Therefore, thorough research combining biodiversity considerations with economic evaluations of ESs will provide decision-makers with a solid foundation upon which to promote public policies that support sustainable development in this sector. This paper's goal is to investigate the necessity of an integrative approach to valuing and measuring forest ESs by considering the numerous connections between ESs and the values they represent, as well as the difficulties people confront today.

The necessity of evaluating ecosystem services

Assets that help boost the efficiency of services supplied to people by NC include natural resources associated with production (such as timber, food, and energy resources) and services linked with protection (such as air quality). There are both positive and negative externalities associated with NC's exploitation (Raihan, 2023f). When one economic unit's actions have unintended consequences on the activities of other economic units or on the population as a whole, this is known as an externality in economics. Negative externalities, which harm other economic units and the surrounding community, can result from the establishment of a slaughterhouse, for example. Decision-makers are often forced to rely on cost-effectiveness assessments of different management options due to the difficulties of assessing total benefits or already demonstrated numerous advantages (Raihan et al., 2019). Most crucially, the perceived value of ecosystems has not accounted for all of the services provided by ecosystems, and these trade-offs occur across location, time, and social groupings. Wood and wood fuel account for less than one-third of the total economic value (TEV) of forests in the nations studied by Silvestro et al. (2021), who evaluated the monetary and nonmonetary values of forest ecosystems in eight Mediterranean countries. Recreational activities, fishing, protection given by the river network, and carbon sequestration accounted for between 25 and 96% of the TEV of the ecosystems examined.

The effects of biodiversity loss have been widely documented by scientists. Yellowstone National Park was established in 1872 as a result of efforts by a group of scientists (Yuan et al., 2023). The notion of ESs, or services supplied by nature to people, was created in the 1960s and 1970s (Balian et al., 2016), although the economic view that people's survival depends on natural resources, which are limited, dates back to the 18th century. Ecosystem conversion, habitat fragmentation, landscape alteration, anthropization of the natural environment over time, and biodiversity loss are all negative human impacts on ecosystems that have a knock-on effect on human well-being (Raihan et al., 2018; Raihan et al., 2022f).

Several United Nations issued papers highlight the significance of preserving and managing forest ESs in a sustainable manner. The 'Rio Forest Principles' from the 1992 UN Conference on Environment and Development; the UN Framework Convention on Climate Change (UNFCCC), which highlights the importance of forests in terms of the global greenhouse gas (GHG) balance; the Convention on Biological Diversity, which addresses forest biodiversity; the UN Forum on Forests (UNFF); the UN Convention to Combat Desertification (UNCCD); and the Paris Agreement (Raihan et al., 2022g).

The loss of biodiversity, changes in land use and spatial planning, climate change, the rise of circular and bio-economies, and the development of new public policies and strategies have all contributed to the rise of ESs as a major topic on the public agenda in recent years (Neill et al., 2020; Verkerk et al., 2020; Raihan and Tuspekova, 2022b). The development of a tool for measuring TEV is necessary to support political decision-making and to inform citizens and businesses about the benefits and costs inherent in projects, programs, and policies (Raihan et al., 2023b). There is a growing consensus that the economic value of ESs is necessary for the creation of effective public policies and strategies in spatial planning, land management, and other decision-making contexts (Bruno et al., 2023). Due to the fact that ES valuation can shift over time and across locations, from simple awareness-raising to in-depth analysis of different policy choices and scenarios, the value of ESs and biodiversity is determined by what societies are willing to offer in exchange for nature conservation. Kim et al. (2020) estimate that annual ES losses owing to land-use change ranged from \$4.3 to \$20.2 trillion between 1997 and 2011.

Ecosystem services and challenges

Conservation and restoration of natural habitats provide societal benefits such as clean air and water, flood management, and agricultural pollination, giving rise to the idea that nature and ESs are capital in recent decades (Raihan et al., 2023c). Taking into account the value of these benefits, it's possible that preserving forest ESs is necessary. Public discussions of ESs have struck a nerve. Some see the concept of ESs as a chance to factor in all the environmental benefits that the market has overlooked when making public and private decisions. The prospect of organizing payments for ESs in a way that assigns and respects property rights while also taming the market's power may seem just as appealing to some (Undheim, 2023) as it does to others.

Reducing emissions and taking steps to adjust to changing climate conditions are both necessary (Raihan and Tuspekova, 2022c; Voumik et al., 2022a; Sultana et al., 2023). By sequestering carbon dioxide (CO_2) and creating useful timber products, the forestry industry and the forest itself contribute significantly to climate change adaptation (Raihan et al., 2023d). In addition, the services they offer can help people prepare for the effects of climate change now and in the future (Raihan and Tuspekova, 2022d). Environmentally sustainable practices (ESs) contribute to resolving climate change and are also vulnerable to its effects (Raihan et al., 2023e; Raihan, 2023g). The ability of forests to offer vital ecosystem services in the decades to come may be compromised by climate change. It is currently unknown to what extent adaptations to forest management techniques are already in progress, but they are necessary to address this challenge (Sallmannshofer et al., 2023). Climate-Smart Forestry has the potential to greatly improve forests and the forestry sector, according to a study by the Environmental Finance Institute (EFI) (Nabuurs et al., 2018). Through the use of synergies with other forest-related demands, this strategy strives to increase the climate benefits of forests and the forestry sector. Reducing or eliminating greenhouse gas emissions to mitigate climate change is the first pillar (Raihan and Voumik, 2022a; Raihan, 2023h), while adapting forest management to build resilient forests and actively managing forests to sustainably increase productivity and provide all of the benefits that forests can offer are the second and third (Raihan and Tuspekova, 2022e). In 2021, the European Environmental Bureau warned that "the global material footprint is already beyond ecological limits, being over 100 billion tons per year and, if we continue 'business as usual,' is expected to double in the next 40 years." This group is an international nonprofit that brings together more than 160 civil society organizations from more than 35 European countries. The effects of overindulgence are substantial. 'Resource extraction and processing account for more than 90% of the global effect on biodiversity loss and water quality and roughly half of global climate change emissions,' the European Commission writes in the European Green Deal (Modarress et al., 2023).

Due to its environmental, social, cultural, and economic components, sustainable development is now a cross-disciplinary, international term (Raihan and Tuspekova, 2022f; Raihan, 2023i). Environmental, social, and economic goals can be reconciled through the implementation of a bioeconomy (Eversberg et al., 2023) that is currently being advocated both for politicians and enterprises. Degradation of the natural environment as a result of human activity has had far-reaching effects on society and the economy, as well as spawned novel conceptual frameworks for the ways in which people interact with and depend on their surroundings (Raihan, 2023j). As the term "bioeconomy" becomes increasingly commonplace in the scientific literature, three key goals are emerging: resource management, biotechnology, and agroecology (D'Amato et al., 2020). Despite the diversity of the publications and the novelty of the methods employed, a review of 45 documents and articles conducted in 2020 revealed that eight topics predominated: (a) the technical and economic feasibility of biomass extraction and use; (b) frames and tools; (d) the sustainability of biology-based processes, products, and services; (e) the ecological sustainability of a bioeconomy; and (f) the governance of a bioeconomy. Despite the fact that bioeconomy and NC both present new interdisciplinary frameworks for environmental sustainability by combining economics and the natural sciences, they are rarely used in tandem (Neill et al., 2020; Raihan, 2023k). With a circular economy in place, technological and productive tasks won't drain ecological systems to the point of exhaustion (Raihan and Tuspekova, 2023a). That's reflected in the greener outcomes of the circular economy. For instance, a circular economy would result in fewer greenhouse gas emissions, cleaner air, water, and soil, and the protection of natural reserves (D'Amato et al., 2019; Raihan et al., 2022h; Subbarao et al., 2023). Services and goods from forest ecosystems include timber, pollination, and potable water. These services will be exhausted in a linear economy due to the unsustainable consumption of natural resources and the emission of toxic byproducts from industrial activities (D'Amato et al., 2019; Raihan and Tuspekova, 2022g). The soil, air, and water will continue to be resilient and productive if the products extracted from an ecosystem are used in a rational and intelligent technological and economic cycle, and if the technological processes do not discharge toxic substances into the environment (D'Amato et al., 2019; Verkerk et al., 2020; Raihan et al., 2022i). Assessing NC and ES flows provides a potent economic engine for nature conservation and nature-based solutions to current economic challenges, processes, and industrial systems (Parida et al., 2019; Raihan and Tuspekova, 2022h), so it's in everyone's best interest to learn more about ESs and their economic applications.

Utilitarian and nonutilitarian approaches of ecosystem valuation

There are many facets of ESs' significance for human society, including ecological, social, and economic ones (Li et al., 2023) that must be taken into account. Various techniques for assessing ESs, such as mapping and modeling supply and demand for ESs to determine their market value (utilitarian approach) and social and environmental assessment techniques to assess their nonmarket value (nonutilitarian approach), have evolved over time in response to growing concerns about the valuation of ESs.

Cost-benefit analysis and welfare economics, which see human flourishing in terms of individual happiness based on the individual usefulness of products and services, are inextricably intertwined with the utilitarian perspective. Researchers in the field of environmental psychology have also confirmed that ESs are important for human well-being beyond just meeting basic physiological and psychological demands (ACB). Unlike market valuation, which can be done with relative ease, evaluating an ecosystem's nonmarket value presents a number of obstacles. Based on Krutilla's (1967) seminal classification, the utilitarian approach separates the TEV of ESs into two categories: the use value, which is related 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 for the benefit of future generations. Both of these classes were later broken down into subclasses. Nonuse value was further subdivided into existence or intrinsic, aesthetic, altruist, bequest, moral, and religious values, while use value was categorized as direct use, indirect use, optional, quasi-optional, and bequest. The value of ESs is directly tied to their use, such as the worth of raw materials. Regulating services, such as water quality regulation, have indirect use value (Shmelev et al., 2023) because of the benefits they provide to society. Values assigned to ESs that take into account only the possibility of using those services in the future are known as "quasi-optional" or "optional" values. Existence value, often called intrinsic value, is one type of nonuse value that refers to the importance that people place on a service or good simply because it exists, regardless of whether or not they intend to use it. The utilitarian approach, which considers the utility of NC for humans and the socioeconomic system, is concerned largely with expressing the associated values of ESs in monetary terms (Zagonari, 2023). Everything in an ecosystem that people and businesses can or do use plays a role in this definition.

Nonuse values are defined and quantified in terms of monetary units in a neoclassical economy, which forms the basis for environmental economics and evaluation methodologies (Kim et al., 2020). Both the contingency assessment method (CVM) and direct choice experiments (DCEs) are used to estimate nonuse values like WTP through preference declarations in questionnaires or interviews (Riegel et al., 2023) that participants fill out. Nonuse values are often estimated using one of two assessment methods. The first method involves determining how many people would be willing to pay for ESs (or the qualities associated with them in the case of DCE) if they knew they would never use them. In this scenario, it is assumed that the interviewees are not current users. In the second method, participants—including end users—are asked to break down their overall WTP for ESs according to factors including inheritance, presence, and personal use. The relative proportions of value categories in WTP estimates or the identification of the warm glow effect in willingness to pay (WTP) answers are also topics that have benefited from the usage of statement decomposition methodologies in numerous CVM-related ES applications (Lawton and Fujiwara, 2023). Nonuse values in WTP are generally believed to be quite large, accounting for anything from 40 percent to 90 percent of the overall WTP (Khatiwada et al., 2023) in most circumstances. The cognitive challenge of addressing the components of a novel and indivisible value is a major reason why the decomposition approach indicated in interviews has severe flaws and is extremely contentious despite its widespread use. Total WTP for an ES is typically the result of multiple reasons that overlap and are intertwined, making them difficult to isolate and study (Lawton and Fujiwara, 2023) because of this. The ES evaluation is typically carried out when picking one service over another is necessary.

Various measurement approaches have been identified and refined over time in an effort to do a thorough economic assessment of ESs. Ecosystems assist populations through ecosystem functions and components (i.e., services), and in 1997, Costanza published the first substantial economic assessment of ESs, even from a nonmonetary standpoint. Ecosystems are priceless because they are one-of-a-kind and impossible to replicate. The author used assessment methods mostly based on WTP to categorize ESs and determine their unit values. When these figures were applied to the whole area of all US ecosystems, the resulting $33 trillion yearly value was more than double the anticipated $16 trillion GDP (Costanza et al., 2014). After another 14 years, it was projected that ESs were worth $18 billion annually worldwide, with 19% of it coming from ES climate regulation and 4% from raw materials related to productive functions. Recreational benefits, protection from extreme events, water supply protection, erosion control, nitrogen cycling, habitat, genetic resources, and non-wood products are all part of the ES's value (Costanza et al., 2014).

The work that Costanza did was ahead of its time. However, the proposed methodology faced technical and ethical hurdles due to the fact that ecosystems, as a source of life, are in a perpetual state of change and cannot be put into monetary terms. Some people are skeptical of the link between ecology and the economy because they worry that if we rely too heavily on the market to protect our ecosystems, we may end up devaluing nature even more. If they are able to maintain their ESs for the benefit of future generations, underdeveloped countries, for instance, could seek and receive financial compensation commensurate with the projected worth of the ESs they give. There was a lot of backlashes to Costanza's method, but that's to be expected when you bring in scientists, policymakers, and stakeholders. Although monetary valuations of ESs are popular, they are far from the sole way to evaluate their worth. The idea of TEV was established and a classification of TEV components and assessment tools that may be used to examine various components of ESs were described in TEEB, published by The Ecological and Economic Foundations in 2010. The authors propose that the value of ESs and biodiversity depends on the sacrifices that societies are ready to make in order to protect natural resources. Ecosystems are a scarce and irreplaceable resource, and the costs associated with their deterioration or destruction must be taken into account by society and policymakers. When resources are scarce, economists talk about "opportunity cost," which is the worth of the best of the sacrificed opportunities (the one passed up when a decision is made). However, it is challenging to make a monetary assessment of ESs because of the irreversibility or prohibitive cost of reversing the changes to ecosystems. Buyer preferences for nature, society, health, technology, and the future are all factored into the predicted economic value (Froese et al., 2023) in various ways. Changing any of the aforementioned variables affects the projected economic value, which in turn affects the scenarios considered (Hernández-Blanco et al., 2020).

Methods such as the price-based method, the cost-based method, and the production function-based method are examples of direct market valuation approaches; the travel cost method and the hedonic pricing method are examples of revealed preference approaches; and the contingent valuation method, choice modeling, and group valuation are examples of simulated valuation. The value of products and services is typically determined by their market price. Since they are exchanged openly, their worth can be determined with relative ease. Manda et al. (2023) cites the worth of wood, honey, and tourist services as examples. Several approaches have been established for calculating costs, one of which is the avoided costs method (Baumbach et al., 2023) that evaluates the costs that would have occurred without the ES. The replacement cost method calculates how much it would cost to replace ESs with artificial technologies, the restoration cost method estimates how much it would cost to mitigate the effects of ecosystem loss or restoration, and the production function-based method calculates how much the nonmarket ESs contribute to other services or goods traded on the market, noting how much their services contribute to increasing the productivity or price of those goods and services.

Value of biodiversity and Ess-related recreational services can be calculated using the journey cost technique (Wubalem et al., 2023). The approach assumes that there are both direct and opportunity costs associated with leisure activities. Changing biodiversity in ecosystems may have an effect on tourist interest (Voumik et al., 2022b). Using the value that a landscape or proximity to an ecosystem can provide to a market, such as the real estate market, hedonic pricing is developed. The value of a property can be affected by changes in the biodiversity of the surrounding ecosystem. Costing a lot of money and taking a long time to complete, revealed preference methods involve a lot of complicated data and statistics. Since these techniques are based on seeing customers directly, they can also provide a snapshot in time (Wubalem et al., 2023) for analysis.

To determine how much people are prepared to endure ecosystem loss or deterioration for compared to how much they are willing to pay to safeguard ESs, the contingent valuation technique uses questionnaires. Human behavior can be modeled via choice modeling, which assumes that individuals would weigh financial considerations with other factors when making decisions among multiple options. The group valuation method is gaining popularity as a means of collecting values such as those associated with the singularity of ecosystems, social justice, and the superiority of human altruism to that of nonhuman species in terms of both the present and the future. Careful application is required, and the methodologies' limitations should be taken into account, especially when determining the nonuse value of a service for which no market price exists (Zegeye et al., 2023).

Extensive research conducted in Europe through the study Operationalization of Natural Capital and Ecosystem Services Integrated (OpenNESS) (Makovníková et al., 2023) 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, E-Tree or ESTIMAP; (ii) integrated mapping-modelling approaches; (iii) land-use scoring; (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 (Wubalem et al., 2023) or hedonic pricing methods (Aziz et al., 2023); and (vii) integrative approaches (Gobster et al., 2023). Many elements, such as the nature of the decision at hand, the merits and drawbacks of the potential approaches, and practical considerations like the quantity and quality of data and the accessibility of relevant experts, might influence the choice of approach to take in any given situation. The unique characteristics of each approach help determine which choices and issues it is best suited to address. It's possible that a method's suitability for a certain task is the most important consideration when choosing between several alternatives. Only a few numbers of techniques, such as modeling approaches and participatory scenario planning (which was developed for this same purpose), can predict how ecosystem services will be provided in the future. Photo-series analyses of cultural ESs are one example of an approach that focuses on a subset of ESs rather than all of them. PGIS, preference assessment methods, photo-elicitation, and multi-criteria decision analysis (MCDA) are all examples of approaches that aim to provide a more comprehensive or strategic view of multiple ESs and can be used to evaluate trade-offs in service provision or demand from various stakeholder groups.

The development of environmentally sustainable decision-support systems requires the combination of ES evaluation and life cycle assessment (LCA). To evaluate the environmental effects of manufacturing processes from "cradle to grave" (Mostafaei et al., 2023), LCA approaches have long been used as management tools (Mostafaei, et al., 2023). In the 1960s, in response to the 'Limits to Growth' discourse's warnings about the earth's finite resources, this strategy was developed. Initially, the evaluations were conducted solely for the purpose of providing corporations with data on energy efficiency and emissions (Raihan and Voumik, 2022b). After the 1980s, LCA was also used in academics and by governments; methodological improvement was made, bolstered by formal attempts at worldwide standardization (Courtat et al., 2023). Despite its clear benefits and drawbacks, LCA has become a standard method for evaluating production-consumption systems from a sustainability perspective (Liu et al., 2020). Although there is growing interest in ES integration in LCA techniques, further research is needed (D'Amato et al., 2020).

Ecological value, sociocultural value, value with direct economic importance, and intrinsic value are the four forms of value identified by the nonutilitarian approach (Ortiz-Przychodzka et al., 2023). Ecosystem factors like complexity, diversity, and scarcity (Morrison et al., 2023) all play a role in establishing an ecosystem's ecological value. Biophysical methodologies, integrated mapping-modeling approaches, and land-use scoring are recommended for assessing ecological value (Berihun et al., 2023). Physical and mental well-being, access to quality education, cultural diversity and distinctiveness (heritage value), personal autonomy and spiritual significance are all central to what we mean by "sociocultural value." Participatory mapping and the sociocultural approaches outlined above are the most common ways to assess it (Guo et al., 2023). 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 frequently identified approaches to determining economic value (Kim et al., 2020; Aziz et al., 2023; Khatiwada et al., 2023; Wubalem et al., 2023) for cultural assets.

Preference prioritizing approaches, multicriteria analysis methods, and photo-elicitation surveys, along with biophysical methods like ecological models, may be the most appropriate methods for assessing intrinsic value. In conclusion, the nonutilitarian approach is in line with the ideas of ecological economists who find the substitutability and valuation of NC controversial, while the utilitarian approach is in line with the philosophy of environmental economists who are in favor of extending monetary valuation methods to nonmarket ESs. Illustration of the nonutilitarian and utilitarian approaches of valuing Ess. The lines between utilitarian and nonutilitarian perspectives are increasingly blurry, and both have access to a large and growing corpus of literature. Although the nonutilitarian approach to ES valuation and the motive to increase conservation efforts are acknowledged, the use of monetary units to promote awareness of their relevance is an effective tool (Finn et al., 2023) for policymakers.

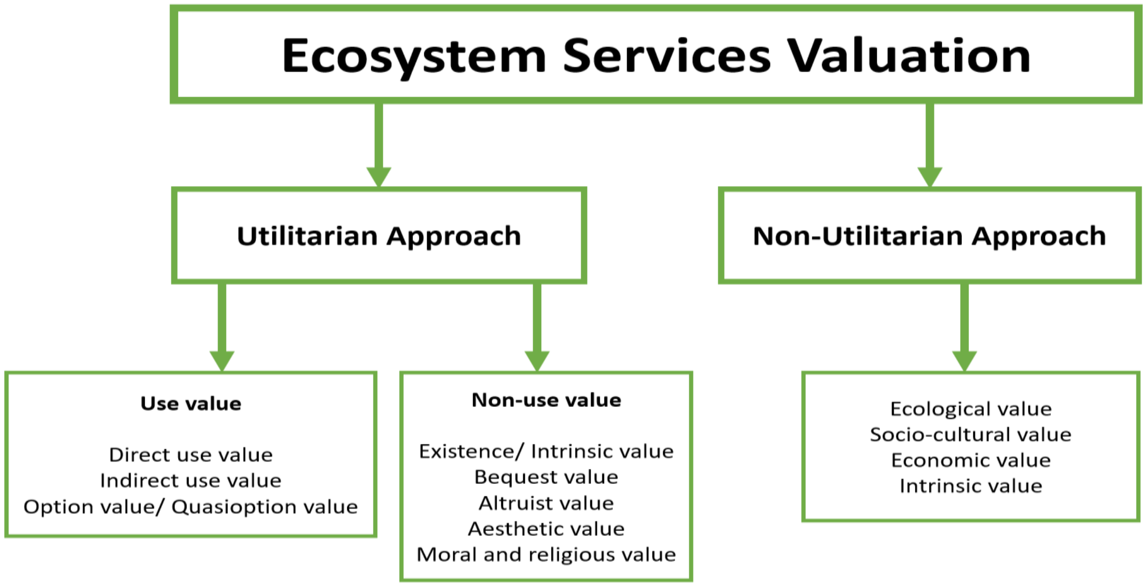

Figure 1. Methods of valuing ecosystem services in a utilitarian and nonutilitarian context

Cost-benefit analysis of ecosystem services

Preserving ecosystems is crucial for achieving sustainable development, as evidenced by the data on all ecosystems and all services. Ecosystems must be cared for even if they are exploited heavily and over long periods of time. Ecosystem conservation strategies are thus required as a countermeasure to resource depletion. For this, it's best to do an environmental cost-benefit analysis (CBA) (Bruno et al., 2023) to weigh the pros and cons. First, a CBA presents the territorial distribution of benefits and costs and compares this distribution with the distribution of biodiversity, allowing for the identification of important areas for both people and biodiversity (win-win areas), as well as areas of potential conflict and areas in need of compromises (negotiations). In some regions, the net economic benefits of conserving ecosystems are little, whereas the values of biodiversity are large. The second benefit of a CBA is that it shows where conservation efforts will have the greatest impact by pinpointing locations with the highest unit cost benefits. Third, ES maps could assist pinpoint ES suppliers and users, leading to the development of more just and effective approaches to funding conservation initiatives. Estimating the monetary value of the environment, particularly the economic value of nonmarketable commodities and services, is the primary task in an environmental CBA (Raihan and Said, 2022). In 1970, CBAs were first used in the United States on projects receiving public funding and having an environmental impact. Since then, CBAs have been adapted and applied to a wide variety of techniques, including stated preference methods (such as the contingent valuation method, WTP, WTA, choice experiments, deliberative group valuation, and health risk valuation) and revealed preference methods (such as the travel cost and hedonic price methods) (Mononen et al., 2023) for determining a person's willingness to pay for something. Additionally, it is crucial to consider spatiotemporal frames when conducting CBA, as ESs are generated at various scales, from the local to the global, and even a small shift in the spatial or temporal frame approached in CBA can generate different consequences and stakeholders considered in CBA.

Future research on the valuation of ecosystem services

Conservation of natural resources, environmental management, and other sectors of public policy have all been affected by ES techniques and evaluation efforts (Raihan and Tuspekova, 2022i). Strategies for natural resource management and conservation through investment in the conservation, restoration, and sustainable use of ecosystems are now widely understood to be best (Raihan and Tuspekova, 2023b) when based on a combination of all values that occur when estimating the TEV (Crook et al., 2021). The holistic method of ES valuation is depicted in Figure 2. Economists' efforts to involve interdisciplinary teams and incorporate a variety of methods and information have demonstrated their flexibility, which reinforces the idea that they are effective in the process of diluting public policy decisions (Raihan and Tuspekova, 2022j). 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. However, local factors and stakeholder interests must be taken into account when developing valuation techniques (Kyriakopoulos and Sebos, 2023) to determine the extent to which public policies are good for people and the environment. It will take radical transformations toward systematic integration of the ESs in decision-making at the individual, corporate, or governmental level to move from conceptual frameworks and theory to practical integration of ESs into credible, replicable, scalable, and sustainable public policies (Li et al., 2021).

Figure 2. An integrated method for assessing ecosystem services

There has been much discussion on how ESs should be accounted for in national accounts because it is mostly a matter of discretion (Zegeye et al., 2023). Valuation has made a big difference in efforts to incorporate the created ES values into national accounts, as evidenced by the 2002 UN System of Environmental-Economic Accounting—Experimental Ecosystem Accounting (SEEA EEA) (Turner et al., 2019). According to the literature, ES accounting can be used to estimate how much value an ecosystem adds to a society's economy (Heckwolf et al., 2021). This can highlight the benefits of ES to the economy, society, jobs, and people's standard of living (Raihan and Tuspekova, 2022k). The data pyramid for SEEA's essential indicators of ES is shown in Figure 3. The information pyramid, which integrates fundamental economic, ecological, and sociodemographic data, emerged as a result of SEEA technique. The collection, centralization, and processing of such data can yield analyses and research that lend credence to public policy decisions and pave the way for the creation of aggregate key indicators at the macro level.

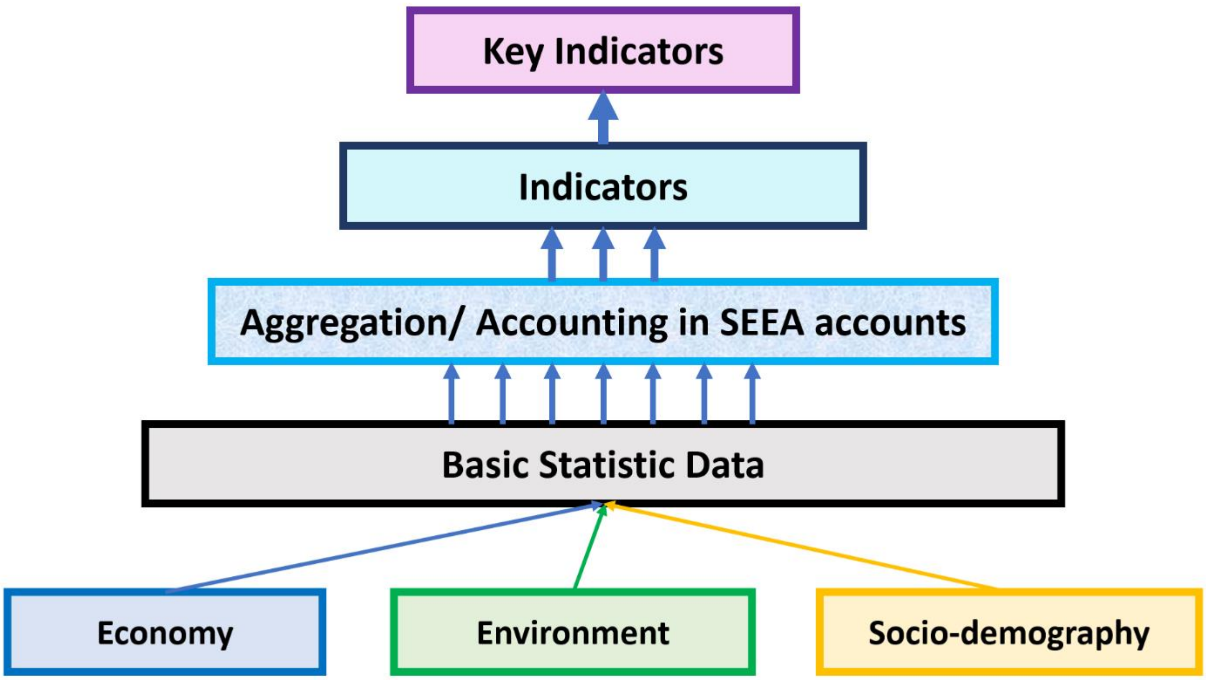

Figure 3. SEEA's pyramid of information for ecosystem service key indicators

However, it is difficult to develop such indicators. However, converting well-being value-based methods into exchange value terms can be challenging (Vallecillo et al., 2019; Heckwolf et al., 2022), so using exchange value methods based on market techniques to quantify ESs is preferable. As a result, it is clear that additional work has to be done to create a value-based strategy that can account for both monetary and nonmonetary benefits (Turner et al., 2019). The development of experimental ES accounts also highlighted the need to create unique indicators for various ESs, as each service is unique. Timber production, biomass harvesting for energy, wild food provision, climate regulation, fire management, air quality regulation, noise reduction, water purification, recreational and aesthetic qualities are some of the most important indicators for forest ecosystems. Because natural, historical, and cultural resources do not have an express monetary value, the accounts established at the EU level face various obstacles, such as a shortage of data and a lack of availability at the needed spatial resolution (Heckwolf et al., 2021). Comparing the cost of living in situations where nature is maintained in acceptable conditions with conditions where nature is allowed to degrade leads to a different conclusion (Costanza et al., 2014), demonstrating that the single-value techniques are no longer viable options (Jacobs et al., 2016).

Conclusion

Different ecosystem services produced by natural capital have different worth in human existence and different needs for evaluation. The values shift throughout time and across locations. Some services' values could be overestimated if they were valued using a single technique or a single service. However, there are costs associated with the exploitation of natural capital, which can be seen as negative externalities or trade-offs for the ecosystem and the community. Compromises are reached between them in real life. Information on multiple dimensions is needed for managerial and policy decisions. Policymakers would benefit from the information provided by integrated valuation methodologies since it would provide information from a variety of angles.
The purpose of an ES assessment is not to set prices in order to make a profit from ESs on the market. Instead, it emphasizes the positive effects ESs have on people's lives and the importance of using them to create effective public policies and initiatives. Different types of ecosystem value assessment tools have been developed by

utilitarian and nonutilitarian natural capital approaches. However, substantial information on the nonuse values of ESs is still lacking. The availability and reliability of data continue to be major points of contention surrounding various ES assessment methods. More study is needed to provide precise methods for determining VET of ESs, along with indicators and methods for modeling and calculating them. It is possible to discover win-win zones and areas of potential conflicts, for both humans and the environment, by employing a pluralist framework made up of a set of decision-making instruments customized to the spatial and temporal scales involved, of which CBA is an important component. These methods might be the most effective way to back the public policy changes that are necessary to address the problems at hand. More attention has been paid in recent years to the impacts of climate change on ecosystems and the relationships between ESs and other areas of sustainability research, such as environmental economies, bio-economies, and circular economies. In order to better assist the decision-making process and public policies, more research utilizing an integrated approach to link ES valuation to sustainability science is required.

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