Forestry: Jurnal Ilmu Kehutanan
Volume. 1, Issue 1, November 2025
Page No: 29-43

Economic Valuation of Forest Ecosystem Services: Methods, Applications, and Policy Implications

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Received : October 05, 2025
Accepted : November 09, 2025
Published : November 30, 2025

Citation: Jumiyati, S., (2025). Economic Valuation of Forest Ecosystem Services: Methods, Applications, and Policy Implications. Forestry: Jurnal Ilmu Kehutanan, 1(1), 29-43.

ABSTRACT: Forests deliver essential ecosystem services that support ecological stability and human well-being, yet their economic value remains underrecognized in policy and planning. This narrative review synthesizes literature on the economic valuation of forest ecosystem services, with a focus on methodologies, key service categories, and regional disparities. Using Scopus, Web of Science, and Google Scholar, studies were selected based on keyword combinations and inclusion criteria targeting empirical analyses on valuation methods and service outcomes. Findings show that Contingent Valuation, Travel Cost, and Replacement Cost methods are widely used to assess both market and non-market values, with each method demonstrating specific strengths and limitations. Carbon sequestration, recreational benefits, and clean water provisioning emerge as the most commonly valued services, with regional studies attributing between 10% to 55% of total forest value to these categories. Systemic factors such as institutional capacity, environmental policy integration, and socio-economic conditions significantly influence valuation implementation and quality. Countries with developed governance structures yield more robust valuation frameworks compared to those in resource-constrained regions. The review highlights the necessity of combining valuation techniques, enhancing data infrastructure, and engaging local stakeholders to address current gaps. By embedding economic valuation into policy mechanisms such as Payments for Ecosystem Services (PES), governments can improve forest management outcomes. These insights advocate for a more inclusive, context-sensitive valuation approach to align conservation goals with economic development needs.

Keywords: Economic Valuation, Forest Ecosystem Services, Contingent Valuation Method, Sustainable Forest Policy, Carbon Sequestration, Environmental Economics, Participatory Conservation.

INTRODUCTION

Forests play a critical role in maintaining global ecological balance by providing a broad range of ecosystem services, including carbon sequestration, water regulation, soil conservation, and biodiversity preservation. These services are not only essential for environmental sustainability but also carry substantial economic value that often remains unrecognized in formal markets. In recent

decades, the economic valuation of forest ecosystem services has gained increasing attention among researchers and policymakers seeking to integrate ecological functions into economic decision-making. The integration of ecosystem service valuation into policy frameworks is seen as a promising approach for aligning economic incentives with conservation goals. According to Lamichhane et al. (2019), effective forest resource evaluation necessitates integrated management systems that consider ecological and economic dimensions simultaneously. However, the inherent complexity in quantifying the value of ecosystem services, particularly in diverse and dynamic ecological systems, continues to pose methodological and empirical challenges. González-Hernández et al. (2023) emphasize that varying valuation methodologies across urban forest ecosystems often produce inconsistent outcomes, highlighting the difficulty in achieving standardized assessment frameworks.

Global land-use changes have further complicated valuation efforts by introducing uncertainties in ecosystem stability. The encroachment of human economic activities into forest areas alters ecological functions, rendering traditional valuation approaches inadequate. Zhang et al. (2020) observed that habitat degradation driven by land-use shifts significantly diminishes the capacity of forests to provide stable services. Moreover, intangible and non-market ecosystem services, such as cultural or spiritual values, often evade accurate monetary estimation, despite their profound social importance. As Filyushkina et al. (2015) note, conventional valuation models frequently overlook these dimensions, necessitating the development of interdisciplinary frameworks that merge natural and social sciences to better capture the full spectrum of ecosystem service benefits.

Recent developments in environmental policy have emphasized the integration of ecological valuation into decision-making. Both global and local policy trends increasingly recognize forests not merely as sources of timber and carbon sinks, but as dynamic providers of multifunctional services crucial to climate resilience and community well-being. Gómez et al. (2023) illustrate how participatory and integrated economic assessment models enhance policy planning by incorporating diverse stakeholder perspectives. In alignment with global sustainability frameworks, such as the UN Sustainable Development Goals, policy initiatives are increasingly oriented toward ecological restoration and biodiversity conservation. Ferraro et al. (2015) argue that conservation programs, particularly in ecologically sensitive and economically marginalized areas, offer not only ecological benefits but also measurable economic returns. This has prompted policymakers to reassess the importance of ecosystem services within national accounting systems and environmental governance models.

Quantitative studies further validate the economic relevance of forest ecosystem services. A meta-analysis conducted by Brouwer et al. (2022) estimated that the Amazon rainforest alone delivers annual ecosystem services valued at USD 488 billion. Similarly, Getzner and Islam (2020) found that mangrove ecosystems generate benefits worth USD 15.5 billion per year, primarily through coastal protection, carbon storage, and habitat provision. These findings underline the substantial, albeit often undervalued, contribution of forests to both local economies and global ecological stability. Henry et al. (2021) provided additional empirical evidence from Bangladesh, where forest-derived goods such as fuelwood and protein resources support the livelihoods of over 70% of rural populations, demonstrating the direct linkage between ecosystem services and socioeconomic resilience.

Valuation methods applied in tropical and subtropical contexts reflect a wide array of techniques tailored to varying ecological and socio-cultural settings. Filyushkina et al. (2015) advocate for the simultaneous use of contingent valuation, replacement cost, and market-based approaches to better approximate forest service values. In tropical forest settings, contingent valuation has been widely employed to capture non-market values, including local community willingness to pay (WTP) for conservation initiatives. Pérez-Rubio et al. (2021) found that local populations often demonstrate high WTP for maintaining forest integrity, particularly when services such as water provision and biodiversity conservation are at stake. Furthermore, D'Amato et al. (2022) emphasized the applicability of mixed-method approaches in Nordic forest enterprises operating in subtropical zones, demonstrating the relevance of context-specific strategies for evaluating ecological-economic interactions.

Despite methodological advancements, critical challenges remain in the economic assessment of forest ecosystem services. First, heterogeneity in geographic, ecological, and sociopolitical conditions makes it difficult to develop universal valuation frameworks. Disparities in data availability and quality often hinder the generalizability of results. Filyushkina et al. (2015) stress that conventional valuation tools are frequently ill-equipped to address ecosystem service heterogeneity, thereby limiting their applicability across diverse biomes. Secondly, the invisibility of non-market values in economic metrics creates a systemic bias that underrepresents the full value of forest ecosystems. Pérez-Rubio et al. (2021) argue that cultural and spiritual values are routinely excluded from economic evaluations, leading to policy recommendations that fail to reflect community priorities.

Third, ecological transformations resulting from deforestation, urbanization, and climate change introduce volatility into ecosystem service provision, undermining the reliability of static valuation models. Zhang et al. (2020) demonstrate that changes in land-use patterns disrupt habitat functionality, complicating efforts to assign consistent economic values to forest services. Fourth, institutional and technical barriers, including the lack of standardized metrics and limited stakeholder participation, further restrict the scope and accuracy of economic assessments. Gómez et al. (2023) emphasize that participatory approaches remain underutilized, despite their potential to improve valuation accuracy and stakeholder engagement.

Given these complexities, several gaps persist in the existing literature. Most notably, the valuation of non-market and intangible services remains underexplored. Kadykalo et al. (2021) advocate for the establishment of global research networks dedicated to developing methodologies that account for the full spectrum of ecosystem services, including cultural, aesthetic, and spiritual dimensions. Furthermore, Brouwer et al. (2022) identify a lack of comparative studies across regions, which limits the transferability of findings and impedes the formulation of globally coherent policy recommendations. There is also a need for localized valuation tools that consider ecosystem-specific characteristics and stakeholder priorities. Lamichhane et al. (2019) call for methodological innovations that reflect the ecological and cultural nuances of forest landscapes. Finally, the role of participatory valuation in empowering local communities and improving the legitimacy of valuation outcomes remains insufficiently examined, as highlighted by Gómez et al. (2023).

The primary objective of this review is to synthesize and critically evaluate current methodologies and empirical findings related to the economic valuation of forest ecosystem services. This review places a particular emphasis on understudied geographical contexts, especially tropical and subtropical forest regions. By focusing on regions where ecological services are essential for local livelihoods, the study aims to illuminate the intersection between environmental conservation and socioeconomic development. Key themes explored include methodological diversity, stakeholder inclusion, policy integration, and regional variation in valuation outcomes. The review seeks to identify best practices, emerging trends, and persistent challenges in the valuation of forest services, offering insights for both researchers and decision-makers.

The scope of this review encompasses a diverse array of forest ecosystems, with a particular focus on those located in low- and middle-income countries where reliance on forest services is most pronounced. These regions often exhibit high biodiversity levels and face significant pressures from land-use change, making them critical sites for ecosystem service valuation. The review includes studies that engage with both quantitative and qualitative valuation methods, acknowledging the complementary strengths of each approach. Furthermore, this study emphasizes participatory frameworks that involve local communities in the valuation process, thereby enhancing the accuracy, relevance, and legitimacy of valuation outcomes. In doing so, the review contributes to a more holistic understanding of forest ecosystem service valuation and its role in informing sustainable forest management and policy development.

METHOD

This review employs a narrative methodology to synthesize relevant literature on the economic valuation of forest ecosystem services. The approach is grounded in a comprehensive and structured search of peer-reviewed and grey literature that focuses on valuation methods, applications, and policy implications related to forest resources. The process followed internationally recognized standards for conducting literature-based research and was designed to maximize transparency, reproducibility, and academic rigor.

The literature search was conducted using three primary academic databases: Scopus, Web of Science, and Google Scholar. These databases were selected due to their broad coverage of interdisciplinary fields, particularly in environmental science, ecological economics, and forest resource management. Scopus was prioritized for its expansive indexing of environmental and economic journals, offering access to high-impact publications and advanced filtering capabilities. As noted by Kadykalo et al. (2021), Scopus has been instrumental in compiling robust evidence on forest ecosystem valuation due to its depth and discipline-specific search filters. Web of Science was used in parallel to access additional high-quality journals and citation analytics, enabling the identification of influential articles and research clusters. This database is particularly valuable for mapping research trends and conducting meta-analytical assessments, as suggested by L'Ecuyer-Sauvageau et al. (2021). Google Scholar was also employed to supplement the search, especially for accessing grey literature, reports, theses, and articles from non-indexed journals. While less selective in scope, Google Scholar broadens the inclusivity of search results and captures diverse

academic outputs, including regional studies that are often underrepresented in more selective databases (Brouwer et al., 2022).

A systematic keyword strategy was implemented to ensure comprehensive coverage of the relevant literature. The keyword combinations were selected based on prior studies and expert recommendations in the field of ecosystem services valuation. Among the most effective combinations were: "economic valuation" AND "ecosystem services" AND "forest resources"; "forest ecosystem services" AND "monetary valuation" AND "sustainability"; "willingness to pay" AND "forest conservation"; and "ecosystem service valuation" AND "biodiversity" AND "policy implications". Each combination was designed to capture a specific dimension of the valuation discourse. For example, the first set targeted general valuation frameworks in forest contexts, while the second added sustainability considerations. The third combination was essential for identifying studies employing contingent valuation or other preference-based methods to assess societal willingness to support forest conservation. The final set explored how ecosystem valuation is linked to biodiversity outcomes and policy decision-making, drawing on the framework recommended by Förster et al. (2019), Filyushkina et al. (2015), Henry et al. (2021), and Pei et al. (2015).

Searches were conducted between January and April 2025, with each database queried independently using advanced search functions to refine results by year, language, document type, and subject area. Only English-language publications were considered, as they dominate the academic discourse on ecosystem service valuation. The initial pool consisted of approximately 1,200 records, including journal articles, conference proceedings, policy reports, and academic theses. Duplicates were removed, resulting in a working corpus of 867 unique records.

Inclusion and exclusion criteria were applied to identify studies relevant to the research questions. To be included, studies had to: (1) focus explicitly on the economic valuation of forest-related ecosystem services, (2) utilize recognized valuation methods (e.g., contingent valuation, replacement cost, travel cost method, benefit transfer, or market pricing), and (3) present original empirical data or structured review findings. Articles focusing solely on theoretical or philosophical debates without empirical or methodological contributions were excluded. Furthermore, studies that discussed valuation of ecosystems unrelated to forest environments, such as marine or desert systems, were excluded unless they provided comparative insights relevant to forest contexts. This ensured that the selected studies offered direct contributions to understanding valuation techniques and outcomes specific to forest ecosystems.

The screening process was conducted in two stages. First, titles and abstracts of the 867 records were reviewed to assess their relevance based on the inclusion criteria. This step resulted in the elimination of 545 articles due to lack of thematic alignment. The remaining 322 full-text articles were then retrieved and assessed for quality, methodological transparency, and relevance to the objectives of the review. Each article was read and coded using a structured template that recorded the study's location, type of forest ecosystem, valuation method used, key findings, and policy relevance. Special attention was given to whether the study included participatory valuation components or addressed intangible, non-market ecosystem services, which are often neglected in standard economic assessments.

The types of studies included in the final synthesis encompassed a variety of empirical designs. These ranged from contingent valuation surveys conducted among forest-dependent communities to benefit-transfer models used in national-scale policy analysis. Case studies from tropical and subtropical regions formed a significant portion of the literature, reflecting the high ecological and socioeconomic stakes in these zones. In addition to contingent valuation and travel cost studies, spatially explicit models integrating GIS data with economic valuation metrics were also considered. These modeling approaches provided insights into regional heterogeneity in forest service values and informed land-use planning processes.

The review also incorporated meta-analyses and systematic reviews where available, particularly those that aggregated findings from multiple countries or ecosystems. These broader studies offered valuable perspectives on methodological consistency and cross-site comparisons. Studies employing qualitative methods, such as participatory rural appraisals or stakeholder interviews, were included when they contributed to understanding local perceptions and cultural dimensions of forest ecosystem value. Such studies were especially important in evaluating intangible benefits and the legitimacy of valuation outcomes.

Throughout the selection and synthesis process, efforts were made to maintain objectivity and academic rigor. Articles were independently reviewed by multiple researchers, and discrepancies were resolved through discussion and consensus. To ensure the credibility of findings, preference was given to peer-reviewed articles published in journals with high impact factors and strong methodological standards. However, select grey literature was included when it offered context-specific insights or addressed understudied geographic regions.

This methodological framework enabled the identification of key themes, patterns, and knowledge gaps in the field of forest ecosystem service valuation. By systematically gathering, filtering, and analyzing diverse studies, the review provides a nuanced and evidence-based foundation for understanding how forest services are economically valued across different contexts. It also supports the formulation of informed recommendations for integrating these valuations into sustainable forest management and policy design.

RESULT AND DISCUSSION

The results of this narrative review highlight a rich body of literature that illustrates the diverse methodologies, types of ecosystem services, and regional differences associated with the economic valuation of forest ecosystem services. The findings are organized into three thematic sub-sections: valuation methods, ecosystem services assessed, and regional and ecosystem-specific variations.

The use of valuation methodologies such as Contingent Valuation Method (CVM), Travel Cost Method (TCM), and Replacement Cost has significantly evolved across studies focusing on forest ecosystems. The CVM, grounded in estimating individuals' willingness to pay (WTP) for non-market goods, is widely applied in studies seeking to evaluate cultural, aesthetic, and conservation-related forest services. Samdin et al. (2019) found that CVM was particularly effective in quantifying public preferences for forest conservation in regions where forests have deep socio-

cultural value. This method allows for the inclusion of subjective perceptions and emotional attachments, which are otherwise excluded from market-based valuations.

The TCM, conversely, is more suitable for estimating the recreational value of forest areas by evaluating visitors' expenditures related to travel, accommodation, and access. Govigli et al. (2019) provided empirical evidence supporting the robustness of TCM in calculating recreational benefits in protected forest zones, demonstrating how travel behavior reflects the perceived utility derived from ecosystem services.

Replacement Cost methods, which estimate the cost of replacing or restoring ecosystem services lost due to degradation, are increasingly recognized as pragmatic tools in valuation. Förster et al. (2019) highlighted that this method provides practical estimates for the financial resources required to restore degraded ecosystem functions, making it especially relevant for policy frameworks that emphasize restoration and compensation.

Each of these methods has strengths and limitations depending on whether the aim is to capture market or non-market values. CVM has proven valuable for assessing non-market services, such as biodiversity preservation and cultural heritage. It captures individual preferences that are not typically expressed in financial terms (Brouwer et al., 2022). Nevertheless, the method is not without criticism; Kornatowska and Sienkiewicz (2018) caution that the reliability of CVM outcomes can be influenced by hypothetical bias, question framing, and respondents' understanding of ecological functions.

TCM is particularly effective in estimating market-related values associated with recreational services. However, its scope is limited to scenarios where a direct monetary expenditure can be observed, and it is inadequate for evaluating services that do not involve visitor spending, such as carbon storage or watershed regulation (Govigli et al., 2019).

Replacement Cost methods bridge the market-non-market divide by estimating actual financial outlays needed to restore services. While this approach offers concrete valuations, it often underestimates the intrinsic or existence value of services that lack direct substitutes. Henry et al. (2021) point out that Replacement Cost may overlook benefits that extend beyond physical restoration, such as the ecological integrity or cultural significance of forests.

The review reveals that certain ecosystem services are more frequently evaluated in economic terms due to their direct relevance to climate policy and local livelihoods. Among these, carbon sequestration emerges as the most frequently assessed service, especially in the context of climate change mitigation. Russo et al. (2023) underscore the pivotal role of forests in carbon capture and highlight financial mechanisms such as carbon credits and offsets that monetize this function, thus integrating it into global carbon markets.

Recreational services also receive substantial attention, particularly in contexts where forest areas are designated for ecotourism or community-based tourism initiatives. Studies such as Kang et al. (2018) have demonstrated that recreation-related services contribute significantly to local economies by generating employment and supporting ancillary industries. These services are often captured through TCM and willingness-to-pay frameworks, revealing the economic value of forest experiences beyond timber and raw materials.

Provisioning of clean water represents another widely evaluated service. Mastrorilli et al. (2018) identify a strong linkage between forest ecosystems and watershed functions, highlighting how forests regulate water flow and maintain water quality. Their study emphasizes that investment in forest conservation can lead to significant savings in water treatment costs and reduce the vulnerability of water supplies to climate variability.

The economic contribution of each of these services to the overall value of forest ecosystems varies by context. Chen et al. (2022) report that carbon sequestration alone can account for up to 55% of total forest ecosystem value in certain regions, especially those with active carbon offset programs. Recreational services, depending on tourism intensity, can represent 20-30% of the overall valuation, as demonstrated in protected areas with high visitor inflows (Govigli et al., 2019). Clean water provisioning contributes between 10-15%, particularly in regions where forests serve as the primary source of drinking water or agricultural irrigation (Mastrorilli et al., 2018).

A comparative perspective reveals important distinctions in valuation outcomes between high-income and low- to middle-income countries. In industrialized nations, valuations tend to be more systematic and grounded in extensive datasets and advanced methodologies. For instance, in Germany, Förster et al. (2019) conducted valuation exercises supported by comprehensive ecological data and sophisticated economic modeling, facilitating integration into national policy and land-use planning.

In contrast, developing countries often grapple with limited data availability, capacity constraints, and a lack of standardized methodologies. Chen et al. (2022) note that in parts of China, ecosystem service valuations sometimes rely on broad assumptions rather than empirical measurements, which can undermine the credibility of the estimates. Additionally, Hjerpe and Hussain (2016) argue that intangible services such as cultural and spiritual values are underrepresented in valuation exercises conducted in developing contexts, resulting in an incomplete picture of forest benefits.

These discrepancies underscore the importance of context-specific approaches to valuation. High-income countries are more likely to produce comprehensive and policy-relevant valuations due to institutional support and technical expertise. Conversely, low- and middle-income countries require capacity-building initiatives and methodological adaptations to ensure valuation reflects local priorities and realities.

Ecosystem-specific characteristics further influence valuation outcomes. Tropical rainforests, with their high levels of biodiversity and ecological complexity, often yield higher valuation estimates due to the range and intensity of services provided. Brouwer et al. (2022) emphasize that the Amazon rainforest delivers exceptional non-market benefits, including climate regulation, flood mitigation, and habitat provision. The vast scope of these services significantly enhances the overall valuation, even when conventional market metrics are not applied.

Mountain forests, in contrast, are more often valued for services like water regulation, erosion control, and microclimate stabilization. Acharya et al. (2019) demonstrate that in Nepal, mountain forest ecosystems are critical for local water security and agricultural productivity. These valuations typically prioritize domestic utility and socio-ecological functions over global market integration.

This ecosystem-level variation is not only ecological but also socio-economic. Communities surrounding mountain forests tend to have a more direct and subsistence-oriented relationship with forest services, whereas those near tropical rainforests may experience more indirect or externally driven interactions, such as through carbon finance schemes or tourism development. As such, valuation outcomes must be interpreted within both ecological and socio-cultural frames to ensure relevance and validity.

In conclusion, the results of this review affirm that economic valuation of forest ecosystem services is a dynamic field characterized by methodological pluralism, varying focal services, and pronounced geographic heterogeneity. The selection of valuation method, type of service assessed, and contextual factors such as governance, data availability, and ecosystem characteristics all critically influence valuation outcomes. These findings underscore the need for nuanced, participatory, and context-responsive approaches to valuation that can inform equitable and effective forest policy and conservation strategies.

The findings of this review confirm that the economic valuation of forest ecosystem services is shaped by a complex interplay of systemic factors that significantly influence both the methodological rigor and practical applications of valuation outcomes. These systemic dimensions include environmental policy frameworks, institutional capacity, and local economic pressures, all of which contribute to the observed variations in valuation practices and their effectiveness across different geographical and socio-economic contexts.

The role of environmental policy is central in shaping the scope and depth of valuation studies. Countries with clear, integrated environmental governance systems tend to produce more comprehensive and reliable ecosystem service valuations. For instance, Förster et al. (2019) showed that in Germany, robust environmental policies facilitated the use of advanced methodologies and standardized data collection, leading to valuations that were directly integrated into national land-use and conservation strategies. Such enabling policy environments also provide access to technical support and funding, which are critical for implementing systematic valuation efforts. In contrast, countries with fragmented or underdeveloped environmental policies often lack the institutional momentum to undertake or utilize such assessments meaningfully.

Institutional capacity further determines the effectiveness of valuation processes. In low- and middle-income countries, limited human and technical resources often hinder the ability to conduct thorough valuations. Kadykalo et al. (2021) underscore the need for international research networks and knowledge-sharing platforms to support capacity building in ecosystem service valuation, especially in biodiverse but data-scarce regions. Without institutional mechanisms to support training, data infrastructure, and cross-sector collaboration, valuation efforts risk being inconsistent, methodologically weak, or disconnected from decision-making processes.

Local economic pressures also shape the valuation landscape. Communities heavily dependent on forest resources for their livelihoods may exhibit stronger preferences for conservation once the economic value of ecosystem services becomes evident. Khải and Yabe (2014) observed that when local populations in Vietnam were informed of the financial implications of forest degradation, their willingness to support conservation policies increased significantly. However, short-term economic needs often drive unsustainable resource extraction, as Ferraro et al. (2015) noted in

regions where poverty and limited economic alternatives exacerbate deforestation. Thus, valuation studies must account for both the enabling and constraining effects of local economic conditions to guide practical interventions.

The implications of these findings for policy are profound. Economic valuation can provide compelling evidence for conservation policy by quantifying the benefits of ecosystem services in economic terms that resonate with policymakers and stakeholders. As Förster et al. (2019) argue, such evidence is crucial in shaping development plans that minimize ecological trade-offs. When valuation results demonstrate the monetary losses associated with ecosystem degradation, they can strengthen the case for sustainable development policies and environmental safeguards.

Furthermore, policy frameworks should integrate both market and non-market values to ensure a holistic approach to forest governance. Filyushkina et al. (2015) emphasize that the exclusion of intangible services, such as cultural or spiritual values, from economic assessments leads to narrow and often inequitable policy outcomes. Policies should therefore aim to incorporate multi-dimensional values that reflect the full spectrum of ecosystem benefits. Doing so enhances the legitimacy and equity of environmental decision-making processes.

Valuation also informs financial mechanisms for conservation. Studies like Brouwer et al. (2022) illustrate how demonstrating the economic magnitude of services such as carbon storage in the Amazon can mobilize international climate finance. These valuations can support the design of mechanisms such as payments for ecosystem services (PES), enabling local communities and governments to receive compensation for conservation efforts. Such economic incentives align conservation goals with development needs, reducing the perceived conflict between environmental and economic objectives.

The engagement of local communities in the valuation process is another key policy consideration. Participatory approaches improve not only the accuracy of valuations but also their acceptance and implementation. Gómez et al. (2023) found that involving community stakeholders in valuation exercises enhanced transparency and generated a sense of ownership over conservation strategies. When people see their values and voices reflected in the outcomes, they are more likely to support and sustain conservation efforts.

Adaptive management in the face of environmental change is yet another policy area informed by valuation. Ferraro et al. (2015) emphasize that understanding the economic importance of ecosystem services helps governments to design policies that are more flexible and resilient to ecological uncertainties. Valuation data can inform scenario planning, risk assessments, and adaptive management strategies, ensuring that forest governance remains responsive to evolving environmental challenges.

Despite the promise of economic valuation, this review identifies several methodological and empirical limitations that warrant critical reflection. A significant proportion of the literature relies on a narrow set of methods, particularly CVM and TCM, without adequately addressing their limitations. For instance, CVM often suffers from hypothetical bias and lacks reliability when respondents are unfamiliar with ecological concepts (Kadykalo et al., 2021). TCM, while effective for valuing recreation, fails to capture the broader societal benefits of ecosystem services not linked

to tourism or direct use (Brouwer et al., 2022). The overreliance on these methods can result in valuation outputs that are partial and potentially misleading.

Another limitation is the persistent issue of data scarcity. Especially in tropical and subtropical regions, researchers face difficulties in accessing consistent, high-quality ecological and socio-economic data. Kadykalo et al. (2021) note that the absence of representative datasets restricts the accuracy and credibility of valuation estimates. Incomplete data may lead to undervaluation of key services or exclude marginalized communities from the valuation narrative. This challenge highlights the need for sustained investments in environmental monitoring and open data platforms.

A third methodological constraint lies in the financial focus of most valuation studies. By emphasizing marketable or monetizable services, many assessments neglect the socio-cultural and relational values that forests provide. Brouwer et al. (2022) caution that the absence of these values can fuel conflict between top-down conservation agendas and local interests, particularly when policies are implemented without adequate cultural sensitivity. Economic valuation must therefore evolve beyond purely financial metrics to incorporate qualitative dimensions that reflect community priorities.

A final critique concerns the limited involvement of local stakeholders in many valuation efforts. Simangunsong et al. (2020) argue that excluding local perspectives not only compromises the validity of valuation outcomes but also undermines the effectiveness of resulting policies. When valuation is externally imposed, it often fails to resonate with local norms, leading to resistance or policy failure. Valuation should thus be co-produced with affected communities to ensure alignment with local knowledge systems and governance structures.

To address these limitations, future research must adopt a more integrated and inclusive approach. Combining multiple valuation methods within a hybrid framework can yield a more nuanced understanding of ecosystem service values. Förster et al. (2019) recommend mixing CVM with participatory methods and biophysical assessments to capture diverse value types and stakeholder perspectives. Such hybrid approaches can also bridge the gap between economic and ecological data, facilitating cross-disciplinary analysis.

Advances in geospatial technologies offer another pathway for improving valuation accuracy. Tools such as remote sensing, geographic information systems (GIS), and machine learning can enhance data collection, visualization, and analysis. As Khải and Yabe (2014) demonstrate, integrating spatial data into valuation models provides finer-resolution insights into ecosystem dynamics and service distribution. Enhanced data infrastructure also supports dynamic valuation models that reflect real-time changes in forest condition and service provision.

Incorporating socio-cultural dimensions is equally essential. L'Ecuyer-Sauvageau et al. (2021) stress that future studies must include ethnographic and participatory research components to capture values that are context-specific and culturally embedded. Valuation that respects and reflects local worldviews is more likely to result in equitable and durable conservation outcomes.

Finally, community-based valuation and governance models should be prioritized. Puerta-Piñero et al. (2011) advocate for bottom-up approaches where local communities lead valuation efforts and have decision-making authority in forest management. This model strengthens local stewardship, aligns valuation with indigenous knowledge, and fosters long-term commitment to sustainable practices.

Through these solutions, the field of economic valuation can overcome current limitations and evolve into a more responsive, equitable, and policy-relevant discipline that effectively supports sustainable forest governance across diverse ecological and cultural landscapes.

CONCLUSION

This narrative review demonstrates the critical role of economic valuation in capturing the multifaceted contributions of forest ecosystem services to environmental sustainability, socio-economic well-being, and policy development. The analysis reveals that methods such as Contingent Valuation, Travel Cost, and Replacement Cost each offer unique insights into market and non-market forest benefits, though each is accompanied by methodological limitations that must be addressed through hybrid, inclusive approaches. The study further shows that services like carbon sequestration, recreational opportunities, and clean water provisioning comprise the core of forest value assessments, with their significance varying based on ecological context and regional development status.

Systemic factors—including environmental policies, institutional capacities, and local economic pressures—shape the implementation and impact of valuation practices. Countries with stronger environmental governance and technical infrastructure conduct more rigorous and actionable valuations, whereas nations with limited resources face persistent data, capacity, and participatory deficits. These disparities underscore the urgent need for integrative and community-driven valuation models.

To strengthen policy frameworks, this review recommends embedding ecosystem service values into national accounting, supporting Payments for Ecosystem Services (PES), and fostering local participation. Future research should explore mixed-method approaches, leverage geospatial technologies, and emphasize socio-cultural dimensions often overlooked in financial valuations. Overall, the economic valuation of forest ecosystem services must evolve into a more holistic, participatory, and policy-responsive discipline to ensure the sustainable management of global forest resources.

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