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Tracing the economic valuation of Mount Merbabu National Park: Benefit transfer method

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Abstract
Natural resource management problems occur because the value of environmental services is often ignored compared to economic commodities, thus increasing pressure and degradation on the National Park forest area. This study analyzes the economic valuation of Mount Merbabu National Park to determine its estimated Total Economic Value (TEV), comprising direct use value (timber, non-timber products, water consumption), indirect use value (soil and water conservation, carbon sequestration, flood prevention, water transportation, and biodiversity), and non use value (option and existence value) as a quantitative basis for sustainability planning. The novelty of this study lies in the first application of the benefit transfer method to Mount Merbabu National Park, transferring reference values from the Food and Agriculture Organization (2009) report on Indonesian Conservation Forests by adjusting for an average inflation rate of 5.28% over the 23 years (2002–2025) and scaling to the park's specific area of 5,820.49 ha. The findings estimate the 2025 economic value of the park at 82,894.81 US$/ha. Notably, Use Value dominates this figure at 77,382.23 US$ / ha, driven primarily by water consumption (32,795.54 US$/ha) and flood prevention (16,383.93 US$/ha), highlighting the vital role of direct and indirect ecological functions for the surrounding community.

Keywords: Economic Valuation, Mount Merbabu National Park, Benefit Transfer.

Abstrak
Permasalahan pengelolaan sumber daya alam terjadi karena nilai jasa lingkungan sering diabaikan dibandingkan komoditas ekonomi, sehingga meningkatkan tekanan dan degradasi pada kawasan hutan Taman Nasional. Studi ini menganalisis valuasi ekonomi Taman Nasional Gunung Merbabu untuk menentukan estimasi Nilai Ekonomi Total (TEV), yang terdiri dari nilai guna langsung (kayu, produk non-kayu, konsumsi air), nilai guna tidak langsung (konservasi tanah dan air, penyerapan karbon, pencegahan banjir, transportasi air, dan keanekaragaman hayati), dan nilai tidak guna (nilai opsi dan nilai eksistensi) sebagai dasar kuantitatif untuk perencanaan keberlanjutan. Keunikan studi ini terletak pada penerapan pertama metode transfer manfaat pada Taman Nasional Gunung Merbabu, dengan mentransfer nilai referensi dari laporan FAO (2009) tentang Hutan Konservasi Indonesia dengan menyesuaikan tingkat inflasi rata-rata sebesar 5,28% selama periode 23 tahun (2002–2025) dan menskalakannya ke luas spesifik taman sebesar 5.820,49 ha. Temuan memperkirakan nilai ekonomi taman pada tahun 2025 sebesar 82.894,81 US$/ha. Secara khusus, Nilai Guna mendominasi angka ini sebesar 77.382,23 US$/ha, terutama didorong oleh konsumsi air (32.795,54 US$/ha) dan pencegahan banjir (16.383,93 US$/ha), yang menyoroti peran penting fungsi ekologis langsung dan tidak langsung bagi masyarakat sekitar.

Kata kunci: Valuasi Ekonomi, Taman Nasional Hutan Merbabu, Benefit Transfer

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1. Introduction

Indonesia possesses various natural tourism areas with complex economic and non-economic values. Natural tourism areas play a major role in supporting sustainable development through interconnected economic, social, and ecological contributions. These areas are facing increased pressure due to tourism growth, land-use changes, and the impacts of climate change, raising concerns about the degradation of ecosystem functions and a decline in the value of the benefits generated (Eijgelaar & Peeters, 2014; Mao et al., 2014). The value of a tourism area is reflected not only in direct economic revenues such as entrance tickets and tourist spending but also in non-economic aspects in the form of ecosystem services, biodiversity, environmental regulatory functions, as well as the social and cultural values perceived by local communities and future generations. Therefore, it is important to measure the economic and non-economic values of natural tourism areas as a basis for decision-making in the management and conservation of natural resources.

The measurement of economic value conceptually refers to the Total Economic Value (TEV) framework, which encompasses direct use value, indirect use value, option value, as well as existence and bequest value (Costanza et al., 1997; Pearce & Moran, 1994). Direct use value can be measured by tourism activities and resource utilization, while indirect use value includes environmental services such as watershed protection, carbon sequestration, and aesthetic functions. Meanwhile, non-economic value is viewed through the existence value of biodiversity, cultural value, and the ecosystem's contribution to community welfare. Empirical evidence indicates that many economic valuation studies focus predominantly on direct economic aspects and overlook intangible non-economic dimensions such as biodiversity maintenance, cultural values, and existence values, potentially resulting in management policies that do not reflect the total economic value. For instance, Pearce & Moran (1994) documented that the omission of non-use values in forest valuation consistently leads to underestimation of conservation benefits, while Costanza et al. (1997) demonstrated globally that non-market ecosystem services account for a substantial proportion of total ecological value yet remain absent from most national accounting frameworks.

According to the Ministry of Environment and Forestry, Indonesia has vast and diverse forest resources, which are classified into production forests, conservation forests, and protection forests (Kementerian Lingkungan Hidup dan Kehutanan, 2018). Conservation forest areas are public assets managed by the government for the public interest and have essential functions as life support systems, biodiversity protectors, and providers of ecosystem services. However, these areas face pressures in the form of environmental degradation, land-use conflicts, and increased human activities that diminish the potential of ecosystem functions and the economic value of forest resources (Mulyana et al., 2010). Forest destruction and global climate change can also reduce the indirect benefits of forests as the largest carbon sinks and climate regulators, which will consequently impact the welfare of local and global communities.

Forests provide complex benefits, including economic and non-economic benefits for communities living around the forest, the government, and the international community (Andersen, 2015). Direct benefits of forests include timber, non-timber forest products, wildlife, and natural tourism potential, while indirect benefits encompass environmental services and water regulation, aesthetic functions, oxygen supply, and carbon sequestration (Nahib, 2014). Ecologically, forests play a crucial role in the global carbon cycle and can sequester ten times more carbon than other vegetation. Therefore, it is important to implement management practices to prevent the decline of ecosystem functions while improving community welfare. Based on Law Number 18 of 2013 concerning the Prevention and Eradication of Forest Destruction, a forest is a unified ecosystem in the form of a stretch of land containing biological natural resources dominated by trees in their natural environment, which cannot be separated from one another. The issue of sustainable forest management is an effort to integrate ecological interests within the framework of forest conservation based on socio-economic interests, according to the Ministry of Environment and Forestry. One method of monitoring forest resources is by calculating their economic value. The calculation of economic valuation based on the benefit transfer method relies on economic valuations conducted in reference areas based on the socio-economic characteristics of the community in the study area (Ecosystem Valuation Organization, 2022).

Mount Merbabu National Park, established based on the Decree of the Minister of Forestry Number SK.3623/Menhut-VII/KUH/2014, covers an area of 5,820 hectares. Administratively, Mount Merbabu National Park is included in the territories of 3 (three) regencies, namely Boyolali Regency, Magelang Regency, and Semarang Regency, Central Java Province. Geographically, Mount Merbabu National Park is located between 110º26’22” East Longitude and 7º27’13” South Latitude. This area has a strategic function as a life support system, a water source for surrounding communities, a habitat for protected flora and fauna, and a rapidly growing natural and cultural tourism destination. It also serves as a nature conservation area on land and water that possesses native ecosystems, managed using a zoning system to be utilized for research, science, education, cultivation support, culture, tourism, and recreation (Balai taman nasional Gunung Merbabu, 2014). With this designation, Mount Merbabu National Park functions as a life support system, preserves the diversity of plant and animal species along with their ecosystems, and sustainably utilizes all its resources and ecosystems.

Studies regarding economic valuation in Mount Merbabu National Park are still limited, especially those using the benefit transfer approach by considering the characteristics of the local ecosystem and socio-economy. Most previous studies in Indonesia tend to focus on direct economic value or use primary valuation methods on a limited scale and thus have not comprehensively described the total ecosystem value of national park areas. A study estimating the economic value of Kerinci Seblat National Park using the contingent valuation method focused only on the willingness-to-pay of tourism users without integrating other ecosystem services such as

regulatory functions or existence value Simangunsong et al. (2020). Another study estimated the economic value of the water environment in the Mount Merbabu National Park area and obtained an estimate of annual economic benefits based on household water utilization and the community's willingness to pay, but it did not include other ecosystem service components such as recreation, carbon storage, biodiversity protection, or the existence and bequest values that are essential parts of the TEV (Dewi et al., 2024).

Many studies in Mount Merbabu National Park emphasize the economic impact of tourism activities at the local scale without estimating the total value of ecosystem services in the conservation area. This condition results in the unavailability of economic and non-economic value information for Mount Merbabu National Park as a basis for conservation management planning, sustainable financing, and evaluating trade-offs between tourism utilization and ecosystem protection. On the other hand, national park areas play a vital role as providers of environmental services that do not always have market prices, such as water regulation functions, carbon sequestration, biodiversity maintenance, and existence values, which are intangible but crucial in the context of sustainable development. A study highlighted the economic impact of climbing through a multiplier effect analysis on the Selo route, which showed economic contributions to the community through business units, goods/services rentals, and job opportunities (Hasan, 2024). Although providing benefits in observing local economic linkages, this approach remains focused on the direct economic benefits of tourism activities and has not discussed the non-market and non-economic values inherent in conservation functions. Empirical evidence shows that valuation research in Merbabu still largely discusses sectoral values and has not accommodated a total valuation that integrates direct use, indirect use, option, and existence/bequest values within a single TEV framework.

Internationally, the literature on economic and non-economic valuation in protected areas shows an increasing trend, although most focus on specific monetary valuation methods, with limitations in incorporating all components of TEV. The valuation of protected areas generally uses economic valuation techniques such as contingent valuation and travel cost, while socio-cultural approaches are still limited (Gross et al., 2023). The value of ecosystem services of national parks in America reaches trillions of dollars per year, although the estimation accuracy is highly influenced by the availability of regional biome data affecting the accuracy of the value (Sutton et al., 2019). Furthermore, a global study on the valuation of ecosystem services and natural infrastructure states that despite the increasing number of studies, there are still geographical and methodological gaps, especially for specific ecosystems and more complex valuation methods such as benefit transfer that are adaptive to local conditions (Stanford et al., 2025).

Total economic valuation studies on national parks in Indonesia have actually been conducted in Leuser National Park using the TEV approach, encompassing various ecosystem services as well as conservation versus deforestation scenarios, producing a more comprehensive policy basis (Van Beukering et al., 2003). In addition, a study

(Agustriani et al., 2023) on Sembilang National Park in South Sumatra demonstrated the use of a combination of market price, benefit transfer, replacement cost, and travel cost methods to calculate provisioning, regulating, and cultural services (Agustriani et al., 2023). To date, such research has not been applied to Mount Merbabu National Park, hence it still requires a more integrated valuation study, specifically through benefit transfer within the TEV framework, to provide more representative estimates of economic and non-economic values as a basis for sustainable national park management. In this study, the benefit transfer approach is applied by transferring the economic value of forests in Indonesia to the Mount Merbabu National Park area. Research shows that the benefit transfer method can be validly used if the natural resources analyzed have relatively similar ecosystem and market characteristics (Krupnick, 1993). Benefit transfer assumes the resource value is the same or has a similar value in different locations (Pearce & Moran, 1994). Based on this framework, this study aims to analyze the economic valuation of the Mount Merbabu National Park area as a basis for strengthening conservation policies and area sustainability.

The research gap identified in this study is threefold. First, no previous study has applied a comprehensive TEV framework to Mount Merbabu National Park that integrates all components direct use value, indirect use value, and non-use value—within a single estimation. Second, existing studies tend to adopt primary valuation methods limited to specific service categories (e.g., tourism willingness-to-pay or water service value), leaving the majority of ecosystem service components unquantified. Third, the benefit transfer method, despite its acknowledged validity for areas with comparable ecological characteristics, has not previously been systematically applied to this conservation area with rigorous temporal and spatial adjustment. This study therefore contributes a first integrated TEV estimate for Mount Merbabu National Park using benefit transfer from Food and Agriculture Organization of the United Nations (2009) reference values, adjusted for 23 years of inflation and the park's actual area. The results are expected to serve as a scientific basis for strengthening conservation policies, sustainable financing planning, and evaluating trade-offs between utilization and protection of the national park ecosystem.

2. Research Method

This study utilizes secondary data, with the object of research being the economic valuation of the Mount Merbabu National Park area. The economic value of the Mount Merbabu National Park area was obtained through benefit transfer from a report published by Organization Food and Agricultural (2009) in Table 1. The 2009 FAO report presents the economic value of Indonesian forests in 2002 in units of US$ per hectare per year. The presented economic values include use value and non-use value. The use value component is divided into direct use value consisting of timber, firewood, non-timber forest products, and water consumption, and indirect use value consisting of soil and water conservation, carbon sequestration, flood prevention, water transport, and biodiversity. All these components were used as the basis for compiling the TEV of the Mount Merbabu National Park area.

Other supporting data include inflation data from 2002 – 2025 from Bank Indonesia and the area of Mount Merbabu National Park obtained from the Mount Merbabu National Park Agency. Supporting data were used to adjust the economic valuation of a region to the location being assessed based on an average inflation rate of 0.0528 (5.28%) from 2002-2025. These secondary data were obtained from various sources including reports, statistical data, and online data. The data collection method in this study is a literature study conducted by collecting and documenting data in the form of annual reports, statistical data, working papers, or research journals related to the issue.

This study employs the benefit transfer method as the primary approach in estimating the TEV of the Mount Merbabu National Park area. This method was developed as an alternative way to assess economic valuation using values from similar studies conducted in other locations, considering the challenges and high costs inherent in assessing actual prices (Eshet et al., 2007). The economic value of Indonesian forests presented by Food and Agriculture Organization of the United Nations (2009) was transferred to the Mount Merbabu National Park area by adjusting based on changes in time value (inflation) and area size. Each component of use and non-use value within the TEV framework was calculated using this reference value, so the TEV in this study is entirely the result of benefit transfer estimation.

The application of the benefit transfer method assumes that the value of ecosystem services can be transferred between locations if the natural resources being assessed have similar ecological characteristics and market contexts (Krupnick, 1993). In line with this, benefit transfer assumes the resource value is the same or has a relatively similar value in different locations (Pearce & Moran, 1994). The benefit transfer method has advantages including savings in terms of cost and time, a screening technique in assessing needs at the reference location, and it is easier and faster to apply estimated values (Barbera, 2012). TEV is not positioned as a standalone method, but as a conceptual framework to organize the results of benefit transfer estimation. TEV is used to group economic values into direct use value, indirect use value, and non-use value, so that the valuation results can represent the economic and non-economic benefits of the Mount Merbabu National Park area more comprehensively.

The theoretical grounding of the TEV framework applied in this study draws upon seminal and recent literature in environmental economic valuation. Plottu & Plottu (2007) provide a conceptual re-examination of TEV within a hierarchical rationality framework, arguing that the tripartite division of value into use, option, and non-use components is not merely taxonomic but reflects distinct behavioral motivations that must be treated separately in empirical estimation. Loomis et al. (2019) further demonstrate the operationalization of integrated TEV quantification for forests, showing how each component can be systematically estimated and aggregated into a coherent policy-relevant total. Zhang et al. (2017) validate the consistency of benefit-transfer-based TEV estimation using Total Economic Value and Equivalent Value factors, providing methodological support for applying transferred reference values across spatially distinct conservation sites as is done in the present study.

To formally illustrate the TEV framework applied in this study, the total economic value of the Mount Merbabu National Park is structured according to the following classification:

$$TEV = Direct\ Use\ Value + Indirect\ Use\ Value + Non - Use\ Value$$

where:

Direct Use Value : Timber + Firewood + Non-Timber Forest Products (NTFP) + \ Water Consumption

Indirect Use Value : Soil & Water Conservation + Carbon Sequestration + Flood Prevention + Water Transportation + Biodiversity

Non-Use Value : Option Value + Existence Value

Each component value is derived from benefit transfer of the Food and Agriculture Organization of the United Nations (2009) Indonesian Conservation Forest reference data, adjusted to 2025 price levels using the compound inflation formula:

$$V_{2025} = V_{2002} \times (1 + r)^{n} \times A$$

where

V_{2025} : estimated component value in 2025 (US$/ha),

V_{2002} : Food and Agriculture Organization of the United Nations (2009) reference value in 2002 (US$/ha),

r : average annual inflation rate (0.0528),

n : number of years (23), and

A : area of Mount Merbabu National Park (5,820.49 ha).

This formula is applied consistently across all TEV components (Loomis et al., 2019; Zhang et al., 2017).

3. Results and Discussion

3.1. Results

The value obtained is a human perception of the meaning of an object for a specific individual at a specific place and time (Nurfatriani, 2006). One instrument for measuring value is economic value. All objects in this world, whether tangible or intangible, can be assessed economically, one of which is natural resources. The United Nation Development Programme (UNDP) and Convention on Biological Diversity (CBD) in that the basis of economic value lies in human preferences and types of motivation in the form of intrinsic, social, cultural, and spiritual values (Robhati & Kusumawardani, 2016). The purpose of economic valuation is to determine a person's preference through willingness to pay (WTP) for the benefits of a good or resource.

Based on the economic valuation analysis conducted on the Mount Merbabu National Park area, the estimated TEV for the year 2025 shows a significant value. The projected economic value of the Mount Merbabu National Park area in 2025 is recorded at 82,894.81 US$ / ha. Use Value accounts for 77,382.23 US$ / ha, wherein the largest contributions originate from water consumption (32,795.54 US$ / ha) under

direct use value and flood prevention (16,383.93 US$ / ha) under indirect use value. Non-Use Value, which comprises option value and existence value, amounts to 5,515.65 US$ / ha. The complete details of the economic value estimation of Mount Merbabu National Park in 2025 are presented in Table 1.

Table 1. Economic Value of Mount Merbabu National Park Area in 2025

Value	Value (US$ /ha) in 2025
Total Economic Value	82894,81
Use Value	77382,23
Direct Use Value	41556,61
Timber	0
Firewood	0
Non timber products	8757,98
Water Consumption	32795,54
Indirect Use Value	35825,61
Soil and Water Conservation	12790,90
Carbon Sequestration	1685,76
Flood Prevention	16383,93
Water Transportation	1784,20
Biodiversity	3183,88
Non-Use Value	5515,65
Option Value	2331,77
Existence Value	3183,88

Source: Data processed by the authors (2025)

The validity of the TEV estimation for Mount Merbabu National Park in this study was selected based on the framework of Peraturan Menteri Lingkungan Hidup Nomor 15 Tahun 2012, which states that to value the economic value of environmental resources, two approaches can be used: market price and non-market approaches. The market price approach consists of the productivity approach, human capital approach, and opportunity cost approach. Non-market approaches include the hedonic value approach, travel cost approach, contingent valuation approach, and benefit transfer approach.

Benefit transfer method can be used if the natural resource has the same ecosystem in terms of both place and market characteristics as the research location (Krupnick., 1993). In this study, reference data was taken from the results of research by the Food and Agricultural Organization (2009) regarding the economic value of Indonesian conservation forests in 2002 (Table 2). The data used to estimate the economic value of the Mount Merbabu National Park area in 2025 is considered representative because it has a similar conservation forest typology to Mount Merbabu National Park. The economic value of Indonesian conservation forests in 2002 was 269.47 US$ / ha. The Economic Value of Indonesian conservation forests in 2002 is shown in Table 2.

To ensure the accuracy of the value transfer results, it is necessary to adjust the parameters because the transfer value cannot be done directly, adjustment factors include two main aspects including the following Nahib et al. (2011), two main adjustment factors were applied in this study. First, an Inflation Correction was performed, whereby the base value of 2002 was adjusted to the projection year 2025

using an average inflation rate of 0,0528 (5,28%). This step is important to mitigate bias due to changes in the time value of money during the 23-year period. Second, a Regional Characteristic Adjustment was applied, in which the calculation was adjusted to the specific area of Mount Merbabu National Park, which is 5,820.49 ha, ensuring that the aggregate value produced reflects the actual physical scale of the area.

The baseline data for 2002 used as model input can be seen in the following Table 2.

Table 2. Economic Value of Indonesian Conservation Forests in 2002

Nilai	Nilai (US$ /ha) tahun 2002
Total Economic Value	269,47
Use Value	251,55
Direct Use Value	135,09
Timber	0
Firewood	0
Non timber products	28,47
Water Consumption	106,61
Indirect Use Value	116,46
Soil and Water Conservation	41,58
Carbon Sequestration	5,48
Flood Prevention	53,26
Water Transportation	5,8
Biodiversity	10,35
Non-Use Value	17,93
Option Value	7,58
Existence Value	10,35

Source: Food and Agricultural Organization (2009)

3.2. Discussion

The application of the benefit transfer method in this study yielded a TEV estimate for the Mount Merbabu National Park area in 2025 of 82,894.81 US$ / ha. This method was used because the area has existing biophysical characteristics and ecosystem services equivalent to the Indonesian forest reference. Value transfer is a valid and cost-effective approach when the characteristics of the policy site have ecological similarities with the study site so the resulting value can be scientifically accounted for to represent the potential of an area.

The dominance of Use Value (77,382.23 US$/ha, or 93.35% of TEV) in the TEV structure of Mount Merbabu National Park can be attributed to specific ecological and socio-economic factors. Water consumption (32,795.54 US$/ha) constitutes the largest single component because Mount Merbabu serves as a critical upstream catchment area for three regencies Boyolali, Magelang, and Semarang, whose agricultural and domestic water supply depends directly on the park's hydrological functions. Similarly, flood prevention (16,383.93 US$/ha) is elevated because the volcanic topography and dense forest cover of Mount Merbabu create a high regulatory capacity against runoff and erosion, a benefit that is particularly valuable for downstream settlements in Java's densely populated lowlands.

In contrast, timber and firewood values are zero, reflecting the conservation zoning status of the park, which prohibits commercial extraction. The relatively modest carbon sequestration value (1,685.76 US$/ha) compared to international estimates reflects the relatively small park area (5,820.49 ha) rather than a lower per-hectare sequestration rate. These findings are consistent with the broader literature showing that regulatory and provisioning services dominate TEV in tropical montane conservation forests where direct extraction is restricted (Costanza et al., 2014); (Richardson et al., 2015).

The comparison of results shows a significant increase in value, where the 2025 valuation value is 30,662% higher than the base value of Indonesian forests. This extreme disparity in value is the result of adjustments in time dimensions and spatial scale, especially inflation factors over a period of more than two decades and the specific area of Mount Merbabu National Park. The findings asserting that changes in ecosystem service value estimates are strongly influenced by changes in unit values over time, land use dynamics, as well as adjustments to exchange rates and inflation base on the time value of money (Costanza et al., 2014).

Despite these significant findings, several methodological limitations warrant critical attention. First, the benefit transfer method rests on the assumption that the ecological and market conditions of the study site are sufficiently similar to the reference site. Although Mount Merbabu National Park shares a conservation forest typology with the broader Indonesian forest reference used by Food and Agriculture Organization of the United Nations (2009), there may be site-specific differences in ecosystem structure, land tenure, governance capacity, and local socio-economic conditions that the aggregate FAO data cannot fully capture. These dissimilarities introduce transferability bias, which is a recognized limitation inherent to benefit transfer applications (Richardson et al., 2015). The use of a single national-level reference value rather than a matched-site primary valuation therefore means that the resulting TEV should be interpreted as an indicative estimate rather than a precise measurement.

Second, the magnitude of the final aggregate value is substantially driven by the compound inflation adjustment over 23 years and the spatial scaling to the park's total area. These arithmetic multipliers amplify the base values considerably and account for the vast majority of the percentage increase observed, rather than reflecting genuine growth in ecosystem productivity or service delivery. This limitation does not invalidate the findings but signals that comparative interpretations across different time periods or spatial scales should be made with caution.

Third, the relatively low share of Non-Use Value (5,515.65 US$/ha, or 6.65% of TEV) merits further scrutiny. While this proportion is partly consistent with studies showing that regulatory and provisioning services tend to dominate TEV in conservation forests where extractive uses are restricted, it may also reflect methodological constraints of the benefit transfer approach rather than actual ecological conditions. Option values and existence values are often the most difficult components to estimate accurately, and the transferred reference values from Food and Agriculture Organization of the

United Nations (2009) may underrepresent these dimensions relative to what primary contingent valuation or choice experiment studies might reveal for Mount Merbabu specifically. Future research employing primary valuation techniques for these components would provide a more robust estimate of total non-use value.

The magnitude of the economic value in this study becomes an important instrument in natural resource management policy making. The results of economic valuation can be used as a cost-benefit analysis when faced with land conversion or forest function transfer options. The framework of The Economics of Ecosystems and Biodiversity (TEEB), the integration of ecosystem economic values into public policy is essential to prevent environmental degradation and ensure that the utilization of forest resources contributes realistically to improving community welfare sustainably, not just short-term economic gains (Pascual et al., 2010).

4. Conclusion

This study aimed to estimate the Total Economic Value (TEV) of Mount Merbabu National Park using the benefit transfer method, adapting Food and Agriculture Organization of the United Nations (2009) reference values for Indonesian Conservation Forests with adjustments for 23 years of inflation (average rate 5.28%) and the park's area of 5,820.49 ha. The estimated TEV in 2025 reaches 82,894.81 US$/ha, composed of Direct Use Value (41,556.61 US$/ha), Indirect Use Value (35,825.61 US$/ha), and Non-Use Value (5,515.65 US$/ha). Use Value dominates at 77,382.23 US$/ha (93.35% of TEV), driven primarily by water consumption (32,795.54 US$/ha) and flood prevention (16,383.93 US$/ha). This dominance reflects the park's critical hydrological role as a water catchment for three regencies and its flood-regulating function for downstream communities, while the absence of timber and firewood values is consistent with the park's conservation zoning prohibiting extraction. The 307-fold increase from the 2002 base value (269.47 US$/ha) is the direct result of compound inflation adjustment over 23 years and spatial scaling to the park's actual area, not a reflection of real growth in ecosystem productivity. These findings answer the research objective by providing the first integrated TEV estimate for Mount Merbabu National Park, establishing a quantitative reference that can serve as an opportunity cost benchmark in land-use decision-making and a basis for conservation budget prioritization.

These economic value findings have strategic implications for the formulation of management policies for Mount Merbabu National Park: Basis for Land Conversion Decisions: The economic value of 82,894.81 US$/ha must become the baseline or opportunity cost that must be considered in every land conversion plan. If there is a proposal for other uses outside of conservation functions, the economic benefits generated from the new use must be able to exceed the economic value of the ecosystem services that will be lost. Instrument for Conservation Budget Priority: The magnitude of the value of environmental services, especially water regulation and flood prevention functions, provides strong justification for the central and regional governments to increase budget allocations for the management and preservation of

the area. Investment in conservation is no longer a cost, but an effort to secure vital economic assets. Improvement of Community Welfare: Policies for the utilization of forest resources must be directed towards sustainable schemes, for example, ecotourism or the utilization of non-timber forest products that are in line with the high use value of the area. This ensures that the economic benefits of the forest can be distributed to improve the welfare of the local community without degrading its main ecological functions.

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