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Comparative Economic Valuation of Mangrove Ecosystems in Conservation and Non-Conservation Zones in North Sulawesi

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Abstract

This study aims to compare the Total Economic Value (TEV) of mangrove ecosystems in two locations in North Sulawesi: the conservation area of Bunaken National Park and the non-conservation coastal region of Bitung City. Employing an economic valuation approach based on Malik et al. (2015), TEV was calculated using the components of Direct Use Value (DUV), Indirect Use Value (IUV), and Option Value (OV). Data were collected through household surveys, field observations, and secondary literature. Preliminary estimates show that the annual per-hectare TEV in Bunaken (USD 7,200) is significantly higher than in Bitung (USD 3,615), primarily due to the substantial contribution of ecosystem services (IUV) in protected areas. The findings emphasize the importance of conservation status in maintaining and maximizing the economic benefits of mangrove ecosystems.

Keywords: Economic valuation; Mangrove; Conservation; Bunaken; Bitung; North Sulawesi

INTRODUCTION

Mangrove ecosystems, found in tropical and subtropical coastal regions, play a critical role in maintaining ecological balance and supporting the livelihoods of coastal communities. These ecosystems offer a wide array of provisioning, regulating, supporting, and cultural services. Among the most notable are their ability to act as nurseries for marine species, sequester large amounts of carbon, and buffer shorelines against storms and erosion. Additionally, mangroves contribute directly to local economies through fisheries and forest products, providing both subsistence and commercial benefits to nearby communities.

The economic valuation study by Malik *et al*. (2015) in Takalar, South Sulawesi, demonstrated that the economic value of mangrove ecosystems can surpass that of aquaculture when broader ecosystem services like coastal protection, carbon storage, and marine nursery grounds are considered. Their research used the Total Economic Value (TEV) framework to highlight how non-market services, often overlooked in traditional assessments, represent substantial economic benefits for coastal communities. Gurney et al. (2015) and similar studies have underlined the importance of integrated conservation and development initiatives. These studies argue that protected areas that involve local communities tend to perform better both ecologically and economically. In the context of mangrove conservation, community-based marine protected areas (MPAs) have been shown to yield higher fish biomass, greater ecosystem resilience, and more stable livelihoods.

Sasmito et al. (2023) further emphasized the alignment between mangrove restoration and sustainable development goals (SDGs), particularly those related to climate action, life below water, and poverty alleviation. Their findings suggest that the ecological restoration of mangrove forests not only contributes to biodiversity conservation but also opens opportunities for carbon credit markets and blue carbon finance.

Other valuation studies in Indonesia have demonstrated varying outcomes depending on land use practices, legal frameworks, and socio-economic conditions. For example, mangrove areas adjacent to aquaculture zones often show degraded ecological performance and reduced economic returns in the long term. In contrast, zones under some form of conservation tend to maintain higher ecological integrity and thus greater TEV. This growing body of literature underscores the importance of incorporating both market and non-market values in decision-making. The current study builds upon this foundation by applying a comparative valuation method to two real-world cases in North Sulawesi, aiming to quantify the economic trade-offs associated with conservation versus non-conservation approaches to mangrove management.

Despite their significant contributions, mangroves face increasing threats from human activities. The expansion of aquaculture, conversion of land for agriculture or development, and pollution have led to rapid degradation and loss of mangrove cover worldwide, including in Indonesia. In areas without legal protection, such as urban and peri-urban coastal zones, mangroves are often viewed as obstacles to development rather than valuable ecological assets. This has resulted in a loss of ecological functions and economic services, particularly in non-conservation areas like Bitung.

Recognizing these challenges, this study investigates the economic value of mangrove ecosystems in two contrasting settings: Bunaken, a protected national park, and Bitung, a coastal area without formal conservation status. By comparing the Total Economic Value (TEV) of mangroves in these locations, the study aims to highlight the tangible benefits of conservation efforts and inform policies for sustainable coastal management. The analysis integrates both market and non-market values to provide a comprehensive perspective on ecosystem services derived from mangroves.

METHODOLOGY

This research employed a comparative case study approach, utilizing the Total Economic Value (TEV) framework to evaluate the economic contribution of mangrove ecosystems in two contrasting zones: Bunaken (a protected national park) and Bitung (a non-conservation coastal area). TEV was disaggregated into three components: Direct Use Value (DUV), Indirect Use Value (IUV), and Option Value (OV), following the methodology outlined by Malik et al. (2015).

Primary data were collected through structured household surveys conducted in March–April 2025, targeting residents within 1 km radius of the mangrove areas. A purposive sampling technique was applied, involving 100 respondents from each site (Bunaken and Bitung). Respondents were selected based on their direct or indirect dependence on mangrove resources. Survey instruments captured data on fishing yields, firewood collection, ecotourism benefits, perceived protective value of mangroves, and potential willingness to pay for conservation.

In addition to surveys, field observations were conducted to verify land use conditions, mangrove density, and anthropogenic pressures. Secondary data were sourced from local government

reports, satellite imagery, existing literature, and carbon valuation databases. Price benchmarks for calculating DUV included average local market prices of fish, shellfish, and wood products, while IUV relied on avoided cost methods (e.g., breakwater construction cost equivalents) and carbon stock conversion factors.

For the Option Value (OV), a contingent valuation method (CVM) was used to estimate community preferences for maintaining mangrove ecosystems in the future. Scenarios were presented to respondents to gauge their support and monetary valuation of conservation and restoration initiatives. To estimate Net Present Value (NPV), the aggregated annual TEV was projected over a 10-year horizon using discount rates of 5%, 10%, and 15%. Sensitivity analysis was conducted to evaluate the robustness of economic values under changing policy and economic conditions, particularly variations in discount rates and mangrove area extent.

RESULTS AND DISCUSSION

The results of this study provide a clear contrast in the economic value of mangrove ecosystems between protected and non-protected zones. In Bunaken National Park, which benefits from regulatory enforcement and active conservation programs, the estimated Total Economic Value (TEV) per hectare reached USD 7,200 annually (Figure 1). In contrast, Bitung's non-conserved mangroves had a TEV of only USD 3,615 per hectare. This disparity reflects differences in ecosystem service integrity, particularly in the Indirect Use Value (IUV) component.

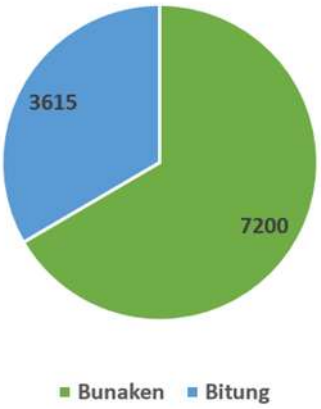

Figure 1. Annual Total Economic Value (TEV) per Hectare

The IUV in Bunaken, amounting to USD 7,000/ha, was primarily driven by coastal protection, carbon sequestration, and nursery functions. These benefits are maintained through healthy and dense mangrove stands, which are actively monitored and less subject to anthropogenic disturbances. In Bitung, these services were diminished, with IUV at USD 3,500/ha, attributed to fragmented mangrove stands and proximity to urban development. Meanwhile, Direct Use Values (DUV) and Option Values (OV) were modest in both sites, though higher in Bunaken due to regulated ecotourism and subsistence activities.

When extrapolated to area level, Bunaken's 500 hectares of mangroves produced an estimated TEV of USD 3.6 million annually, while Bitung's 800 hectares generated a lower total value of USD 2.89 million despite larger area coverage. This underlines that conservation enhances not only per hectare value but also overall economic returns.

The Net Present Value (NPV) analysis over a 10-year projection reinforced this trend (Figure 2). At a 10% discount rate,

Bunaken's NPV reached USD 44,244/ha, nearly double that of Bitung's USD 22,198/ha. Sensitivity tests revealed that under more favorable discount conditions (5%), Bunaken's value rose to USD 55,835/ha. Even at a higher discount rate of 15%, Bunaken maintained a significantly higher NPV, indicating resilience of conservation benefits.

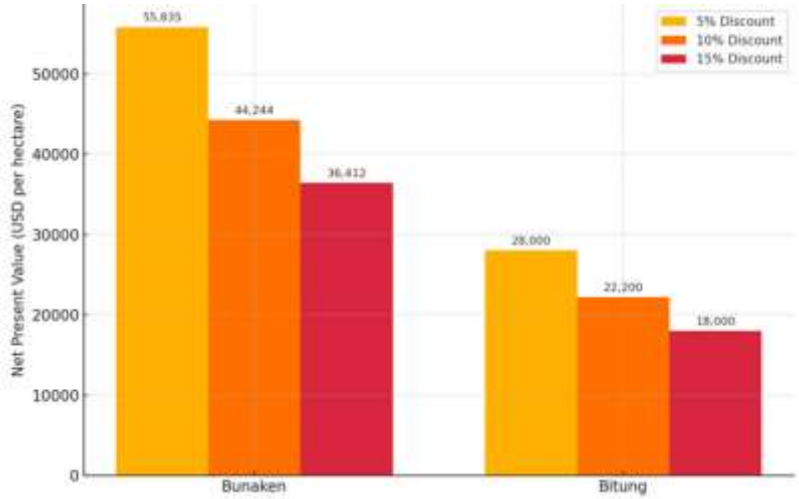

Figure 2. NPV of Mangrove Ecosystems over 10 Years under Different Discount Rates

The graphical comparison illustrates these findings visually, confirming that mangrove conservation status is a determining factor in long-term economic value. These results align with prior studies and affirm that conservation is not only ecologically responsible but economically prudent. The findings have direct implications for coastal planning and policy in North Sulawesi and beyond.

CONCLUSION

Conservation status plays a vital role in enhancing the economic value of mangrove ecosystems. Local governments are encouraged to consider expanding protected areas and implementing environmental incentive schemes such as REDD+ or carbon credit programs in non-conservation zones. The research suggests that investment in protection delivers significantly greater returns over time, even under fluctuating economic conditions.

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