

Re-evaluating Seagrass Ecosystem Services: Integrating Community Gleaning and Cultural Values into Economic Valuation in Selayar Island, Indonesia

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RESEARCH ARTICLE

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ABSTRACT

Dominant marine conservation and blue economy paradigms systematically prioritize biophysical metrics, such as biodiversity or carbon sequestration, frequently rendering the cultural and subsistence values of coastal communities invisible. This study contests these biophysically-centered frameworks by applying a holistic valuation approach to seagrass meadows at the Selayar Archipelago, South Sulawesi, Indonesia. Utilizing the Common International Classification of Ecosystem Services (CICES) framework as an instrument for recognition of cultural values, we applied participatory methodologies to evaluate the relational values embedded in traditional gleaning—the small-scale, intertidal harvesting of marine invertebrates (*a'sulo/ngatti-ngatti*). The findings reveal a socio-economic and cultural reality that contradicts formal market assessment: 52.2% of harvested biomass bypasses formal cash economies, serving as a crucial non-monetary safety net. Moreover, results from a participatory Token Allocation Game suggest that local inhabitants prioritize non-extractive cultural services (social cohesion and healing, 52%) over direct economic extraction (48%). While we apply the Replacement Cost method to illustrate the ecosystem's crucial role as an active “Natural School” for intergenerational knowledge transfer, we argue these monetary estimates serve as tactical, illustrative proxies rather than functional substitutes. Rather than merely presenting alternative economic metrics, this study asserts that

Received 5 July 2026; revised 1 September 2026; accepted 1 September 2026.

Available online 9 September 2026

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<https://doi.org/10.65844/2549-4333.1279>

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these relational values are not simply undervalued, they cannot be fully captured through the dominant metric driving global blue economy and carbon agendas. As Indonesia rapidly advances its blue economy, we contend that relying exclusively on carbon-centric legibility risks enclosing the marine commons, disenfranchising local populations and overlooking intangible, critical values coastal ecosystems provide. Coastal governance and national policies must urgently evolve to incorporate these structurally invisible socio-cultural dimensions.

Keywords: Seagrass gleaning, Relational values, Blue economy, Seagrass valuation, Political ecology, Environmental justice, Cultural services, Coastal governance

1. Introduction

The global blue economy paradigm is designed to advance ecosystem-based management and sustainability (Pauli, 2010). However, in practice, its implementation in marine conservation and environmental governance is often primarily influenced by market-centric and biophysical metrics (Barbesgaard, 2017; Brent et al., 2020; Pascual et al., 2017). This creates a systemic, widespread bias in policy frameworks that prioritize quantifiable, market-compatible values such as blue carbon, while structurally ignoring the non-market dimension of human-environment relations (Chan et al., 2016; Pascual et al., 2017). As a result, the deeply embedded cultural, subsistence, and social values that sustain coastal communities are frequently rendered invisible in formal ecosystem assessment.

Indonesia exemplifies a significant and high-stakes representation of this global issue. As a prominent seagrass hotspot (Peng et al., 2026), Indonesia's seagrass meadows hold considerable ecological importance for marine biodiversity, ecosystem services, and the livelihoods of coastal communities (Ambo-Rappe et al., 2026). However, national ecosystem valuations reveal a pronounced global biophysical bias. A recent economic assessment of Indonesian seagrass meadows estimates their value at a substantial 2024 USD 18,800/ha/year, with carbon sequestration and other regulating services comprising up to 97% of this total (Sjafrie et al., 2024). In contrast, provisioning and cultural services are estimated to constitute less than 1% (Sjafrie et al., 2024). In the Selayar Islands, located off the southern peninsula of South Sulawesi, Indonesia, local communities exhibit a significant reliance on seagrass meadows for small-scale intertidal harvesting of marine invertebrates, commonly referred to as “gleaning” (*a'sulo/ngatti-ngatti*), which constitutes a crucial component of their food security and protein intake (Furkon et al., 2020). However, previous research in Selayar suggests that while local communities intimately understand these relational values (Regulating and Provisioning services), they frequently lack a formal recognition of “Cultural Services” within the ecosystem services framework (Ambo-Rappe et al., 2019). This systemic invisibility is mirrored in the academic literature, where cultural contributions are often acknowledged merely in terms of research value rather than as reflections of local heritage, local ecological knowledge, and social cohesion (Sjafrie et al., 2024). As anthropogenic pressures such as anchoring, fish fences (*sero*), and marine debris continue to degrade these meadows and the livelihoods they sustain (Ambo-Rappe et al., 2021; Furkon et al., 2020; Lindsay et al., 2020), failing to account for their social-cultural dimensions risks exacerbating environmental injustices, since top-down management interventions often disenfranchise the communities most dependent on the ecosystem (Bennett et al., 2019; Martin et al., 2016).

This structural invisibility is particularly critical as Indonesia rapidly accelerates its blue economy and carbon mitigation agendas. Emerging national policies, such as Presidential Regulation No. 110 of 2025 (Republik Indonesia, 2025), strongly promote the conservation

and restoration of coastal ecosystems, focusing predominantly on their capacity for natural blue carbon storage. This emphasis often overlooks the varied socio-cultural services that these ecosystems offer. To effectively support community-led enforcement and alternative livelihoods, these carbon-centric policies must be expanded using a holistic, standardized valuation framework that captures non-monetary dimensions of seagrass ecosystem services. While scholars increasingly emphasize that seagrass meadows function as highly interconnected social-ecological systems (SES) (Jones et al., 2022; Wang et al., 2025), current carbon-centric policies threaten to narrow conservation priorities, overlooking the vital relational values of these landscapes (Barbesgaard, 2017; Brent et al., 2020).

Therefore, rather than merely filling a gap in valuation data, this study aims to critically examine why certain values are rendered invisible and to reveal the profound socio-environmental implications of this omission (Kallis et al., 2013; Kull et al., 2015). We contend that the cultural and subsistence practices of coastal communities are not merely *undervalued* in monetary terms; rather, they remain only partially commensurable with the prevailing carbon-centric metrics that inform Blue Economy and conservation decisions. By operationalizing the Common International Classification of Ecosystem Services (CICES) framework (Haines-Young, 2023)—alongside participatory methodologies, including Contingent Valuation such as Willingness to Pay (WTP) and Willingness to Accept (WTA)—we utilize economic valuation not as the end goal, but as a critical tool to elevate community gleanings, subsistence, and cultural heritage into the formal policy discourse. Ultimately, our findings suggest that the national coastal governance and blue economy framework should evolve beyond carbon-centric metrics to embrace holistic, equitable, and locally grounded socio-environmental management strategies in Indonesia.

2. Materials and methods

2.1. Study site

The research was conducted in Pulau Gusung, a small island within the Selayar Archipelago, South Sulawesi, Indonesia (Fig. 1). This island features a sloping coastal geomorphology and serves as a residential area for local fishing and inter-island transport vessels. The site was selected to expand upon an existing database of community perceptions and anthropogenic threat profiles established in prior studies (Ambo-Rappe et al., 2019; Jones et al., 2022; Lindsay et al., 2020).

Pulau Gusung is characterized by robust coastal ecosystems, where seagrass beds are located in close proximity to the Gusung mangrove forest. The seagrass meadows cover approximately 283.7 hectares and are in excellent ecological condition, with a Seagrass Quality Index (SEQI) of 0.85 (Ambo-Rappe et al., 2026). These meadows represent a significant carbon sink, with total carbon storage estimated at 191 tC/ha. This high ecological performance is attributed to the synergy between the seagrass and the adjacent mangroves (Fakhraee, 2026), which likely function as a natural filter for land-based runoff and sedimentation, allowing the meadows to thrive despite the pressures of local maritime activity.

2.2. Conceptual framework

To critically examine why the non-monetary dimensions of seagrass ecosystems remain structurally invisible in blue economy policies, this study grounds its analysis within the political ecology of ecosystem services and the concept of relational values (Chan et al., 2016; Kull et al., 2015). Dominant coastal governance paradigms frequently operate upon a

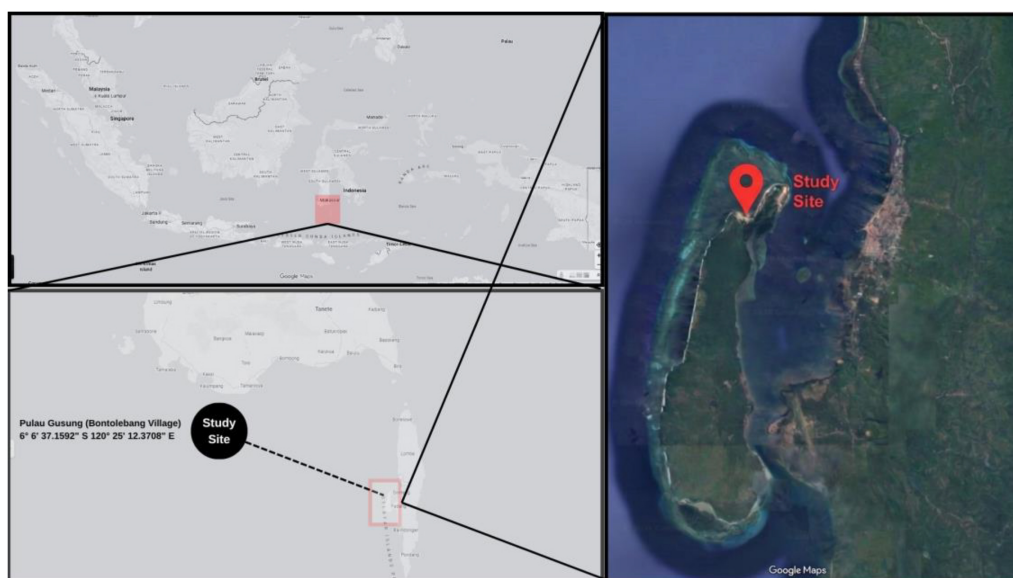


Fig. 1. Location of the study site at Pulau Gusung (Bontolebang Village), Selayar Archipelago, South Sulawesi, Indonesia. The map displays the broad regional context within Indonesia (left) alongside a detailed satellite view (right). Map imagery sourced from google maps and google earth (©2026 google) and utilized in accordance with non-commercial academic use guidelines.

valuation hierarchy that privileges easily commodified biophysical metrics, such as carbon storage or commercial fish yields, while actively marginalizing the localized subsistence practices, local ecological knowledge, and cultural identities that sustain coastal communities. Relational values—defined as the preferences, principles, and meaning derived from reciprocal human-natural relationships (Chan et al., 2016)—provide a critical theoretical lens to understand these overlooked dimensions. From a Social-Ecological Systems (SES) point of view, the failure to recognize these relational values in formal policy often leads to environmental injustice, where state interventions inadvertently sever the vital social-ecological feedback that maintains community resilience (Martin et al., 2016).

To bridge the gap between these nuanced relational values and formal governance structure, this study utilizes the Common International Classification of Ecosystem Services version 5.2 (CICES v5.2; Haines-Young, 2023) as its operational framework. Rather than deploying CICES merely as a biophysical accounting tool, we utilize it as an instrument of recognition justice, systematically identifying and categorizing the invisible dimensions of social-ecological connectivity in Pulau Gusung.

To evaluate provisioning services, this study systematically categorizes the socio-economic importance of gleaning to illustrate the study community's reliance on marine resources. Within the Biotic/Biophysical section and the Biomass division of the CICES framework, we classify gleaning as the extraction of wild aquatic animals (fish, mollusks, and crustaceans) utilized for nutritional purposes. By operationalizing this dimension using Market Price and Substitute Price methods, we aim to capture not only formal cash economy integration but also the non-monetized subsistence values that function as critical socio-economic safety nets.

Furthermore, cultural services are classified within the Biotic/Biophysical section, divided into three primary categories: physical and experiential interactions; intellectual and representative interactions; and spiritual, symbolic, and other cultural interactions.

As proposed by Haines-Young (2023), these categories are further organized into three specific groups that characterize the nature of human-ecosystem interactions. These include direct, in-situ, and outdoor interactions that involve active physical engagement within the meadows; elements of living systems that hold indirect significance for local inhabitants without necessitating their immediate presence; and other biophysical characteristics valued in their own right. Within these broader groups, this research identifies four specific classes representing the non-material connection between the local community’s social fabric, history, and the seagrass landscape. These classes include Health and Social Bonds, defined as elements facilitating activities that promote health, recuperation, or enjoyment; Traditional Ecological Knowledge, which supports scientific investigation or the development of local ecological knowledge; Sense of Place, capturing elements with symbolic meaning that define the distinctiveness of the setting for local inhabitants; and Bequest Value, representing features whose inter-generational existence holds inherent importance to the coastal community.

The CICES V5.2 classification architecture standardizes relational dimensions, thereby offering a structural foundation for converting qualitative, localized dependencies into reliable metrics. This theoretical integration facilitates the incorporation of non-monetized coastal realities into the wider political discourse concerning Indonesia’s coastal management and blue economy planning.

2.3. Valuation tools development and framework development

To transcend traditional, top-down valuation frameworks that often marginalize local perspectives, the survey instruments and valuation indicators were collaboratively developed through a three-day multidisciplinary participatory scoping workshop held in Makassar in January 2026. This process involved academic experts in marine ecology, environmental economics, and social sciences, alongside local government representatives, NGO practitioners, and traditional gleaners from Pulau Gusung. The collaboration adapted the CICES V5.2 framework to align with the specific maritime and cultural context of Indonesian small-island systems. Instead of depending on generalized metrics, the workshop identified localized indicators. Firstly, social connectivity was recognized not merely as a secondary outcome but as a fundamental benefit of communal gleaning. The traditional practices of *ngatti-ngatti* (daytime gleaning) and *a’sulo* (night gleaning) play a crucial role in fostering essential social bonds and facilitating labor exchange among community members. Secondly, human capital and education were emphasized, with seagrass meadows serving as a *sekolah alam* (nature school), where young individuals gain firsthand exposure to essential principles such as environmental ethics, traditional ecological knowledge (TEK), and *gotong-royong* (collectivism) through their direct involvement in harvesting practices. Thirdly, provisioning services were seen to encompass both high value commercial species (e.g. octopus and crab) and crucial subsistence staples (e.g. *Bimba’* and *Gempang*) that maintain the local household food security and protein safety nets.

To quantify these localized typologies, a tailored economic valuation framework was established mapping CICES V5.2 classifications to Selayar-specific proxies and distinct economic methodologies. The resulting framework is presented in Table 1.

Table 1. Mapping of CICES V5.2 classifications to localized proxies and valuation methods in pulau gusung.

CICES V5.2 Class	Localized Proxy	Valuation Method
Provisioning	<i>A’sulo</i> / <i>Ngatti-ngatti</i>	Market Price Survey
Health/Social	Healing, mental well-being, and social bonding	Contingent Valuation (WTP/WTa)
Education	“Natural School” (Environmental ethics/TEK)	Replacement Cost (Education Program)
Sense of Place	Seagrass as “Common Property” and identity	Contingent Valuation (WTA)

2.4. Data collection strategy

2.4.1. Qualitative baseline and value weighting

Field data collection in Pulau Gusung was conducted in Selayar's traditional language. An initial semi-structured Focus Group Discussion (FGD) was organized with 10 cross-generational gleaners (comprising 6 women and 4 men) to establish the foundational price points (bid design) for the quantitative valuation models, as outlined by [Carmona-Torres and Calatrava-Requena \(2006\)](#). To assess subjective local community priorities regarding extractive versus non-extractive benefits, a participatory Token Allocation Game (TAG) was employed, adapted from the Pebble Distribution Method ([Pfund et al., 2011](#)). Participants distributed a budget of 10 tokens among three localized benefit categories represented by physical plates: Catch Value (Provisioning), Healing/Recuperation Value, and Togetherness/Social Value. Furthermore, Key Informant Interviews (KIIs) with senior gleaners ($n = 2$) and local educators ($n = 2$) provided historical insights into gleaning practices and established the programmatic replacement parameters necessary for valuing informal environmental education.

2.4.2. Quantitative valuation (household and market surveys)

Quantitative data were obtained through a structured household survey involving 70 active gleaners (36 men, 34 women) selected via purposive and snowball sampling methods. Due to the informal and unregistered nature of traditional gleaning, random probability sampling was not feasible. Acknowledging the selection biases inherent in snowball sampling, such as network homogeneity and the over-representation of highly connected individuals ([Biernacki & Waldorf, 1981](#); [Kirchherr & Charles, 2018](#)), we implemented mitigation measures by starting with multiple socio-demographically diverse seed informants, representing various ages, genders, and primary livelihoods, to ensure recruitment extended across distinct, non-overlapping social networks. Additionally, purposive criteria were consistently applied throughout the recruitment to encourage broader sample diversity and reduce over-reliance on any single referral chain ([Biernacki & Waldorf, 1981](#); [Kirchherr & Charles, 2018](#)). This deliberate mitigation is evidenced by the nearly equal gender distribution in the final sample, with 36 men and 34 women, ensuring the survey captured a representative cross-section of the active harvesting community.

To ensure international comparability, all local currency values (IDR) collected during the 2026 fieldwork were converted to US Dollars (USD) using the official Bank Indonesia exchange rate average for February 2026 (IDR 16,000 per USD). For methodological clarity, the survey was explicitly structured around three analytical components corresponding to the framework in [Table 1](#). First, concerning provisioning dynamics, a structured memory-recall method ([Kronen et al., 2007](#)) was employed to document seasonal harvesting frequencies and the distribution of biomass across commercial sales, household consumption, and non-monetary social sharing. Monetary values were determined from market surveys with local collectors ($n = 2$) using Direct Market Pricing for commercial species and Substitute Pricing for subsistence yields by calculating the equivalent market cost of alternative protein staples.

Second, regarding cultural services valuation, stated-preference elicitation scenarios ([Johnston et al., 2017](#)) were used to quantify respondents' WTP for physical habitat conservation (Sense of Place) and educational initiatives (Bequest Value), as well as Willingness to Accept (WTA) compensation for the hypothetical loss of access to cultural and healing spaces. For intangible regulating and educational services (*Sekolah Alam*), the Replacement Cost method was applied using empirical cost estimates of formal educational

excursions and ecological restoration benchmarks. Key Informant Interviews (KIIs) were conducted with local educators ($n = 2$) to ascertain a Replacement Cost.

Third, to evaluate Bequest Value and the cross-generational transmission of environmental ethics, an intergenerational validation assessment, operationalized as a ‘Child Test’, was conducted. Standard economic valuation surveys, such as WTP or WTA, are cognitively inappropriate for young children as they rely on abstract financial concepts. Therefore, a scenario-based behavioral assessment using visual prompts (Fig. 2) was adapted to translate complex relational values into accessible, age-appropriate formats (Hayball & Pawlowski, 2018). Administered to a subset of the primary respondents’ children ($n = 9$) aged 8–12 years with prior parental consent, the assessment presented two localized, highly relatable dilemmas. The first scenario tested social cohesion and resource sharing (*gotong-royong*) by asking the children how they would react if their gleaning bucket was full while a peer’s was empty. The second scenario tested environmental stewardship by presenting an image of a peer deliberately damaging the seagrass habitat. This behavioral methodology allowed for an exploratory assessment of whether the cultural and relational values claimed by the adult generation are actively being internalized by the youth, thereby serving as an indicative proxy for Bequest Value and the efficacy of the *sekolah alam*.



Fig. 2. Child test to validate bequest value.

3. Results

3.1. Pre-survey elicitation and baseline outcomes

Initial focus group assessments provided the essential baseline social-ecological data and established the foundational price points (bid design) employed in the subsequent quantitative valuation models. The results of the participatory mapping exercise offer concrete evidence of the intricate nature of Local Ecological Knowledge (LEK), as community members accurately identified specific environmental features, including complex ocean current patterns and localized shellfish distribution. To establish a baseline for the scientific Replacement Cost method, we systematically documented the temporal investment required to acquire this expertise among the 10 FGD participants. Responses ranged from one and a half years to three years, with a strong consensus ($n = 10$) identifying that a minimum two years of experiential learning is necessary to master this specialized knowledge. This temporal metric offers a critical quantifiable baseline for the Replacement Cost of marine education; should this traditional knowledge transfer be disrupted, the formal educational system would necessitate a minimum of four semesters of a specialized, substitute curriculum to replicate it. Furthermore, the mapping exercise empirically

suggested that community gleaning (*a'sulo/ngatti-ngatti*) constitutes a complex, acquired ecological skillset representing a significant intangible cultural asset, rather than mere unskilled labor.

In the subjective valuation baseline, the collective consensus among FGD participants resulted in 5 tokens for economic value, 3 tokens for social value, and 2 tokens for healing value. This consensus-based distribution reflects a balanced group perspective, resulting in equal division between extractive provisioning services (50% economic value) and non-extractive cultural services (50% combined social and healing value).

In the baseline elicitation scenarios, responses for Scenario A (WTP for Physical Conservation/Sense of Place) ranged from IDR 5,000 (USD 0.31) to IDR 100,000 (USD 6.25), with a median value of IDR 50,000 (USD 3.13). In Scenario B (WTA for Loss of Access to Cultural Spaces), the assessed values revealed significant variability; the compensation required for the loss of access to the meadows for social and healing activities ranged from IDR 50,000 (USD 3.13) to an extreme maximum of IDR 100,000,000 (USD 6,250), with a median of IDR 100,000 (USD 6.25). Lastly, in Scenario C (WTP for Educational Initiatives/Bequest Value), responses regarding the funding of a Coastal Nature School ranged from IDR 20,000 (USD 1.25) to 2026 IDR 500,000 (USD 31.25). Notably, the median WTP for this educational initiative IDR 100,000 (USD 6.25) was precisely double the median WTP recorded for physical conservation. This qualitative phase effectively revealed that cultural services are a significant factor influencing seagrass interaction. The elicited median values IDR 20,000 (USD 1.25) IDR 50,000 (USD 3.13) IDR 100,000 (USD 6.25) offered empirically substantiated anchor prices for the quantitative phase, ensuring that the final economic valuation was firmly grounded in the local community's socio-economic context rather than abstract scientific estimates.

3.2. Household survey outcomes

Drawing from the data collected through 70 household surveys, this section evaluates the perceived ecosystem benefits among the local community. A survey of active seagrass harvesters at the Pulau Gusung study site ($n = 70$) confirmed that gleaning activities, including both *a'sulo* (night gleaning) and *ngatti-ngatti* (daytime gleaning), were predominantly maintained by a mature demographic (age range 15–63 years, median 40.5 years) whose primary livelihoods were intricately connected with marine resources.

Occupational profiling indicates that the study community's primary means of livelihood were intricately connected to and heavily dependent on marine resources. The largest occupational group comprised fishermen, with 32 respondents, suggesting that gleaning served as a crucial supplementary activity to traditional offshore fishing. The second-largest group consisted of housewives, accounting for 23 respondents, highlighting the essential yet often underrepresented role of women in subsistence harvesting and maintaining household food security. Furthermore, a distinct subset of respondents explicitly identified the daytime gleaning as their primary occupation, underscoring the direct economic reliance of the Livelihood System on the ecological integrity of the seagrass meadows.

The survey results indicate that gleaning activities were significantly influenced by seasonal weather patterns and tidal cycles. During the East Monsoon, characterized by calm waters and low tides occurring during the day, the intensity of gleaning activities was notably high, with respondents visiting the seagrass beds an average of 4.31 times per week (range: 1–7 visits). Conversely, during the West Monsoon, which is associated with rougher seas and low tides occurring at night, community access was markedly restricted, reducing the average frequency to merely 1.86 times per week (range: 0–7 visits). This seasonality

highlights the study community’s physical vulnerability in accessing this essential marine resource.

While seagrass ecosystems are traditionally evaluated for their contributions to commercial fisheries, the survey indicates that gleaning fundamentally operated outside the conventional market economy. The data on catch distribution revealed that less than half of the harvested biomass (47.8%) was sold to local collectors or traditional markets.

Importantly, the remaining 52.2% of the catch was not commercialized, functioning instead as an informal socioeconomic safety net. Of the total yield, 31.4% was retained for household consumption, providing an indispensable, free source of daily protein that supported local food security. Additionally, 20.8% of the catch was distributed at no cost to neighbors and extended family. This non-monetary distribution underscores the ecosystem’s role in facilitating *gotong royong* (mutual assistance) and maintaining community cohesion.

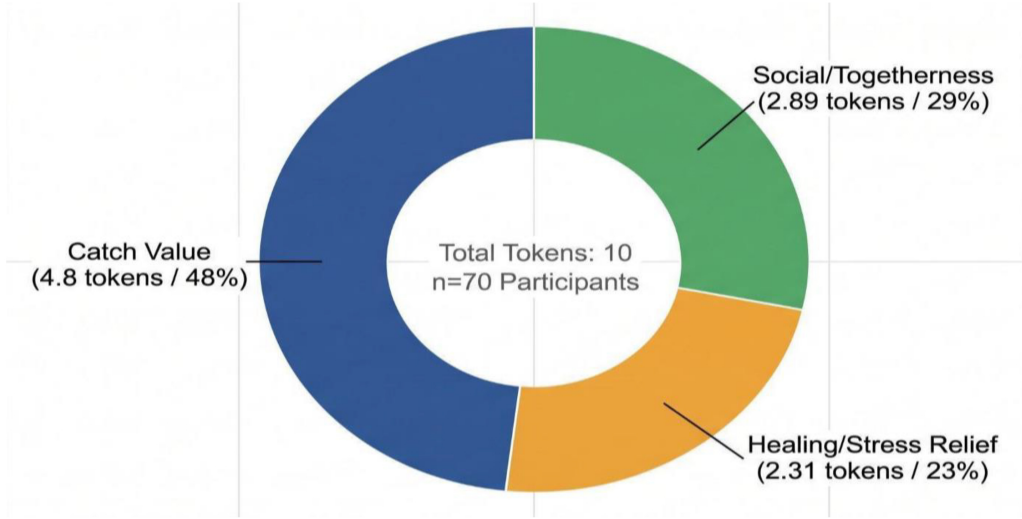


Fig. 3. Aggregate results of the participatory token allocation game (n = 70), demonstrating the community’s subjective valuation of seagrass ecosystem services distributed across extractive provisioning (48%) and non-extractive cultural services (52%).

In evaluating perceived ecosystem benefits, respondents allocated an average of 4.8 tokens (range: 0–9) to Economic/Catch Value. The aggregate Cultural Services represented the majority of the allocation, with an average of 2.89 tokens (range: 0–8) designated to Social/Togetherness Value and 2.31 tokens (range: 0–7) to Healing/Stress Relief Value. Consequently, 52% of the respondents’ subjective valuation of the seagrass meadow was attributed to non-extractive services rather than resource extraction (see Fig. 3). In the open elicitation of WTP for the physical conservation of seagrass, reflecting a Sense of Place, no respondents declined to contribute (“True Zero”). Responses ranged from IDR 5,000/USD 0.31 to IDR 100,000 (USD 6.25), with a median value of IDR 38,428/USD 2.4 per month. Conversely, when respondents were asked to specify a Willingness to Accept (WTA) compensation value for the hypothetical loss of access to seagrass as a social and healing space, the majority rejected standard monetary options, opting for other. This resulted in high variance among the stated values, ranging from IDR 50,000 (USD 3.13) to IDR 50,000,000 (USD 3,125), with a median value of IDR 2,449,202 (USD 153.08). Furthermore, the WTP for educational initiatives (*Sekolah Alam*) associated with Bequest

Value ranged from IDR 20,000 (USD 1.25) to IDR 1,000,000 (USD 62.5), with a median of IDR 75,785 (USD 4.74) per month.

Finally, in the scenario-based behavioral assessment involving the respondents' children (the child test), 100% of the participants chose to share their catch when presented with a scenario where their own bucket was full while a peer's was empty. No participants elected to retain the entire catch for personal use. In the subsequent habitat-interaction scenario depicting a peer deliberately damaging seagrass, 55.5% of the children indicated they would actively reprimand the individual or report the behavior.

3.3. Key informant interviews: Revealing “invisible” ecosystem services

Interviews conducted with elderly, highly experienced gleaners revealed significant generational shifts in the Gusung community's interaction with the seagrass ecosystem. Historically, the community faced severe economic hardship, rendering the seagrass a vital resource. At the time of the study, the elders observed a notable decline in youth participation in gleaning—particularly among young women—attributable to upward mobility and migration for formal higher education in mainland Selayar or Makassar. Despite this demographic shift, the elders provided critical insights into the ecosystem's resilience and local conservation dynamics. They noted that traditional gleaning (*a'sulo/ngatti-ngatti*) does not permanently degrade the habitat, observing that the seagrass consistently regenerated despite regular human foot traffic. Furthermore, the elders indicated the successful cessation of destructive fishing practices (e.g., blast fishing) due to effective local law enforcement. The interviews also revealed deep-seated cultural taboos that served as informal conservation mechanisms. Oral histories and observations from elders indicated that dugongs, although still present in the region, had become critically rare compared to previous decades. Historically, community members refrained from consuming dugongs due to local folklore that attributed human-like physical characteristics, such as hands, to the species. This exemplifies how local myths and intangible cultural heritage have historically functioned as natural regulatory mechanisms for marine megafauna. Although this cultural barrier continued to serve as a latent protective measure, its effectiveness was compromised by external hunting pressures and insufficient awareness of bycatch protocols. This situation highlights the urgent necessity to formally reinforce these traditional values to safeguard the remaining dugong population.

Beyond these historical and cultural insights, the quantitative survey indicated that the seagrass meadow functioned as a vital site for the inter-generational transmission of environmental ethics and collectivism (*gotong-royong*). Regarding the Replacement Cost for these educational services, local educators provided precise, market-based estimates for alternative substitute activities per semester. Firstly, at the Primary School Level (SD), to emulate the collaborative nature of traditional gleaning, the school would need to organize a guided fishing excursion (*Wisata Pancing*). For a cohort of 38 students, this would involve renting a vessel (IDR 300,000/USD 18.75), purchasing marine bait (IDR 45,000/USD 2.81), providing fishing gear (IDR 190,000/USD 11.88), and supplying meals (IDR 950,000/USD 59.38). This amounts to IDR 1,485,000/USD 92.81 per semester (approximately IDR 39,078/USD 2.44 per child). Secondly, at the Junior High School Level (SMP), to impart active environmental stewardship, the school would organize a coastal mangrove planting initiative. For 46 students, the costs would include purchasing 100 mangrove seedlings (IDR 500,000/USD 31.25), hiring a local ecological guide (IDR 300,000/USD 18.75), and providing meals (IDR 1,150,000/USD 71.88). This totals IDR 1,950,000/USD 121.88 per semester (approximately IDR 42,391/USD 2.65 per child). These figures are highly insightful, providing an empirical, market-based baseline that

reveals the Gusung seagrass ecosystem currently offers millions of Rupiah worth of “free” educational and character-building services each semester. However, it is essential to highlight that these monetary replacement costs function solely as financial proxies to make the ecosystem’s ‘avoided costs’ apparent to policymakers. We do not propose that formal, structured excursions can genuinely replace the holistic function of the Natural School. While a funded school program might replicate basic environmental exposure, it cannot artificially reproduce the profound social relations, cultural identity, and organic intergenerational transmission of Traditional Ecological Knowledge (TEK) inherent in localized gleaning practices. Nonetheless, this quantitative replacement cost effectively supports the high WTP for the *Sekolah Alam* (nature school) identified in the household survey, affirming the community’s intrinsic recognition of the meadow as an irreplaceable pedagogical asset.

3.4. Economic valuation of provisioning services: Market and substitute pricing

Interviews with local collectors ($n = 2$) elucidated a distinct hierarchical pricing structure for seagrass-associated marine biota entering the formal cash economy. High-value target species, often intended for export or broader regional markets, commanded substantial prices per kilogram. Notably, octopus emerged as the most valuable commodity at IDR 105,000/kg, followed by crabs priced between IDR 40,000 and IDR 50,000/kg. Sea cucumbers, another high-value benthic resource, were acquired individually at IDR 1,000,000 per piece. In contrast, localized gleaning catches, primarily consisting of various shellfish and bivalves, were commercialized in bulk, unstandardized units, reflecting their status as traditional, high-volume commodities. Bivalves such as *Biri-biri/Bimba* were valued between IDR 20,000 to IDR 50,000 per bucket, while *Gempang*, another bivalve, commanded up to IDR 70,000 per plastic basket. Household survey data indicates that a typical gleaning session yielded between 1 to 2 buckets per household, illustrating a consistent potential for supplementary income when these catches exceed immediate household consumption needs.

Beyond the commercial market, a critical component of the seagrass provisioning service was its contribution to household food security, effectively bypassing the commercial market. For catches that were either unsuitable for sale or reserved for family consumption, the survey determined the baseline costs of alternative protein sources that households would need to purchase if seagrass gleaning were no longer an option. For subsistence catches retained for household food security, the baseline cost for alternative protein sources were identified as IDR 2,500 per egg, IDR 3,000 per pack of instant noodles, and IDR 7,000 per standard pelagic fish (*Ikan layang/banyar*). These figures represent the minimum economic substitution value of the free protein harvested daily from the seagrass meadows by gleaners.

4. Discussion

The valuation of coastal ecosystems has traditionally been shaped by market-centric paradigms that emphasize commercial extraction while neglecting intangible human-nature interactions (Barbier et al., 2011; Chan et al., 2011; Pascual et al., 2017). The present study expands on early foundational critiques, such as those by Clifton et al. (2014) and Chan et al. (2016), which advocate for alternative social-ecological valuation methodologies. It contributes to this discourse by offering a clear empirical approach to implementing these concepts. By systematically applying and operationalizing the CICES

v5.2 framework within the Selayar Archipelago, this research illustrates how seagrass ecosystems serve as both an indispensable socio-economic safety net and a dynamic educational landscape. The data illustrate that the non-monetary and subsistence benefits derived from the meadows—ranging from daily food security to the intergenerational transfer of environmental ethics—are not peripheral artifacts of coastal life. Rather, they are central to the ecosystem's total economic and cultural worth. Ultimately, this illustrates that while national level policies may prioritize national-scale metrics such as blue carbon potential, biodiversity, or biomass production, assessing seagrass meadows solely through a formal market perspective would lead to significant undervaluation of localized socio-cultural assets. Neglecting these unique local values entails disregarding the mechanisms that support coastal community resilience and cultural continuity.

4.1. *The socio-economic safety nets of small-island gleaning*

To achieve a comprehensive valuation that accurately reflects the lived realities of small-island social-ecological systems (SES), a fundamental reassessment of the measurement of provisioning services is necessary. Traditional economic valuations of marine ecosystems predominantly focus on industrial or offshore commercial fisheries, assessing value almost exclusively through the lens of formal market integration (Clifton et al., 2014). However, empirical quantification of traditional gleaning (*a'sulo and ngatti-ngatti*) in Pulau Gusung reveals a markedly different paradigm that the majority of harvested biomass operates entirely outside the formal cash economy. With less than half of the catch sold to local markets or collectors, evaluating these seagrass meadows solely by commercialized output captures only a portion of their actual provisioning utility, systematically underestimating their crucial role in sustaining coastal livelihoods.

The non-commercialized portion of the harvest represents an indispensable, unmone-
tized socio-economic safety net. Approximately one third of the harvest is allocated for direct household consumption, and one fifth is distributed freely among neighbors and relatives, thereby sustaining a robust informal distribution network founded on social capital and reciprocal altruism (Grantham et al., 2021). This provisioning dynamic is deeply gendered; women and children are the primary actors in day-to-day intertidal harvesting, ensuring continuous household nutrition even when offshore artisanal fishing by men is unviable due to seasonal weather disruptions during the West Monsoon. In isolated coastal communities susceptible to macroeconomic volatility and supply chain shocks (Grantham et al., 2021), this consistent supply of domestically consumed protein provides a crucial buffer against acute food insecurity and structural poverty (Canty & Deichmann, 2022).

These findings contribute to a growing body of literature challenging conventional, market-centric valuations. A number of studies indicate that intertidal gleaning contributes substantially to local subsistence economies yet remains systematically underreported when assessments rely solely on formal market pricing (Harper et al., 2012; Teh & Pauly, 2018). Traditional commercial models inadequately account for the “avoided costs” associated with subsistence living, overlooking the financial resilience coastal ecosystems afford to vulnerable households (Lazo, 2002; Canty & Deichmann, 2022). When applying the Substitute Price method—a recognized cost-based approach for valuing non-market ecosystem benefits (Tinch et al., 2019)—to calculate the expenditure households would incur if forced to purchase commercial protein substitutes, the true magnitude of this provisioning service becomes apparent. Seagrass meadows do not merely generate supplemental cash income; they act as a foundational economic buffer that protects limited household financial assets from being entirely consumed by basic nutrition costs. Therefore, assessing

traditional gleaning through the narrow framework of commercial fisheries fundamentally misrepresents the habitat's role in poverty alleviation—a persistent omission in global ecosystem service syntheses (Brander et al., 2024).

4.2. Relational values, incommensurability, and intergenerational continuity

A central objective of this study was to transcend qualitative descriptions and empirically capture the systemic invisibility of non-material human-environment interactions. The necessity of a paradigm shift in how we conceptualize coastal valuation is most starkly revealed by the 48/52 subjective value divide observed during the participatory Token Allocation Game. Rather than perceiving the seagrass meadow primarily as a fishery resource, the study community attributed less than half of the ecosystem's value to extractive provisioning (catch) and a majority of the value to non-extractive cultural services (social cohesion, togetherness, and psychological healing). This finding prompts a critical question: why does a resource-dependent community prioritize intangible social and healing values over direct economic extraction? The findings suggest that for the residents of Pulau Gusung, community gleaning was fundamentally a relational practice (Chan et al., 2016). The extraction of marine biomass was intrinsically linked to maintaining the community's social fabric; thus, intangible cultural benefits were not perceived as peripheral luxuries but as the foundational core of coastal well-being and collective resilience (Hirons et al., 2016).

The deep relational attachment to these coastal spaces is further reinforced by empirical validation from cognitive assessments conducted with younger cohorts (Child Test). Notably, the unanimous decision among the children to share their hypothetical catch demonstrates an early-stage internalization of *gotong royong* (mutual assistance). Additionally, the majority's tendency to reprimand peers for habitat destruction indicates the development of active environmental stewardship rather than passive observation. Collectively, these behavioral responses provide indicative evidence for the cognitive accessibility and cross-generational transmission of relational values. The scenario-based assessments suggest that the meadows functioned as an active, lived institutional space, locally conceptualized as *Sekolah Alam*. In this dynamic intertidal classroom, Traditional Ecological Knowledge (TEK), environmental ethics, and intergenerational stewardship were seamlessly transmitted through participatory observation during communal harvesting. This cross-generational continuity demonstrates that cultural ecosystem services in Selayar were dynamic social-ecological processes that actively shaped youth preference formation, cultural identity, and intergenerational equity (Tidball & Krasny, 2010; Retalack & Schott, 2014).

However, operationalizing these qualitative dependencies into economic metrics necessitates confronting a conceptual tension inherent in our methodology: does translating relational values into monetary equivalents—via WTP, substitute pricing, and replacement cost calculations—inadvertently risk reproducing the same logic of market commensuration that this study seeks to critique (Gómez-Baggethun & Ruiz-Pérez, 2011; Kallis et al., 2013)? We argue that our approach is not an endorsement of commodification, but rather an exercise in tactical commensuration (Kallis et al., 2013). In a coastal governance landscape increasingly dominated by quantifiable, carbon-centric “Blue Economy” metrics, deeply localized subsistence practices and social-ecological connections are systematically rendered invisible (Alinsug & Alinsug, 2026; Barbesgaard, 2017). By calculating the replacement cost of the *sekolah alam* or the substitute price of local protein safety nets, we have used economic valuation not to integrate these practices into formal market exchange, but as an instrument of recognitional justice (Kull et al., 2015; Martin et al., 2016). It is

a strategic translation intended to make structurally invisible socio-cultural dimensions legible to state policymakers and transnational donor regimes.

A local resistance to perceiving seagrass ecosystems purely in commercial terms was apparent in the community's own responses. Specifically, the remarkably high values observed in Willingness to Accept (WTA) scenarios. While conventional environmental economics often dismisses infinite or unquantifiable responses as statistical anomalies or “protest bids” (Jorgensen et al., 1999; Meyerhoff & Liebe, 2005), political ecology interprets these expressions as lexicographic preferences (Huber & Finger, 2019). Respondents' refusal to trade cultural and healing access for hypothetical cash compensation reflects an absolute moral boundary against the commodification of environmental integrity. This aligns with a broader global literature indicating that indigenous and traditional resource-dependent communities often reject the monetization of ancestral or communal biophysical spaces, perceiving nature as an incommensurable component of collective identity (Gómez-Baggethun & Ruiz-Pérez, 2011; O'Garra, 2011; Venn & Quiggin, 2006). Ultimately, the psychological restoration, social cohesion, and educational functions (*Sekolah Alam*) embedded within the seagrass meadows cannot be adequately replaced or compensated by standard financial mechanisms; our monetary calculations merely illustrate the immense scale of what is at stake.

4.3. Deconstructing blue economy paradigms: From carbon-centricity to recognitional justice

This study synthesizes the empirical realities of subsistence safety nets and relational continuity to reveal a significant epistemological gap in contemporary marine governance. Current national and global “Blue Economy” agendas are predominantly influenced by biophysical and carbon-centric accounting paradigms, such as Blue Carbon sequestration schemes and stringent spatial conservation regimes. Recent baseline studies in Indonesia, including those by Sjafrie et al. (2024) and Ambo-Rappe et al. (2019), indicate that provisioning and cultural services constitute a minimal portion (often less than 1%) of the total economic value of Indonesian seagrass ecosystems. When state policies and associated Payment for Ecosystem Services (PES) or Blue Carbon schemes rely on these skewed metrics for spatial planning, they commodify carbon storage while rendering local social-ecological dependencies structurally invisible.

From a political ecology perspective, prioritizing biophysical metrics over localized relational practices results in a form of recognitional injustice (Martin et al., 2016; Kull et al., 2015). This issue raises a critical question in global marine governance: which values are recognized by state and transnational institutions, and which lived experiences are marginalized? When international financial institutions and donor regimes mandate standardized, commodified biophysical outputs to validate carbon offset investments, they systematically exclude those aspects of human-environment relations that cannot be fully captured by these metrics. Socio-economic safety nets and intergenerational knowledge transfers, exemplified by practices such as *a'sulo* and *ngatti-ngatti*, are structurally disregarded because they cannot be quantified solely in terms of sequestered carbon or commercial harvest yields. Consequently, conservation initiatives that enclose marine areas to enhance carbon sequestration capacity, while providing financial compensation only for “lost fishing income,” overlook the concurrent degradation of the community's social structure and educational environments.

Our Replacement Cost analysis with local educators indicates that replicating the experiential learning naturally provided by the *sekolah alam* through formal outdoor education programs would require substantial financial investment. However, as evidenced by our

findings on lexicographic preferences and protest bids, the intrinsic value of these spaces cannot be easily quantified. By providing this educational utility at no cost, the seagrass meadow effectively subsidizes local capacity building, character education, and social reproduction (Tidball & Krasny, 2010; Gould et al., 2018) in ways that formal institutional alternatives cannot fully replicate. Prevailing governance frameworks fail to recognize these avoided costs, thereby structurally undervaluing the habitat's role in sustaining human capital.

Gleaning transcends a simple extractive activity, acting instead as an essential mechanism for cultural continuity that actively shapes relational values and social connectivity (Gould et al., 2018). To render this additional invisible cultural service legible to state policymakers, the study applied the Replacement Cost method. Through expert elicitation with local educators, we found that replicating the experiential learning naturally provided by the seagrass ecosystem with structured outdoor education programs would necessitate considerable financial resources. By delivering this educational service at no financial expense to the community, the seagrass ecosystem effectively subsidizes local capacity building and character education, which could only partly be made up by formal education. However, dominant coastal governance frameworks rarely account even for these partial avoided costs, thereby structurally undervaluing the ecosystem's role in sustaining human capital.

The findings align with emerging critiques that emphasize the need for marine conservation efforts to transcend isolated biological metrics (Poe et al., 2013; Jones et al., 2022; Wang et al., 2025). Data from Pulau Gusung offer localized empirical evidence that top-down enclosures pose threats extending beyond biodiversity or carbon loss; they risk dismantling the traditional safety nets and informal learning spaces that sustain small-island resilience. Ultimately, cultural and subsistence provisioning services are not peripheral artifacts; they are central to social-ecological connectivity. Implementing a standardized yet contextualized CICES framework serves not merely as an economic exercise but as a policy instrument for recognition justice, urging decision-makers to integrate relational values into equitable, community-centered maritime governance.

4.4. Policy and governance implications

To ensure that the empirical recognition of relational values is effectively integrated into equitable maritime governance, it is essential that current national and global policy frameworks undergo fundamental structural reform. This necessity is particularly pronounced within the context of Indonesia's evolving blue economy agenda. The recent enactment of Presidential Regulation No. 110 of 2025, concerning National Greenhouse Gas Emission Reduction and Carbon Economic Value (Republik Indonesia, 2025), provides significant institutional momentum to value coastal ecosystems. However, a political ecology analysis of the actors shaping this framework reveals a pronounced structural bias. Presently, blue carbon valuation is disproportionately influenced by international financial institutions and transnational donor regimes, which demand standardized, biophysically commodified outputs to justify carbon offset investments (Barbesgaard, 2017).

Consequently, existing Measurement, Reporting, and Verification (MRV) guidelines focus almost exclusively on carbon stock sequestration per hectare per year. This top-down, donor-driven MRV framework and state regulatory bodies create significant socio-legal risks: they incentivize the enclosure of marine commons for global climate mitigation targets while structurally neglecting localized food safety nets and relational practices (Atchison et al., 2024; Tarigan, 2025). As observed in broader coastal governance (Bennett et al., 2019; Ngaji et al., 2021; Kamlun et al., 2024), strict reliance on externally mandated

biophysical metrics inevitably exacerbates social-ecological trade-offs, undermines local institutional legitimacy, and compromises long-term conservation compliance.

To achieve genuine environmental and recognition justice, national coastal policies would benefit from evolving beyond serving external carbon accounting. The economic and stated-preference data collected from Pulau Gusung provide a community-validated foundation for reforming local conservation financing (Hamuna et al., 2018). Rather than treating localized WTP as merely a measure of household disposable wealth, policymakers should utilize these figures as empirical indicators of community environmental dependence and stewardship motivation (Gagarin et al., 2022; Prasetyawan, 2023).

Practically, these empirical baselines can be integrated into decentralized fiscal mechanisms, such as redirecting village allocations into a dedicated Village Conservation Fund. Instead of distributing top-down compensation based on flawed biophysical assumptions, these funds could serve to directly empower local resource stewards—subsidizing grassroots institutional initiatives such as *sekolah alam*, securing traditional gleaning tenure for women, and supporting sustainable alternative livelihoods. By grounding conservation finance in localized relational values rather than global carbon markets, marine governance can effectively safeguard small-island social-ecological resilience (Mojiol et al., 2022).

5. Conclusion

This study contributes to the literature on the political ecology of coastal governance by empirically demonstrating the relational values, particularly gendered subsistence safety nets and intergenerational knowledge transmission, form the foundational core of social-ecological resilience on small islands. Our findings crucially indicate that these relational values are not merely undervalued by current environmental economics; they remain only partially commensurable with the prevailing metrics that drive global Blue Economy and Blue Carbon agendas. Instead of considering non-market cultural interactions as peripheral, our localized application of the CICES v5.2 framework illustrates how standardized classification systems can be repurposed as analytical tools for recognition justice. By translating structurally invisible human-nature dependencies into quantifiable economic and behavioral metrics, this research challenges the dominance of biophysically biased valuation hierarchies in marine economics.

The strategic implications for contemporary maritime policy are therefore substantial. Evaluating marine commons solely through donor-driven carbon accounting or biophysical Measurement, Reporting, and Verification (MRV) targets risks fostering exclusionary conservation practices and severe environmental injustice. To mitigate this, it is essential that Indonesia and other maritime nations advancing their Blue Economy agendas adopt a more holistic governance approach. Primarily, there is an urgent need to reform Blue Carbon MRV protocols. National frameworks, such as Indonesia's Presidential Regulation No. 110 of 2025, could be strengthened by incorporating socio-cultural safeguard to ensure that spatial carbon enclosures do not displace traditional protein safety nets and disrupt cultural values.

Moreover, this regulatory reform could be supported by the implementation of decentralized conservation financing. Governance should transition from top-down enclosures to community-centered models, a shift that can be achieved by redirecting carbon revenues or state allocations into dedicated 'Village Conservation Funds.' These funds would directly support grassroots institutional initiatives. Underpinning both of these financial and regulatory shifts is the critical necessity to secure informal tenure rights. Institutional mechanisms should consider providing legal protection for intertidal gleaning

tenure, specifically empowering the local women and practitioners who sustain these vital socio-economic networks. Ultimately, sustainable coastal conservation is best served by anchoring formal policy not in the abstract currency of global carbon markets, but in the reciprocal, lived relationships that sustain coastal ecosystems and their traditional stewards.

Acknowledgments

This research is funded by the Indonesian Endowment Fund for Education (LPDP) on behalf of the Indonesian Ministry of Higher Education, Science, and Technology, and managed under the EQUITY Program (**Contract No. 4307/B3/DT.03.08/2025 and No. 47103/UN4.1/PM.01.01/2025**).

We extend our sincere appreciation to the experts and participants of the multidisciplinary workshop held in Makassar from January 13 to 15, 2026, whose collaborative insights were instrumental in developing the valuation tool utilized in this study. Furthermore, we would like to express our deepest gratitude to the community of Pulau Gusung, Kepulauan Selayar, including the local elders, teachers, and active gleaners, for their invaluable time, participation, and willingness to share their local ecological knowledge during the data collection process.

Conflicts of interest

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Author contributions

H.B.D.S., R.A.-R., M.L., and S.C.A.F. conceived and designed the study; H.B.D.S. and R.A.-R. performed the study; H.B.D.S. and R.A.-R. analyzed the data; H.B.D.S., R.A.-R., M.L., and S.C.A.F. wrote the paper.

Data availability

The data that support the findings of this study are available on request from the corresponding author.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the authors used Gemini and OpenAI for grammar checking and text clarity improvement. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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