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Legitimacy Of Coastal Resource Management Through Environmental Accounting Of Blue Carbon Assessment Of Mangrove Forests In Surumana Village

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ABSTRACT

Environmental accounting is needed to explain the interaction between the economy and the environment, while carbon estimation is a form of reporting the value of carbon or biomass produced from mangrove forests for sustainable coastal resource management in Surumana Village, South Banawa District. This study aims to calculate the amount of biomass and, as a form of legitimacy for interested parties, report the biomass produced by mangrove forests for coastal resource management. A mixed-methods approach is the method used in this study through interviews, observations, and plot sampling as data collection techniques. The results show that the carbon absorption of the mangrove ecosystem in Surumana Village is 154,54 tCO_2e with an asset value of Rp 22.253.760. This monetary value provides an absolute legal mandate for the Regional Government (Environmental Agency) to actively participate and implement Presidential Decree No. 98/2021 in upholding regulatory legitimacy, ensuring social legitimacy through transparency, and ensuring a solid legal and financial foundation for the Surumana Village mangrove ecosystem to be managed protectively and sustainably.

INTRODUCTION

Sustainable environmental issues are increasingly highlighting the global news, from climate change to biodiversity loss, the exploitation of small islands for mining to weak environmental law enforcement, indicating clear evidence of the environmental crisis that is occurring so that it is urgent to take real action in mitigating climate change. Indonesia as an archipelagic country has the potential for large coastal ecosystems to create economic growth, especially for coastal communities. However, climate change and extreme weather threaten the lives and livelihoods of the community. Fajar Kaprawi (2025), said that one of the climate action

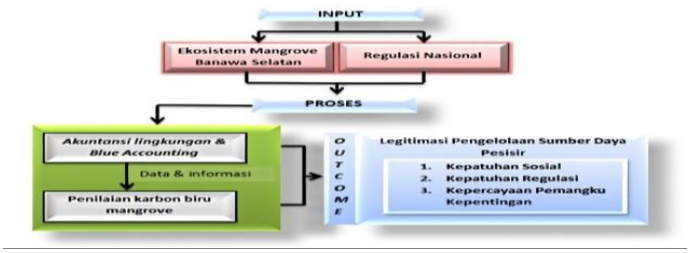
plans to mitigate climate change is through carbon projects that play an important role in achieving Indonesia's climate commitments by generating economic incentives. Thus, Indonesia needs to maximize the potential of blue carbon in coastal ecosystems that are geographically very dominant in the archipelago, such as mangrove forests that are rich in blue carbon in protecting coastlines from abrasion, especially for areas with significant coastal wealth, such as those in Central Sulawesi Province.

Central Sulawesi Province has a geographical shape that reflects its unique characteristics as an archipelagic province dominated by water. However, this geographical richness is often inversely proportional to the ecological conditions found at the local level. In fact, the Donggala region is currently rife with mining activity, particularly C (sand and rock) mining, which raises potential concerns about ecological disasters, including coastal abrasion and marine pollution. One area that is still far from mining and has the potential to contribute blue carbon is Surumana Village, South Banawa District, which has mangrove forests that are key to preventing abrasion, maintaining biodiversity, and absorbing and storing blue carbon. Despite this significant potential, some residents still do not fully understand the ecological function of mangroves. Mangroves in this area grow wild without planned planting or conservation programs. For the community, mangroves are not yet viewed as assets that must be protected because they provide no direct input or output benefits to their economic activities. This situation clearly reflects the unbalanced relationship between community activities and the ecological function of mangroves and reveals a gap in understanding of the ecological and even economic value of their coastal resources. As obtained from the results of the pre-research, there are serious gaps, *…"There has been no recording of mangrove areas and their results to date. This village needs outreach because the community still lacks knowledge, especially regarding bookkeeping and resource management.."…* Said Nurhayati S.Kom, Secretary of Surumana Village.

The ecological value of mangrove forests is an important basis for consideration in economic calculations. A study by Komiyama et al. (2005), showed that nearly 50% of mangrove biomass is stored in the roots, making them a highly effective long-term carbon sink for climate change mitigation. The carbon sequestration stored in mangroves must be measured accurately so that it can be fully implemented into the decision-making process. To bridge the gap between economic and ecological values, an accounting system is needed that can systematically integrate economic and environmental data. An environmental accounting system is the main international statistical standard needed because it provides a methodology for explaining the interaction between the economy and the environment. By applying the SEEA framework, data regarding the blue carbon value of mangroves in Surumana Village can be calculated and presented legitimately, providing a strong foundation for local governments and communities to formulate sustainable coastal resource management policies, while simultaneously increasing the legitimacy of environmental economic value-based management in the eyes of the public and stakeholders. While the SEEA framework provides a robust methodology for integrating economic and environmental values, its application in the context of coastal resource management also needs to be reviewed from a policy legitimacy perspective, particularly the reporting and utilization of the blue carbon value of mangrove ecosystems.

Conceptual Framework Of The Legitimacy Of Coastal Resource Management

Figure 1. Conceptual Framework of the Research



Successfully ratifying the legitimacy of coastal resource management is key to social compliance among both the community and the government, ensuring compliance and a successful conservation program. This legitimacy will unlock three significant benefits: first, for social compliance, the ratified regulations will be widely accepted by the community, making principles such as "cut 1 plant 5" a common practice that is obeyed without coercion. Second, for regulatory compliance, it will encourage local governments to create official Regional Regulations (PERDA) that contain the rules outlined in the first ratification, for example, "cut 1 plant 5," or perhaps establish regulations that are mutually created and agreed upon, thus becoming mandatory law for all. Third, the realization of social and regulatory compliance will build mutual trust among stakeholders such as the community, government, and entrepreneurs, thus encouraging coastal communities and stakeholders to implement better and more sustainable coastal area management.

Most research on environmental accounting focuses on calculating assets and losses at the national level, while specific assets, such as those in coastal areas, are still lacking. This often leaves island villages, such as Surumana Village, neglected due to limited human resources. This gap makes it difficult for local communities to realistically measure the economic value of mangrove forest conservation. This research focuses on demonstrating the value of blue carbon through estimating the biomass produced by mangrove forests so that the results can be used to support sustainable coastal resource management and strengthen the legitimacy of coastal resource management among stakeholders and the local community of Surumana Village.

LITERATURE REVIEW

Legitimacy Theory (Legitimacy Theory) is defined as a social contract so that the theoretical framework that explains entities such as organizations, companies, or management bodies is in accordance with the actions, limitations, and norms that apply in society Ogunode (2022). When an entity fails to align its implementation with societal values, it will result in a legitimacy gap, which threatens the entity's survival or public support. In the context of natural resource management, legitimacy theory is crucial because management entities such as local governments that manage coastal areas are required to demonstrate that their activities are in line with community expectations, especially those related to environmental sustainability and social welfare Pratama (2025). In this context, environmental accounting (EA) plays a role as an instrument providing information on environmental costs and benefits while simultaneously encouraging improved environmental performance and transparency for stakeholders. The application of environmental accounting is in line with the principles of the blue economy through blue accounting, which emphasizes the importance of economic activities that do not disrupt the balance of marine ecosystems, making coastal ecosystems an important object that must be systematically assessed, especially ecosystems that have a strategic function in mitigating climate change through carbon storage.

Blue carbon is organic carbon captured and stored by coastal and marine ecosystems over the long term, with mangrove forests being a significant carbon store. Murdiyarso et al. (2015), explain that the conversion of mangrove land into ponds is a major threat that causes a decline in carbon storage function. Witomo (2018), emphasizes that shrimp pond cultivation can trigger mangrove degradation, leading to coastal erosion and ecosystem loss. In addition, Slamet et al. (2020), also state that land reclamation activities have the potential to release carbon stocks stored in mangrove soil and contribute to increased greenhouse gas emissions. Ong & Gong (2013), emphasize that the management and restoration of blue carbon ecosystems in Indonesia can increase carbon storage capacity while supporting ecosystem conservation and human well-being. At the national level, coastal resource management is strengthened by regulations that demand environmental accountability, as stated by Agustina (2023).

Coastal and mangrove resource management in Indonesia has a strong regulatory framework, further reinforcing the need for environmental accountability Agustina (2023). Regulation Number 98/2021 concerning the implementation of the carbon economic value (NEK) serves as the legal basis for market instruments such as carbon trading and performance based payments to achieve nationally determined contribution targets (Nationally Determined Contribution/NDC) Pemerintah Indonesia (2021). The NEK regulation explicitly creates an obligation to assess, measure, and report carbon sequestration in natural ecosystems, including mangrove blue carbon, thus strengthening the legal aspect of the legitimacy theory. Meanwhile, Government Regulation Number 27/2025 concerning the protection and management of mangrove ecosystems provides a clear mandate that mangroves must be managed for their ecological benefits, including as carbon storage Indonesia (2025).

METHODS

Sampling

This study uses a combination approach (mixed-methods) to gain a deep, holistic, and comprehensive understanding of the legitimacy of coastal resource management through a blue carbon assessment of mangrove forests. This approach systematically integrates quantitative and qualitative methods to produce complementary findings. According to Mulia (2024) mixed-methods is a research method that combines quantitative and qualitative approaches in an integrated manner to produce new, comprehensive findings from which scientific conclusions can be drawn.

The unit of analysis in this study was the mangrove forest ecosystem in the coastal area of Surumana Village. The study population included all mangrove stands at the study site and stakeholders involved in coastal resource management. Quantitative sampling techniques are carried out throughplot samplingfor measuring mangrove biomass, with the unit of analysis being individual mangrove trees in each observation plot. Meanwhile, qualitative sampling was carried out purposive towards informants such as local people.

Data Collection

Data collection in this study was carried out using three main techniques, namely interviews, direct observation, and field sampling (plot sampling). Quantitative data were obtained through direct measurements of mangrove tree diameters in predetermined sampling plots at the research site. This data was used to calculate mangrove biomass as a basis for assessing blue carbon stocks.

Qualitative data was collected through in depth interviews with informants to gain an understanding of the legitimacy of coastal resource management, applicable policies, and stakeholder perceptions of the economic value of blue carbon. In addition, direct observations were conducted to obtain an empirical picture of the condition of the mangrove ecosystem and its management practices in the field.

Measurement

Quantitative measurements in this study focused on calculating mangrove biomass using the allometric equation of Komiyama et al. (2005). The biomass obtained was then converted into carbon stocks using a carbon conversion factor, which was then converted into equivalent carbon emissions (tCO_2e).The economic value of blue carbon is calculated based on the fair value of carbon applicable on IDX Carbon, using the following formula:

$$tCO_2e = (0{,}251 \times \rho \times D^{2{,}46} \times 0.47) \times 3{,}67$$

The quantitative measurement results were then analyzed and integrated into qualitative analyses using interactive analysis methods. The quantitative findings served as the basis for

explaining and interpreting the legitimacy aspects of coastal resource management based on legitimacy theory. This integration aims to strengthen management legitimacy for stakeholders by scientifically and empirically demonstrating the economic value of mangrove forests' blue carbon.

RESULTS

Specifically, the research was conducted in Surumana Village, an area rich in mangrove forests that have great potential for protecting the coastline and supporting biodiversity. Field data analysis shows that the mangrove structure at the location provides an important function as a habitat for various flora and fauna species and is effective in preventing coastal erosion and abrasion. The lack of government and community attention to mangrove forest management in this area attracted the attention of researchers because historically, coastal areas are often eroded by storms and floods that come during the west wind season, as researchers found from the results of pre-research in Surumana Village.

…"Every season with big waves, what we call the westerly wind, the beach is constantly eroded by storms and flooding. Regarding the mangroves, they grow on their own in Surumana. They used to be a popular tourist spot, but now no one takes care of them, so they're neglected. The local people feed on the mangroves, usually finding shellfish, crabs, and small fish. The Environmental Agency has come to intervene, but their management methods haven't been very effective. What's clear is that there have never been any official records or reports about these mangroves. I hope young people will have good ideas for developing them, but they need help and support from the government."… said Losrin as a local traditional shop and fisherman.

This situation shows that mangroves are not yet considered by most residents as a valuable resource, this problem urges the need for strong data-based justification through biomass calculations. The research is based on a conceptual framework of the legitimacy of coastal resource management which emphasizes that legitimacy is not only in terms of legal compliance, but also comes from transparency of environmental economic data and social acceptance through analysis by measuring carbon sequestration in mangrove ecosystems. From the results of the biomass measurement of mangrove characteristics, four main types were obtained: Sonneratia alba (Pedada), Avicennia marina (Api-api), Rhizophora apiculata (Mangrove) and Nypa fruticans (Nipah). The types of mangroves show variations in stem diameter, wood density, and above-ground biomass weight (Above Ground Biomass/AGB).

Figure 2. Process Of Taking Mangrove Tree Diameter To Calculate Carbon Cost Per Tree

Calculation of carbon absorption in the mangrove ecosystem using the allometric equation of Komiyama et al. (2005), with the formula AGB (kg) = 0,251 × ρ × $D^{2.46}$. Determination of aboveground biomass (AGB) is calculated, where D represents tree diameter (cm) and ρ

indicates wood density (g/cm3). The obtained AGB value is then converted into carbon content (tC) and then multiplied by 0,47 as a factor of determination from the Intergovernmental Panel on Climate Change. Furthermore, to obtain the CO2 equivalent value (tCO_2e) the carbon content is converted by a factor of 3,67 which comes from the ratio of the molecular mass of CO2 to carbon 44/12 according to the guidelines of the Intergovernmental Panel on Climate Change so that the complete formula for calculating the economic value of carbon is $tCO_2e = (0{,}251 \times \rho \times D^{2.46} \times 0{,}47) \times 3{,}67$.

Table 1. Biomass Estimation and Conversion of Blue Carbon to Economic Value

Types of Mangrove	Carbon Stock (tC)	Stock CO2e (tCO_2e)	Carbon Pricen Reference (Rp/tCo_2e)	Economic Value of Carbon Stock (Rp)
Pedada (*S.alba*)	8,91	32,73	Rp. 144.000	Rp. 4.713.120
Fire*(A.marina)*	6,52	23,94	Rp. 144.000	Rp. 3.447.360
Mangroves*(R. apiculata)*	5,36	19,68	Rp. 144.000	Rp. 2.833.920
Nipah *(N. fruticans)*	21,30	78,19	Rp. 144.000	Rp. 11.259.360
Total	42,09	154,54	n/a	Rp. 22.253.760

(Source: Field Data 2025)

Overall, this mangrove biomass stores 42,09 tons of carbon (C) absorption, equivalent to 154,54 tons of CO2e. Based on the carbon price reference on the Indonesian stock exchange of IDR 144.000 per ton (tCO_2e), the total economic value of carbon absorption stored in the mangrove forest ecosystem in this region in 2025 is IDR 22.253.760. From the table, it can be seen that the nipah species is the largest carbon contributor with a previously unrecorded environmental asset value, thus providing a concrete basis for efforts to increase the legitimacy of coastal resource management.

Table 2. Economic Value of the Mangrove Ecosystem in Surumana Village, South Banawa District, Donggala Regency

Picture	Type	Wide	Condition	Nominal (Rp/tCO_2e)
	Pedada	0,18 ha	Good	Rp 4.713.120
	Api-Api	0,91 ha	Good	Rp 3.447.360
	Bakau	0,91 ha	Good	Rp 2.833.920
	Nipah	1,14 ha	Good	Rp 11.259.360

(Source: Field Data 2025)

Blue carbon assessment through blue accounting, incorporated into the biomass estimation, significantly contributes to strengthening regulatory compliance. The monetary value

of carbon sequestration of Rp 22.253.760 provides strong economic legitimacy for the conservation function of mangroves, which can serve as a strong foundation for local governments in implementing Presidential Regulation No. 98/2021 concerning the economic value, carbon, and governance of mangroves. By uncovering the economic value, regulatory decisions protective of mangroves, such as the denial of permits for land conversion for fish ponds and the logging of mangrove forests, become more easily justified financially and environmentally, thereby improving regulatory compliance and effectiveness in Surumana Village.

The mangrove carbon economic value of Rp 22.253.760 serves as ecological and economic evidence that provides a legal basis for the local government, particularly the Environmental Agency, to carry out its supervisory function and play a more active role in supporting and ensuring sustainable management in Surumana Village. The resulting active involvement encourages a transition to an innovative and adaptive management model, where carbon value is utilized as an economic model through planned spatial planning (zoning) and the development of supporting infrastructure. Disclosure of the carbon economic value not only improves regulatory compliance but also strengthens the legitimacy of coastal resource management before stakeholders and the community.

The legitimacy of coastal resource management generated through this research consists of three main aspects: scientific legitimacy, regulatory legitimacy, and social legitimacy. Scientific legitimacy arises because the local government now has accurate carbon biomass and economic value data as a basis for justification for each management action, resulting in stakeholder trust. Regulatory legitimacy is strengthened through the direct link between the economic value of carbon and the implementation of policies such as Presidential Regulation No. 98/2021, thus providing the local government with a better legal basis for determining zoning, limiting land conversion, and enforcing mangrove protection. Meanwhile, social legitimacy is built through data transparency that is understandable to the community, so that management decisions are no longer perceived as unilateral but are perceived as evidence-based and ecologically and economically beneficial. In this regard, this research produces a comprehensive form of management legitimacy, enabling the government in Surumana Village to manage coastal resources more credibly, accepted and sustainable in the eyes of all stakeholders.

Strengthening management legitimacy generated through blue carbon assessments will provide strategic direction for future coastal management. With measurable economic value, local governments have greater opportunities to access environmentally based funding, such as carbon trading. Legitimacy will also open up broader collaboration with communities, fishing groups, customary institutions, and the private sector, as management decisions can be openly explained with tangible economic benefits. Furthermore, integrating carbon data into zoning planning and infrastructure development can strengthen long term ecosystem resilience while ensuring that coastal utilization activities remain in good condition. This legitimacy not only strengthens the government's position as manager but also creates a foundation for adaptive, inclusive, and sustainability oriented coastal management.

DISCUSSION

Blue Carbon Assessment and the Scientific Legitimacy of Mangrove Management

The results of the study indicate that blue carbon assessment through mangrove biomass measurements provides strong scientific legitimacy in coastal resource management in Surumana Village. Biomass calculations using the allometric equation The results of the study indicate that blue carbon assessment through mangrove biomass measurements provides strong scientific legitimacy in coastal resource management in Surumana Village. Biomass calculations using the allometric equation of Komiyama et al. (2005), resulted in carbon stocks of 42,09 tons of C or equivalent to 154,54 tons of CO_2e. This finding is in line with research by

Donato et al., (2011) and (Murdiyarso et al., 2015). which stated that mangroves are a higher carbon absorbing ecosystem compared to terrestrial forests. The availability of this quantitative data can overcome the limitations of mangrove management without the support of scientific documentation. Within the framework of legitimacy theory, measurable scientific evidence serves as the basis for local governments to justify mangrove protection policies rationally and responsibly.

The Economic Value of Carbon and the Regulatory Legitimacy of Coastal Management

The disclosure of the economic value of mangrove carbon based on the Indonesian Carbon Exchange carbon price of IDR 144.000 per tCO_2e indicates a total economic value of IDR 22.253.760. This value confirms that mangrove carbon has tangible economic benefits relevant to the national policy on the Economic Value of Carbon. These results support the research of Larasasti et al. (2024), which emphasizes the role of blue accounting in bridging ecological values and public policy. The existence of this monetary value strengthens the regulatory legitimacy of local governments in limiting the conversion of mangrove land and supports the implementation of Presidential Regulation Number 98 of 2021 and Government Regulation Number 27 of 2025. This finding is in line with Slamet et al., (2020) and Witomo (2018) who show that land conversion pressure is a major threat to mangrove sustainability. From a legitimacy theory perspective, economic value-based policies increase the effectiveness and compliance with environmental regulations (Ogunode, 2022).

Carbon Data Transparency and Social Legitimacy of Mangrove Management

Interview results indicate that mangroves in Surumana Village are still perceived as a source of subsistence livelihoods, rather than as a strategic asset. This condition aligns with the findings of Nopianti & Himawati (2022) regarding the community's low understanding of the value of coastal ecosystems. Disclosure of the economic value of carbon plays a crucial role in raising public awareness that mangroves have sustainable economic potential. Within the context of legitimacy theory, transparency of carbon data strengthens social acceptance of mangrove management policies and encourages community support for conservation (Ogunode, 2022). These findings support Anjune (2025) and Fajar Kaprawi (2025) who emphasize the importance of understanding the economic value of ecosystems in encouraging community participation in blue economy schemes, such as ecotourism and carbon projects.

CONCLUSION

Based on the research results, researchers concluded that the mangrove forest in Surumana Village is a source of natural assets with economic and ecological value in addressing management challenges that have been neglected. The analysis results show that there are four types of mangroves: pedada, api-api, mangrove, and nipah. Data generated from mangrove biomass was then converted into carbon absorption of 154,54 tons of CO_2e with a monetary value of IDR 22.253.760.

This value is the core of the legitimacy framework for coastal resource management proposed by researchers in this study. The disclosure of the economic value of carbon not only strengthens scientific legitimacy through accurate data but also provides a strong basis for the local government to uphold regulatory legitimacy Pemerintah Indonesia (2021) and guarantees social legitimacy through transparency, giving the mangrove ecosystem of Surumana Village a solid legal and financial basis for protective and sustainable management, transforming a vulnerable area into a strategic regional asset.

LIMITATION

This study has limitations because the resulting blue carbon sequestration value has not been integrated into regional development planning documents, particularly the Regional Medium-Term Development Plan (RPJMD), so its use as a policy basis cannot be empirically evaluated. Furthermore, local community involvement and understanding of the role of mangroves as a source of sustainable income, such as ecotourism, have not been comprehensively analyzed, so the socio-economic impacts of blue carbon-based mangrove management are not fully described.

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