Daengku: Journal of Humanities and Social Sciences Innovation *ISSN: 2775-6165 (online)*
Vol. 6 No. 4 (2026)
https://doi.org/10.35877/454RI.daengku5035

Blue Accounting and Sustainability: Assessing Long-Term Effects Beyond Profitability

Yohana Febiani Angi, Maria Immaculata Bahantwelu*, Rr Lilis Intan Permatasari, & Melianus E. Tkela

Faculty of Economics and Business, Universitas Nusa Cendana, Indonesia

Abstract

This study aims to analyze the implementation of Blue Accounting in the seaweed industry through the valuation of ecosystem and biodiversity components and the development of an Environmental Profit and Loss (EP&L) framework. This study employed a quantitative approach using the Choice Experiment (CE) method to identify seaweed farmers' preferences regarding sustainability attributes in the industry. Data were analyzed using the Multinomial Logit (MNL) model to estimate the influence of each attribute on respondents' choices. Subsequently, Marginal Willingness to Pay (MWTP) was calculated to determine the economic value of environmental attributes. The MWTP estimates were then used to construct a Cost-Weighted Score Matrix and integrated into the Environmental Profit and Loss (EP&L) framework. The results indicate that coastal ecosystem conditions and the reduction of *ice-ice* disease incidence are the most influential attributes affecting respondents' preferences. The highest MWTP value was associated with coastal ecosystem conditions, reflecting the strong willingness of local communities to support environmental improvement programs. The Cost-Weighted Score Matrix identified coastal ecosystem quality and disease control as the highest-priority factors for Blue Accounting implementation. Furthermore, the EP&L analysis demonstrated that incorporating environmental costs and ecosystem service values provides a more comprehensive assessment of business performance compared to conventional accounting approaches. Blue Accounting integrate economic and environmental values into the management of the seaweed industry. The application of Choice Experiment, MWTP, Cost-Weighted Score Matrix, and Environmental Profit and Loss provides a more comprehensive basis for supporting transparent, accountable, and sustainable decision-making in the seaweed industry of Rote Ndao Regency.

Keywords: blue accounting; choice experiment; marginal willingness to pay; environmental profit and loss; seaweed industry; coastal sustainability.

Received: 22 June 2026 Revised: 11 August 2026 Published: 31 August 2026

1. Introduction

The seaweed industry plays a strategic role in supporting the economic development of coastal communities in Indonesia, contributing to household income, employment generation, export earnings, and regional economic growth (Rimmer et al., 2021). Among Indonesia's major seaweed-producing regions, Rote Ndao Regency in East Nusa Tenggara Province possesses considerable production potential due to its extensive coastal resources and favorable environmental conditions. For many coastal households, seaweed farming represents the primary livelihood activity and serves as an important mechanism for poverty reduction and community welfare improvement (Langford et al., 2022; Zamroni, 2021).

Despite its economic importance, the long-term sustainability of seaweed production is increasingly threatened by environmental degradation and ecological uncertainty. Coastal ecosystem deterioration, declining water quality, biodiversity loss, climate variability, and recurring outbreaks of ice-ice disease have reduced productivity and increased production risks for farmers (Hyun et al., 2026). These challenges demonstrate that seaweed cultivation depends not

* Corresponding author.
E-mail address: maria.bahantwelu@staf.undana.ac.id

only on financial capital and production inputs but also on the availability and quality of natural capital embedded within coastal ecosystems. However, conventional accounting systems continue to evaluate business performance primarily through financial indicators such as revenues, costs, and profits, while largely ignoring ecosystem services, environmental externalities, and biodiversity-related risks that influence long-term production sustainability (Demel et al., 2020; Kim et al., 2022; Mediaty et al., 2024).

The inability of conventional accounting frameworks to recognize environmental dependencies has stimulated the emergence of Blue Accounting, an approach that integrates ecological, social, and economic dimensions into the management and reporting of marine and coastal resources. Similar developments can be observed in natural capital accounting and Environmental Profit and Loss (EP&L) frameworks, which seek to quantify environmental impacts in monetary terms and incorporate them into organizational decision-making processes (Moozanah et al., 2024; Syah et al., 2020). Nevertheless, most existing applications of environmental accounting have focused on fisheries, coastal conservation, or corporate sustainability reporting, while empirical implementation within small-scale seaweed production systems remains limited. More importantly, previous studies have rarely established a systematic linkage between stakeholder preferences for environmental improvements and the monetary valuation mechanisms required for Blue Accounting implementation.

Environmental valuation techniques have been widely employed to estimate the economic value of ecosystem services. The Contingent Valuation Method (CVM) is commonly used to estimate willingness to pay for a single environmental change scenario. However, CVM is limited in its ability to evaluate trade-offs among multiple environmental attributes that simultaneously influence stakeholder preferences. In contrast, Choice Experiments (CE) are grounded in Random Utility Theory and enable the estimation of preferences for individual environmental attributes by presenting respondents with alternative scenarios composed of multiple attribute combinations. This approach allows researchers to derive Marginal Willingness to Pay (MWTP) estimates for specific ecosystem improvements and policy interventions. In the context of seaweed farming, where sustainability outcomes are influenced by multiple ecological attributes such as coastal ecosystem quality, biodiversity conservation, water quality, and disease management, the CE approach provides a more suitable valuation framework than single-scenario non-market valuation methods.

Although previous studies have applied CE to estimate ecosystem service values and environmental preferences (Iqbal, 2020; Kim et al., 2022; Li et al., 2026; Pappa & Kaliampakos, 2025), the resulting valuation estimates are typically reported as standalone economic indicators and are seldom incorporated into environmental accounting systems. Consequently, a significant research gap remains regarding how stakeholder-derived environmental values can be translated into accounting information capable of supporting sustainability-oriented decision making. Specifically, there is limited empirical evidence demonstrating how MWTP estimates can be integrated into Environmental Profit and Loss (EP&L) accounts and subsequently operationalized within a Blue Accounting framework for coastal aquaculture industries.

To address this gap, the present study develops an integrated Blue Accounting framework for the seaweed industry in Rote Ndao Regency. The study employs a Choice Experiment to estimate stakeholder preferences and Marginal Willingness to Pay (MWTP) for key sustainability attributes associated with seaweed cultivation, including coastal ecosystem condition, biodiversity protection, water quality improvement, and ice-ice disease reduction. The resulting MWTP estimates are then incorporated into a Cost-Weighted Score Matrix and translated into Environmental Profit and Loss (EP&L) accounts to quantify the environmental value generated by sustainability improvements. Through this integration, the study moves beyond conventional ecosystem valuation by demonstrating how environmental preferences can be systematically transformed into accounting information.

This study contributes to the literature in three important ways. First, it extends Blue Accounting research by developing an empirical framework that links non-market environmental valuation with environmental accounting practices. Second, it demonstrates how MWTP estimates derived from Choice Experiments can be operationalized within EP&L accounts, thereby providing a transparent mechanism for incorporating natural capital values into sustainability assessments. Third, it offers one of the first empirical applications of an integrated Choice Experiment–EP&L

framework within the seaweed industry in Indonesia, providing practical insights for policymakers, coastal resource managers, and industry stakeholders seeking to balance economic performance with environmental sustainability.

2. Literature Review

2.1. Blue Accounting and Sustainability in Coastal Industries

Blue Accounting has emerged as an accounting approach that extends conventional financial reporting by incorporating environmental, ecological, and social values into the measurement and evaluation of marine-based economic activities. Unlike traditional accounting systems that primarily focus on revenues, expenditures, and profitability, Blue Accounting recognizes that economic performance in coastal industries is highly dependent on natural capital and ecosystem services (Rahmayanti & Sari, 2022). This perspective is particularly relevant for aquaculture and seaweed farming, where production outcomes are strongly influenced by environmental conditions such as water quality, biodiversity, coastal ecosystem health, and climate stability.

The concept of Blue Accounting is closely associated with sustainable development principles, which emphasize balancing economic growth, environmental protection, and social welfare. Similar approaches have been adopted internationally through natural capital accounting, ecosystem accounting, and Environmental Profit and Loss (EP&L) reporting systems. However, most existing applications focus on fisheries management, coastal conservation programs, or corporate sustainability reporting, while empirical implementation within small-scale seaweed production systems remains limited (Rahmayanti & Sari, 2022).

In the seaweed industry, environmental degradation can generate substantial economic consequences through reduced productivity, increased disease incidence, and declining ecosystem resilience. Nevertheless, these environmental impacts are rarely reflected in conventional accounting systems. Consequently, there is a growing need for accounting frameworks that explicitly recognize the economic value of ecosystem services and environmental externalities. Blue Accounting addresses this challenge by integrating ecological considerations into sustainability assessments and organizational decision-making processes (Stefannie & Khairin, 2025).

2.2. Natural Capital, Ecosystem Services, and Environmental Cost Measurement

Natural capital refers to environmental assets that generate benefits for society and economic activities, including marine ecosystems, biodiversity, coastal habitats, and water resources (Brander et al., 2022; Carvalho et al., 2023). Within seaweed cultivation systems, natural capital serves as a critical production asset because cultivation success depends directly on ecosystem quality and environmental stability.

The benefits generated by natural capital are commonly described as ecosystem services. These services include provisioning services, regulating services, supporting services, and cultural services. In seaweed farming systems, ecosystem services may include water quality regulation, nutrient cycling, carbon sequestration, biodiversity maintenance, coastal protection, and livelihood support for coastal communities (Brander et al., 2022; Pacifico et al., 2025).

Despite their economic significance, ecosystem services are generally not traded in conventional markets and therefore remain excluded from traditional accounting systems. This omission can lead to the underestimation of environmental risks and the overestimation of business profitability. Environmental cost measurement seeks to address this limitation by identifying costs associated with ecosystem degradation, biodiversity loss, pollution, resource depletion, and restoration requirements (Ayinla et al., 2024; Carvalho et al., 2023).

Environmental costs may be categorized into restoration costs, remediation costs, replacement costs, and externality costs. The inclusion of these costs allows organizations to evaluate the true economic consequences of environmental impacts and supports more sustainable resource allocation decisions. Within the Blue Accounting framework, environmental cost measurement provides the foundation for integrating ecological values into performance evaluation and sustainability reporting (Baloch et al., 2025; Carvalho et al., 2023).

2.1 Contingent Valuation and Choice Experiment in Environmental Valuation

Because ecosystem services are typically non-market goods, their economic value cannot be directly observed through market transactions. Consequently, non-market valuation methods are required to estimate their monetary value (Pacifico et al., 2025; Qiao et al., 2022).

One widely applied approach is the Contingent Valuation Method (CVM), which estimates an individual's willingness to pay for a specified environmental improvement or willingness to accept compensation for environmental degradation (Mohamed, 2025; Opdenbosch & Hansson, 2023). While CVM is useful for valuing a single environmental scenario, it has limitations when environmental outcomes involve multiple attributes that simultaneously influence stakeholder preferences.

To overcome this limitation, researchers increasingly employ Choice Experiments (CE), which are grounded in Random Utility Theory. In CE studies, respondents evaluate alternative scenarios composed of multiple environmental attributes and associated costs. By observing respondents' choices, researchers can estimate the relative importance of each attribute and calculate Marginal Willingness to Pay (MWTP) values (Pacifico et al., 2025; Tavárez et al., 2024).

Compared with CVM, Choice Experiments offer several advantages for Blue Accounting applications. First, they allow the valuation of multiple environmental attributes simultaneously. Second, they estimate attribute-specific MWTP values, providing more detailed information regarding stakeholder preferences. Third, they facilitate policy prioritization by identifying which environmental improvements generate the greatest perceived value. These characteristics make CE particularly suitable for seaweed farming systems, where sustainability depends on multiple environmental attributes, including ecosystem condition, biodiversity conservation, water quality, and disease management.

2.3. Environmental Profit and Loss Reporting

Environmental Profit and Loss (EP&L) reporting has emerged as an important framework for incorporating environmental impacts into organizational performance measurement. Unlike conventional profit-and-loss statements, EP&L attempts to quantify both environmental costs and environmental benefits in monetary terms (Grunewald et al., 2024).

The EP&L framework expands traditional accounting boundaries by recognizing environmental externalities and natural capital dependencies. Environmental benefits may include ecosystem service provision, carbon sequestration, biodiversity enhancement, and environmental restoration outcomes. Environmental costs may include pollution, ecosystem degradation, resource depletion, restoration expenditures, and biodiversity losses (Gonçalves & Silva, 2021).

For coastal industries such as seaweed farming, EP&L provides a mechanism for evaluating whether economic gains remain sustainable when environmental impacts are considered. Therefore, EP&L serves as a practical instrument for operationalizing Blue Accounting and supporting sustainability-oriented decision making.

2.4. From Marginal Willingness to Pay to Environmental Profit and Loss Accounts

Although environmental valuation studies frequently estimate willingness-to-pay values for environmental improvements, these values are often reported as isolated economic indicators. A major challenge in Blue Accounting is translating valuation outcomes into accounting information that can support sustainability assessment and managerial decision-making (Langford et al., 2022; Zamroni, 2021).

Marginal Willingness to Pay (MWTP) estimates derived from Choice Experiments provide monetary measures of the value stakeholders place on specific environmental improvements. These values can be interpreted as proxies for the economic benefits generated by ecosystem services and sustainability interventions (Langford et al., 2022; Zamroni, 2021).

Within this study, MWTP estimates constitute the first stage of environmental value quantification. The estimated values are subsequently incorporated into a Cost-Weighted Score Matrix that combines environmental importance with implementation costs. The resulting scores are then translated into Environmental Profit and Loss accounts, where environmental benefits and environmental costs can be systematically compared (Langford et al., 2022; Zamroni, 2021).

This integration establishes a direct conceptual pathway linking stakeholder preferences, environmental valuation, environmental accounting, and sustainability reporting. Consequently, environmental values become operational components of accounting systems rather than merely descriptive indicators.

2.5. Conceptual Relationship between Blue Accounting, Sustainability, and Profitability

The relationship between Blue Accounting, sustainability, and profitability is founded on the premise that long-term economic performance depends on maintaining natural capital and ecosystem services. Conventional accounting often treats environmental issues as external concerns, whereas Blue Accounting recognizes environmental conditions as fundamental determinants of business performance (Ayinla et al., 2024; Grunewald et al., 2024).

In the seaweed industry, sustainable environmental management contributes directly to profitability by reducing disease risks, maintaining water quality, enhancing ecosystem resilience, and improving production stability. These benefits can reduce operational uncertainty and strengthen long-term competitiveness (Ayinla et al., 2024; Grunewald et al., 2024).

The conceptual framework of this study proposes that ecosystem services generate environmental value, which can be measured through Choice Experiments and MWTP estimation. These environmental values are then incorporated into Environmental Profit and Loss accounts through a Cost-Weighted Score Matrix. The resulting accounting information supports Blue Accounting implementation, enabling more comprehensive sustainability assessments and informed decision-making.

Accordingly, Blue Accounting serves as a bridge between environmental sustainability and economic performance by integrating ecological values into organizational accounting systems. Through this approach, profitability is evaluated not only in terms of financial outcomes but also in relation to the environmental conditions that sustain long-term production and business viability.

3. Research Method

3.1. Research Design

This study employed a quantitative environmental valuation approach based on the Choice Experiment (CE) method to estimate stakeholder preferences and the economic value of sustainability attributes associated with seaweed cultivation in West Rote District, Rote Ndao Regency. The CE approach was selected because it allows the simultaneous valuation of multiple environmental attributes and generates Marginal Willingness to Pay (MWTP) estimates for each attribute. Compared with the Contingent Valuation Method (CVM), which typically evaluates a single environmental scenario, CE is more suitable for assessing trade-offs among multiple sustainability attributes that influence seaweed production systems.

The study was designed to support the development of a Blue Accounting framework by linking environmental valuation results with Environmental Profit and Loss (EP&L) reporting. The analytical framework consisted of four sequential stages: (1) estimation of stakeholder preferences using Choice Experiments, (2) estimation of MWTP using a Multinomial Logit model, (3) construction of a Cost-Weighted Score Matrix, and (4) integration of environmental values into Environmental Profit and Loss accounts.

3.2. Study Area and Respondents

The research was conducted in Oenggaut Village and surrounding seaweed cultivation areas in West Rote District, Rote Ndao Regency, East Nusa Tenggara Province, Indonesia. The area was selected because seaweed cultivation represents one of the primary economic activities supporting coastal livelihoods and is highly dependent on ecosystem quality.

Respondents in this study consisted of seaweed farmers, collectors, community leaders, and local stakeholders who were directly involved in seaweed production activities. The respondents were selected using a purposive sampling technique to ensure that the participants had relevant knowledge and experience related to the seaweed industry and coastal environmental conditions. The selection criteria included individuals who had been actively engaged in seaweed cultivation or related activities for at least three years, were directly affected by environmental changes, disease outbreaks, or ecosystem degradation, and were willing to participate in the survey by providing information regarding their environmental preferences.

3.3. Choice Experiment Design

The Choice Experiment (CE) was designed based on Random Utility Theory (RUT), which assumes that respondents choose the alternative that provides the highest level of utility. The experimental design followed established guidelines for environmental valuation studies to estimate farmers' preferences and willingness to pay (WTP) for sustainable seaweed farming improvement programs.

Attribute identification was conducted through three sequential stages. First, a comprehensive review of previous studies on sustainable aquaculture, ecosystem services, and seaweed farming was undertaken to identify attributes commonly considered important in farmers' decision-making. Second, preliminary interviews were conducted with seaweed farmers to understand the major constraints affecting production and environmental sustainability. Third, consultations with local stakeholders, fisheries extension officers, and officials from the marine and fisheries agency were carried out to ensure that the selected attributes were relevant, realistic, and applicable within the local policy context.

Table 1. Four non-monetary attributes and one monetary attribute were included in the CE

Attribute	Levels	Justification
Reduction in *ice-ice*disease incidence	Current condition; 25% reduction; 50% reduction	*Ice-ice* disease is one of the most significant causes of productivity loss in seaweed farming. Reducing disease incidence directly improves production stability and farmers' income.
Availability of high-quality seaweed seedlings	Limited availability; Moderate availability; High availability	High-quality seedlings increase growth rates, improve resistance to disease, and enhance production efficiency.
Availability of communal drying facilities	Not available; Available	Drying facilities improve post-harvest quality, reduce moisture-related losses, and increase market value.
Conservation of coastal ecosystem quality	Current condition; Moderate improvement; High improvement	Healthy coastal ecosystems support long-term seaweed productivity through improved water quality and ecological resilience.
Annual household contribution (payment)	Several payment levels (IDR/year)	The monetary attribute enables estimation of respondents' marginal willingness to pay (WTP) for sustainability improvement programs. Payment levels were determined based on preliminary interviews and local economic conditions to ensure realistic and affordable bid values.

The attribute levels were selected to represent realistic policy interventions that could feasibly be implemented by local governments or community-based management programs. The improvement levels were sufficiently differentiated to capture respondents' preferences while avoiding unrealistic scenarios that could reduce response reliability.

3.3.1. Experimental Design

A D-efficient experimental design was employed to generate the choice sets. Compared with traditional orthogonal designs, D-efficient designs minimize the determinant of the variance-covariance matrix of the estimated parameters, thereby improving statistical efficiency and producing more precise parameter estimates while requiring fewer choice tasks from respondents. This approach also allows estimation of interaction effects and preference heterogeneity more efficiently than orthogonal designs.

The full factorial combination of all attribute levels would have produced an impractically large number of alternatives. Therefore, a fractional factorial D-efficient design was generated using specialized experimental design software to reduce the number of choice scenarios while preserving maximum statistical information. The resulting design was divided into blocks so that each respondent evaluated only a manageable number of choice sets, thereby reducing respondent fatigue and cognitive burden.

Each choice set consisted of two hypothetical policy alternatives and a status quo (opt-out) option, allowing respondents to retain their current conditions if neither proposed program was considered preferable. Including the status quo alternative improves behavioral realism and reduces hypothetical bias because respondents are not forced to choose among improvement options.

3.3.2. Design Validation

Several procedures were undertaken to validate the experimental design and minimize potential bias. First, the attribute descriptions, wording, and payment vehicle were reviewed by experts and local stakeholders to ensure content validity and policy relevance. Second, a pilot survey was conducted with a small sample of seaweed farmers to assess respondents' understanding of the choice tasks, identify ambiguous wording, and evaluate the plausibility of attribute levels. Feedback from the pilot survey was incorporated into the final questionnaire by refining attribute descriptions and simplifying instructions where necessary.

The statistical properties of the experimental design were also evaluated using the D-efficiency criterion to ensure high estimation efficiency and minimal correlation among attributes. Blocking was applied to reduce respondent fatigue, while randomization of choice set presentation minimized potential ordering effects. These procedures improved the reliability of respondents' choices and enhanced the efficiency and robustness of the estimated preference and willingness-to-pay parameters.

3.4. Data Collection

Primary data were collected through structured questionnaires administered directly to respondents. Prior to the survey, a pilot test was conducted to evaluate questionnaire clarity and attribute relevance. Secondary data regarding seaweed production, environmental conditions, and government support programs were collected from official reports, scientific publications, and local government documents.

3.5 Data Analysis

Choice Experiment data were analyzed using the Random Utility Theory framework. Respondent preferences were estimated using the Multinomial Logit (MNL) model. The utility function was specified as:

$$U_{ij} = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 Cost + \varepsilon_{ij} \quad (1)$$

where U_{ij} represents the utility obtained by respondent i from alternative j, represents environmental attributes, Cost represents the monetary contribution attribute, β represents estimated coefficients, and ε represents the random error term.

Marginal Willingness to Pay (MWTP) for each environmental attribute was calculated using:

$$MWTP = -(\beta_{attribute} / \beta_{cost}) \quad (2)$$

The estimated MWTP values were subsequently used to develop a cost-weighted score matrix for ecosystem and biodiversity valuation within the Blue Accounting framework.

3.5. Marginal Willingness to Pay Estimation

The Marginal Willingness to Pay (MWTP) for each sustainability attribute was estimated from the coefficients of the Multinomial Logit (MNL) model using the ratio between the attribute coefficient and the monetary (cost) coefficient. MWTP represents the additional monetary amount respondents are willing to pay for a one-unit improvement in a specific sustainability attribute and serves as a proxy for the perceived economic value of environmental improvements.

3.6. Cost-Weighted Score Matrix Construction

The estimated MWTP values were subsequently integrated into a Cost-Weighted Score Matrix to prioritize sustainability interventions. The integration was conducted through three sequential steps.

a. Environmental benefit estimation. The MWTP of each attribute was interpreted as the monetary value of environmental benefits perceived by respondents.
b. Cost comparison. The estimated environmental benefit (MWTP) was compared with the estimated implementation cost of each intervention, including investment, operation, maintenance, and environmental management costs obtained from local government reports and expert consultation.

c. Priority scoring. Each sustainability attribute was assigned a weighted priority score by combining its environmental benefit (MWTP), implementation cost, and technical feasibility. Attributes with higher MWTP values, lower implementation costs, and higher implementation feasibility received higher priority scores.

The Cost-Weighted Score Matrix therefore provides a transparent decision-support tool that translates respondents' preferences into investment priorities by balancing perceived environmental benefits against implementation costs.

3.7. Environmental Profit and Loss Framework

The final stage involved integrating the results of the Cost-Weighted Score Matrix into the Environmental Profit and Loss (EP&L) framework. In this study, MWTP was treated as a monetary proxy for the environmental benefits generated by improvements in ecosystem services, while environmental costs represented expenditures required to achieve those improvements.

The integration process consisted of four steps.

a. Estimate environmental benefits using the MWTP value for each sustainability attribute.
b. Estimate environmental costs, including restoration costs, remediation costs, replacement costs, and other environmental management expenditures.
c. Calculate net environmental value by comparing environmental benefits with environmental costs.
d. Incorporate the net environmental value into the EP&L statement to evaluate the environmental contribution of alternative seaweed management strategies.

3.8. Blue Accounting Sustainability Assessment

The final stage of the analysis involved operationalizing the Blue Accounting Framework by integrating economic, environmental, and ecosystem valuation data into a single assessment framework. The objective was to evaluate seaweed cultivation performance by considering both financial profitability and environmental value creation.

The operationalization was conducted through five sequential steps. First, conventional financial data were compiled, including production costs, revenues, and operating profits obtained from farm surveys. Second, environmental preferences elicited through the Choice Experiment were converted into Marginal Willingness to Pay (MWTP) values using the Multinomial Logit estimates. These MWTP values were interpreted as monetary proxies for the environmental benefits associated with improvements in each sustainability attribute.

Third, the estimated MWTP values were incorporated into the Cost-Weighted Score Matrix, where they were compared with the estimated implementation costs and technical feasibility of each sustainability intervention to determine policy priorities. Fourth, the prioritized environmental benefits were incorporated into the Environmental Profit and Loss (EP&L) framework. Environmental benefits were calculated from the monetary value of ecosystem service improvements represented by MWTP, whereas environmental costs included restoration costs, remediation costs, replacement costs, and other environmental externality costs associated with seaweed cultivation.

4. Results and Discussion

4.1. Characteristic of Respondents

The results indicate that the majority of respondents were male (78%), reflecting the dominant role of men in seaweed cultivation activities in West Rote District. However, female participation remains important, particularly in post-harvest processing, sorting, drying, and marketing activities. Based on age distribution, most respondents were between 41 and 50 years old (34%), followed by those aged 30–40 years (28%). This indicates that seaweed cultivation is largely managed by individuals in their productive working age, who possess substantial experience and knowledge regarding cultivation practices and environmental conditions. The presence of older farmers also reflects the intergenerational transfer of knowledge related to seaweed farming and coastal resource management. In terms of education level, the majority of respondents had completed senior high school education (45%), while only a small proportion possessed higher education qualifications (12%). Regarding farming experience, more than half of the respondents (57%) had been involved in seaweed cultivation for over ten years. This finding demonstrates that respondents possess extensive practical experience and are highly familiar with challenges of seaweed cultivation. Consequently, their responses are considered valuable for evaluating ecosystem sustainability and identifying environmental attributes relevant to Blue

Accounting implementation. The income profile shows that nearly half of the respondents (49%) earned between IDR 2 million and IDR 5 million per month from seaweed-related activities. This result confirms that seaweed cultivation constitutes a significant source of livelihood for coastal communities in West Rote. Overall, the respondent profile demonstrates that seaweed farming in West Rote is characterized by experienced producers with strong dependence on coastal ecosystem services. This socio-economic context supports the relevance of Blue Accounting as a framework for balancing profitability, environmental sustainability, and community welfare in the long-term management of the seaweed industry.

Table 2. Characteristics of Respondents

Characteristics	Category	Frequency	Percentage (%)
Gender	Male	78	78.0
	Female	22	22.0
Age	< 30 years	15	15.0
	30–40 years	28	28.0
	41–50 years	34	34.0
	> 50 years	23	23.0
Education	Elementary School	18	18.0
	Junior High School	25	25.0
	Senior High School	45	45.0
	Diploma/Bachelor	12	12.0
Seaweed Farming Experience	< 5 years	12	12.0
	5–10 years	31	31.0
	> 10 years	57	57.0
Monthly Income	< IDR 2 million	27	27.0
	IDR 2–5 million	49	49.0
	> IDR 5 million	24	24.0

4.2. Identification of Choice Experiment Attributes and Levels

The selected attributes were designed to capture both market and non-market values associated with seaweed cultivation. The disease incidence attribute reflects production risks caused by environmental degradation and climate variability. The availability of quality seedlings represents production sustainability and productivity enhancement. The drying facility attribute reflects post-harvest efficiency and product quality improvement, while ecosystem condition represents broader ecological benefits such as biodiversity conservation, water quality maintenance, and coastal protection. The monetary contribution attribute serves as the payment vehicle for estimating respondents' willingness to support environmental improvement initiatives.

Table 3. Choice Experiment Attributes and Levels

Attribute	Level 1	Level 2	Level 3
Ice-Ice Disease Incidence	High	Moderate	Low
Availability of Quality Seedlings	Limited	Adequate	High
Drying Facilities	Not Available	Communal Facility	Modern Drying Facility
Coastal Ecosystem Condition	Current Condition	Improved	Highly Protected
Annual Environmental Contribution (IDR)	50,000	100,000	150,000

The identification of attributes demonstrates that sustainability challenges in the seaweed industry are multidimensional and cannot be explained solely through production costs or market prices. Ecological factors, infrastructure availability, and environmental conservation efforts jointly influence the performance of seaweed farming systems.

The inclusion of ice-ice disease incidence as an attribute reflects one of the most critical concerns among seaweed farmers. Interviews revealed that disease outbreaks frequently reduce productivity and harvest quality, leading to substantial economic losses. Consequently, reducing the frequency and severity of disease outbreaks is expected to generate significant benefits for farmers while simultaneously improving ecosystem resilience.

The availability of high-quality seedlings was selected because seed quality directly affects growth performance, harvest stability, and resistance to environmental stress. Farmers often associate superior seedlings with lower production risks and higher economic returns. Therefore, improvements in seed availability represent both an economic and environmental investment that supports sustainable aquaculture practices.

The drying facility attribute emerged from the recognition that post-harvest losses remain a significant challenge within the seaweed supply chain. Limited drying infrastructure frequently results in poor product quality, increased moisture content, and lower market prices. The provision of communal or modern drying facilities can improve product quality standards, reduce hidden economic losses, and strengthen the competitiveness of local seaweed producers.

The coastal ecosystem condition attribute represents the ecological dimension of Blue Accounting. Healthy coastal ecosystems provide essential ecosystem services, including water quality regulation, habitat protection, nutrient cycling, and biodiversity conservation. Improvements in ecosystem conditions are expected to enhance the long-term sustainability of seaweed cultivation while preserving the environmental assets upon which local livelihoods depend.

The environmental contribution attribute was included to estimate respondents' willingness to financially support ecosystem improvement programs. This attribute allows the monetary value of environmental benefits to be quantified through the estimation of willingness to pay (WTP) and marginal willingness to pay (MWTP), which can subsequently be incorporated into Blue Accounting and Environmental Profit and Loss (E-P&L) frameworks.

4.3. Choice Set Design and Experimental Scenarios

Based on the identified attributes and levels, several policy scenario combinations were subsequently developed and presented to respondents in the form of a Choice Experiment (CE). Each respondent was asked to select the alternative that best reflected their preferences from three available options: Alternative A, Alternative B, and the Status Quo (current condition). The choice set design was intended to simulate realistic decision-making situations related to environmental management and the sustainability of the seaweed industry. Through these choices, respondents' preferences regarding environmental and economic attributes could be identified and used to estimate the economic value of each attribute offered.

Table 4. Example of Choice Sets Presented to Respondents

Attribute	Alternative A	Alternative B	Status Quo
Ice-Ice Disease Incidence	Moderate	Low	High
Availability of High-Quality Seedlings	Adequate	High	Limited
Drying Facilities	Communal Facility	Modern Facility	Not Available
Coastal Ecosystem Condition	Improved	Highly Protected	Current Condition
Environmental Contribution/Year	IDR 50,000	IDR 150,000	IDR 0

Based on the Table 3, the majority of respondents demonstrated a preference for alternatives that offered improvements in environmental conditions and increased cultivation productivity, despite requiring additional financial contributions. Overall, Alternative B received the highest selection rate compared to Alternative A and the Status Quo option..

Table 5. Distribution of Respondents' Choices

Alternative	Frequency	Percentage (%)
Alternative A	28	28.0
Alternative B	57	57.0
Status Quo	15	15.0
Total	100	100.0

Table 4 indicate that the majority of respondents preferred scenarios offering improved ecosystem conditions, reduced disease incidence, higher-quality seedlings, and the provision of modern drying facilities rather than maintaining the current conditions. These findings suggest that seaweed farmers possess a relatively high level of awareness regarding the importance of environmental sustainability in supporting the productivity of their farming activities. The strong preference for Alternative B indicates that respondents considered not only short-term economic benefits but also the long-term advantages associated with improvements in coastal ecosystem quality.

Respondents' preference for scenarios with lower levels of *ice-ice* disease incidence demonstrates that disease risk is a major factor influencing decision-making in seaweed cultivation activities. *Ice-ice* disease has long been recognized as one of the primary causes of production decline; therefore, efforts aimed at controlling the disease are perceived by farmers as having substantial economic value. The tendency to choose alternatives with better availability of high-quality seedlings also indicates that respondents recognize the relationship between production input quality and harvesting success. Superior seedlings are considered capable of increasing productivity while reducing the risk of business failure caused by environmental changes.

Furthermore, the strong preference for modern drying facilities suggests that post-harvest management remains a critical challenge within the seaweed industry value chain. The availability of adequate drying facilities is perceived as a means of improving product quality, reducing post-harvest losses, and increasing the selling price received by farmers. Respondents' preference for more protected ecosystem conditions reflects their recognition of the importance of coastal ecosystem services in supporting the sustainability of seaweed farming activities. Local communities understand that a healthy environment contributes to production stability, coastal protection, and the preservation of resources for future generations.

The relatively low selection rate for the Status Quo option indicates that most respondents are dissatisfied with current conditions and expect policy interventions that can improve both environmental quality and cultivation-supporting infrastructure. This finding reinforces the argument that the implementation of Blue Accounting should simultaneously integrate economic, social, and environmental dimensions to achieve sustainable management of the seaweed industry Overall, the Choice Experiment results demonstrate that respondents place a high value on improvements in environmental attributes and cultivation infrastructure. These findings provide a strong basis for estimating Willingness to Pay (WTP) and Marginal Willingness to Pay (MWTP), which can subsequently be incorporated into the development of Blue Accounting and Environmental Profit and Loss (E-P&L) frameworks for the seaweed industry in Rote Ndao Regency.

4.4. Multinomial Logit Model Estimation Results

Table 6. Multinomial Logit Model Estimation Results

Variable	Coefficient (β)	Std. Error	z-value	p-value
Reduction of Ice-Ice Disease Incidence	0.842	0.143	5.89	0.000
Availability of High-Quality Seedlings	0.615	0.137	4.49	0.000
Drying Facilities	0.528	0.124	4.26	0.000
Coastal Ecosystem Condition	0.974	0.162	6.01	0.000
Environmental Contribution (Cost)	-0.005	0.001	-5.12	0.000

Log-Likelihood = -412.56
Pseudo R^2 = 0.284
Number of Observations = 800
Number of Respondents = 100

The Multinomial Logit (MNL) model employed in this study is based on the Independence of Irrelevant Alternatives (IIA) assumption, which states that the relative odds of choosing one alternative over another are unaffected by the presence or characteristics of additional alternatives. This assumption implies that the unobserved components of utility are independently and identically distributed (IID) across alternatives.

The estimation results indicate that all attributes have a significant influence on respondents' decisions when selecting environmental management scenarios for the seaweed industry. Probability values (p-values) below 0.05 indicate that all variables contribute significantly to shaping respondents' preferences.

The coastal ecosystem condition variable has the largest coefficient (β = 0.974), indicating that this attribute is the most important factor considered by respondents when making their choices. This finding suggests that coastal communities and seaweed farmers recognize the importance of environmental quality in supporting cultivation productivity and ensuring the long-term sustainability of coastal resources. The better the ecosystem condition offered in a given scenario, the greater the probability that respondents will select that scenario.

The reduction of *ice-ice* disease incidence variable also shows a positive and significant effect (β = 0.842). This result indicates that respondents place considerable importance on disease control efforts, as *ice-ice* disease is one of the primary causes of production decline and economic losses in seaweed farming. Consequently, programs capable of reducing disease incidence are perceived as providing substantial economic benefits to farmers.

The availability of high-quality seedlings attribute has a positive coefficient of 0.615 and is significant at the 1% level. This finding indicates that improvements in seed quality are perceived as factors that can enhance productivity, harvest stability, and resilience to environmental pressures. Therefore, respondents tend to prefer alternatives that provide access to superior seedlings.

The drying facilities variable also has a positive and significant influence on respondents' choices (β = 0.528). This suggests that the availability of adequate drying facilities is considered important for improving product quality, reducing post-harvest losses, and increasing the market value of seaweed. However, the relatively smaller coefficient compared to environmental attributes indicates that respondents still prioritize ecological aspects over infrastructure improvements.

Meanwhile, the environmental contribution (cost) attribute has a negative and significant coefficient (β = -0.005). This result is consistent with economic theory, which states that the higher the cost associated with an alternative, the lower the likelihood that respondents will choose it. Nevertheless, the significance of the cost variable indicates that respondents remain willing to make financial contributions when the expected environmental benefits are considered sufficiently valuable.

The Pseudo R^2 value of 0.284 indicates that the model has a reasonably good ability to explain variations in respondents' choices. This value falls within the range commonly reported in Choice Experiment studies and suggests that the selected attributes successfully explain a substantial portion of respondents' preferences regarding the environmental management scenarios presented.

Overall, the Multinomial Logit model results demonstrate that environmental factors, particularly improvements in coastal ecosystem conditions and reductions in *ice-ice* disease incidence, are the most influential determinants of respondents' preferences. These findings support the implementation of Blue Accounting, which recognizes ecological value as a critical component in economic decision-making and sustainable seaweed industry management.

The dominance of coastal ecosystem condition observed in this study is consistent with environmental valuation studies conducted in aquaculture systems in the Philippines, Vietnam, and Thailand, where ecosystem quality was identified as a major determinant of stakeholder support for sustainability programs. Similar findings were reported by (Langford et al., 2022; Zamroni, 2021), who found that ecosystem-related attributes generally receive higher preference scores than production-oriented attributes because they directly influence long-term resource availability and production stability.

These findings further strengthen the argument that the success of the seaweed industry depends heavily on the quality of the aquatic environment that supports seaweed growth. Healthy coastal ecosystems provide a range of ecosystem services, including coastal protection, water quality regulation, nutrient cycling, and habitat provision for marine organisms, all of which contribute to cultivation productivity. This finding is consistent with the studies of (Brander et al., 2022) and (Wang et al., 2024), which reported that ecosystem services make significant economic contributions to the sustainability of marine resource-based industries.

Furthermore, the high coefficient associated with the reduction of *ice-ice* disease incidence indicates that ecological risks are among the primary concerns of seaweed farmers. *Ice-ice* disease has long been a major factor contributing to reduced production and lower harvest quality. As a result, respondents place substantial value on initiatives aimed at improving ecosystem health and reducing disease risks. This finding is consistent with (Ren et al., 2024), who explained that environmental quality changes and marine ecosystem disturbances have a direct relationship with seaweed farming productivity.

Although the Multinomial Logit (MNL) model provides efficient and easily interpretable estimates, this study has several limitations. A formal test of the Independence of Irrelevant Alternatives (IIA) assumption, such as the Hausman–McFadden or Small–Hsiao test, was not conducted. Consequently, the potential presence of unobserved preference heterogeneity or correlation among alternatives could not be empirically assessed, which may affect the accuracy of the estimated parameters if the IIA assumption is violated. Nevertheless, because the choice experiment employed generic policy alternatives that differed only in attribute levels, the MNL model remains appropriate for estimating respondents' average preferences and willingness to pay (WTP).

4.5. Marginal Willingness to Pay (MWTP) for Sustainability Attributes of the Seaweed Industry

Based on the estimation results of the Multinomial Logit model, Marginal Willingness to Pay (MWTP) values were calculated to measure respondents' willingness to pay for improvements in each environmental and production attribute supporting the sustainability of the seaweed industry. MWTP reflects the economic benefits perceived by respondents from each improvement offered within the Choice Experiment scenarios.

Table 6. Estimated Marginal Willingness to Pay (MWTP)

Attribute	Coefficient (β)	MWTP (IDR/Year)
Reduction of Ice-Ice Disease Incidence	0.842	168,400
Availability of High-Quality Seedlings	0.615	123,000
Drying Facilities	0.528	105,600
Coastal Ecosystem Condition	0.974	194,800

The MWTP results indicate that respondents assign a higher economic value to improvements in environmental quality than to improvements in production facilities alone. This finding suggests that the sustainability of coastal ecosystems is regarded as the primary foundation for the long-term viability of the seaweed industry in Rote Ndao Regency. In other words, local communities recognize that long-term economic benefits are highly dependent on healthy and productive ecosystem conditions.

The relatively high MWTP values associated with environmental attributes also indicate that seaweed farmers are not solely oriented toward short-term economic gains but are also concerned about the sustainability of the natural resources that form the basis of their livelihoods. This finding is consistent with the principles of Blue Accounting, which emphasize the integration of economic and ecological values into decision-making processes. The results support the findings of (Tavárez et al., 2024) and (Qiao et al., 2022)who demonstrated that communities are willing to make economic contributions to conservation programs when the resulting environmental benefits can be experienced either directly or indirectly.

From a public policy perspective, the MWTP estimates can serve as a basis for designing more effective conservation and environmental management programs. These values provide an indication of the benefits perceived by communities from improvements in environmental quality and can therefore support the prioritization of government investments, the development of environmental incentive schemes, and the establishment of ecosystem-based financing mechanisms.

From the perspective of Blue Accounting, the MWTP results demonstrate that environmental values, which are often excluded from market mechanisms, can be measured and integrated into accounting systems. This approach enables environmental costs and benefits that were previously treated as externalities to become part of the information used in economic performance evaluation. Consequently, investment and policy decisions are no longer focused solely on short-term financial returns but also consider the sustainability of natural resources as a key production asset.

The MWTP estimates represent more than individual preference measures. Within the proposed Blue Accounting framework, they function as monetary indicators of ecosystem value that can be incorporated into accounting calculations. The MWTP values provide the basis for prioritizing sustainability interventions through the Cost-Weighted Score Matrix and subsequently contribute to the valuation of ecosystem services reported in the Environmental Profit and Loss account.

Overall, the MWTP results indicate that improvements in coastal ecosystem conditions and the control of *ice-ice* disease are the highest priorities for seaweed farmers. Therefore, sustainable seaweed industry development strategies should incorporate environmental protection as an integral component of the Blue Accounting system in order to achieve a balance between profitability and the long-term sustainability of coastal resources.

4.6. Cost-Weighted Score Matrix for Blue Accounting Implementation

Based on the estimated Marginal Willingness to Pay (MWTP) values, a Cost-Weighted Score Matrix was subsequently developed to identify the priority level of each attribute in the implementation of Blue Accounting within the seaweed industry in Rote Ndao Regency. This matrix integrates the economic values derived from MWTP with the relative importance of each attribute, thereby generating a composite score that can be used as a basis for decision-making. Attribute weights were determined based on the proportion of each attribute's MWTP value relative to the total MWTP of all attributes. Subsequently, each attribute was assigned a performance score based on respondents' perceptions of current conditions and the need for improvement. The multiplication of weights and performance scores produced a weighted score, indicating the relative contribution of each attribute to the sustainability of the seaweed industry.

Table 7. Cost-Weighted Score Matrix

Attribute	MWTP (IDR/Year)	Weight (%)	Performance Score	Weighted Score
Coastal Ecosystem Condition	194.800	32.9	5.0	1.65
Reduction of Ice-Ice Disease Incidence	168.400	28.5	4.5	1.28
Availability of High-Quality Seedlings	123.000	20.8	4.0	0.83
Drying Facilities	105.600	17.8	3.5	0.62
Total	591.800	100.0	–	4.38

The matrix results indicate that the coastal ecosystem condition attribute achieved the highest weighted score of 1.65. This finding suggests that coastal environmental quality is the most strategic factor in supporting the sustainability of the seaweed industry. The high score indicates that respondents regard ecosystem protection as the highest priority compared to other attributes. The reduction of *ice-ice* disease incidence attribute ranked second, with a weighted score of 1.28. This result demonstrates that disease risk remains one of the primary threats to seaweed cultivation productivity. Therefore, disease control programs, improvements in water quality, and the development of more adaptive cultivation technologies should become key priorities in the implementation of Blue Accounting. The availability of high-quality seedlings attribute obtained a weighted score of 0.83. This finding indicates that production input quality plays an important role in enhancing productivity and maintaining harvest stability. The provision of superior seedlings through government support programs or local hatchery initiatives could therefore become an effective strategy for improving the sustainability of the seaweed industry. Meanwhile, the drying facilities attribute received a weighted score of 0.62. Although this was the lowest score among the evaluated attributes, the result nevertheless demonstrates that post-harvest infrastructure remains an important component within the seaweed industry value chain. Adequate drying facilities can improve product quality, reduce post-harvest losses, and enhance product competitiveness in the marketplace.

The results of the Cost-Weighted Score Matrix indicate that environmental attributes contribute more significantly than infrastructure-related attributes to the successful implementation of Blue Accounting. This finding suggests that the sustainability of the seaweed industry depends heavily on the quality of coastal ecosystems as the primary resource supporting production activities. The total weighted score of 4.38 indicates that, overall, the evaluated attributes have a high level of importance for the sustainability of the seaweed industry. The higher the total score, the greater the contribution of these attributes to achieving the objectives of Blue Accounting, which seeks to balance economic, environmental, and social considerations. From a policy perspective, this matrix can serve as a tool for investment prioritization and resource allocation. Local governments may focus programs and budget allocations on attributes with the highest weighted scores, particularly coastal ecosystem protection and *ice-ice* disease control. At the same time, private sector actors and seaweed farmer groups can use this information to direct investments toward improving seed quality and post-harvest infrastructure.

Within the Blue Accounting framework, the Cost-Weighted Score Matrix provides a more measurable mechanism for integrating economic and ecological values into decision-making processes. As a result, industry profitability is no longer assessed solely based on financial returns but also takes into account contributions to ecosystem conservation and the long-term sustainability of coastal resources. These findings indicate that investments in environmental protection provide greater benefits than development approaches focused exclusively on increasing production capacity. This result is consistent with the findings of (Grunewald et al., 2024), who emphasized the importance of integrating ecosystem service values into economic reporting systems in order to achieve sustainable development.

A key contribution of this study lies in the integration of stakeholder-derived MWTP estimates with a Cost-Weighted Score Matrix. Previous environmental valuation studies generally stop at the estimation of willingness-to-pay values, whereas the present study extends these results into a prioritization framework that can directly support environmental accounting and investment decisions.

4.7. Environmental Profit & Loss (EP&L) in the Seaweed Industry of Rote Ndao Regency

Environmental Profit & Loss (EP&L) is used to integrate economic and environmental values into the performance evaluation of the seaweed industry. Unlike conventional financial statements that only consider revenues and operational costs, EP&L also incorporates environmental costs arising from the use of natural resources, ecosystem degradation, and the need for environmental restoration and conservation. Based on environmental valuation results obtained through the Choice Experiment approach and the estimation of Marginal Willingness to Pay (MWTP), ecosystem service values and environmental costs can be integrated into the Environmental Profit & Loss framework as presented in Table 8.

Table 8. Environmental Profit & Loss (EP&L) of the Seaweed Industry

Component	Value (IDR/Production Cycle)
Revenue	
Seaweed Sales	8.500.000
Ecosystem Service Value	1.200.000
Total Revenue	9.700.000
Costs	
Cultivation Operational Costs	2.400.000
Environmental Restoration Costs	450.000
Remediation Costs	350.000
Environmental Externality Costs	300.000
Productivity Loss Costs Due to Ice-Ice Disease	500.000
Total Costs	4.000.000
Environmental Net Profit	5.700.000

The analysis results indicate that the total revenue generated from seaweed cultivation activities reaches IDR 9.700.000 per production cycle. This value is derived not only from seaweed sales amounting to IDR 8.500.000, but also includes an ecosystem service value of IDR 1.200.000, generated from environmental benefits such as coastal protection, improved water quality, carbon sequestration, and support for biodiversity conservation. From the cost perspective, the total costs accounted for within the EP&L framework amount to IDR 4.000.000. In addition to cultivation operational costs of IDR 2.400.000, several environmental costs that are typically excluded from conventional accounting systems are incorporated, including environmental restoration costs, remediation costs, environmental externality costs, and productivity losses resulting from *ice-ice* disease outbreaks. After incorporating all economic and environmental components, the Environmental Net Profit is estimated at IDR 5.700.000 per production cycle. This figure represents a more comprehensive measure of net profit because it explicitly considers the environmental impacts associated with seaweed cultivation activities.

The EP&L results demonstrate that the profitability of the seaweed industry is determined not only by production volume and market prices but also by the condition of coastal ecosystems that support cultivation activities. By incorporating ecosystem service values into revenue calculations, the contribution of the environment to business success becomes more visible and measurable. This finding suggests that coastal ecosystems possess tangible economic value for seaweed farming communities. Traditionally, benefits such as coastal protection, high water quality, and biodiversity have often been treated as free goods. However, through the EP&L approach, these benefits can be translated into monetary values, providing a more accurate representation of the industry's dependence on environmental resources.

The findings are broadly consistent with existing Environmental Profit and Loss (EP&L), Natural Capital Accounting (NCA), and Environmental Management Accounting (EMA) approaches, all of which emphasize the incorporation of environmental impacts into economic decision-making. However, the proposed Blue Accounting Framework differs from these approaches in both its conceptual orientation and operational capability. Conventional NCA primarily quantifies changes in natural capital stocks and ecosystem services at national or regional scales, while EMA focuses on improving organizational decision-making through the identification and allocation of environmental costs within business operations. Similarly, most existing EP&L applications estimate environmental externalities using biophysical indicators, environmental impact models, and corporate accounting data, with relatively limited consideration of stakeholder preferences in the valuation process.

In contrast, this study integrates Choice Experiments (CE) with Environmental Profit and Loss (EP&L) accounting by incorporating Marginal Willingness to Pay (MWTP) estimates directly into environmental valuation and investment prioritization. Rather than treating environmental values solely as biophysical or accounting metrics, the framework explicitly captures the economic value that local stakeholders assign to improvements in coastal ecosystem quality and sustainable seaweed production. Consequently, environmental impacts are assessed not only in terms of ecological outcomes but also according to their perceived social and economic importance. This integration generates capabilities that extend beyond a simple application of existing methods. First, CE-derived MWTP transforms environmental accounting from a descriptive reporting system into a decision-support framework that reflects stakeholder preferences when evaluating sustainability interventions. Second, the estimated preference values are operationalized through the Cost-Weighted Score Matrix, enabling direct comparison of alternative investments by simultaneously considering implementation costs, environmental benefits, and social priorities. Third, the integration establishes a transparent linkage between environmental valuation, accounting information, and resource allocation decisions, thereby supporting evidence-based policy formulation and investment appraisal rather than retrospective sustainability reporting alone.

Accordingly, the principal contribution of the Blue Accounting Framework lies not merely in combining CE and EP&L, but in creating an integrated accounting architecture that connects stakeholder preferences, environmental externalities, and economic decision-making within a single analytical framework. This enables policymakers, investors, and coastal industries to evaluate sustainability trade-offs using a common decision metric, thereby enhancing the operational relevance of environmental accounting for blue economy governance beyond the capabilities of conventional NCA, EMA, or stand-alone EP&L approaches.

From the cost perspective, the findings reveal the existence of several hidden environmental costs that are not captured by traditional accounting systems. Restoration costs, remediation costs, and environmental externality costs reflect the economic consequences that must be borne when environmental quality declines. Consequently, profitability that appears high in conventional financial statements may actually decrease when environmental costs are fully accounted for.

Furthermore, the productivity losses associated with *ice-ice* disease indicate that environmental degradation has a direct impact on farmers' incomes. This finding reinforces the Choice Experiment results, which showed that disease reduction and ecosystem protection are the attributes most highly valued by respondents. The results suggest that sustainable profitability cannot be separated from environmental quality that supports production activities. This finding supports the study of (Grunewald et al., 2024), which concluded that natural capital-based reporting provides a more comprehensive representation of organizational performance than traditional financial reporting.

From a policy perspective, the findings provide important implications for the Government of Rote Ndao Regency and other coastal administrations seeking to balance economic development with marine ecosystem conservation. The high MWTP values associated with environmental attributes indicate strong community support for conservation programs and sustainable coastal resource management. This evidence can be used to justify public investments in ecosystem rehabilitation, disease prevention and monitoring programs for seaweed cultivation, climate adaptation initiatives, and supporting infrastructure that enhances both environmental quality and industry competitiveness.

Beyond serving as an evaluation tool, the Blue Accounting Framework offers a practical decision-support mechanism for policy formulation and investment planning. Specifically, the Cost-Weighted Score Matrix enables policymakers to prioritize alternative interventions by simultaneously considering environmental benefits, implementation costs, and stakeholder preferences. For example, local governments can compare investment options such as mangrove restoration, seaweed disease surveillance systems, improved post-harvest facilities, or water quality monitoring programs, and allocate limited budgets to interventions that generate the greatest combined ecological and socio-economic value. Likewise, Environmental Profit and Loss (EP&L) reporting provides quantitative information on environmental externalities, allowing government agencies to incorporate environmental costs and benefits into regional development planning and coastal resource governance.

The framework also generates practical value for a broad range of stakeholders. For local governments, it supports evidence-based budgeting, coastal spatial planning, and sustainability-oriented policy evaluation. For investors and financial institutions, the framework improves environmental risk assessment by incorporating ecosystem impacts into investment appraisal, thereby facilitating more responsible and resilient investment decisions. Seaweed producers and processors can utilize the framework to identify operational practices that simultaneously improve environmental performance, reduce production risks, and enhance long-term business sustainability. Furthermore, development agencies, NGOs, and coastal communities may use the framework to strengthen stakeholder engagement, monitor conservation outcomes, and evaluate the effectiveness of sustainability programs.

The practical impact of this research extends beyond the study area by providing a structured implementation pathway for integrating Blue Accounting into both public policy and private-sector decision-making. At the policy level, the framework can be incorporated into regional coastal management strategies, environmental monitoring systems, sustainability reporting requirements, and the evaluation of publicly funded coastal development projects. At the business level, companies can integrate the framework into environmental, social, and governance (ESG) reporting, investment feasibility studies, risk management, and sustainability performance assessments. By combining economic valuation, stakeholder preferences, and environmental accounting, the framework enables decision-makers to evaluate trade-offs more transparently and consistently than conventional financial assessments alone.

Although this study focuses on Rote Ndao Regency, the proposed framework demonstrates considerable potential for application in other seaweed-producing regions across Southeast Asia, where similar sustainability challenges including ecosystem degradation, disease outbreaks, climate variability, and competing coastal resource uses are widely observed. Because the framework is based on broadly applicable analytical components, namely Choice Experiments, MWTP estimation, Cost-Weighted Score Matrices, and Environmental Profit and Loss reporting, it can be adapted to different institutional settings and environmental conditions by modifying the valuation attributes and stakeholder priorities to reflect local contexts.

More broadly, the transferability of the Blue Accounting Framework is not limited to the seaweed industry. The framework may also be applied to other coastal and marine industries, including aquaculture, capture fisheries, mangrove-based enterprises, shellfish production, marine ecotourism, and integrated coastal resource management. Across these sectors, the framework provides a consistent approach for quantifying environmental values, incorporating stakeholder preferences into decision-making, evaluating environmental externalities alongside financial performance, and supporting more transparent and accountable sustainability governance. Consequently, the principal contribution of this study lies not only in its empirical findings for Rote Ndao Regency but also in demonstrating a transferable decision-support framework that can assist policymakers, investors, industries, and other stakeholders in advancing sustainable blue economy development across diverse coastal regions.

5. Conclusion

This This study concludes that Blue Accounting offers a comprehensive and practical framework for integrating economic, environmental, and social values into the management of the seaweed industry in Rote Ndao Regency. The Choice Experiment results show that respondents give the highest priority to improvements in coastal ecosystem conditions and reductions in ice-ice disease incidence, indicating that environmental quality is perceived as the main foundation of production sustainability. The Marginal Willingness to Pay (MWTP) estimates demonstrate that seaweed farmers are willing to contribute financially to environmental improvement programs when the benefits are directly related to ecosystem protection, disease control, seedling quality, and post-harvest infrastructure. The Cost-Weighted Score Matrix further confirms that coastal ecosystem quality and disease control are the most strategic priorities for Blue Accounting implementation. Meanwhile, the Environmental Profit and Loss (EP&L) analysis shows that the profitability of seaweed cultivation cannot be measured only through sales revenue and operational costs, because ecosystem service values, restoration costs, remediation costs, externalities, and productivity losses also shape the real economic performance of the industry. Therefore, Blue Accounting can function not only as an environmental reporting tool, but also as a decision-making framework for strengthening sustainability, accountability, and resilience in coastal economic development.

This study has several limitations. First, the research was conducted in West Rote District, Rote Ndao Regency, so the findings may not fully represent the conditions of seaweed industries in other coastal regions with different ecological, institutional, and market characteristics. Second, the valuation of ecosystem services was based on stated preferences through the Choice Experiment method, which may be influenced by respondents' perceptions, knowledge, and ability to evaluate hypothetical scenarios. Third, although the Multinomial Logit (MNL) model was considered appropriate for analyzing the Choice Experiment data, the Independence of Irrelevant Alternatives (IIA) assumption was not formally tested; therefore, potential unobserved preference heterogeneity and correlations among alternatives could not be assessed. Fourth, the EP&L framework developed in this study remains a model-based estimation and has not yet been fully tested through longitudinal accounting records or real-time environmental monitoring data. Finally, this study focused on selected sustainability attributes, namely coastal ecosystem condition, ice-ice disease reduction, seedling quality, drying facilities, and environmental contribution, while other relevant factors such as market volatility, climate variability, governance capacity, and supply chain dynamics were not examined in greater depth. Future research should expand the study area to other seaweed-producing regions in Indonesia to compare the applicability of Blue Accounting across different coastal contexts.

Further studies are encouraged to employ more flexible discrete choice models, such as Mixed Logit or Latent Class Model, while integrating stated preference methods with revealed preference data, environmental monitoring, production records, and financial accounting data to improve the robustness of ecosystem valuation. Longitudinal research is also needed to evaluate how the implementation of Blue Accounting affects farmer income, environmental quality, disease incidence, and industry competitiveness over time, as well as to develop a more comprehensive EP&L model that incorporates carbon sequestration, biodiversity indicators, climate risk, supply chain performance, and institutional readiness. Collaboration among researchers, local governments, seaweed farmers, and private sector actors is also recommended to transform Blue Accounting from a conceptual framework into an operational reporting and policy instrument for sustainable marine-based industries.

References

Ayinla, B. S., Ike, C. U., Asuzu, O. F., Atadoga, A., Ndubuisi, L., & Adeleye, R. A. (2024). Environmental costing and sustainable accounting : A comprehensive review : Delving into methods of accounting for environmental impacts in financial statements. *World Journal of Advanced Research and Reviews*, *21*(2), 235–251.

Baloch, A., Kalhoro, M. A., Memon, A. M., Raza, H., Sanaullah, S., Barua, S., Chen, X., Ma, Y., Mehreen, A., & Liu, Q. (2025). Comparative study of stock status and sustainable management of Pomadasys olivaceus fishery along Pakistan coast. *Journal of Oceanology and Limnology*. https://doi.org/10.1007/s00343-025-5016-1

Brander, L. M., Schägner, J. P., & Groot, R. De. (2022). On the potential use of the Ecosystem Services Valuation Database for valuation in the System of Environmental Economic Accounting. *One Ecosystem*, 1–17. https://doi.org/10.3897/oneeco.7.e85085

Carvalho, S. H. C. de, Cojoianu, T., & Ascui, F. (2023). From impacts to dependencies: A first global assessment of corporate biodiversity risk exposure and responses. *Business Strategy and the Environment*, *32*(5), 2600–2614. https://doi.org/https://doi.org/10.1002/bse.3142

Demel, S., Longo, A., & Mariel, P. (2020). Trading off visual disamenity for renewable energy: Willingness to pay for seaweed farming for energy production. *Ecological Economics*, *173*, 106650. https://doi.org/https://doi.org/10.1016/j.ecolecon.2020.106650

Gonçalves, A., & Silva, C. (2021). Looking for Sustainability Scoring in Apparel: A Review on Environmental Footprint, Social Impacts and Transparency. In *Energies* (Vol. 14, Number 11, p. 3032). https://doi.org/10.3390/en14113032

Grunewald, K., Zieschank, R., Förster, J., Hansjürgens, B., & Wildner, T. M. (2024). The future of economic reporting : ecosystem services and biodiversity in government and corporate accounting. *One Ecosystem*, *9*. https://doi.org/10.3897/oneeco.9.e131326

Hyun, M.-K., Chong, G.-H., & Yoo, S.-H. (2026). Economic valuation of coastal ecosystem services mitigating climate impacts: A choice experiment in South Korea. *Journal of Coastal Conservation*, *30*(3), 38. https://doi.org/10.1007/s11852-026-01223-4

Iqbal, Md. H. (2020). Valuing ecosystem services of Sundarbans Mangrove forest: Approach of choice experiment. *Global Ecology and Conservation*, *24*, e01273. https://doi.org/https://doi.org/10.1016/j.gecco.2020.e01273

Kim, J.-H., Nam, J., & Yoo, S.-H. (2022). Public perceptions of blue carbon in South Korea: Findings from a choice experiment. *Marine Policy*, *144*, 105236. https://doi.org/https://doi.org/10.1016/j.marpol.2022.105236

Langford, A., Zhang, J., Waldron, S., Julianto, B., Siradjuddin, I., Neish, I., & Nuryartono, N. (2022). Price analysis of the Indonesian carrageenan seaweed industry. *Aquaculture*, *550*, 737828. https://doi.org/https://doi.org/10.1016/j.aquaculture.2021.737828

Li, Y., Jiang, S., & Lin, Y. (2026). A Comparative CVM-Based Evaluation of Non-Use Values for the Zhongjieshan and Liuheng Marine Ranches in China. In *Sustainability* (Vol. 18, Number 2, p. 608). https://doi.org/10.3390/su18020608

Mediaty, M., Anto, F. A., & Habbe, A. H. (2024). Profitability and Ownership Structure as Determinants of Financial Reporting Timeliness in Healthcare Companies Listed on the Indonesian Stock Exchange. *Journal of Law and Social Politics*, *2*(1), 42–49.

Mohamed, M. K. (2025). Economic Valuation of Mangrove Ecosystem Services: Insights from Willingness to Pay Analysis for Chwaka Bay Mangrove Forest, Zanzibar. In *Wild* (Vol. 2, Number 2, p. 21). https://doi.org/10.3390/wild2020021

Moozanah, S., Rusdiansyah, N., Rosyidah, D. M., & Riany, M. (2024). Profit and Sustainability Perceptions Related to the Implementation of Blue Accounting in the Fishing Industry in Palabuhanratu. *Journal of Accounting Auditing and Business*, *7*(2), 36–43.

Opdenbosch, H., & Hansson, H. (2023). Farmers' willingness to adopt silvopastoral systems: investigating cattle producers' compensation claims and attitudes using a contingent valuation approach. *Agroforestry Systems*, *97*(1), 133–149. https://doi.org/10.1007/s10457-022-00793-0

Pacifico, A. M., Mulazzani, L., & Malorgio, G. (2025). Are the economic valuations of marine and coastal ecosystem services supporting policymakers? A systematic review and remaining gaps and challenges. *Frontiers in Marine Science*, *11*.

Pappa, D., & Kaliampakos, D. (2025). Unveiling the Non-Market Value of a Fragile Coastal Wetland: A CVM Approach in the Amvrakikos Gulf, Greece. In *Environments* (Vol. 12, Number 2, p. 59). https://doi.org/10.3390/environments12020059

Qiao, D., Liu, H., Zhang, D., Xu, T., & Gan, Y. (2022). Chasing the unbiased willingness to pay: Using an integrated contingent valuation survey in estimating the non-market value of rubber plantation ecological restoration programs in China. *Frontiers in Ecology and Evolution*, *10*.

Rahmayanti, A. Y., & Sari, D. K. (2022). Blue Accounting to Enhance the Quality of Sustainability Report. In *Proceedings* (Vol. 83, Number 1, p. 69). https://doi.org/10.3390/proceedings2022083069

Ren, W., Xu, Y., & Xiao, H. (2024). Research on the impact of marine ecological civilization demonstration zone policies on the green development level of China's marine economy: A quasi natural experiment based on coastal cities. *Marine Policy*, *161*, 106048. https://doi.org/https://doi.org/10.1016/j.marpol.2024.106048

Rimmer, M. A., Larson, S., Lapong, I., Purnomo, A. H., Pong-Masak, P. R., Swanepoel, L., & Paul, N. A. (2021). Seaweed Aquaculture in Indonesia Contributes to Social and Economic Aspects of Livelihoods and Community Wellbeing. In *Sustainability* (Vol. 13, Number 19, p. 10946). https://doi.org/10.3390/su131910946

Stefannie, D., & Khairin, F. N. (2025). Open Access Blue Accounting Practices for Marine Economic Sustainability : A Descriptive Analysis of the Implementation of Blue Accounting in the Fisheries Sector in West Kutai Regency. *American Journal of Humanities and Social Sciences Research*, *09*(06), 218–225.

Syah, S., Saraswati, E., Sukoharsono, E. G., & Roekhudin. (2020). *Blue Accounting and Sustainability BT - Proceedings of the 23rd Asian Forum of Business Education(AFBE 2019)*. 502–508. https://doi.org/10.2991/aebmr.k.200606.085

Tavárez, H., Abelleira, O., & Elbakidze, L. (2024). Environmental awareness and willingness to pay for biodiversity improvement in Puerto Rico. *Journal of Environmental Studies and Sciences*, *14*(1), 154–166. https://doi.org/10.1007/s13412-023-00869-y

Wang, X., Kim, J., Kim, J., & Koh, Y. (2024). Application of Natural-Resource-Based View to Nature-Based Tourism Destinations. In *Sustainability* (Vol. 16, Number 6, p. 2375). https://doi.org/10.3390/su16062375

Zamroni, A. (2021). Sustainable seaweed farming and its contribution to livelihoods in Eastern Indonesia. *IOP Conference Series: Earth and Environmental Science*, *718*(1), 12099. https://doi.org/10.1088/1755-1315/718/1/012099