



Enhancing Economic Sustainability of Seaweed Processing Through Value Chain Restructuring: Evidence from Indonesia's Blue Economy

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ABSTRACT

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This study examines the economic sustainability of a seaweed processing enterprise in East Java, Indonesia, within the framework of the Blue Economy, by integrating value chain analysis and financial assessment. Using a case study approach, the research analyzes how operational configuration, cost structure, and financial performance interact to shape business sustainability. The results show that the enterprise operates under a production- and compliance-driven structure, with operational activities accounting for 64.64% of total costs and regulatory obligations representing 25.15%. Fixed capital is highly concentrated in processing machinery (95.06%), indicating that competitiveness is primarily driven by production efficiency and quality control. Financial feasibility was evaluated using a 10-year investment horizon and a 6% discount rate. The results confirm that the enterprise is financially feasible and profitable under current conditions. However, sensitivity analysis reveals that the enterprise is vulnerable to cost increases of up to 31% and revenue declines of up to 22%, particularly when these occur simultaneously. This finding indicates that financial resilience is highly dependent on the stability of raw material prices, export market conditions, and the effective management of export-related costs. Based on these findings, value chain restructuring pathways, including process restructuring, procurement restructuring, product restructuring, and market restructuring, are proposed to enhance financial resilience and support long-term sustainability.

1. INTRODUCTION

Seaweed has emerged as a strategic marine commodity driven by increasing global demand for aquaculture-based and marine-derived products [1]. In addition to its economic contribution to coastal livelihoods and export activities, seaweed farming is widely recognized as an environmentally sustainable practice due to its low input requirements and compatibility with sustainable coastal management systems [2, 3].

Since 2014, Indonesia has reoriented its fisheries development strategy toward a Blue Economy framework that emphasizes sustainable utilization of marine resources and value-added development [4]. Within this context, seaweed has become a strategic commodity due to its export potential and environmental sustainability. The Indonesia Blue Economy Roadmap (2023–2045) further highlights the importance of strengthening downstream processing and enhancing value creation along the marine product value chain [5]. However, the extent to which these policy directions translate into firm-level performance and sustainability

remains unclear.

Despite this potential, Indonesia's seaweed sector still faces structural challenges, including limited domestic processing capacity, dependence on raw material exports, fragmented supply chains, and weak governance coordination [6]. These constraints limit value capture and reduce cost efficiency, making it difficult for policy initiatives to translate into firm-level improvements. As a result, seaweed-based micro, small, and medium enterprises (MSMEs) remain vulnerable to market fluctuations, cost increases, and uneven value distribution along the supply chain [3]. These conditions indicate that increasing production and export performance do not necessarily lead to long-term economic sustainability.

From an industrial systems perspective, seaweed processing enterprises constitute production systems in which operational configuration, cost structure, and supply chain coordination determine overall performance and economic sustainability. Understanding how these activities are organized within the value chain is therefore critical to assessing how operational efficiency can be transformed into financial resilience and long-term sustainability.

Previous studies have examined seaweed production performance, livelihood contributions, and financial feasibility, often in isolation. However, research integrating value chain configuration with financial performance and examining how these internal structures influence long-term economic sustainability remains limited. In particular, there is a lack of studies that explore how value chain restructuring can support financial resilience and provide actionable strategic development pathways at the firm level. Understanding this relationship is essential to assessing whether policy-driven marine development can effectively enhance the sustainability of seaweed-based MSMEs.

Porter's value chain framework provides a systematic approach to analyse how coordinated primary and support activities influence cost structure, differentiation, and margin formation [7]. However, operational efficiency alone does not guarantee long-term economic sustainability. Therefore, financial analysis is required to assess whether value chain performance translates into financial resilience and sustainable business outcomes.

To address this gap, this study integrates value chain analysis with financial assessment to examine how operational configuration influences financial resilience in seaweed processing enterprises. By situating firm-level performance within Indonesia's Blue Economy framework, this study further explores how value chain restructuring can enhance economic sustainability. Additionally, this study identifies strategic development pathways to support the long-term sustainability of export-oriented seaweed-based MSMEs.

2. RESEARCH METHOD

This study adopts a single-case study approach to examine the financial resilience and value chain configuration of a seaweed-based small-scale enterprise operating within Indonesia's Blue Economy policy framework. The case study design [8, 9] is appropriate for an in-depth investigation of how internal operational structures interact with external governance environments, particularly to understand firm-level economic sustainability in policy-driven development contexts within Indonesia's Blue Economy policy framework, with an emphasis on value chain restructuring for economic sustainability.

The selected enterprise is an export-oriented, small-scale seaweed-processing firm legally registered as a limited liability company (PT) and actively engaged in marine and fisheries development initiatives aligned with Indonesia's Blue Economy framework. The case was selected purposively based on three criteria: (1) active involvement in seaweed processing and export activities, (2) engagement in policy-driven development programs, and (3) availability of complete financial and operational data. This analysis also provides the basis for identifying potential areas for value chain restructuring to improve efficiency and value creation.

Primary data were collected through structured interviews with enterprise management, direct observation of production processes, and internal financial records. Secondary data were obtained from policy documents, industry reports, and national statistics on seaweed development and the implementation of the Blue Economy. Financial data included investment costs, fixed and variable costs, production volume, and revenue, all standardized to annual values. Data triangulation was applied to enhance validity by cross-

verifying interview results with financial and observational data.

Value chain analysis was conducted based on Porter's framework to examine how primary and support activities contribute to cost formation, value creation, and margin generation [7]. The analysis covered inbound logistics, operations, outbound logistics, marketing and sales, and services, as well as supporting activities including firm infrastructure, human resource management, technology development, and procurement. This approach enables the identification of activity-level efficiency and structural sources of competitive advantage [10-14].

Financial analysis was performed using standard investment appraisal indicators, including Net Present Value (NPV), Internal Rate of Return (IRR), Net Benefit–Cost Ratio (Net B/C), and Payback Period (PP), to assess economic viability [15-17]. To further capture how operational performance translates into financial outcomes, profit margin was calculated as the proportion of profit to total revenue. This measure indicates the share of revenue remaining after covering all production and operating expenses. In this study, profit margin is used to complement the value chain analysis by linking activity-based value creation to financial performance, thereby demonstrating how efficiently the value generated across primary and support activities is converted into economic returns. Profit margin was calculated to represent the proportion of profit relative to total revenue:

$$\text{Profit Margin (\%)} = \left(\frac{\pi}{TR} \right) \times 100 \quad (1)$$

This measure indicates the share of revenue that remains after covering all production and operational expenses. In this study, profit margin is utilised to complement the value chain analysis by linking value creation at the activity level with financial performance, thereby demonstrating how effectively value generated across primary and support activities is converted into economic returns.

Financial feasibility analysis was conducted using a 10-year investment horizon and a 6% discount rate. Annual net cash flows were derived from the company's financial records. Export revenues denominated in USD were converted into Indonesian Rupiah (IDR) using the exchange rate applied by the company at the time of transaction recording. NPV, IRR, Net B/C, and Payback Period were subsequently calculated based on annual net cash flows expressed in IDR.

To further evaluate financial performance from an investment perspective, NPV was used to assess the net financial return by comparing discounted cash inflows with the initial capital outlay. An investment is considered financially feasible when the NPV value is positive. The NPV is calculated as follows:

$$NPV = -A_0 + \sum_{t=1}^n \frac{A_t}{(1+i)^t} \quad (2)$$

where, A_0 represents the initial investment, A_t denotes net cash inflows in year t , i is the discount rate, and t is the project period. Other indicators, such as IRR, Net B/C, and Payback Period, were calculated using standard financial evaluation methods. These indicators are widely used to assess investment feasibility and the enterprise's capacity to sustain operations amid changing economic conditions. The results of these analyses are used to identify strategic development

pathways to enhance economic sustainability through value chain restructuring.

While the enterprise may be financially feasible, its performance is not immune to fluctuations in costs and revenue. Therefore, a sensitivity analysis was conducted to examine how such changes affect financial stability and to evaluate the business's robustness under varying conditions [18-22]. Sensitivity analysis was further applied to evaluate financial resilience under scenarios of cost increases and revenue reductions, thereby identifying key vulnerabilities to market and operational risks [23-25]. The results of these analyses are used to identify strategic development pathways for enhancing economic sustainability through value chain restructuring.

3. RESULT AND DISCUSSION

The enterprise analyzed operates as a seaweed-processing company in East Java, Indonesia, producing export-oriented semi-processed products within a downstream marine value chain. The enterprise integrates procurement, processing, quality control, packaging, and distribution within a relatively compact organizational structure. Operating amid fluctuating raw material prices and export market volatility, the enterprise faces both cost pressures and regulatory constraints on quality standards and export compliance. These conditions position the enterprise in a production-dependent, compliance-sensitive operating environment that directly shapes its value chain configuration and financial resilience.

The value chain configuration reflects a semi-integrated, production-centered system characterized by strong coordination of upstream and operational activities, while downstream functions remain relatively limited. Rather than relying on product differentiation or technological innovation, the enterprise constructs its competitiveness through quality stabilization, supply continuity, and regulatory compliance. This indicates that value creation is primarily driven by operational control and input management rather than by market-based value-enhancement strategies. The configuration of these activities is illustrated in Figure 1, which presents the structure of primary and support activities within the enterprise's value chain.

The value chain structure illustrated in Figure 1 reflects how primary and support activities interact in shape value creation and cost formation within the enterprise. These activities are further analyzed to identify how operational processes, procurement systems, and governance mechanisms contribute to overall performance.

Value-Adding Primary Activities

Inbound logistics. Inbound logistics functions as the initial control point of value creation. The enterprise receives dried seaweed from multiple sourcing regions, including Makassar (South Sulawesi), East Nusa Tenggara (NTT), West Nusa Tenggara (NTB), Java, Madura, and Bali. Upon arrival, delivery documents are verified, and raw materials undergo quality inspection. If product quality does not meet agreed specifications, price renegotiation occurs, indicating that cost-control mechanisms are embedded directly at the receiving stage. Warehouse management applies first-in, first-out (FIFO) inventory control, ensuring that earlier-received materials are processed first to prevent moisture deterioration and quality decline. According to the study [26], structured inventory control systems, such as FIFO, are highlighted as key mechanisms to reduce spoilage and improve efficiency in perishable supply chains.

Then, raw material planning follows Material Requirements Planning (MRP), a system that determines the timing and quantity of procurement based on production demand forecasts. According to the study [27], Effective inventory planning and control are essential in managing uncertainty and maintaining supply continuity in agri-food supply chains. Together, these mechanisms demonstrate that upstream logistics is structured to stabilize input quality, reduce storage risk, and support production continuity.

Operations. Operations serve as the primary value-creation stage in the enterprise. The production system is structured around sequential quality control points, from raw material acceptance through final packaging. Rather than emphasising technological sophistication, the enterprise relies on process discipline and standardised procedures to maintain export-grade consistency. Mechanical chopping and controlled sun-drying function as the main transformation processes, where moisture content and impurity levels are monitored to meet buyer specifications. These control parameters reduce variability and protect product integrity prior to shipment. The semi-mechanized configuration indicates that operational competitiveness stems from procedural consistency rather than from capital-intensive automation. Sequential screening, controlled drying, and standardized packaging collectively minimize post-processing risk and strengthen compliance with export standards. The semi-mechanized configuration indicates that operational competitiveness is driven more by procedural consistency than by capital-intensive technological investment. Accordingly, value creation in this stage is primarily generated through quality stabilization, disciplined processing, and reliable compliance, positioning the enterprise within a cost-conscious yet standards-oriented production system. Based on the research [28], the implementation of structured quality control throughout the production process reduces variability and ensures product consistency, which is essential in maintaining product quality in agri-food supply chains.

Outbound logistics. Outbound logistics integrates production output into export-oriented distribution channels. Finished products are stored in designated warehouse areas

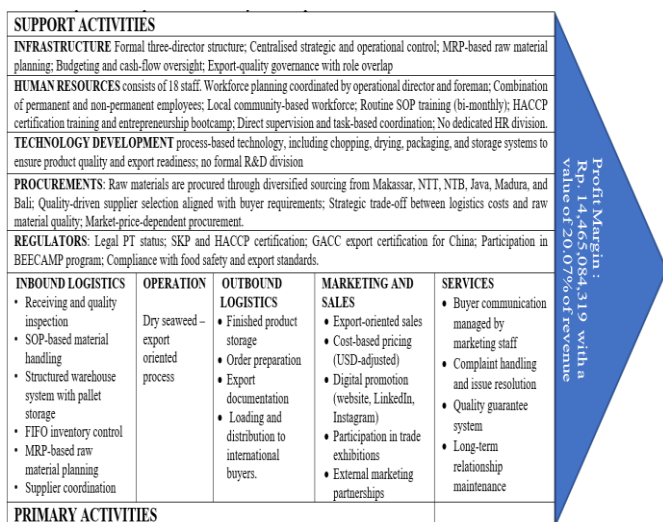


Figure 1. Seaweed processing value chain in East Java, Indonesia

prior to shipment, where activities include order preparation, documentation processing, loading, and international distribution. These processes are structured to ensure timely delivery and alignment with buyer requirements.

A critical aspect of outbound logistics lies in the management of export documentation and compliance procedures, where accuracy and timeliness facilitate smoother cross-border trade. In export-oriented markets, logistics performance plays a key role in ensuring delivery reliability and supporting export competitiveness [29]. Beyond physical distribution, value is also generated through coordination efficiency and regulatory compliance, which enhance market access and support long-term relationships with international buyers [30].

Marketing and sales. Marketing and sales activities are export-oriented and supported by cost-based pricing adjusted to USD exchange rate fluctuations. Promotional strategies combine digital platforms—such as the official website, LinkedIn, and Instagram—with participation in international trade exhibitions, including the Japan International Seafood and Technology Expo (JISTE) 2024. The enterprise also engages external market-access partners to identify and establish cooperation with potential international buyers, indicating a marketing approach that integrates direct engagement and network-based expansion.

Market positioning is constructed through credibility, certification legitimacy, and relationship-based transactions rather than relying solely on price competition. In export-oriented markets, buyer interaction and trust play a crucial role in strengthening long-term relationships and improving performance [31, 32]. In this context, marketing and sales functions not only facilitate transactions but also support sustained market access and long-term buyer relationships.

Service. Service activities extend beyond the completion of transactions and serve to maintain export reliability and buyer confidence. The enterprise maintains direct communication with international buyers, facilitated by designated marketing personnel who coordinate responses to quality concerns, shipment constraints, and contractual adjustments. Complaint handling and issue resolution are managed through structured interaction with buyers to ensure alignment with agreed specifications. The implementation of a quality-guarantee approach reinforces accountability for post-delivery performance.

Rather than functioning solely as reactive problem-solving, service activities operate as a reputational safeguard that supports long-term contractual relationships. In export-oriented commodity markets, such responsiveness strengthens customer trust and satisfaction while supporting repeat engagement with buyers [33, 34], thereby sustaining long-term business relationships.

Support Activities

Support activities to improve the effectiveness of primary value chain processes through organizational control, resource management, and regulatory compliance.

Firm infrastructure. Firm infrastructure functions as the central coordinating mechanism across procurement, production, and export management. The enterprise operates under a centralized three-director structure that consolidates strategic and operational decision-making. MRP is a managerial planning system that determines the timing and quantity of raw material procurement based on production demand forecasts, ensuring alignment between sourcing

decisions, warehouse capacity, and production scheduling. Financial oversight is supported by an integrated online accounting system that enables budgeting and cash flow monitoring. Regulatory compliance and export certifications are embedded within this governance structure, strengthening institutional legitimacy and market access.

Through this centralized, planning-oriented configuration, infrastructure serves as the stabilizing backbone of the enterprise's value chain by enabling coordination and operational control across activities, while also supporting financial stability through systematic cash flow monitoring, in line with the role of integrated activity systems and sustainable financial flows in maintaining organizational resilience [35, 36].

Human resource management. is centrally coordinated by the operational director in collaboration with the foreman, beginning with workforce planning that aligns with required qualifications and production needs. The enterprise employs both permanent and non-permanent personnel, with all employees drawn from the local community. Routine training is implemented through regularly scheduled Standard Operating Procedure (SOP) sessions. In addition, management facilitates capacity-building initiatives, including hazard analysis and critical control points (HACCP) certification training and entrepreneurship bootcamp programs.

The structured training efforts indicate that workforce development is supported not only by operational experience but also by formal instruction, contributing to process consistency, error reduction, and operational performance [37, 38]. Coordination is reinforced through direct supervision and task-based management in the absence of a dedicated HR division, reflecting a lean but functionally controlled organizational system. This configuration aligns workforce capabilities with production needs and quality standards, supporting reliable, standardized operations.

Technology development within the enterprise is embedded in operational functionality rather than formal innovation systems. The production process incorporates a dedicated seaweed-chopping machine, indicating selective mechanization at critical stages of the transformation process. This specialized equipment enhances size uniformity and processing efficiency, directly supporting product standardization prior to drying. Beyond the chopping stage, processing remains largely semi-manual, particularly during drying and material handling. Technological refinement occurs through incremental adjustments informed by operational experience rather than through structured research and development programs. This learning-by-doing approach enables functional improvements without increasing capital intensity.

This approach is consistent with process-oriented production systems, where efficiency is achieved through continuous operational improvement rather than reliance on advanced technological investment [39]. The technological configuration, therefore, reflects targeted mechanization: critical stages are supported by specific equipment to stabilize output quality, while the overall system remains cost-conscious and operationally adaptive. Technology functions primarily as a consistency-enhancing mechanism rather than as a source of technological differentiation.

Procurement within the enterprise is structured around multi-regional sourcing and quality-aligned supplier selection. Raw materials are obtained from several production regions, including Makassar, East Nusa Tenggara (NTT), West Nusa

Tenggara (NTB), Java, Madura, and Bali. This geographic diversification reduces dependency on a single supply base and mitigates localized production risks. Supplier selection is guided by buyer specifications, indicating that procurement decisions are demand-driven rather than solely price-oriented. Quality conformity at the sourcing stage minimizes the risk of downstream rejection and stabilizes operational performance. Procurement planning is closely coordinated with production requirements, taking lead times into account and accounting for storage capacity constraints. Active communication with suppliers functions as a risk-mitigation mechanism against delivery delays and price volatility. This configuration reflects a supply stabilization strategy in which procurement functions not only as a purchasing activity but also as a mechanism for balancing cost efficiency and input quality under uncertain supply conditions, consistent with supply chain practices that emphasize supplier coordination and risk management to maintain operational continuity.

The regulatory environment functions as a structural enabler within the enterprise's value system. The company operates under formal business licensing (Nomor Induk Berusaha (NIB)) and complies with food safety and processing standards, including SKP (Fish Processing Feasibility Certificate), Good Manufacturing Practice (GMP), Badan Pengawas Obat dan Makanan (BPOM) registration, and halal certification. These certifications establish legitimacy in both domestic and export markets. Regulatory compliance is not merely an administrative obligation but a market-access mechanism. Food safety certification and formal licensing reduce transaction uncertainty and strengthen buyer confidence, particularly in export-oriented transactions where traceability and quality assurance are critical. Institutional facilitation through the BEECAMP program of the Ministry of Marine Affairs and Fisheries further reinforces regulatory alignment. Government involvement contributes to capability upgrading and strategic visibility, embedding the enterprise within the broader blue economy policy framework. Regulation operates as a trust-building infrastructure that supports market penetration and export credibility rather than as a passive compliance requirement.

The configuration of primary and support activities outlined above forms the structural basis of the enterprise's value system. However, the sustainability of this configuration ultimately depends on its financial performance. Operational discipline, procurement diversification, and compliance-oriented governance inevitably influence production costs and revenue stability, as value chain activities play a critical role in managing and reducing costs across the production system [40]. Consequently, an examination of cost structure and profit margin is required to determine whether the identified value drivers are economically sustainable, given that value chain performance and cost efficiency are key determinants of firm profitability and financial stability [41].

The preceding value chain analysis indicates that the enterprise adopts a production-centered, cost-conscious configuration, in which operational discipline and selective mechanization serve as the primary value drivers. Such a configuration inherently shapes the business's cost structure and margin formation. In particular, the concentration of activities in processing and supply stabilization suggests a cost-driven orientation, where efficiency and controlled expenditure are central to competitiveness. To assess how this structural orientation translates into financial performance, the fixed capital investment forming the basis of cost allocation is

presented in Table 1.

Table 1. Capital investment of the seaweed enterprise in East Java

No.	Description	Amount (IDR)
1	Processing machinery	162,000,000
2	Supporting equipment and utensils	37,733,300
3	Packaging and sealing equipment	2,885,000
4	Electrical and utility installations	5,000,000
5	Office and administrative equipment	14,500,000
	Total	222,118,300

The distribution of capital (Table 1) demonstrates a pronounced concentration in operational activities (95.06%), indicating that structural investment is predominantly embedded in production capacity. This reflects a transformation-oriented asset structure in which machinery and core processing equipment function as the primary drivers of value creation. Capital concentration at this stage reinforces production stability and processing control as key determinants of structural competitiveness. The limited allocation to outbound logistics (2.48%), represented by packaging machinery, suggests that distribution activities rely on targeted, function-specific assets rather than on large-scale logistical infrastructure. As a result, export readiness is achieved through operational integration rather than capital-intensive distribution systems. Firm infrastructure accounts for only 2.46% of total fixed capital, indicating a lean administrative configuration with minimal investment outside production functions. There is no fixed capital investment in human resource management, technology development, marketing, and regulatory activities, indicating that the enterprise's competitive positioning is not driven by managerial expansion or innovation-based assets, but remains predominantly production-centered. This finding is consistent with studies [42] on seaweed value chains, which show that value creation is primarily concentrated in processing and transformation stages, where operational capability and processing activities play a central role in determining competitiveness and export performance. In addition, the cost structure is shaped by the enterprise's value chain configuration, as shown in Table 2.

Table 2. Cost structure of the seaweed enterprise in East Java

No.	Description	Amount (IDR)
	Fixed Costs	
1	Depreciation	29,557,834
2	Warehouse Rent	300,000,000
3	Labour Costs (Directors, Staff, and Workers)	692,400,000
4	Office and Administrative Expenses	76,800,000
	Total Fixed Cost	1,098,757,834
	Variable Costs	
1	Raw Material Cost	25,680,000,000
2	Production and Processing Cost	1,842,000,000
3	Logistics and Transportation Cost	2,808,000,000
4	Operational Supporting Cost	108,000,000
5	Export Tax	10,721,163,072
	Total Variable Cost	41,520,363,072
	Total Cost	42,619,120,906

Based on Table 2, the cost distribution shows that operational activities are the dominant cost driver (64.64%), indicating that value creation is primarily driven by production

intensity and raw material dependence. Export-related regulatory costs account for a substantial proportion of total expenditure (25.15%), demonstrating that financial performance is influenced not only by internal production efficiency but also by costs that vary with export transactions and compliance requirements. Logistics-related costs, particularly outbound logistics (5.12%), represent a secondary but structurally relevant component, reflecting the distribution requirements of export-oriented operations, while marketing, human resource management, and service-related expenditures remain marginal (each below 0.2%), suggesting that competitive positioning is not driven by service differentiation or managerial expansion, but by production efficiency and regulatory compliance. This cost structure is consistent with studies [43], showing that operational cost intensity and logistics expenditures play a central role in determining firm efficiency and competitiveness, particularly in export-oriented production systems

The revenue from seaweed products will affect profit. The revenue structure by product, as presented in Table 3, shows the revenue per product from the seaweed enterprise that has stable sales in one year.

Table 3. Revenue structure of the seaweed enterprise in East Java

No.	Description (Kind of Species)	Amount (IDR)
1	<i>Chopped Sargassum</i>	5,612,341,239
2	<i>Sargassum Polycystum</i>	14,914,096,660
3	<i>Eucheuma Cottonii</i>	9,143,612,067
4	<i>Eucheuma Spinosum</i>	11,564,326,572
5	<i>Gracilaria Folifera</i>	11,660,171,489
6	<i>Ulva Lactuca</i>	7,189,657,197
Total		60,084,205,225

Table 3 shows that financial performance is primarily scale-driven, with total revenue closely aligned with high production volumes across export-oriented commodities. This scale dependency interacts directly with the cost structure, where operational activities constitute the dominant cost driver. Because raw materials and processing account for the largest share of total costs, margin formation is highly sensitive to procurement efficiency and price stability at the production level. At the same time, the substantial regulatory cost component further compresses potential margins, indicating that revenue growth does not automatically translate into proportional profit expansion. Instead, margin resilience depends on maintaining production efficiency while controlling export-related financial burdens. The relatively small allocation to marketing and service activities suggests that revenue generation is driven by volume throughput rather than value differentiation. Given this cost–revenue interaction, the enterprise’s financial performance can be further evaluated through profitability and feasibility indicators, as presented in Table 4.

Table 4 shows that the enterprise operates with strong profitability, as reflected by a Revenue–Cost (R/C) ratio of 1.4 and a profit margin of 29.07%, indicating that nearly one-third of total revenue remains after covering all associated costs. This suggests that revenue is effectively converted into financial surplus rather than being absorbed by operational inefficiencies. The financial feasibility results confirm that the enterprise satisfies the standard investment criteria. The relatively short payback period (1.5 years) further suggests that capital invested in production assets is recovered rapidly

through operating cash flows. This performance reflects a financially sustainable, production-intensive cost structure under current conditions. However, because profitability is largely determined by production costs and regulatory burdens, fluctuations in input prices and export-related expenses may significantly affect margin stability. The enterprise’s reliance on raw material procurement and export-oriented pricing, therefore, exposes it to potential financial volatility. The enterprise’s dependence on raw material procurement and export-oriented pricing exposes it to potential financial volatility. Therefore, sensitivity analysis is necessary to evaluate how changes in revenue and cost assumptions affect overall financial feasibility, as shown in Table 5.

Table 4. Profitability analysis and financial feasibility of seaweed enterprise in East Java

Analysis	Unit	Amount
Profitability Analysis		
BEP sales	IDR.	3,419,917,431
Profit	IDR.	14,465,084,319
Profit Margin	%	29.07
R/C		1.4
Profitability	%	25
Financial Feasibility (Discount Rate 6%, 10-Year Period)		
NPV	IDR.	96,400,379,525
Net B/C		1.30
IRR	%	60.36
PP	Year	1.5

Note: BEP = Break-Even Point

Table 5. Sensitivity analysis of the seaweed enterprise in East Java

No.	Assumptions	(%)	NPV (IDR)	Net B/C	IRR (%)
1	Increased Costs	31	-1,452,599,400	0.98	5.0
2	Decreased Benefits	22	-3,729,915,004	0.98	5.1
3	Increased Costs	14	-2,750,148,687	0.99	3.8
	Decreased Benefits	13			

Sensitivity analysis is an important tool in investment evaluation, as it helps identify critical variables that influence project feasibility under changing economic conditions [44]. By simulating variations in key parameters, such as costs and revenues, this approach enables an assessment of financial robustness and risk exposure.

Table 5 shows that the enterprise is financially sensitive to significant changes in both cost and revenue parameters. With a 31% increase in costs, the NPV becomes negative, the Net B/C ratio falls below 1, and the IRR drops below the discount rate, indicating that the project no longer meets feasibility criteria. A similar outcome occurs when benefits decrease by 22%, at which point NPV becomes negative, and investment indicators fail to meet the minimum thresholds. When moderate cost increases (14%) are combined with revenue reductions (13%), the feasibility indicators deteriorate further, confirming that simultaneous shocks amplify financial vulnerability.

This sensitivity can be explained by the enterprise’s cost structure, in which a large proportion of total expenditure is allocated to raw materials, processing, and regulatory obligations. Because these components are directly linked to

production volume and export requirements, increases in input prices or compliance-related costs can significantly reduce margins. The enterprise's strong dependence on raw material procurement further exposes it to input price volatility, while export-oriented pricing limits its flexibility in passing cost increases on to buyers. As a result, even moderate changes in cost or revenue can substantially affect financial feasibility, consistent with studies showing that variations in key parameters can significantly alter investment outcomes [19]. In addition, dependence on export-oriented markets exposes the enterprise to price volatility and demand uncertainty, which constrains its ability to adjust output prices. This condition amplifies the negative impact of combined cost increases and revenue declines, as the interaction between these factors accelerates margin erosion and reduces financial resilience. Similar patterns have been observed in fisheries value chains, where economic performance is strongly influenced by value chain structure, market dependency, and price transmission mechanisms [45-47]. These findings suggest that the root cause of financial sensitivity lies in the combination of a cost-intensive value chain and limited pricing power within the market.

Based on the value chain configuration, cost structure, revenue structure, and sensitivity analysis, several value chain restructuring pathways can be identified to enhance the enterprise's economic sustainability. Process restructuring is a primary priority, as operational activities account for the largest share of total costs; this can be achieved through improved raw material utilization, process optimization, and reduced material losses to stabilize margins. At the same time, procurement restructuring is essential to reduce exposure to input price volatility by establishing long-term supplier partnerships, diversifying sourcing, and improving inventory planning. Enhancing revenue resilience also requires product restructuring, involving a shift from a purely volume-based approach toward value-oriented strategies; in line with the enterprise's export-oriented marketing practices, expanding product differentiation through higher-value processed products, quality grading, and branding, as well as optimizing digital promotion and participation in international trade exhibitions, can improve market positioning and value capture. In addition, market restructuring may focus on expanding market access and strengthening export networks to reduce dependence on specific buyers and improve revenue resilience. Better management of regulatory and export-related costs is also necessary to reduce financial pressure, particularly through more efficient compliance planning and coordination with export stakeholders. Given the high sensitivity identified in the analysis, strengthening financial resilience through cost-monitoring systems, financial buffers, and adaptive pricing strategies is critical to mitigate the impact of cost and revenue fluctuations. These strategic directions are consistent with findings that competitiveness in agri-food value chains is enhanced through process upgrading, product differentiation, and stronger coordination among value chain actors [40, 48, 49].

4. CONCLUSION

This study demonstrates that the sustainability of a seaweed processing enterprise is structurally determined by its value chain configuration. The dominance of operational costs (64.64%) and regulatory obligations (25.15%) indicates a

production- and compliance-driven system, while the concentration of fixed capital in processing machinery (95.06%) confirms that competitiveness is primarily anchored in transformation efficiency and quality control.

Based on the vulnerabilities identified through the value chain, cost structure, and sensitivity analyses, several value chain restructuring pathways can be proposed to strengthen the enterprise's economic sustainability. Procurement restructuring may focus on strengthening coordination with suppliers across multiple sourcing regions and improving quality control at the sourcing stage to reduce supply uncertainty and maintain raw material consistency. Process restructuring may emphasize greater efficiency in sorting, drying, and processing activities, where operational costs are concentrated. Product restructuring may involve developing higher-value seaweed products and quality-grading systems to reduce dependence on volume-based revenue. Market restructuring may focus on expanding export market networks and strengthening the use of digital marketing platforms and trade exhibitions to diversify market access. These restructuring pathways are derived from the key vulnerabilities identified in the enterprise's value chain and financial performance, particularly its dependence on operational efficiency, raw material procurement, and export market conditions.

The enterprise shows strong financial performance under current conditions, supported by its ability to generate sufficient returns and recover capital investment. However, sensitivity analysis reveals a high level of financial vulnerability, as the enterprise becomes infeasible under cost increases of 31% or revenue declines of 22%, particularly when both occur simultaneously. This finding indicates that profitability is highly dependent on the stability of raw material prices, export market conditions, and effective regulatory cost management.

These conditions place the enterprise within a relatively narrow resilience margin, where sustainability can only be maintained through disciplined operational efficiency and stable external conditions. To address this vulnerability, strengthening procurement coordination, improving operational cost control, and enhancing market diversification are critical strategies to enhance financial resilience.

This study contributes to understanding how value chain structure and financial dynamics interact to shape the sustainability of small-scale export-oriented enterprises. It highlights that long-term economic sustainability in resource-based industries depends not only on profitability but also on the ability to manage cost volatility, market uncertainty, and regulatory pressures within an integrated value chain system.

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