Development Strategy of Red Seaweed Industry (*Rhodophyta*) in the Poleang Minapolitan Cluster Bombana Regency

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ABSTRACT

Indonesia is the world's largest producer of red seaweed, but its utilization as a source of economic growth is still not optimal, as evidenced by the large amount of exports in raw form, insufficient land utilization, and harvest yields that do not meet standards. This study aims to formulate development strategies for the red seaweed industry in the Poleang sub-district of Bombana Regency through the identification of internal and external conditions. Data was collected through observation, interviews, and questionnaires. The analysis used includes descriptive, financial, and SWOT analysis. The results of the study show that the red seaweed industry in Poleang still faces various challenges, such as red seaweed production that does not meet standards, unstable production volumes, seaweed processing plants operating below full capacity, low educational levels among farmers, limited market access and capital resources for farmers, the absence of structured farmer groups, the suboptimal role of financial institutions, climate and weather changes, pests and diseases, and highly volatile seaweed prices. However, there are also significant development opportunities, such as the availability of extensive cultivation areas conducive to seaweed growth, a sufficient labor force, experienced farmers, relatively easy seaweed marketing, simple cultivation techniques, the availability of tissue culture technology and processing industries, profitable cultivation efforts with an RC ratio of 1.94, and the significant potential of the red seaweed market and its processed products both domestically and internationally. Strategies that can be implemented for the development of the red seaweed industry in the Poleang Sub-district cluster of Bombana Regency include optimizing seaweed production through resource optimization, improving productivity and production quality, enhancing the role and functions of institutions, increasing human resource capacity, promoting the use of high-quality seeds, and establishing and strengthening partnership and marketing patterns for seaweed.

Keywords: Internal and external condition; minapolitan area; red seaweed industry; SWOT

INTRODUCTION

Indonesia, as an archipelagic country with a coastline of 99,093 km and a water area of 3.2 million km, has enormous marine biological resources (Directorate General of Aquaculture, Ministry of Marine Affairs and Fisheries, 2019). One of the biological commodities with great potential for development is seaweed. According to the FAO (2021a), Indonesia is the second-largest seaweed producer in the world, holding a 27.81% share of the global market with a production volume of 9.9 million tons in 2019.

Seaweed can generally be classified into three main divisions based on the pigments they contain:

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Rhodophyta (red seaweed), Phaeophyta (brown seaweed), and Chlorophyta (green seaweed). According to FAO data (2021a), until 2010, brown seaweed production dominated with 11.1 million tons, surpassing red seaweed, which reached 8.9 million tons. However, by 2019, this ratio had changed, with total red seaweed production increasing significantly to 18.2 million tons, compared to brown seaweed, which reached 16.3 million tons (FAO, 2021). This increase in red seaweed production was driven by high industrial demand for hydrocolloid compounds such as carrageenan and agar. These compounds function as gelling agents, thickeners, stabilizers, suspending agents, protective agents, film formers, syneresis inhibitors, and flocculating agents, which are commonly used in the food, cosmetic, textile, and printing industries (Prajapati et al., 2014; Saha & Bhattacharya, 2010; Yuan et al., 2014; Cao et al., 2021; Ooi et al., 2015; Moenne & Gonzalez, 2021; Amin et al., 2022; Maruyama & Seki, 2022; Chopin & Tacon, 2020).

Indonesia is the world's leading producer of red seaweed (*Eucheuma*, *Kappahycus*, *Gracilaria*) with a total production of 9.92 million tons in 2019 (Kambey et al., 2020) and is the only country besides China capable of producing more than 100,000 tons of *Gracilaria* red seaweed (FAO, 2021). Southeast Sulawesi Province is one of the main red seaweed-producing provinces in Indonesia, with a cultivation potential of 83,000 hectares (Directorate General for Strengthening the Competitiveness of Marine Products and Fisheries Ministry of Marine Affairs and Fisheries, 2021). In 2022, red seaweed production in this region reached 313,146 tons with an economic value of IDR 1.48 trillion (KKP, 2022). According to Ministry of Marine Affairs and Fisheries statistical data from 2022, Bombana Regency, particularly Poleang District, is one of the largest contributors to red seaweed production in Southeast Sulawesi, with a total production of 19,306 tons.

Indonesia can be said to have a strong position and significant market potential in the red seaweed commodity. However, this potential has not yet been fully utilized, as a significant portion of seaweed exports are in raw form without processing (dried seaweed), resulting in low added value. In 2019, the value of Indonesia's processed red seaweed exports reached only USD 110 million, trailing behind France (USD 144 million), Chile (USD 123 million), Spain (USD 138 million), the Philippines (USD 214 million), and China (USD 523 million). According to Zhang et al (2023), in 2021, approximately 65% of Indonesia's red seaweed was exported in dried form, while only 35% was used for domestic processing industries. Therefore, the orientation of red seaweed utilization as raw material must be changed and directed toward optimizing processing into a product with higher added value through the development of the red seaweed industry.

The red seaweed-based minapolitan area is a government initiative to support the creation of a sustainable red seaweed industry by establishing a balanced economic and social ecosystem and ensuring environmental sustainability. Bombana Regency and the Poleang District cluster are minapolitan area designated through Ministerial Decree No. 35/2013 and Regency Regulation No. 8/2013. However, its implementation still faces challenges such as production fluctuations, suboptimal utilization of cultivation land, low harvest quality, and slow development of the marine economy due to limitations in infrastructure, institutional capacity, and human resource quality.

Every challenge that arises in the development of the red seaweed industry is always related to every aspect of the internal and external factors of the red seaweed agribusiness system. If a problem occurs in one aspect, it will have an impact on other aspects. Therefore, the development of the red seaweed industry in the minapolitan cluster of Poleang District, Bombana Regency, needs to be carried out by considering the potential strengths and carrying capacity, opportunities for excellence, and problems from every internal and external aspect. Based on this background, this study was conducted to determine the conditions and formulate appropriate alternative strategies for the development of the red seaweed industry in the minapolitan cluster of Poleang District, Bombana Regency.

METHODS

Framework

The development of the red seaweed industry is inseparable from the interrelationship between each aspect of internal and external factors in the seaweed agribusiness system. Problems in one aspect can affect other aspects. Therefore, a comprehensive approach is needed, taking into account the potential support, opportunities, advantages, and obstacles of each aspect. This study will examine the current state of the red seaweed industry in the Poleang sub-district cluster of Bombana Regency through the identification of internal factors, namely production, human resources, marketing, finance, technology, and institutional frameworks (Raissa et al., 2014; Setyaningsih, 2011; Fatonny et al., 2023). Meanwhile, external factors comprise political, governmental,

and legal considerations, as well as environmental, economic, technological, and informational influences (Raissa et al., 2014; Setyaningsih, 2011; Fatonny et al., 2023). The subsequent development strategy will be formulated using the SWOT approach, which aims to optimize strengths and opportunities while systematically reducing weaknesses and threats.

Types and Sources of Data

This study uses primary and secondary data. Primary data was obtained through field observations, interviews, and questionnaires with stakeholders involved in the development of the red seaweed industry in the Poleang subdistrict cluster of Bombana Regency. Secondary data was obtained from journals, institutional data, articles, books, government publications, and relevant previous reports.

Data Collection Methods

The data for this study was collected through field observations, interviews, and questionnaires. The initial stage began with identifying the conditions of the red seaweed industry in the Poleang sub-district of Bombana Regency through observations and interviews to explore perceptions and information about the internal and external conditions of the red seaweed industry. The respondents consisted of 40 people, including 32 seaweed farmers, 5 seaweed traders, 1 fisheries extension officer, and 2 representatives from the relevant government agency, with each interview lasting 30–60 minutes per respondent. The second stage involved formulating development strategies through an assessment by five experts. The assessment was conducted using a questionnaire based on a 1-4 scale to measure the influence of internal and external factors. Subfactor values were obtained from the average expert assessments, while subfactor weights were calculated by dividing the total factor value.

Data Analysis

This study is descriptive in nature with a mixed method approach (qualitative and quantitative) (Sugiono, 2014). Qualitative analysis was used to identify the condition of the red seaweed industry, while quantitative analysis through questionnaires was used to assess the feasibility of cultivation and formulate a development strategy for the red seaweed industry in the minapolitan cluster of Poleang District, Bombana Regency, using financial and SWOT analysis.

Financial analysis aims to assess the profitability and feasibility of red seaweed cultivation in the Poleang District cluster. These are the formulas used:

Total cost is calculated using Equation 1.

$$TC = VC + FC \quad (1)$$

TC = Total Cost (IDR/cycle)
VC = Variable Cost (IDR)
FC = Fixed Cost (IDR)

Total revenue is calculated using Equation 2.

$$TR = P \times Q \quad (2)$$

TR = Total Revenue (IDR/cycle)
P = Price (IDR/kg)
Q = Quantity (kg)

Profit is calculated using Equation 3.

$$\Pi = TR - TC \quad (3)$$

Π = Profit
TR = Total Revenue
TC = Total cost

Revenue cost ratio (R/C) is calculated using Equation 4.

$$R/C = \frac{Total\ Revenue\ (TR)}{Total\ Cost\ (TC)} \quad (4)$$

R/C = Business Feasibility
TR = Total Revenue
TC = Total cost

Break even point (BEP) is calculated using Equation 5.

$$BEP = \frac{Fixed\ Cost\ (TR)}{(Price\ (P) - Variable\ Cost\ (VC)} \quad (5)$$

BEP = Break Even Point
P = Price
VC = Variable Cost

SWOT analysis is a method for identifying internal factors (strengths and weaknesses) and external factors (opportunities and threats) in formulating strategies to achieve objectives. According to David (2017), the process of formulating strategies through SWOT consists of three stages. The first stage is the input stage, which involves identifying and assessing internal and external factors using the IFE and EFE matrices. The next stage is analysis to determine the position of the business using the IE matrix and grand strategy. The final stage is decision making, which involves formulating alternative strategies using the SWOT matrix.

Table 1. Internal conditions of red seaweed industry in Poleang Sub-district minapolitan cluster area

Internal factors	Strengths	Weakness
Production aspect	1. There is a large red seaweed cultivation area available. 2. The condition of the waters/cultivation areas is perfect to support the growth of red seaweed.	1. Red seaweed production results do not meet standards. 2. The production volume of red seaweed is unstable. 3. Red seaweed processing factory is not running at full capacity.
HR aspect	3. Plenty of labor/available. 4. The cultivator has substantial experience.	4. The education level of cultivators is still low.
Marketing aspect	5. Marketing dried red seaweed is relatively easy.	5. Cultivator market access is limited.
Financial aspect	6. Red seaweed cultivation business is profitable	6. The cultivator's capital resources are limited.
Technological aspects	7. There is tissue culture technology to produce quality red seaweed seeds. 8. The methods for cultivating red seaweed are easy and simple.	
Institutional aspects		7. A structured group of cultivators has not yet been formed. 8. The role of capital institutions is still not optimal.

RESULTS AND DISCUSSION

Conditions for the Development of Red Seaweed Industry

Internal Conditions (Strengths and Weaknesses)

The identification of internal conditions includes determining strengths and weaknesses of red seaweed industry in Poleang Sub-district cluster. The internal conditions in this research are divided into six aspects, namely production, human resources, marketing, finance, technology, and institutions.

Production aspect

Production aspects are key internal factors in the development of the red seaweed industry. Ministry of Marine Affairs and Fisheries (2022) statistical data shows a fluctuating trend in red seaweed production in the Poleang District Cluster during 2019-2022. This is influenced by the repeated use of seeds and limited access to capital. These findings align with the findings of Masad et al. (2021) and Sudirman (2020), who stated that the use of repeated seeds can reduce the productivity and quality of red seaweed, while limited capital can hinder increases in production and income for farmers.This production instability impacts the performance of the red seaweed processing plant in the Poleang District Cluster, PT. Inti Nusa Raya Indonesia, which can only process 1-2 tons of red seaweed per day out of its capacity of 10-12 tons per day. Additionally, the failure to meet quality standards for red seaweed harvests, such as moisture content and carrageenan levels, results in farmers' harvests having low market value and being unable to be absorbed by the factory. This is due to the poor harvesting and post-harvest handling processes carried out by farmers, such as harvest age that does not meet the SNI 2690 2015 standard (45 days) and poor seaweed drying methods. These findings align with Abidin's (2018) statement that harvesting and post-harvest handling that do not meet standards can reduce the quality and added value of red seaweed that can be obtained.

However, the Poleang subdistrict cluster also has great potential for increasing red seaweed production because it is supported by suitable water conditions and the availability of extensive cultivation land. The water conditions meet the SNI 7579.2:2010 standard with a land potential of 1,199 ha (Bombana Regency Marine and Fisheries Service, 2021b)

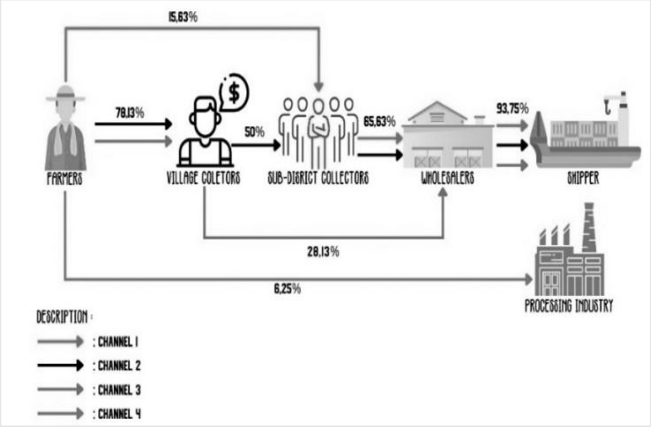

Figure 1. Red seaweed marketing channels in Poleang Sub-district Cluster

Human resources aspect

The quantity and quality of human resources are important elements in the development of the red seaweed industry. In Bombana Regency, red seaweed cultivation has become a major commodity and source of income for the coastal community, with around 1,163 households dependent on this sector (Mansyur, 2021). Data from the Bombana Regency Central Statistics Agency (2022) shows that there are 10,829 workers in the seaweed cultivation sector, with 56.99% or 6,172 people located in the Poleang District cluster. This result indicates that there is a significant availability of labor to support the development of the seaweed industry in the Poleang District cluster.

In terms of educational attainment, the quality of education among farmers in the Poleang District cluster remains relatively low, with the majority having only completed primary school education (59.38%). According to Annisa (2022), low educational attainment may limit the adoption of innovations. However, the farmers' experience is quite adequate, with 68.75% of farmer respondents having more than 10 years of experience, which indicates knowledge and skills in farming.

Marketing aspect

In the Poleang subdistrict cluster, there are four marketing channels, with seaweed purchases generally made directly at the farmers' homes, so farmers do not need to worry about transportation costs. Collectors at the village and subdistrict levels do not set specific quality standards such as harvest age, moisture content, or gel strength, but assessments are only made through simple sorting based on dryness and cleanliness. Most farmers are indebted to collectors for capital, which limits their market access and leaves them as price takers. However, transparency in price information among business actors prevents price manipulation, ensuring that the prices received by farmers remain in line with current market standards.

Financial aspect

The financial analysis in Table 2 shows that the average production cost per cycle of red seaweed cultivation is IDR 6,294,122, with revenue of IDR 12,223,906 and net profit of IDR 5,929,748 per cycle. The R/C ratio of 1.94 indicates that this business is profitable, where every IDR 1 spent generates a net profit of IDR 1.94. This result is consistent with the research by Naufal et al. (2022), which states that seaweed farming is profitable, achieving an R/C ratio of 1.32 in seaweed cultivation. The BEP analysis shows that the break-even point is reached at sales of IDR 2.07 million or 149.24 kg of seaweed. With revenue and production volume exceeding the BEP value, the red seaweed cultivation business in the Poleang sub-district cluster is deemed viable for implementation and development.

Most farmers in the Poleang subdistrict cluster access capital through village and subdistrict collectors using a patron-client system. In this system, farmers are informally bound to sell their harvest to capital providers. This scheme is chosen because it is considered easier and does not require collateral or interest compared to formal institutions such as banks, which are seen as complicated, require collateral, and charge interest. The limited access to capital causes farmers to depend on collectors as their only financing option.

Technological aspect

Red seaweed cultivation is a relatively simple process that requires minimal technical expertise. The essential equipment includes a motorboat and basic cultivation tools such as ropes, buoys, and repurposed bottles. Considering the rising demand for this commodity, both domestically and internationally, adopting the right cultivation technology is very important to ensuring large-scale production that meets quality standards. In response to this growing demand, Bombana Regency government has introduced a significant innovation in Poleang Sub-district cluster by promoting the use of high-quality red seaweed seeds developed through tissue culture technology.

Institutional aspects

The formation of farmer groups is an effective strategy for improving human resource capacity

Table 2. Feasibility and an average profit of red seaweed cultivation business *E. cottoni* per cycle in Poleang Sub-district cluster.

No	Description	Unit	Values
1	Production	kg	830.31
2	Revenue		
	a. Cash revenue	IDR	12,223,906
	Total revenue	IDR	12,223,906
3	Fixed cost		
	a. Tool depreciation	IDR	1,153,810
	Total fixed costs	IDR	1,153,810
4	Variable costs		
	a. Seeds	IDR	4,112,500
	b. Labor	IDR	915,313
	c. Fuel	IDR	112,500
	Total variable costs		5,140,313
5	Total cost	IDR per cycle	6,294,122
6	Profit	IDR per cycle	5,929,784
7	R/C ratio		1.94
8	BEP	IDR	2,077,748

because through farmer groups, members can exchange information related to technical issues in farming, market access, and assistance with capital and production facilities (Hermawan et al., 2017). However, in the Poleang subdistrict cluster, there are no structured farmer groups, so the flow of information, technology, and extension activities is hampered. From a financial perspective, support from formal institutions such as banks and the government remains limited. As a result, farmers prefer to borrow from middlemen. The low utilization of banking services by farmers is due to challenges such as distance, complex administrative procedures, and difficult-to-meet collateral requirements.

External Conditions (Opportunities and Threats)

The identification of external conditions is very important for assessing the opportunities and threats faced by red seaweed industry in Poleang Sub-district cluster minapolitan area of Bombana Regency. In this research, external conditions are categorized into four key aspects, namely political, governmental, legal, environmental, and economic, as well as research and development aspects.

Political, government, and legal aspects

One form of the government's commitment to supporting the development of the national seaweed industry is the issuance of Presidential Regulation No. 33 of 2019, which outlines the development of a self-reliant, competitive, and sustainable national seaweed industry. At the regional level, the Bombana Regency government has established a seaweed processing plant in the Poleang District cluster as part of efforts to support local industrial growth and the development of a tissue culture laboratory to address seedling shortages and provide high-quality seedlings for seaweed farmers.

Environmental aspects

Environmental factors are the main cause of crop failure in seaweed cultivation. Crop failure is usually caused by strong winds, high waves, and unpredictable rainfall (Rohman et al., 2018; Fatonny, 2021). Inappropriate environmental conditions cause stress in the seaweed, reducing intracellular protective substances and triggering the release of organic compounds that stimulate bacterial growth and cause ice-ice disease in red seaweed species such as *E. cottoni* and *E. spinossum*. The symptoms of this disease are characterized by white spots on the thallus, causing it to become brittle and easily broken when hit by waves. Interview results indicate that during the western season (December-February), seaweed growth in the Poleang sub-district cluster tends to slow down and becomes more susceptible to disease attacks. These findings align with Maryunus (2018) findings, which state that during the west monsoon season, there is a decrease in salinity and an increase in seawater turbidity due to the mixing of seawater with freshwater caused by heavy rainfall, resulting in seaweed being more susceptible to disease and hindering its growth.

Economic aspects

Global demand for red seaweed is expected to continue to increase every year. This is driven by industrial demand for hydrocolloids such as carrageenan and agar (Waters et al., 2019). In 2019, the demand for hydrocolloids reached 12 million tons and is projected to grow by 9.2% during the 2020-2027 period, with the market value expected to reach USD 12.116 million by 2031 and a CAGR of 8.8% (Directorate General for Strengthening the Competitiveness of Marine Products and Fisheries Ministry of Marine Affairs and Fisheries, 2021). In Indonesia, there are 41 red seaweed processing companies with an annual production capacity of 68,604 tons, but in 2021, only 42%

Table 3. External conditions of red seaweed industry in the Minapolitan cluster area of Poleang Sub-district

External factors	Opportunity	Threat
Political, government, and legal aspects	1. There is strong support from the central and regional governments for the development of red seaweed industry.	
Environmental aspects		1. Climate change and weather 2. Pests and diseases
Economic aspects	2. Demand for red seaweed and its processed products in global and national markets continues to increase.	3. Red seaweed prices are very volatile
Research and development aspects	3. There are developments in technology and knowledge to support the development of red seaweed industry.	

of this was processed. This indicates significant market and economic potential in Indonesia, particularly in the Poleang sub-district cluster, to increase value added and export earnings through enhanced production and export of processed red seaweed.

The selling price of red seaweed is a crucial factor in trade and business sustainability. High price fluctuations can harm all stakeholders in the supply chain, and for farmers in particular, it can lead to income instability and reduced production.

Research and development aspects

Advances in science, technology, and information can contribute positively to the development of the red seaweed industry. Currently, research has been conducted by various institutions, governments, research institutions, and universities related to the cultivation, content, and utilization of red seaweed. Advancements in technology and knowledge play a role in enhancing the productivity of cultivators, the quality of harvests, and the competitiveness of Indonesia's red seaweed industry.

Red Seaweed Industry Development Strategy

Evaluation of Internal and External Factors

An evaluation of internal and external factors was conducted to identify the strengths and weaknesses of internal aspects, as well as the opportunities and threats of the external environment that affect the sustainability and development of the red seaweed industry in the Poleang District cluster of Bombana Regency through the IFE matrix, EFE matrix and IE matrix.

IFE Matrix (Internal Factor Evaluation)

IFE was carried out with the aim of evaluating the strategic subfactors of each internal factor. The obtained results are presented in Table 4.

EFE Matrix (External Factor Evaluation)

EFE was carried out to evaluate the strategic subfactors in each external factor. The results of the evaluation are presented in Table 5.

IE Matrix (Internal-External)

Based on the matching of the total IFE matrix score (3.64) as the X-axis and EFE (3.79) as the Y-axis, the position of the red seaweed industry in the Poleang District cluster on the IE matrix is in cell I, which reflects the grow and build phase. The recommended strategy for this phase is an intensive strategy, such as market penetration through market access expansion, market development by improving product quality, and product development through seaweed processing diversification to increase added value. Additionally, to strengthen its competitive position, the industry can implement integration strategies, including backward integration, forward integration, and horizontal integration. The results of the position evaluation using the IE matrix can be seen in Figure 2 below.

Formulation of Alternative Strategies

Alternative strategies in this study were formulated through SWOT analysis aligned with the IE matrix results, which led to intensive strategies. The SWOT matrix in Table 6 produced six recommendations for the development strategy of the red seaweed industry in the minapolitan area of the Poleang Subdistrict Cluster, Bombana Regency, namely:

SO strategy (Maximizing strengths to take all opportunities)

The optimization of red seaweed production through the efficient utilization of resources (S1, S2, S3, S4, S5, S6, S7, S8, O1, O2, O3). This can be achieved by maximizing the use of available resources, expanding cultivation areas in correspondence with land capacity

Table 4. Evaluation Results of Internal Factors for the development of red seaweed industry in the Minapolitan cluster area, Poleang Sub-district, Bombana Regency

No	Internal Factors	Source					Total Value	Weight (a)	Rating (b)	Score (axb)
		NS1	NS2	NS3	NS4	NS5				
	Strength (S)									
1	There is a large seaweed cultivation area available	4	4	4	4	4	20	0.07	4	0.28
2	The condition of the waters/ cultivation areas is very good to support the growth of seaweed	4	4	3	4	4	19	0.07	3.8	0.25
3	Labor is plentiful/available	3	3	4	4	4	18	0.06	3.6	0.23
4	The cultivator has a lot of experience	4	4	4	3	4	19	0.07	3.8	0.25
5	Marketing dried seaweed is relatively easy	4	4	4	3	4	19	0.07	3.8	0.25
6	Seaweed cultivation business is profitable	4	4	4	4	4	20	0.07	4	0.28
7	There is tissue culture technology to produce quality seaweed seeds	4	4	4	4	4	20	0.07	4	0.28
8	The techniques for cultivating seaweed are easy and simple	4	3	4	4	4	19	0.07	3.8	0.25
	Total Score Strenght									2.07
	Weakness (W)									
1	Red seaweed production results do not meet standards	4	4	4	4	4	20	0.07	4	0.28
2	The production volume of red seaweed is unstable	4	4	4	3	3	18	0.06	3.6	0.22
3	Seaweed processing factory is not running *at capacity*	4	4	3	4	4	19	0.07	3.8	0.25
4	The education level of cultivators is still low	2	2	3	3	3	13	0.04	2.6	0.12
5	Cultivator market access is limited	4	4	3	3	3	17	0.06	3.4	0.20
6	The cultivator's capital resources are limited	3	3	3	3	4	16	0.06	3.2	0.18
7	A structured group of cultivators has not yet been formed	3	3	3	3	3	15	0.05	3	0.16
8	The role of capital institutions is still not optimal	3	3	3	3	3	15	0.05	3	0.16
	Total Score Weakness									1.57
	Grand Total Internal Factor						287	1.00		3.64

Table 5. Evaluation Results of Internal Factors for the development of red seaweed industry in the Minapolitan cluster area, Poleang Sub-district, Bombana Regency

No.	Faktor Internal	Source					Total Value	Weight (a)	Rating (b)	Score (axb)
		NS1	NS2	NS3	NS4	NS5				
	Opportunity (O)									
1	There is strong central and regional government support for the development of seaweed industry	4	4	4	4	4	20	0.18	4	0.71
2	Demand for seaweed and its processed products in global and national markets continues to increase	4	4	4	4	4	20	0.18	4	0.71
3	There are developments in technology and knowledge to support the development of seaweed industry	4	4	4	3	4	19	0.17	3.8	0.64
	Total Score *Opportunity* (O)									2.05
	Threat (T)									
1	Climate and weather change	4	4	3	3	4	18	0.16	3.6	0.57
2	Pests and diseases	3	4	3	3	3	16	0.14	3.2	0.45
3	Seaweed prices are very volatile	4	4	4	4	4	20	0.18	4	0.71
	Total Score *Threat* (T)									1.73
	Grand Total External Factors						113	1.00		3.79

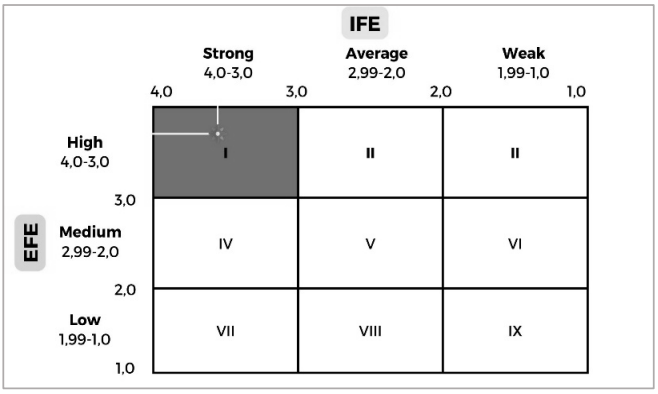

Figure 2. IE Matrix Analysis Results

and labor availability, implementing appropriate regulations and policies, as well as fully leveraging government assistance and support.

WO strategy (taking advantage of opportunities to minimize weaknesses)

Increase the productivity and quality of red seaweed (W1, W2, W3, W4, O1, O3). Improvements in seaweed productivity and quality can be achieved through the application of appropriate technologies such as the use of tissue culture seedlings and suitable cultivation methods. Support in the form of technical guidance and intensive supervision by the relevant agencies is also crucial in ensuring harvest standards and post-harvest handling, such as the appropriate harvest age and drying methods. Enhancing the role and function of cultivator institutions (W5, W6, W7, W8, O1). Intensification of extension programs, training, and information dissemination by relevant agencies plays an important role in improving the independence, skills, and knowledge of farmers. The formation of structured joint business groups, cooperatives, and village-owned enterprises (BUMDes), accompanied by business and financial management training, can also strengthen access to markets and sources of financing.

ST strategy (utilizing strengths to avoid threats)

Enhancing human resource capacity (S3, S4, T1, T2). This can be achieved through counseling and guidance on scheduling seaweed planting cycle.

Table 6. SWOT matrix of red seaweed industry development strategies in Poleang Sub-district cluster minapolitan area of Bombana Regency

Internal / External	Strength (S)	Weakness (W)
	1. There is a large seaweed cultivation area available 2. The condition of the waters/cultivation areas is very good to support the growth of seaweed 3. Labor is plentiful/available 4. The cultivator has a lot of experience 5. Marketing dried seaweed is relatively easy 6. Seaweed cultivation business is profitable 7. There is tissue culture technology to produce quality seaweed seeds 8. Seaweed cultivation techniques are easy and simple	1. Red seaweed production results do not meet standards 2. The production volume of red seaweed is unstable 3. Seaweed processing factory is not running at full capacity 4. The education level of cultivators is still low 5. Cultivator market access is limited 6. Cultivator capital resources are limited 7. A structured group of cultivators has not yet been formed 8. The role of capital institutions is still not optimal
Opportunity (O)	SO	WO
1. There is strong support from the central and regional governments for the development of seaweed industry. 2. Demand for seaweed and its processed products in global and national markets continues to increase. 3. There are developments in technology and knowledge to support the development of seaweed industry.	1. Optimize red seaweed production through optimization of resource utilization (S1, S2, S3, S4, S5, S6, S7, S8, O1, O2, O3)	2. Increase the productivity and quality of red seaweed (W1, W2, W3, W4, O1, O3) 3. Improving the role and function of cultivator institutions (W5, W6, W7, W8, O1)
Threat (T)	ST	WT
1. Climate and weather change 2. Pests and diseases 3. Seaweed prices are very volatile	4. Increasing the capacity of human resources (S3, S4, T1, T2) 5. Massive use of quality seeds (S1, S2, S7, T1, T2)	6. Build and strengthen partnership patterns and seaweed marketing (W3, W5, W6, T3)

For example, during the western season, cultivators should reduce the use of stretch ropes or switch to cultivating *E. spinosum*, which is more resistant to environmental fluctuations and has relatively affordable seed prices. This is particularly important because establishing a structured planting schedule can help cultivators plan effectively, thereby minimizing the risk of crop failure and financial losses. Additionally, experienced farmers can share insights on selecting optimal cultivation sites during unfavorable seasons to further mitigate risks. Expanding the use of quality seeds (S1, S2, S7, T1, T2). Utilizing high-quality seeds is an effective strategy for preventing harvest failures and improving seaweed quality. In this context, tissue culture technology, which

produces resilient seeds capable of withstanding seasonal and weather fluctuations as well as pests and diseases, should be widely adopted. Moreover, the vast cultivation areas, which are highly conducive to seaweed growth, can be optimized by developing specialized nurseries dedicated to producing seedlings of the appropriate age and quality.

WT strategy (minimizing weaknesses while overcoming threats)

Building and Strengthening Partnership Patterns and Seaweed Marketing (W3, W5, W6, T3). Establishing strong partnerships among actors in the red seaweed cultivation supply chain can foster a positive and sustainable business culture. Cultivators need market certainty and price stability, while collectors, exporters, and processing industries need guarantees of continuity and consistent raw material quality.

CONCLUSION

The red seaweed industry in the Poleang District cluster of Bombana Regency has great potential for development but faces challenges that still need to be addressed. Internal challenges include production that does not yet meet standards, unstable production volumes, limited processing capacity, and institutional and human resource weaknesses. Externally, challenges include weather changes, pest and disease attacks, and price fluctuations. Despite these challenges, the Poleang Sub-District cluster has extensive and suitable cultivation areas for seaweed growth, a skilled workforce, experienced cultivators, technology, and a large market potential. Recommended development strategies include optimizing resources, improving productivity and quality, strengthening institutional capacity and human resources, and developing partnerships and marketing.

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CONFLICT OF INTEREST

The authors declare no conflict of interest with any party regarding this article.

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