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Leverage Factors Affecting the Sustainability of Seaweed Agro-industry Development in Central Sulawesi, Indonesia

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ABSTRACT

There has been a decline in seaweed prices in Central Sulawesi in the last five years, particularly in the processing and marketing sub-systems. The processing problems have constrained the volume of market demand. In contrast, marketing problems have disturbed the fulfillment of industrial and consumer demand for raw materials, thereby declining economic activity and profit. This research aimed to examine the leverage factors affecting the sustainability of the seaweed agro-industry integrated between sub-systems in Central Sulawesi Province. The collected numerical and non-numerical data were analyzed using the multidimensional scaling approach of the RAP-Seaweed technique. The results revealed that social conflict, labor absorption, the low value-added of the seaweed processing, and the high cost of raw material procurement caused the unsustainable development of the seaweed agro-industry. Therefore, government policies are required to facilitate investment in the seaweed industry, supported by enhancing the quality of transportation infrastructure, the use of local workers, and the security stability of the local area.

Keywords: Multidimensional factors; Processing industry; Seaweed Sustainability

INTRODUCTION

The seaweed industry in Indonesia is still facing various problems, such as low productivity, low-quality standards of seaweed at the cultivator level, low bargaining power of cultivators against traders and processors, high transportation costs, low level of processing technology, and the issues of creating domestic value-added (Nuryartono et al., 2021; Sutinah, Riniwati, Sahidu, & Suryani, 2020). Fluctuation in fishery commodity prices becomes a phenomenon in production center areas. The problems of commodity price fluctuations are caused by the limited infrastructure for transportation, information, processing industries (Hidayat & Safitri, 2019), and commodity marketing institutions (Nor, Gray, Caldwell, & Stead, 2020). Such problems also occur in the Province of Central Sulawesi; seaweed production is the third largest and contributes 90.19% of the total production of marine and coastal aquaculture in Indonesia. The data depict that the decline

in seaweed prices at the cultivator level in Central Sulawesi began in 2014, ranging IDR 5,000 – 6,000 per kilogram, and then increased to IDR 14,000 per kilogram in 2020 (Dinas Kelautan dan Perikanan, 2021). Total seaweed production in this province was 925,339 tons in 2019, lower than the 2018 production of 1,136,458 tons, with seaweed production centers covering Banggai Islands, Morowali and Parigi Moutong Regencies (BPS-Statistics of Sulawesi Tengah Province, 2020).

The infrastructure of seaports and airports in Central Sulawesi is still limited, being in the category of national scale and not international, resulting in the limited flow and volume of trade in goods. Likewise, there is no seaweed processing industry on medium and large scales, except for the food and beverage processing industry on a household scale. The decline in seaweed prices at the cultivator level has also been triggered by the decreasing volume of exports to China, Japan, Korea and several other importing countries and the relatively low prices set by importing countries (Saputro, Nuryartono, Arifin, & Zulbainarni, 2021). The low seaweed prices are due to the goods being sold in raw material and not semi or refined carrageenan (Purnomo et al., 2021). The low seaweed prices, especially *Eucheuma cottonii*, have caused a decrease in the motivation of cultivators and seaweed production. The decline in production is also caused by the low quality of seawater around the cultivation area, triggering the development of pests and diseases of seaweed. The low quality of coastal water results from mining activities on land, which during the rainy season, surface water flows bring the soil to the coast and cause turbidity (Campbell et al., 2019). These problems indicate that the inhibiting factors for the implementation of seaweed industrialization are caused by multidimensional factors, such as aquaculture environment, cultivation technology (Buschmann et al., 2017), distribution channels and logistics, availability of processing industry, institutional support (government and marketing), and the unintegrated activities among seaweed business actors (Picaulima, Hamid, Ngamel, & Teniwut, 2016).

In other words, increasing the value-added of the seaweed commodity through the development of processing industries is necessary to improve the welfare of seaweed business actors, especially cultivators. The obstacles to the seaweed agribusiness development are the upstream agribusiness sub-system, and cultivators do not obtain superior seeds (Eranza, Bahron, Alin, Mahmud, & Malusirang, 2017). Meanwhile, to develop appropriately, seaweed cultivation requires seeds with a high growth rate and are disease resistant (Zamroni, Laoubi, & Yamao, 2011). In the cultivation sub-system, cultivators do not possess enough knowledge about cultivation methods (Alemañ, Robledo, & Hayashi, 2019), including that of land suitability, cultivation construction, superior seed selection, cultivation techniques, prevention, and control of ice-ice disease, as well as harvest and post-harvest methods. Apart from that, the cultivators' bargaining position for supporting sub-system is also weak due to the absence of the processing industry, weak trading, and marketing systems, as well as an unorganized logistics and distribution system causing price fluctuations (Muthalib, Putra, Nuryadi, & Afiat, 2017).

The lack of integration between sub-systems in the seaweed agribusiness in Central Sulawesi demonstrates that the industrialization development of this commodity has not

been well planned. Due to the decreased production and fluctuations in seaweed prices at the cultivator level, the low production value can affect the sustainability of the seaweed industry and the welfare of businesspeople, especially cultivators (Hidayat & Safitri, 2019). Therefore, the development of the seaweed industry requires integration between upstream, production (on-farm), and downstream sub-systems to enhance the added value of the seaweed commodity (FAO, 2018; Yong, Chin, Thien, & Yasir, 2014).

In order for value-added from seaweed cultivation to be obtained from business actors in the downstream sub-system (processing and marketing) and mutual support between dimensions, studies are highly required to reveal the essential factors in the dimensions of ecological, economic, social, technological and institutional development (Mulyati & Geldermann, 2017), influencing the sustainability of seaweed industrialization in Central Sulawesi Province with Multidimensional Scaling (MDS) approaches. These essential factors are expected to be the basis for consideration for the government in planning programs and activities for the seaweed industry development.

One of the MDS approaches aimed at sustainable development is the Rapid Appraisal for Fisheries (RAPFISH) technique, applied to sustainable management of fisheries resources in five dimensions of ecological, economic, social, technological, and ethical (Lam, 2016; Pitcher et al., 2013; Pitcher & Preikshot, 2001). Meanwhile, studies on the sustainability of the seaweed processing industry are limited, except for those aimed at the sustainable aspects of seaweed cultivation management (Irfan, Abdullah, Yuliana, Samadan, & Subur, 2020; Marzuki, Nurjaya, Purbayanto, Budiharso, & Supriyono, 2014), aspects of seaweed product processing and semi-product processing (Han, Zhang, Ma, & Liu, 2012), and seaweed marketing network (FAO, 2018). Therefore, this study aimed to examine the leverage factors affecting the sustainability of the integrated seaweed agro-industry development between sub-systems and business actors in Central Sulawesi Province.

RESEARCH METHOD

The study area included the producing and processing seaweed center regencies in Central Sulawesi Province, comprising Banggai Islands, Morowali, Parigi Moutong, Banggai, and Palu City. The research object included all stakeholders in the seaweed industrialization development in this province, such as seaweed cultivators, distributors (traders), product processors, and staff of the Provincial and Regency Marine Affairs and Fisheries Offices to dig up information about the regional seaweed agro-industrial development policies. Given the breadth of the research study, the selection of research objects was carried out by purposive sampling by considering the representation of each research object, such as cultivators, traders, processors, industry, and the government. Seaweed cultivators were selected to determine the production capacity in the field, represented by 20 cultivators. The selection of cultivator respondents employed a simple random sampling method. Other respondents comprised two sample collectors from Mepanga District, Parigi Moutong Regency, five micro and small seaweed processing industries from Palu City, one Marine

Affairs and Fisheries Office staff of Central Sulawesi Province, and one staff each from the Marine Affairs and Fisheries Offices of Parigi Moutong and Banggai Regencies.

Research data were sourced from primary and secondary data, both quantitative (numeric) and qualitative (non-numeric). Primary data were sourced from interviews with samples of cultivators and seaweed processors, while secondary data were obtained from the department and literature studies, especially those related to the distribution of results, types of processing industries, and supporting policies from the government. The data collected to answer the research objective were based on five dimensions: seaweed raw material management (stock, distribution, and logistics), economic, social, processing technology, and institutions formed or influenced by several attributes or factors affecting sustainability. Some of these factors included the availability and price of seaweed industrial raw materials, technology types, the availability and price of production inputs for processing, warehousing and distribution, market availability, information on the price of processed products, industry and marketing actors, and the institutional role by the government in program implementation.

The method used to analyze crucial factors influencing the sustainability of seaweed agro-industry development in Central Sulawesi Province was the Rapid Appraisal for Fisheries (RAPFISH) technique (Kavanagh & Pitcher, 2004; Pitcher & Preikshot, 2001). The use of the RAPFISH technique was modified in such a way that the attributes in each dimension were adjusted to attributes that conceptually and empirically could affect the sustainability of the seaweed processing industry. Modification of the RAPFISH technique for the development of seaweed agro-industry was termed RAP-Seaweed. The dimensions used in the study of the sustainability of the development of the seaweed agro-industry were adapted from Picaulima et al., (2016), consisting of the dimensions of raw material management (natural resources), economy, social, technology, ethics (Lam, 2016) and institutions (Irfan et al., 2020), derived into several levels of sustainability. The analysis stages in the RAP-Seaweed technique as proposed by (Kavanagh & Pitcher, 2004) were as follows:

1. Determination of the leverage factors of each dimension was based on literature studies or the results of previous research for coastal resource management criteria (Stelzenmüller et al., 2013), as well as logistics and processing. Meanwhile, the attributes of each dimension were determined by selecting two to three attributes with a high level of importance (leverage).
2. Scoring all factors in the categories of "bad", "good", and "intermediate". The scoring of each attribute applied an ordinal measurement scale (de Afus, 2022), divided into four categories: a score of 3 mean very good; 2 was indicate good; 1 was signify bad; and 0 imply very bad.
3. Ordination of RAP-Seaweed included: (a) Rating the main horizontal reference points for the "bad" category (0% score) and the "good" category (100% score), (b) determining other main reference points, namely the "midpoint", and a vertical reference point or referred to as an "anchor" useful for stabilizers, (c) standardizing scores on each attribute

to have uniform weights to eliminate differences in measurement scale, and (d) calculating the distance between reference points using the Euclidean distance square method (seuclied).

4. Estimating the sustainability index of seaweed agro-industry development in the range of 0% - 100% and dividing it into four categories of sustainability status. The four categories of sustainability status were poor or unsustainable (0 -25.0%), less sustainable (25.01 - 50.0%), moderately sustainable (50.1 - 75.0%), and good or sustainable categories (75.1 - 100.0%).
5. Analysis of sensitivity was carried out to determine which factors were dominant in influencing changes in the sustainability index of seaweed agro-industry development. The sensitivity strength of each factor can be seen from the "Root Mean Square" (RMS) value on the X-axis. In simple terms, RMS can be formulated as follows:

$$RMS=\sqrt{\sum_{i=1}^{n}\frac{(Vf_i-Va_i)^2}{n}} \quad (1)$$

Va_i was the actual data value, Vf_i was the forecast value, and n showed the number of the attribute.

6. The scoring validity and the accuracy measurement of the RAP-Seaweed analysis results utilized three test tools: (1) based on the value of the standardized residual sum of the square (stress) calculated using the following formula (Pitcher & Preikshot, 2001):

$$Stress=\sqrt{\frac{1}{m}\sum_{k=1}^{m}\left[\frac{\sum_i\sum_j\left(d_{ijk}^2-o_{ijk}^2\right)^2}{\sum_i\sum_j o_{ijk}^4}\right]} \quad (2)$$

where d_{ijk} was the squared distance; O_{ijk} was the origin point in dimensions (i, j, k); and m showed the number of dimensions. It is valid and accurate if the "stress" value is less than 0.20; (2) the coefficient of determination (R^2) is above 50.00%; and (3) the results of the Monte Carlo ordinance are good if obtaining a narrow interval value. The results of the RAP-Seaweed analysis disclosed a "stress" value of 0.14 (stress<20%), a coefficient of determination (R^2) of 95.28% (>50%), and the results of the Monte Carlo ordinance acquired almost the same value for both parameters, namely 47.79% for scatter, and 47.75% for scatter plots. Thus, the scoring and results of the RAPFISH ordinance have met the statistical requirements of the leverage attribute built and implemented for further policies in the seaweed agro-industry development in Central Sulawesi Province.

RESULT AND DISCUSSIONS

Determination of the Factors and Scoring

The results of scoring the attributes of each dimension of seaweed agro-industry development are exhibited in Table 1.

TABLE 1. DETERMINATION OF THE FACTORS PER DIMENSION AND SCORING

Dimensions and factors	Existing data factor	Score
Dimension of raw material management		
- Production and adequacy of raw materials	Central Sulawesi Province ranks third for seaweed producers in Indonesia	3
- Distribution and continuity raw materials	The sea highway distribution is relatively smooth	2
- Environmentally friendly processing	The industry is still on a household scale with a clear SOP	1
Economic dimension		
- Raw materials procurement cost	The cost of procurement of raw materials is 75% of the total cost	1
- Value-added per unit type of processing	Limited ATC Chip processing and generally food processing	1
Social dimension		
- Status and frequency of conflict around industrial sites	Frequency of conflict at industrial sites: twice in the last five years	2
- Absorption of labor around industrial locations	Employment of 1-2 people per home industry (10 - 20%)	1
Technological dimension		
- Differentiation of processed products	Types of processed seaweed products: food, tortilla, and ATC chip	1
- Research and Development (R&D) ability to create new products	Two products are resulting from R&D in the last five years, namely seaweed flour and SRC-RC	1
Institutional dimension		
- Agro-industry development program policies	There are warehouses/depots and processing industries with warehouse receipt systems available	3
- Basic infrastructure development policies	Access to roads, electricity, telecommunications, and clean water	2

According to the statistical data on aquaculture listed in Table 1, Central Sulawesi had become the third-largest seaweed-producing province in Indonesia, thus having a score of 3. The availability of the coastal water area suitable for seaweed cultivation in Parigi Moutong Regency (three districts) was 61,615 ha. The level of utilization of coastal water for seaweed cultivation merely reached 12.06 percent (7,429.49 ha). Meanwhile, the use of seawater to support the availability of raw materials was 6,200 ha in Banggai Regency (in Pagimana, West Toili, and Bualemo Districts), and 670 ha in Poso Regency, specifically in Poso Pesisir. However, the distribution of cultivation products to industrial locations and marketing to Java took longer, up to 1-2 weeks, thus obtaining a score of 2. The processing of seaweed products was on a household industrial scale with clear standard operating procedures (SOP).

Regarding the economic dimension, the cost factor for the procurement of raw materials dominated the structure of processing production costs in the household industry. Being on a household industrial scale, the value-added was also low. On the other hand, the seaweed cultivation business implied that it was feasible to serve as an economic source for coastal communities. It is related to the general seaweed harvest being relatively short (40-45 days), low in production costs, and technically easy to cultivate. The source of seaweed seeds and institutional strengthening of cultivator groups comes from the assistance of the Indonesian Government, resulting in a significant increase in yield.

However, the decline and fluctuations in prices at the exporter level, due to the relatively long chain of seaweed commodity marketing in this region, where the marketing actors involved cultivators, village-level collectors, district collectors, district traders, wholesalers, and exporters, would lead to the low feasibility effort at the cultivator level.

Price conditions, where the purchase price of dried seaweed by collectors has fluctuated in the range of IDR 6,000 - 13,500 per kg in the last five years, currently has reached IDR 15,000 - 18,000 per kg. The price of the seaweed commodity can increase if the marketing chain is shorter or only involves cultivators and exporters or the processing industry as the final marketing agency (Muthalib et al., 2017). In short, an increase in the value of profit at the processing industry level can provide a high multiplier effect in cultivation financial feasibility.

Regarding the social dimension, the status and frequency of conflict were relatively low. However, the labor absorption rate was still low at the processing industry level than at the cultivation level, which tended to be high because it involved family and outside workers (Ginigaddara, Lankapura, Rupasena, & Bandara, 2018; Laapo & Howara, 2016). The absorption of labor in the seaweed industry was extremely limited, considering the scale of the existing processing industry still being a home industry. Seaweed processing training programs for home industries have also been carried out. However, limited consumers have caused the production capacity also to be limited. From the cultivators' point of view, the increase in productivity and quality of seaweed is obtained from long experience in cultivation activities, as well as the introduction of technology from outside parties to change their mindset and skills (Hussin, Yasir, Kunjuraman, & Hossin, 2015).

From the perspective of the technological dimension, the development of seaweed research and development by universities and other Research and Development institutions in Central Sulawesi Province was limited in its types and applications to entrepreneurs, merely research on carrageenan content, making biscuits from seaweed flour and making fish feed (Nuryartono et al., 2021). The quality factor of seaweed seeds could affect the quality of seaweed and processed seaweed. Generally, cultivators used local seeds, while superior seeds could only be obtained from government program assistance. The limited micro, small and medium scale seaweed processing industries in the downstream sub-system have caused limited product diversification and value-added.

On the other hand, from the government policy perspective, infrastructure such as electricity, telecommunications and water resources, transportation, licensing policies, and a Special Economic Zone (SEZ) for the location of infrastructure development for the agricultural and fishery processing industry in Palu City have been provided. However, in the last five years, fluctuations in production and pollution of the marine environment, extreme climate changes, earthquakes, declining prices for the seaweed commodity, the influence of global markets, and the COVID-19 pandemic had caused delays in investment for processing industries, and some seaweed cultivators left this business for other works such as mining workers.

Sustainability of Seaweed Agro-Industry

The results of the RAP-Seaweed technique on the sustainability status of seaweed agro-industry development in Central Sulawesi Province are displayed in Figure 1.

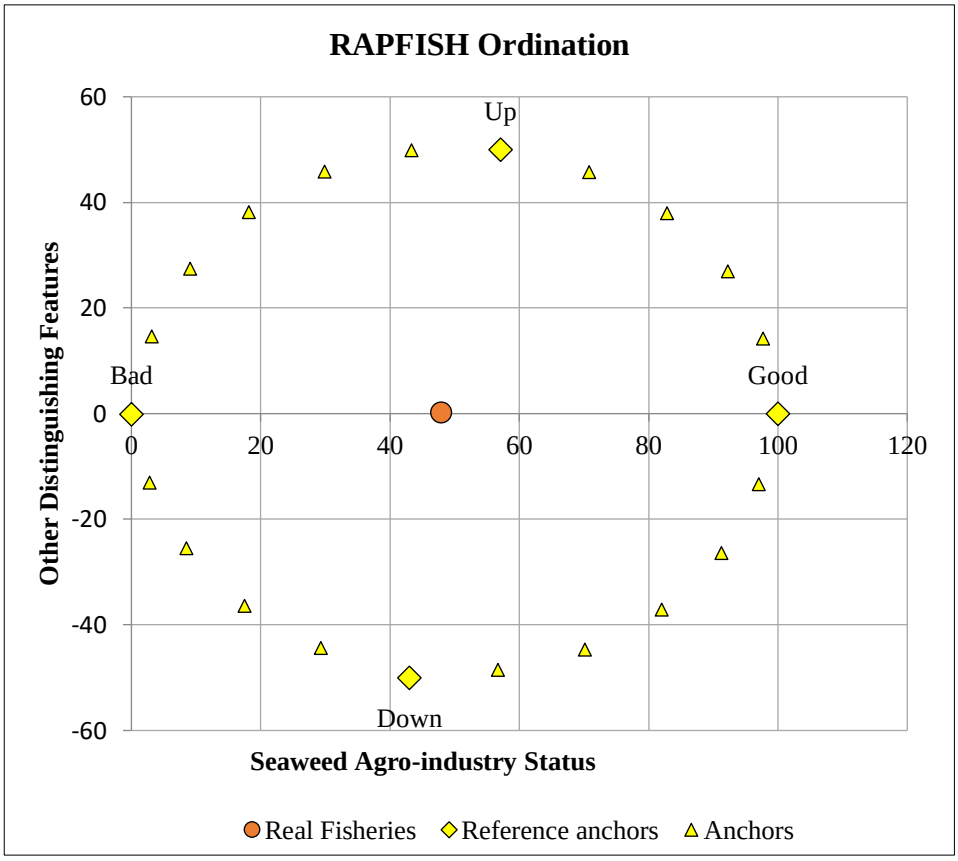

FIGURE 1. SUSTAINABILITY INDEX OF SEAWEED AGRO-INDUSTRY DEVELOPMENT

Figure 1 displays the sustainability index value of seaweed agro-industry development in Central Sulawesi Province reaching 47.92%, indicating a less sustainable category. In other words, the implementation of the seaweed industrialization program has not been optimal. The economic and technological dimensions had an insufficient level of achievement (obtaining an average score of 1). The achievement of raw material and social management dimensions was in the moderate category, while the institutional dimension provided better achievement for supporting the improvement of the sustainability status or sustainable category. The development of the program was not only production-oriented but was also accompanied by the preparation of infrastructure and regulations for the seaweed processing industry, such as energy availability, optimizing the utilization of existing industrial areas and complicated investment licensing processes.

Several essential attributes influencing the sustainability index of the seaweed industry development in Central Sulawesi Province are depicted in the following figure. Figure 2 depicts one dominant factor influencing the sustainability of agro-industry development—the status and frequency of social conflict, a factor in the social dimension requiring serious attention from the government and all parties who play a role in maintaining regional security stability. The declined interest in investment in Central Sulawesi could be caused by a historical conflict in one regency affecting other areas. In addition to the social conflict factor, labor absorption has been a vital factor as well. It is related to the involvement of the surrounding community, which will be able to enhance employment and the community's

economy to reduce social conflict between the community and agro-industry companies. It was in line with (FAO, 2018), stating that the seaweed industry, through factory construction and the use of technology and innovation, was required to improve the regional and national economy by producing competitive and commercialized products in the international market. However, the labor absorption will be greater if followed by the growth of micro (household) and small-scale seaweed processing businesses by producing several products that consumers can consume directly. In order to increase the absorption of labor in this industry, both micro and small-scale businesses, it is necessary to increase the skills of local workers, especially female workers (Swanepoel et al., 2020). It was supported by other leverage factors, such as the need to differentiate processed seaweed products or increase value-added through improved manufacturing (Sarkar et al., 2017) to enhance industrial scale and employment.

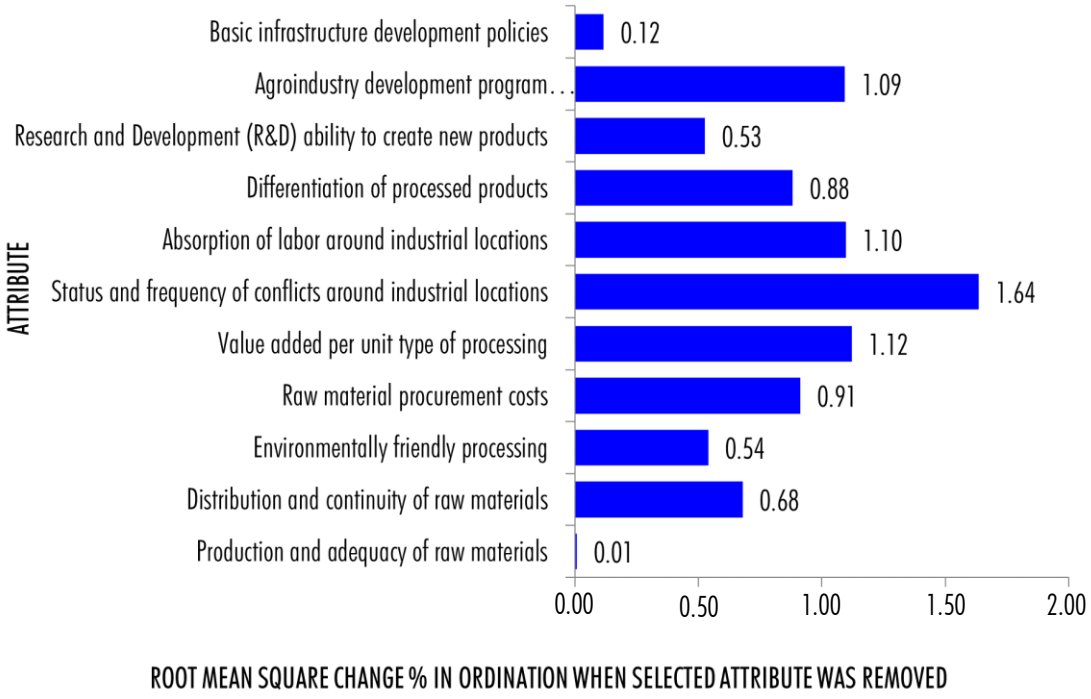

FIGURE 2. LEVERAGE FACTORS FOR THE SUSTAINABILITY OF THE SEAWEED AGRO-INDUSTRY

In terms of the economic dimension, the factor of increasing value-added from processing has affected the sustainability of the seaweed agro industry. This condition requires efficient processing technology that can diversify the resulting products. On the technical side, increasing value-added requires the quality of seeds to improve the quality of processed carrageenan (Yong et al., 2014), processed products and food safety. The lack of processing industry, the weak bargaining position of aquaculture in trade, as well as an irregular logistics and distribution system have led to fluctuations of seaweed prices (van Den Burg, Dagevos, & Helmes, 2021), especially with the large number of speculators appearing during the over production (Marzuki et al., 2014; Megyesi, Kelemen, & Schermer, 2011; Voulgaris & Lemonakis, 2013). Diversification of processed seaweed products is

aimed at increasing added value in order to reduce the impact of fluctuations in seaweed commodity prices at the farmer level (Rimmer et al., 2021).

Other research findings on the leverage factors of the institutional dimension indicate that the seaweed agro-industry development policy programmed by the local government requires consistency in its implementation to provide logistics infrastructure, transportation, and ease of investment. Meanwhile, the leverage factor related to the high cost of procuring raw materials was caused by the long market distribution chain pattern from cultivators to processors. It greatly affected the bargaining position of the products produced by cultivators, resulting in an unaccepted added value of the products by cultivators (Purnomo, Subaryono, Utomo, & Paul, 2020).

The five crucial factors above are mutually supportive, related to each other and can affect the sustainability status of the seaweed agro industry. Other factors affecting the low sustainability of seaweed agro-industry development are market uncertainty and seaweed export policies, generally in raw materials causing the low commodity prices (Muthalib et al., 2017). It has implications for increasing the government's role in facilitating the market supply of processed seaweed products through investment cooperation (partnerships) between cultivators and medium and large-scale processing industries (Laapo & Howara, 2016). Institutional roles in the seaweed industry were necessary both at the level of cultivators and processing industries. The role of the cultivator group through the group leader is to facilitate, motivate and mobilize its members to increase productivity and commodity marketing to help them become price takers in the market. On the other hand, social and communication relationships are formed as non-formal bonds between community members and providers of capital and as a container for seaweed harvests, commonly referred to as social capital(Megyesi et al., 2011).

Furthermore, increasing knowledge and skills of seaweed processing for local communities requires collaboration with research institutions and the development of appropriate technology (Blankenhorn, 2007; Ginigaddara et al., 2018). It agrees with Picaulima et al., (2016), stating that human resource development is required through formal and informal education programs directly associated with household-scale processing and processed products to help build business sustainability by avoiding nepotism and collusion. Simultaneously, the government should accelerate the preparation of basic infrastructure such as electricity, transportation infrastructure improvements, industrial estates complete with facilities and infrastructure to support increased production (van Den Burg et al., 2021), ease of doing business regulations, and maintain regional security stability.

In sustainable development, it is necessary to strengthen cooperation between the government as a facilitator, industrial workers, local communities, especially seaweed cultivators to monitor processing industry activities that will have an environmental impact in agro-industrial areas (Picaulima et al., 2016). The sustainability of a production system, especially in the processing of agricultural products, according to (Brissaud, Frein, & Rocchi, 2013), rests on three things: (1) production systems through the use of technological

innovations (research) to produce high added-value products; (2) linkages between sub-systems in the production system; and (3) collaboration of actors, either directly or indirectly in the production system. While to Rebours et al., (2014), collaboration between stakeholders in the seaweed industry throughout the project area is needed in all aspects related to seaweed production, research, ecosystem services, management of artisanal and small-scale aquaculture; traditional markets, and alternative economic sources.

CONCLUSION

The essential leverage factors of the sustainable status of the seaweed agro-industry were security disturbances. The security disturbance caused social conflict between communities around industrial estates and household micro-scale seaweed processing businesses. Increasing labor absorption from communities around the processing business was one of the measures to alleviate these issues. Moreover, it was necessary to enhance distribution and transportation technology to reduce the cost of procuring raw materials and increase the value-added of products. Government policy is immensely required to support preparing logistics, transportation infrastructure and easy investment in seaweed processing factories and small industries.

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