

Development model of agroindustry-based seaweed export in Southeast Sulawesi Province, Indonesia

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Abstract. Southeast Sulawesi Province is one of the major seaweed cultivation centers in Indonesia. However, it is important to emphasize that since 2020, the province has experienced a significant decrease in seaweed production, and this has impacted its prospects for future development. Typically, the widespread development of seaweed is closely associated with the enthusiasm of coastal communities for engaging in its cultivation. Considering the potential profits and added value, production volume can significantly influence the community's selling price and this is primarily because the marketing focus is on the export market and agroindustry, both domestically and internationally. Therefore, this research aims to thoroughly analyze agroindustry-based export development model and its potential to make Southeast Sulawesi Province independent in exporting seaweed, while also increasing the added value received by cultivators in the long term. The investigation was carried out in the scope of two regencies, namely South Konawe and Bombana. These locations were selected based on production numbers and Southeast Sulawesi Provincial Maritime Affairs and Fisheries Office's plans to develop marine cultivation centers in the areas. The analysis incorporated the adoption of an exponential comparison method, which was used to determine design priorities for agroindustry-based seaweed export management. The obtained results showed that three alternative decisions could be adopted when developing agroindustry-based export centers in Southeast Sulawesi Province. These decisions include (1) Priority decisions to improve quality by enhancing cultivation technology, drying methods, and seed quality, (2) Priority decisions on the export independence strategy by strengthening partnerships and cooperation, improving the quality of human resources, and increasing cultivator capital, (3) Priority decisions on export products design, with a focus on alkali treated cottonii (ATC) and semi refined carrageenan (SRC).

Key Words: aquaculture, cooperation, cultivation, priority.

Introduction. The coast is an area that can be used for various economic activities, including aquaculture, fishery product processing, fisheries-based tourism, and trades. In the aquaculture business, seaweed is a primary commodity. This is evidenced by the fact that the product has been observed to serve as a major economic pillar for coastal communities, increase employment rate, as well as increase sources of regional and state income. Over the last decade, the national seaweed production in Indonesia has shown a significant increase, from a total production of 391,506 tons in 2012 to 9,234,267.61 tons in 2022, with the highest production of 11,269,341.65 tons in 2015 (Ministry of Marine Affairs and Fisheries 2023). It is important to state that the national output and production values generally reflect the conditions of seaweed production in Southeast Sulawesi Province. However, the seaweed production rate of the province has recently

experienced a more significant decrease (Department of Maritime Affairs and Fisheries of Southeast Sulawesi Province 2023).

Seaweed production value in Southeast Sulawesi Province from 2010 to 2021 is shown in Figure 1.

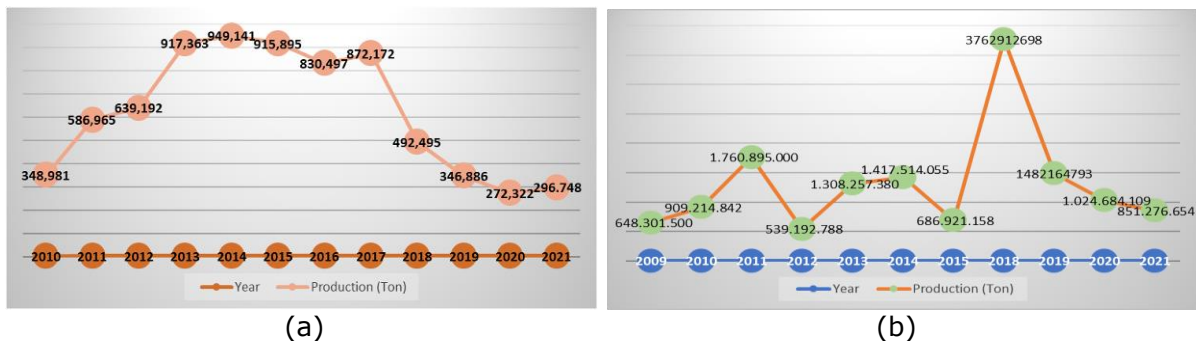


Figure 1. Production (a) and production value (b) of Southeast Sulawesi Province seaweed business in 2010-2021 (Department of Maritime Affairs and Fisheries of Southeast Sulawesi Province 2023).

The decrease in seaweed production in Southeast Sulawesi Province, as shown in Figure 1, indicates that there are problems in the cultivation process and these problems can occur due to the presence of pests and diseases, low water biosecurity and a low seed quality (Campbell et al 2022). Furthermore, the decrease experienced proved that the competitiveness in Southeast Sulawesi Province is still low. This fluctuation was possibly caused by certain marketing factors, or the lack of implementation of export quality standards in the cultivation process and post-harvest handling. The increase in added value has also not been optimal, even though approximately 80% of national fisheries exports can be accounted for by seaweed exports (Saleh & Sebastian 2020). According to Nuryadi et al (2017), seaweed problems are partly caused by the inefficient management of businesses at the cultivator level, which is still primarily focused on production aspects and not yet based on agribusiness activities. Despite the observed associated problems, seaweed cultivation still has the potential to increase the community's economy because of its easy cultivation process, which requires low capital, and its fast harvest time (Ferdouse et al 2018; Zainudin 2020). As stated by Miller (2021), the enactment of policies can ensure the realization of sustainable fisheries development, prioritize economic benefits, prioritize the interests of local and rural communities, and reduce legal obstacles in managing businesses. The decrease in production can also be attributed to the decreasing interest of coastal communities in its cultivation as well as certain environmental problems in several areas leading to low selling prices and unmet continuity of demand. Typically, the cultivation methods used by the community are still generally traditional and do not have production standards that can be viewed as a reference for other cultivators when carrying out cultivation activities (Nuryadi et al 2020).

Seaweed cultivation is a business that comprises various complex aspects, is associated with different problems in terms of management, and faces several challenges. Regardless of these facts, its potential benefits for the economy are very significant. Therefore, this research aims to thoroughly analyze agroindustry-based export development model and its potential to make Southeast Sulawesi Province independent in exporting seaweed and increase the added value received by cultivators in the long term. The investigation further serves to meet the needs of business actors and cultivators to increase business capacity and obtain increased production and income. It also aims to meet the needs of the government and private institutions in planning and decision-making processes, specifically those made in efforts to promote export-oriented seaweed agribusiness activities in the province.

In Indonesia, the export of seaweed commodities has been observed to experience a significant increase in volume and export value yearly. The number and values of exports are presented in Figure 2.

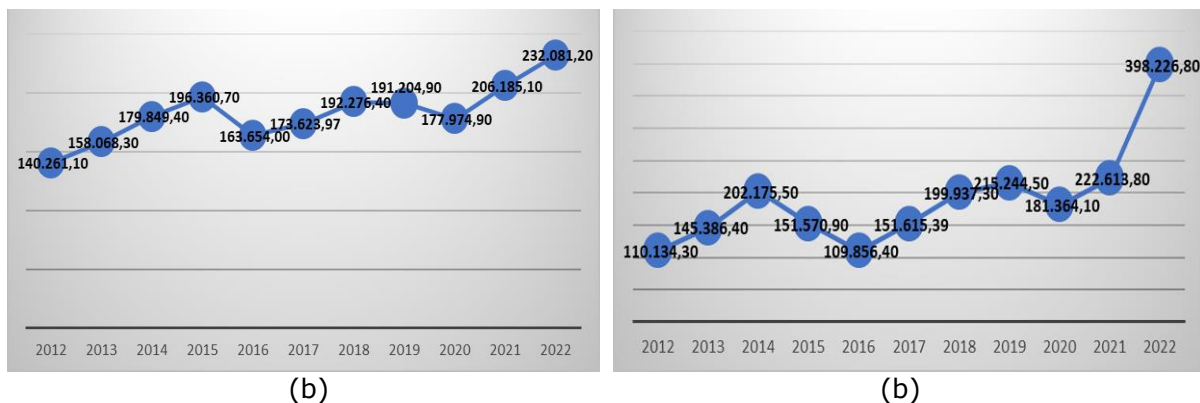


Figure 2. (a). The number of national seaweed exports 2012-2022; (b) The value of national seaweed exports 2012-2022 (Ministry of Maritime Affairs and Fisheries of Indonesia 2023).

Figure 2 shows that over the years, the global demand for seaweed has experienced a significant increase, and this is evidenced by the increasing trend observed regarding the subject matter. The observation emphasizes the presence of a huge opportunity for the Southeast Sulawesi Province. It serves as an encouragement for seaweed business owners in the research area to increase production rate, while also improving the quality of the product to meet export needs. Therefore, this research aims to examine the export-oriented agroindustry-based seaweed agribusiness system in Southeast Sulawesi Province by formulating a priority analysis for business development.

Material and Method

Description of the research areas. This research comprises two regencies namely South Konawe and Bombana. The selection of these areas was based on four considerations including Southeast Sulawesi seaweed production data by district/city in 2020, the 2018-2038 Coastal Area and Small Islands Zoning Plan Document (RZWP3K), and the plan to develop seaweed centers in Southeast Sulawesi Province (Department of Maritime Affairs and Fisheries of Southeast Sulawesi Province 2020).

The research data was obtained through several stages which include stakeholder identification and initial survey, direct interviews with seaweed business actors at the cultivation and marketing levels, and preparation of production facilities. Additionally, focus group discussions (FGDs) with experts were conducted to gather relevant input and corrections to the research results and to refine the resulting model concepts. The investigation included the participation of 60 respondents, comprising seaweed cultivators, traders, cultivator groups, exporters, and experts from academia, practice, and bureaucracy.

Other alternatives and criteria decisions used in determining the model are as follows:

1. Improving seaweed quality:
 - a. in this regard, the alternatives include improving cultivation technology, seed quality, harvesting systems, storage systems, and shipping methods;
 - b. the criteria include technological updates, technology, human resource readiness, cost readiness, and ease of implementation.
2. Export independence:
 - a. alternatives include increasing factors such as the quantity and continuity of production, production quality, business facilities and infrastructure, cultivator capital, human resources quality, and institutions, as well as strengthening partnerships and collaborations;
 - b. criteria include effectiveness, usefulness, potential regional original income, cultivator needs, and potential success.

3. Seaweed export product design:
 - a. alternatives, in this context, include alkali treated cottonii (ATC), semi refined carrageenan (SRC), refined carrageenan (RC), and dried seaweed;
 - b. criteria include market opportunities, selling price, added value, potential for success, technological readiness, and human resource readiness.

Statistical analysis. The resulting data were analyzed using multi-person evaluation (MPE) analysis. MPE is defined as a decision-making method that quantifies opinions on a specific scale. This method emphasizes assigning values to alternatives based on criteria, thereby assisting in decision-making by producing well-defined models with alternative values (Marimin 2004). MPE analysis is considered advantageous in the present research because it reduces bias by clearly showing priority orders. Accordingly, the steps in this decision-making process comprise (1) determining alternative decisions, (2) identifying decision criteria for investigation, (3) assigning relative importance to each criterion using a specific conversion scale in accordance with the decision-makers preferences, (4) evaluating the relative importance of each alternative decision, and (5) ranking the alternatives based on evaluated values.

Calculations using MPE method are as follows:

$$TN_i = \sum_{n=1}^m (RK_{ij})^{TKKj}$$

where: TN_i = total value of the i^{th} alternative;

RK_{ij} = the relative importance degree of the j^{th} criterion in the i^{th} decision choice;

$TKKj$ = the importance degree of the j^{th} relative criterion ($TKKj > 0$);

n = number of alternative decisions;

m = number of criteria decision.

Results and Discussion. The analysis results on several indicators for the development of agroindustry-based seaweed exports are described in the aspects of quality standardization, export independence, and export product design, as follows:

Improving seaweed quality. Quality is one of the determinants of the demand and selling value of seaweed for both domestic and foreign industrial needs.

The results of seaweed quality standardization strategy analysis are presented in Table 1.

Table 1

Alternative decision strategy for improving seaweed quality

| No. | Alternatives decision | Value | Priority |
|-----|--|-------|----------|
| 1 | Improving cultivation technology | 5.397 | 1 |
| 2 | Improving seed quality | 5.378 | 3 |
| 3 | Harvesting system improvements | 5.280 | 5 |
| 4 | Improving drying/drying methods | 5.380 | 2 |
| 5 | Improving warehousing and shipping methods | 5.327 | 4 |

MPE analysis results, as presented in Table 1, show that the primary effort to improve seaweed quality should be enhancements to the cultivation system, as evidenced by the effort's priority value of 5.397. Accordingly, the second in line of priority was observed to be improvements to drying and processing methods. The prioritization of improving cultivation technology emphasizes the various challenges faced by cultivators. According to Angadiredja et al (2011), a development strategy can be implemented by mapping and organizing cultivation areas, developing business systems, strengthening institutions, and empowering cultivators. In accordance, Henriques-Antipa & Carcamo (2019) emphasized the need for sustainable development efforts for small-scale cultivators due to concerns about net benefits, the unequal distribution of seaweed commodities, and the

lack of support for cultivators' sustainability. In the context of the blue economy, expanding cultivation businesses can increase cultivators' income, aid marine conservation, and promote environmental sustainability (Freitas et al 2022). Additionally, seaweed cultivation has been found to significantly enhance factors such as local income, cultivators' earnings, and community living standards (Muthalib et al 2017).

The selection of improving cultivation technology explains its critical role in maintaining the sustainability of the cultivation environment. Typically, technological aspects are closely related to economic and environmental factors and these aspects play a crucial role in determining the sustainability of seaweed cultivation. The present cultivation method predominantly used by the people of Southeast Sulawesi is the longline method, which has been in use for decades. This system is considered effective, easy to implement, and requires low investment costs. However, it has been observed to be associated with several challenges, including vulnerability to pest attacks and ice-ice disease due to temperature stress and surface salinity (Kasim et al 2016). In response to these challenges, a new cultivation system was devised, which incorporates the use of nets. This method offers high productivity, low investment costs, and protection from destructive pests and ice-ice disease (Kasim et al 2022). Figure 3 shows seaweed cultivation technology using longline and net systems.



Figure 3. Seaweed cultivation technology with longline technology (a) and net technology (b, c).

The second priority includes improving the drying method. This aspect is specifically crucial in preventing the contamination of seaweed from dust, sand, and uneven water content. Typically, improper drying can also lead to contamination by microorganisms such as fungi and mold, which significantly impacts seaweed quality.

The field survey results show that some cultivators still dry seaweed on sandy or dusty soil floors, and even on public roads, while others adopt para-para (parallel air drying) and hanging methods. According to Wabang et al (2022), the hanging drying method presents optimal results because it preserves seaweed base or stems during the drying process. Para-para method is considered effective and efficient, while the dome dryer method is known to potentially damage the dried seaweed (Wabang et al 2022).

Figure 4 shows the drying method cultivators use in Southeast Sulawesi Province.



Figure 4. (a; b) Drying on a sandy floor; (c) Hanging method drying; (d) Para-para method drying.

Export independence. This aspect was analyzed across seven alternative aspects of decision-making. These alternatives were selected with the aim of prioritizing actions that could enhance seaweed export capability of Southeast Sulawesi Province. The results of this analysis are presented in Table 2.

Table 2

Alternative decision strategy for export independence

| <i>No.</i> | <i>Alternatives decision</i> | <i>Value</i> | <i>Priority</i> |
|------------|---|--------------|-----------------|
| 1 | Increasing quantity and continuity of production | 5.397 | 5 |
| 2 | Increasing production quality | 5.375 | 6 |
| 3 | Improving business facilities and infrastructure | 5.357 | 7 |
| 4 | Increasing cultivator capital | 5.476 | 3 |
| 5 | Improving the quality of human resources | 5.479 | 2 |
| 6 | Improving the institutional system of cultivation | 5.461 | 4 |
| 7 | Strengthening partnerships and cooperation | 5.489 | 1 |

The analysis results presented in Table 2 show that the primary priorities for enhancing export independence in managing seaweed business include establishing partnership and cooperation systems, improving the quality of human resources, and upgrading the institutional framework. According to Setthasakko (2007), partnerships and cooperation are crucial for businesses dealing with commodities related to aquaculture. These alliances are intended to ensure market and price certainty for cultivators, thereby protecting against potential losses. The concept of partnership and cooperation was further emphasized by Neish (2007) where it was stated that approximately 60-70% of cultivators in Indonesia maintained binding relationships with collectors or inter-island traders.

The sustainability of seaweed cultivation businesses should be facilitated through integrated planning and the inclusiveness of relevant management bodies, including the government, the industrial sector, and cultivators, while also taking into account economic, institutional, and technological factors (Soejarwo et al 2019). The Indonesian seaweed supply chain generally operates through vertical collaboration among cultivators, traders, producers, and exporters (Mulyati & Geldermann 2017), and this has necessitated the development of institutions that provide capital, information, and supplies (Ramadan et al 2018). Additionally, Nuryadi et al (2017) emphasized the interconnectedness between traders and cultivators and the role of institutions in seaweed agribusiness system and explained the importance of enhancing institutional aspects as a priority. Anggadiredja et al (2011) further stated that the development of measures for strengthening institutions and empowering cultivators are crucial for achieving sustainability and increasing the value added in agroindustry sector, and cooperatives are identified as one of these essential institutions (Nuryadi et al 2020).

In the context of another investigation, Nuryadi et al (2019) emphasized the importance of strengthening the position of cultivators in developing seaweed agribusiness. This includes streamlining the marketing chain, facilitating access to capital through cooperatives and banks, and providing training and guidance from universities and government entities. Accordingly, Neish (2007) also laid emphasis on the potential for cultivators to empower one another by forming joint business groups (KUB) capable of facilitating the engagement of trading activities, including marketing, and exports.

Following the observations made, the second priority includes increasing human resources. This priority was evidenced by the obtained survey results where it was presented that a significant majority of seaweed cultivators had low educational attainment, with 68.29% of respondents having only completed elementary school. The limited education among cultivators poses challenges for business development as it can hinder the ability of individuals to absorb and adopt innovative advancements in cultivation technology and business systems. Considering these challenges, it becomes critical to enhance cultivators' knowledge. As stated in an investigation conducted in Malaysia, the low level of education among cultivators hampers the effective dissemination of government policies at the grassroots level (Kambey et al 2021). Romer (2012) further posited that economic growth was anchored by knowledge accumulation, continuous technological advancements, and industrial innovation, all of which were important for achieving sustained financial development.

Following partnerships and human resources, the third priority in the strategy to increase seaweed exports is strengthening the capital system. In the research area, cultivators were found to rely solely on two main models for capital. These models include self-financing and loans obtained from traders who purchase products. Analysis of the capital system shows that 73% of cultivators utilize borrowed capital, while 27% use self-funds. Based on this understanding, Natalia & Nurozy (2012) admonished banks to facilitate access to capital, as the measure can serve as a crucial step for enhancing competitiveness in the seaweed industry. Henriques-Antipa & Carcamo (2019), as well as Nuryadi et al (2023), further laid emphasis on the fact that ensuring the sustainability of seaweed availability required robust support for small-scale cultivators across various aspects, including funding, innovation, marketing, education, social justice, and infrastructure development.

Export product design. According to Wibowo et al (2014), processing dried seaweed into various forms such as ATC can increase its value by 5 times, into SRC increases value by 7 times, and into pure carrageenan in RC form can elevate value approximately 18 times. Based on this observation, inferences can be made that simply increasing seaweed production and prices does not necessarily lead to higher income for cultivators (Limi et al 2018). These products, whether in dry form or processed into ATC, SRC, or RC, can be exported for increased market value. The stages of seaweed products export are presented in Figure 5.

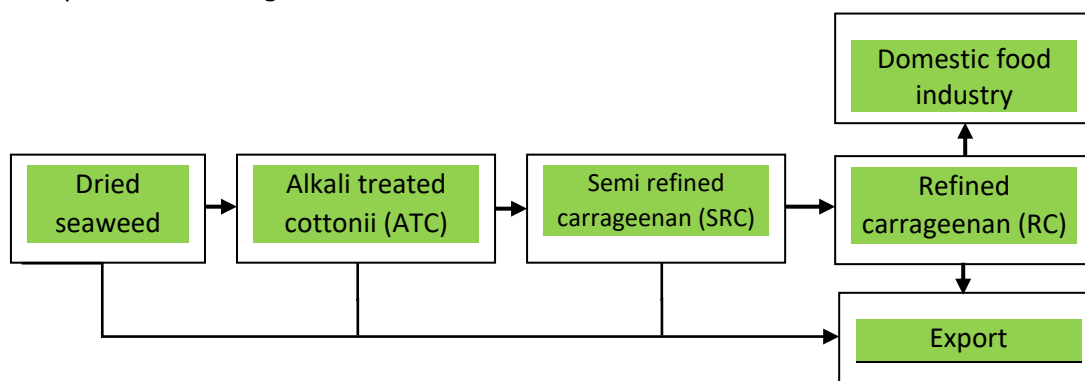


Figure 5. Types of seaweed product exports.

The analysis results of alternative decisions on the export product design are presented in Table 3.

Table 3
Alternative decision for seaweed export product design

| No. | Alternatives decision | Value | Priority |
|-----|--------------------------------|--------|----------|
| 1 | ATC (alkali treated cottonii) | 5.4544 | 1 |
| 2 | SRC (semi refined carrageenan) | 5.4508 | 2 |
| 3 | RC (refined carrageenan) | 5.3094 | 4 |
| 4 | Dried seaweed | 5.3221 | 3 |

The selection of ATC products as export priorities is associated with efforts that are aimed at accelerating raw material absorption, increasing added value, and leveraging the easier and faster processing compared to SRC and RC (Hendrawati 2014). Domestically, processing seaweed into ATC provides cost savings and efficiency in shipping or transportation, as carrageenan in chip form minimizes volume and weight compared to dried seaweed. Transportation costs for ATC can be reduced by 53%, and this process also decreases the risks associated with handling waste generated during its production in destination countries (Bank Indonesia 2011). Lastly, previous research conducted in Alaska showed effective seaweed management required policies that ensured fair and sustainable industry development, prioritize economic benefits and the interests of local

and rural communities, address legal obstacles, and promote cooperative business development (Miller 2021).

Conclusions. Alternative decisions for developing agroindustry-based seaweed exports in Southeast Sulawesi Province were as follows:

- priority decisions for improving seaweed quality. These decisions included measures developed specifically for improving cultivation technology, refining drying methods, and improving seed quality;
- priority decisions on the export independence strategy, comprising efforts for strengthening partnerships and cooperation, improving the quality of human resources, and increasing cultivator capital;
- priority decisions for the design of seaweed export products. These decisions focused on the production of commodities such as ATC and SRC.

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Conflict of interest. The authors declare that there is no conflict of interest.

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