

Improving Margins of the Indonesian Seaweed Supply Chain Upstream Players: The application of the Kaizen Approach

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Abstract. The margin obtained at the upstream in the Indonesian commercial seaweed supply chain is generally small and makes the motivation for business development low. The research aimed to identify the opportunities to overcome these problems. The research conducted with the Kaizen analysis approach that seven upstream business nodes were chosen at three locations: two *Gracilaria* sp. farmers and one *Gracilaria* sp. trader in Brebes, one Eucheumatoid farmer and one intermediary trader in Serang, also two Eucheumatoid farmers in Sumenep. The results show some inefficiency in several loci in the business lines of intermediate farmers and traders. These include a gap on moisture content (*Gracilaria* of 2 % and Eucheumatoid of 4 %), productivity of *Gracilaria* pond 0.6 t ha⁻¹ yr⁻¹ and its by-product is 50 %, while the productivity of Eucheumatoids was 10 %. The quality of dry *Gracilaria* is one grade only. All result loss of potential margin. Root problem analysis found several external factors outside the Kaizen domain and other internal aspects can be corrected through intervention. The Kaizen analysis determined some simple interventions including improvement of cultivation embankments and extension of maintenance periods, use of monofilament net to dry seaweed, optimization of cultivation spacing, and use of moisture checker.

Keywords: Eucheumatoid, hydrocolloid, seaweed industry

1 Introduction

Indonesia has an excellent opportunity to create massive revenue through seaweed hydrocolloid trades. Hydrocolloid markets tend to increase over time continuously and carrageenan is the most necessary type of product. Hydrocolloid trade appeared firstly in 2009, reaching USD 1.01×10^9 , an increase of almost 60 % over the previous decade. In that period, the trade value of agar increased by 35 % while carrageenan increased by 81 %. The increase in international demand for hydrocolloid resulted in significant needs of raw materials. In the last 5 yr, it took nearly 3 500 000 t of wet carrageenophyte and almost

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1×10^6 t of wet agarophyte and now increases by 4.5 % yr⁻¹. Indonesia has the power to become an essential player in the trade or product as well as raw materials (carrageenophyte, especially *Eucheuma* sp. J.Agardh, and agarophyte, especially *Gracillaria* sp. [Greville , 1830]). As the world prominent seaweed producer, Indonesia has relatively been prosperous in mastering the market share of the raw material but plays minimal role in the processes product market (hydrocolloid). For consumption seaweed, with a 29.9 % share, Indonesia secures the second position after South Korea. Meanwhile, for non-consumption seaweed, with a share of 14.6 % Indonesia occupies the second position under Chile, outperforming China in the third. Success in the raw material market did not occur in the hydrocolloid market; in this context Indonesia caught less than 4 % of world market share, far behind China, Chile, Spain and the Philippines.

The weakness of Indonesia at the global market competition of seaweed can be traced on the micro-problems in the country. In the year of 2015, a study on Indonesian seaweed supply chain found that there is detected quality degradation, such as inconsistencies in yield, quality, price, and technologies in one part of the supply chain can affect the whole chain [1], marked with low gel strength and undesirable color. There is something wrong with managing and developing the seaweed industry. A country with high production of raw materials just becomes an insignificant player in the product market, even for intermediate products. The government wants the support of scientific data needed to make the high-value seaweed industry.

Some studies related to this problem have been carried out by previous researchers. These for example, research of the Lombok case [2], Kendari Bay case [3], the Sumenep case [4], and the Tarakan case [5]. Unfortunately, with local specific approaches adopted in these studies, the recommendations obtained are not enough to provide a basis for national policy-making [6]. The researches have come up with reasonable remedial steps including the development of seed ponds, the creation of cultivation clusters, the development of processing activities at the local level; however, local specific approaches make the resulting output insufficiently connected with supply chain nodes in other regions.

In an ACIAR 2017 research, there is a multi-location value chain analysis on the complex roles played by persons (leading producers, processors, traders, service providers) of seaweed. Problems have been identified as occurring at nodes in the commodity supply chain [7]. Among the outputs of this research is a finding the margin obtained by the person at the upstream node in the Indonesian commercial seaweed supply chain is generally small and makes the motivation for business development low.

Problems found in the 2017 research activities are still global and need to be explored through further analysis carried out in 2018, using a productivity analysis approach. Through the Kaizen technique, the productivity analysis was applied to identify the leverage actions needed to improve efficiency. The Kaizen approach itself can be briefly described as 'a change towards a better' which is done continuously. In industries, Kaizen are generally applied to formulate strategies to increase production, increase product quality, reduce operational costs, reduce waste, and increase job security. Productivity analysis has been applied generally to industrial cases in Indonesia [8], but it was reported that this approach is also being applied to seaweed processing plants in Indonesia [9].

Based on those situations, the research reported in this paper was based on the Kaizen approach and aimed at identifying opportunities to overcome problems related to the inefficiency in upstream activities in the Indonesian seaweed supply chain. In this case, focuses were given to identification of problem loci, root cause analysis, priority problem selection, and determination of intervention options.

2 Methods

This research focused on productivity analysis [10], which was carried out following the Kaizen framework. Moreover, this study was a follow-up to the previous years' research results. Based on this, seven upstream business nodes, hereby referred to as Kaizen research collaborators, were chosen in the commercial seaweed supply chain at three locations: two *Gracilaria* farmers in Brebes, one *Gracilaria* trader in Brebes, one Eucheumatoid farmer in Serang, one intermediary trader in Serang, and two Eucheumatoid farmers in Sumenep, Indonesia. In each of these selected nodes, four analysis phases were carried out to identify opportunities for improving production performance i.e. i) identification of problem loci, ii) root cause analysis, iii) determination of priority problems, and iv) determination of intervention for changes. In implementing the Kaizen application, researchers must provide understanding, and get assurance that research collaborators fulfil the following requirements such as open minded, same vision to improve the work system in their business units, same mission to increase margins, and are willing to provide time/capital/energy to make observations of agreed changes. The steps of the intended Kaizen methodology shown in Figure 1.



Fig 1. Steps of Kaizen methodological approach

3 Results and discussion

Kaizen research collaborators set to represent each district/regency case, was a joint decision between the researchers and the local fisheries service department which a chairman or a group member registered in the fisheries service department. Where available, records of business activities such as those regarding seaweed ponds, buying and selling, business facilities such as warehouses, postharvest processing equipment, handling techniques, and other relevant matters, are provided by collaborators for references in discussions and consultations during implementation Kaizen activities.

The results of intensive discussion and consultations were focused on searches and the handling of shared problems, as the decisions outlined in the project charters for Kaizen improvement scenario. The results are presented in groups per district/regency case as follows. The presentation of individual district cases will start with exposure to the relevant

strategic environment and proceed with the summary of specific problems identification in each Kaizen research collaborators.

3.1 General situation of the case locations

3.1.1 Brebes

Brebes Regency is one of the country's primary concentrations for *Gracilaria* sp. cultivation. *Gracilaria* sp. cultivation in this area began in 2006 and developed on the northern side of the district, especially the villages of Randusanga Wetan and Randusanga Kulon of the Brebes Sub-district, and Prapag Lor and Prapag Kidul of Losari Sub-district. Currently, businesses that are based on *Gracilaria* sp. seaweed are an important economic activity for the community in the Brebes Regency. Based on the statistics of fisheries Brebes in the year 2017, the total production of dried seaweed reached 62 057 t, with production value amounting to IDR 186×10^9 (conservative price assumption of *Gracilaria* sp. dried IDR 3 000).

This economic activity also creates quite a lot of employment in cultivation, handling, transportation and trade in the commodity. The seaweed cultivation to the post-harvest stage requires around 45 workers ha^{-1} [7]. The potential of seaweed aquaculture in Brebes Regency is very high, supported by 12 678 ha of ponds spread over a 53 km coastline.

At present *Gracilaria*'s cultivation is decreasing, because the payment of the products has stalled. The main factory intended for *Gracilaria* sp. dry marketing is PT. Agarindo in West Java and PT. Agarsari in East Java. PT. Agarindo is the most targeted factory because it provides high prices for high quality seaweed. Meanwhile, other factories represent only alternative destinations because they do not demand high quality even though the purchase price is lower. Within the last four months at the time of this research (February, June 2018) data on payment of products that had passed quality checking were not obtained. However, according to farmers and middlemen, there is a tendency that farmers are forced to accept the price set by the factory because there was already a lot of dried seaweed deposited in the factory, and this can be intereted as fraud by the factory.

The upstream side of the seaweed industry includes groups of cultivators and collectors, with work stages consisting of seaweed cultivation, postharvest to produce dried seaweed, and handling dried seaweed that meets factory requirements (low moisture content, clean, and uniform colour). Aside from its strategic environmental factors, there are a number of internal deficiencies in the upstream side of the seaweed supply chain in Brebes. The disadvantage is the inability of the players to control impurities i.e moss, clamps, traces, dry mud, and colours fading due to exposure to dew. Impurities occur due to poor and postharvest cultivation pond water circulation (washing and drying). Meanwhile, fading colors occur due to the night drying, which was left without cover so that it was exposed to fresh water from dew.



Fig 3. Barnacle and moss at the *Gracilaria* ponds



Fig 4. Distinct appearances of ponds – well maintained and poorly maintained



Fig 5. Messy and unhealthy look of harvested *Gracilaria* due to moss or barnacle

3.1.2 Serang

Seaweed production in Serang Regency comes mainly from *Eucheuma* cultivation, where the figure is close to 20 000 t yr⁻¹. Such high production makes Serang seaweed the biggest contributor to the statistics of commodity production at the provincial level. However, there are problems where farmers generally harvest seaweed at the age of 30 d, so the quality is poor, carrageenan content is low, and the price is cheap. Cash flow pressure is a common reason that causes farmers to harvest at less than the recommended age, which is 45 d. If harvested at the ideal age, the price of fresh dried seaweed on the market should be IDR 12 000 kg⁻¹, salted dried seaweed IDR 8 000 kg⁻¹, and wet seaweed IDR 4 000 kg⁻¹. In fact, with 30 d of harvesting, prices dropped by 40 % to 60 %.

The existence of a seaweed development policy in Serang Regency is characterized by the implementation of the Minapolitan program, which is a concept of fisheries-based area development, centralized in Domas Village, Pontang District, Indonesia. In addition, there is also a concentration of development on the area of seaweed cultivation in the Lontar waters of the Tirtayasa District. In the past, there were also intensive efforts to develop seaweed on Pulau Panjang, but at the moment it no longer continues because the waters in the region have been heavily polluted. The latest development shows that all land on the coast of Lontar, Tirtayasa Subdistrict covering an area of 100 ha is used as ponds for seaweed cultivation.

Although Serang has positive development of *Eucheuma* sp. seaweed but lately there are challenges faced for example in Lontar Village occur crop failure. Change of weather and sea water quality make difficulty for seaweed to grow, and even eventually die.

Gracilaria sp. cultivation is not as intensive as *Eucheuma*'s, but its-based economic activities can't be ignored. *Gracilaria* sp. cultivation in this area was initiated by a processing plant, which in time became the main market of dried *Gracilaria* in the Serang region. The cultivation began in a 36 ha area, which was projected to supply raw materials for processing plants with a capacity of 3 000 t to 6 000 t.

The general problems of the business *Gracilaria* sp. are quality. The grade of dried *Gracilaria* sp. is lower than Brebes. This problem is related to the awareness of farmers to

produce and sell good quality products. A number of interventions have been tried by traders, but it did not work well.

3.1.3 Sumenep

Sumenep has a conducive area for *Eucheuma* sp. cultivation including the land protected by small islands, the calm and stable currents along year, the good of water sources. This condition also ensures the availability of seeds.

Seaweed *Eucheuma* sp. cultivation in Sumenep is high and increased in the last 4 yr (2015 to 2018). This production spread across 10 sub-districts including on several small islands, with average productivity of 3.71 t ha⁻¹. Among these locations, seaweed cultivation concentrated in Sub-districts of Bluto, Talango, and Bungkek. In Sumenep, middlemen play a major role in the development of seaweed in their area, both in terms of quality and quantity. Now, the middlemen have a stronger bargaining position that intensively carried out by improving the quality of dried seaweed and providing good quality seeds, as well as applying the ideal harvest age. The middlemen also coordinate with relevant institutions or groups such as the local fisheries office, seaweed producer associations, seaweed processing associations.

In Sumenep Regency there are eight large traders, spread in Pakandangan Sangra areas, Pakandangan Barat, Aeng Dake (Bluto). The big problem of the seaweed industry in Sumenep is unexpected results although the middlemen have tried to provide instructions to farmers. In addition, there is a low quality seaweed from Sumenep and unoptimized cultivation because of improper harvest time and not dried product. The other problem is the competition between middlemen leads to unfair competition and causes a lot of poor quality seaweed on the market. Moreover, the absence of seaweed processing units also contributed to the problems.

3.2 Problems and solutions as observed in Kaizen research collaborators's cases

3.2.1 Problems as observed in Kaizen research collaborators' cases

It can be described that local businessmen have opportunities that are constrained by several external aspects. Thus, a more appropriate strategy is to identify and implement internal measures that can improve the situation. The following are the results of field observations conducted to explore such internal measures. As mentioned in the method section, the problem and the relevant potential internal measures were explored in three cases that occurred in three Kaizen research collaborators such as two *Gracilaria* sp. farmers, and one *Gracilaria* sp. trader, three eucheumatoid farmers, and one intermediary trades. Table 1 summarizes problems and relevant conditions facing the local businessmen as reflected by the selected respondents.

Table 1. Problems and relevant conditions

Respondent's name, type of business and general profile	Problem	Relevant condition
Warsono, <i>Gracilaria</i> farmer, Brebes, 2.7 ha ponds, intercropping <i>Gracilaria</i> + milkfish, and vannamae	i. Wastewater pollutant from the onion fields, ii. Prices are often lower because of impurities iii. Tidal flooding	i. Farmers have skill but do not practice it ii. Embankments are damaged, so cultured milk fishes are escaping iii. Drying is carried out on the streets; quality checking is done by buyers
Slamet Riyadi, <i>Gracilaria</i> middleman, Brebes, purchases seaweed from local farmers, supplies grade three dried seaweed to agar factories in Tangerang and Malang	i. High impurities, which affects quality & price	i. Purchases made without re-drying ii. Determination of quality in the factory is very dependent on the weigher iii. Middlemen check the water content only by palpation
Abdul Latief, farmer, Brebes, 4 ha seaweed ponds intercropped with milkfish	i. Pond productivity is low so the margins obtained are low	i. Harvesting age is 8 wk; productivity is 2 t ha ⁻¹ yr ⁻¹ of dried seaweed. ii. Farmers focus on operational costs and are not aware of opportunities to increase margins
Asmawi, <i>Eucheuma</i> farmer, Serang, 100 spans of seaweed planting, each of which holds 1.2 t of seedlings	i. Distance between the nodes for the cottonii planting does not follow what is recommended ii. Demand for white cottonii increased, so that the salted dry cottonii decreased	i. Farmers receive additional knowledge of good cultivation techniques but has not applied much ii. Seaweed is sold in two types of products, i) white seaweed: not require long harvests, high price, low turnover, ii) salted seaweed: requires long harvests, low price, big turnover, continuous demand
Karim, Serang, <i>Gracilaria</i> middleman, purchases dried <i>Gracilaria</i> from local farmers, sell 90 % of it of Grade 3 to Tangerang and Malang	i. Yield is low because the material received from farmers is dried on soil ii. Extra cleaning can improve the quality from Grade 4 to three	i. Drying and cleaning are done by the employees, which are earned by him at a price of IDR 250 kg ⁻¹
Junaidi, <i>Eucheuma</i> farmer and group leader, Sumenep	i. Prices of cultivated seaweed are generally IDR 1 000 lower than the average price	i. <i>E. cottonii</i> is harvested at 35 d; productivity of 500 kg per <i>ancak</i> in summer (4 mo yr ⁻¹) and 1 t per <i>ancak</i> during the rainy season (8 mo yr ⁻¹)
Mr. Mukhrasam, <i>Cottonii</i> cultivator and group leader, Aeng Dake Village, Bluto District	i. The price of wet seaweed is IDR 7 000 is cheaper than the price of seaweed with 40 % water content	i. Farmers deliver harvests directly to collectors without additional handling. ii. Productivity of 500 kg per <i>ancak</i> in summer (4 mo yr ⁻¹) and 1 t per <i>ancak</i> during the rainy season (8 mo yr ⁻¹).

3.2.2 Potential solutions as observed in Kaizen research collaborators' cases

The problems and conditions stated in Table 1 were explored through direct and in-depth observations with business owners and staff. The problems and potential solutions are outlined in the project charters, as summarized in Table 2.

Table 2. Summary of Project Charters

Case	Project	Assumption
Warsono, <i>Gracilaria</i> farmer	Improve maintenance water circulation by embankment & waterways repairs	i. The purchase price: IDR 5 300 (highest quality) and IDR 4 700 (lowest quality) $Gracilaria$ value = four harvests per location x 1.5 t per harvest x IDR 600 kg ⁻¹ = IDR 3.6 × 10 ⁶ yr ⁻¹ per location ii. Milkfish lost when the embankment breaks =50 % Milkfish value = four harvest times x 100 kg x IDR 20 000 kg ⁻¹ = IDR 8 × 10 ⁶ yr ⁻¹
Slamet, <i>Gracilaria</i> middleman	Reduce the gap between product moisture content and required water content by 2 %	i. 40 wk yr ⁻¹ x 2 trucks wk ⁻¹ x 8 000 kg per truck = 640 000 kg yr ⁻¹ of Tangerang shipment @ IDR 7 000 ii. 40 wk yr ⁻¹ x 1 truck/k x 8 000 kg per truck = 320 000 kg yr ⁻¹ to Malang @ IDR 5 000 iii. The difference in product water content and water content required by the factory is 2 %, equivalent to a loss of IDR89.6 × 10 ⁶ + IDR 32 × 10 ⁶ yr ⁻¹ = IDR 121.6 × 10 ⁶ yr ⁻¹
Abdul Latif, <i>Gracilaria</i> farmer	Increase pond productivity from 2.0 t to 2.6 t ha yr ⁻¹ through a 3 wk to 4 wk harvest extension	i. Seaweed productivity averages 2.0 t ha ⁻¹ yr ⁻¹ with an average harvesting age of 8 wk ii. Production target is 2.6 t ha ⁻¹ yr ⁻¹ with an average harvesting age of 12 wk iii. Profit margin of IDR 5 300 kg ⁻¹ x 600 kg = IDR 3.18 × 10 ⁶ ha ⁻¹ yr ⁻¹ iv. With a land area of 4 ha, the profit margin becomes IDR 12.7 × 10 ⁶ yr ⁻¹
Asmawi, <i>Eucheuma</i> farmer	Improve productivity by increasing the distance between nodes per span in planting	i. Seeds needed for 100 spans are 1.2 t ii. Seeds obtained from their own harvest: harvest diverted into seeds for each planting cycle/group members = 20 spans x 50 kg per span = 1 000 kg. iii. With the price of IDR 1 500 kg ⁻¹ of seeds, the cost of seedling/member = IDR 1 × 10 ⁶ → total cost IDR 30 × 10 ⁶ iv. Seeds purchased from others: costs per planting cycle/member = 1 200 kg x IDR 3 000 = IDR 3.6 × 10 ⁶ → total cost of seeds for one group= IDR 72 × 10 ⁶ v. Harvest weight with inter-node distances 5 cm to 7 cm is 50 t per 100 spans per planting cycle vi. Harvest weight with the distance between nodes of 10 cm is 70 t per 100 spans per planting cycle

(Continued on next page)

Table 2. Continued

Case	Project	Assumption
Karim, <i>Gracilaria</i> middlemen	Loss reduction attributed to the use of waring net mat in the drying process in ponds from 20 % to 2 % within 3 mo	i. Shipments to the factory = $40 \text{ wk yr}^{-1} \times 3 \text{ trucks wk}^{-1} \times 8\,950 \text{ kg per truck} = 1\,074\,000 \text{ kg yr}^{-1}$ ii. Products from farmers of 20 % impurities, purchase volume = $1\,070\,000 \text{ kg yr}^{-1} \times (120/100) = 1\,284\,000 \text{ kg yr}^{-1}$ iii. Drying costs = IDR 250 kg for relatively seaweed and IDR 275 kg for dirty seaweed iv. With drying with no net mat, two options: cleaning to obtain grade three or leaving it to obtain grade four v. Price of grade four = IDR 5 000 kg^{-1} and grade three = IDR 7 500 kg^{-1} . Equivalent to a loss due to unclean harvest = $1\,074\,000 \text{ kg} \times \text{IDR} (7\,500 \text{ to } 5\,000) = \text{IDR } 2\,685 \times 10^6 \text{ yr}^{-1}$ vi. With cleading, total additional costs = $(1\,284\,000 \text{ kg} \times \text{IDR } 25 \text{ kg}^{-1}) + (1\,284\,000 \text{ to } 1\,070\,000) \text{ kg} \times \text{IDR } 250 \text{ kg}^{-1} = \text{IDR } (32 + 53.5) \times 10^6 \text{ yr}^{-1} = \text{IDR } 85.5 \times 10^6 \text{ yr}^{-1}$
Junaidi, <i>Eucheuma</i> farmer, Sumenep	Applying of Kaizen approach to improve gel strength by increasing cultivation time from 35 d to 40 d	i. Current price of dried cottonii = IDR 7 500 kg^{-1} . ii. Price of 35 d of dried cottonii = IDR 6 500 kg^{-1} iii. Harvest frequency = 5 times yr^{-1} iv. Harvest frequency = 7 and production = 500 kg of dried cottonii. Income earned by farmers from seaweed harvested at age 35 d is IDR 22.75×10^6 per cycle or IDR $113.75 \times 10^6 \text{ yr}^{-1}$ v. Income earned by farmers from seaweed harvested at age 40 d = IDR 26.25×10^6 per cycle or IDR $131\,250 \times 10^6 \text{ yr}^{-1}$. vi. Extending harvest from 35 d to 40 d will give additional revenue of IDR 3.5×10^6 per cycle (IDR $17.5 \times 10^6 \text{ yr}^{-1}$)
Mukhrasan, <i>Eucheuma</i> farmer, Sumenep	Applying a Kaizen approach to increase cottonii dryness from pond-wet condition to dry condition (40 % moisture content).	i. Current price: wet IDR 5 000; water content 40 % IDR 12 000; water content 38 % IDR 14 000; and water content 37 % IDR 15 000 ii. Farmers apply five cycles of cultivation per year iii. Each farmer has five cultivation ropes and production per cultivation rope of 500 kg dry cottonii; based on that: iv. The income earned by farmers from selling wet seaweed is IDR 12.5×10^6 per cycle (5 cultivation ropes \times 500 kg \times IDR 5 000) or IDR. $62.5 \times 10^6 \text{ yr}^{-1}$ v. Income earned by farmers from selling dried seaweed (40 % moisture content) is IDR. 30×10^6 per cycle (5 cultivation ropes \times 500 kg \times IDR 12 000) or IDR $150 \times 10^6 \text{ yr}^{-1}$ vi. By drying up to 40 % moisture content, a farmer will get an additional income of IDR 17.5×10^6 per cycle or IDR $87.5 \times 10^6 \text{ yr}^{-1}$

4 Conclusion

The results show there are inefficiencies in a number of loci in the business lines of intermediate farmers and traders include a gap (actual vs. standard value) on moisture content (2 % in *Gracilaria* and 4 % in *Euchematoid*), pond productivity ($0.6 \text{ t ha}^{-1} \text{ yr}^{-1}$ of *Gracilaria*), productivity of by-products (50 % of *Gracilaria*), the productivity (10 % of *Euchematoids*). Moreover, the quality of dry *Gracilaria* is just in the same grade, thus all of the inefficiencies cause a loss of potential profit (margin). Basic problem analysis found a number of external factors outside the Kaizen domain and other internal aspects that can be corrected through intervention. The internal aspects include the objective measurement of water content and good drying method for the inter-trade business and the implementation of *Gracilaria* cultivation pond maintenance techniques and spacing on *Euchematoid*. The results of the analysis determined a number of simple interventions including improvement of cultivation embankments and extension of maintenance periods, use of monofilament net for drying seaweed, optimization of cultivation spacing, and measurement of water content using standardized gadgets. The potential benefits were IDR $13 \times 10^6 \text{ ha yr}^{-1}$ through the intervention of extending the 4 ha of *Gracilaria* pond life; IDR $122 \times 10^6 \text{ yr}^{-1}$ through intervention in measuring dry *Gracilaria* water levels; and IDR $8 \times 10^6 \text{ yr}^{-1}$ through *Gracilaria* by products; IDR $2.8 \times 10^6 \text{ yr}^{-1}$ through improvement in the way of drying *Gracilaria*; and IDR $30 \times 10^6 \text{ yr}^{-1}$ through the improvement of the *Euchematoid* cultivation spacing. These results indicated the opportunity to significantly increase margins through the intervention of post-harvest aspects.

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