Increasing incomes in carrageenan seaweed value chains in Takalar, South Sulawesi

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Increasing incomes in carrageenan seaweed value chains in Takalar, South Sulawesi

Australian Government

The Australia-Indonesia Centre

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This report provides policymakers with a rich source of information and up-to-date evidence that can inform their decision-making. The findings of these PAIR initiatives are essential reading for anyone interested in the future of these key sectors in Indonesia.

Sincerely yours,

Dr Eugene Sebastian
PAIR Program Director
The Australia-Indonesia Centre

EXECUTIVE SUMMARY

This report analysed the seaweed-carrageenan value chain in the Takalar region of South Sulawesi province, Indonesia, a region that produces about 20 percent of the world's supply of carrageenan seaweed.

Seaweed production contributes to the livelihoods of thousands of farmers and traders in South Sulawesi.

We aimed to document the relationships and interactions between the different actors, understand the prices and costs within the value chain and explore opportunities to increase the incomes of seaweed farmers and traders. To achieve these objectives, we investigated various aspects of the seaweed production process, cost and price structures and relationships between different actors in the value chain, including farmers, traders and processors.

By analysing the value chain of seaweed-carrageenan, we are able to provide a number of insights. These include the relationships and interactions between actors in the value chain, quantitative primary data on the prices and costs within the value chain and opportunities to increase the incomes of seaweed farmers and traders. The insights have led us to a number of recommendations:

1 The establishment of farmer groups or cooperatives and micro-credit schemes to improve seaweed production and prices obtained. Cooperatives would help improve farmer incomes and assist with providing extension services for disease control, drying and storing facilities and reducing farmers' dependence on credit for seedlings. Farmers have sometimes relied on close relationships with traders in order to secure credit for buying seedlings and the establishment of cooperatives is likely to contribute to a more transparent and fairer arrangement.

2 The government helps provide market price information. Price information flows from processors to traders to farmers can be opaque and confusing; processors of seaweed often struggle to make a profit due to price volatility and rising costs of raw dried seaweed. Better access to market information would assist processors in coping with price volatility.

3 We recommend using a marketing margin framework to evaluate options for enhancing profits along the value chain. Effectively evaluating market displacements, or distortions, requires an improved understanding of factors such as total annual production of raw dried seaweed, the price elasticity of seaweed supply, the price elasticity of carrageenan demand and quantitative data on competition between value chain actors and market power. The complexity of the seaweed value chain becomes apparent in this report as well as the importance of collaboration between all the people involved in it to improve seaweed industry profitability and sustainability in Takalar Regency. Policymakers can play a critical role by providing better information and support. This study is part of a wider and comprehensive investigation by the Australia-Indonesia Centre into the seaweed value chain in South Sulawesi to investigate all aspects from production to consumption. The analysis of the South Sulawesi seaweed sector also provided insights into the impact of global forces, the structure of value chains and the effects of the COVID-19 pandemic on more than 35,000 households along the coast involved in seaweed farming. Our report also examined opportunities for Indonesia to capitalise on its competitive advantage in seaweed and opportunities to sustainably upgrade the industry.

Image credit: Pahala Basuki on Unsplash

1.0 INTRODUCTION

This study analysed the value chains of seaweed-carrageenan in the Takalar and Kota Makassar regions of Indonesia's South Sulawesi province. The province generates about 20 percent of the world's supply of carrageenan seaweed, making it the nation's largest producer. A new international port is being constructed in the capital city of Makassar to support the direct export of seaweed and other products from eastern Indonesia. The Takalar region is known for its long history of intensive seaweed production using traditional methods. These factors make Takalar a crucial location to study the growth of the carrageenan seaweed industry especially given the significant role it has in the livelihoods of thousands of farmers and traders.

2.0 METHODS

This study follows a three-step approach that incorporates both qualitative and quantitative methods (as shown in figure 1). The focus of the study is on the red seaweed species *Kappaphycus alvarezii* (*Cottonii*) and *Kappaphycus striatus* (sacol), referred to as seaweed. These species are used to produce carrageenan and agar. In Takalar, these two species are commonly grown and marketed together and have similar prices. They are the dominant seaweed species cultivated in Takalar. The study looks at seaweed produced during the main production season of 2022 which is typically from late November to May. The geographical scope of the study is the seaweed-carrageenan value chain, referred to as the 'value chain'. This involves seaweed produced in Takalar that is then moved to Makassar where it is either exported as raw dried seaweed or processed into carrageenan in the form of semi-refined carrageenan or alkali-treated *Cottonii*.

The study has three objectives:

- Describe and document the relationships and interactions between actors in the seaweed value chain in the project location.
- Better understand the prices received and costs paid by actors in the seaweed value chain.
- Explore economic analysis opportunities to increase the incomes for seaweed farmers and traders.

To achieve these objectives, the study used three methods:

1 **Value chain mapping:** To gain a better understanding of the value chain, we used value chain mapping. This involved identifying the main groups, activities and connections in the chain, using information from literature searches, interviews and field observations. Our sources included research articles, seaweed statistics and policy documents from various agencies, such as the Ministry of Marine Affairs and Fisheries, Badan Pusat Statistik, Indonesia Seaweed Industry Association and JASUDA - a seaweed research organisation based in Makassar. We also drew on field observations from PAIR's "Sustainable Upgrading of South Sulawesi Seaweed Industry" report for contextual information.

2 **Value chain actor surveys:** To understand the prices and costs within the value chain, we conducted field research and semi-structured interviews with major actors, from seedling suppliers to processors. We surveyed a total of five seedling suppliers, 15 farmers, 12 traders and two processors selected based on their experience and willingness to share data on costs and prices. The interviews covered background information, activities, prices received, costs paid, business relationships and price elasticities of demand and supply. We obtained informed consent before each interview. Face-to-face interviews took place in Laikang with seedling suppliers, farmers and local traders and in Takalar and Makassar with regional traders and processors. The interviews helped us gain insights into actors' activities, costs, prices and business relationships within the value chain.

3 **Marketing margin model:** We used a model to study how seaweed supply, carrageenan demand and marketing margin are related. 'Marketing margin' are all the services and activities that connect seaweed farmers and carrageenan businesses. In the model, carrageenan manufacturers use raw dried seaweed and a "conglomerate" marketing input to produce carrageenan. The "conglomerate" input includes all the costs involved in processing, transporting, marketing and trading seaweed. This model has been used to study other agricultural products like beef, pork, wheat, bananas, vegetables and rice (see Appendix X for further details and the data required to develop our marketing model).

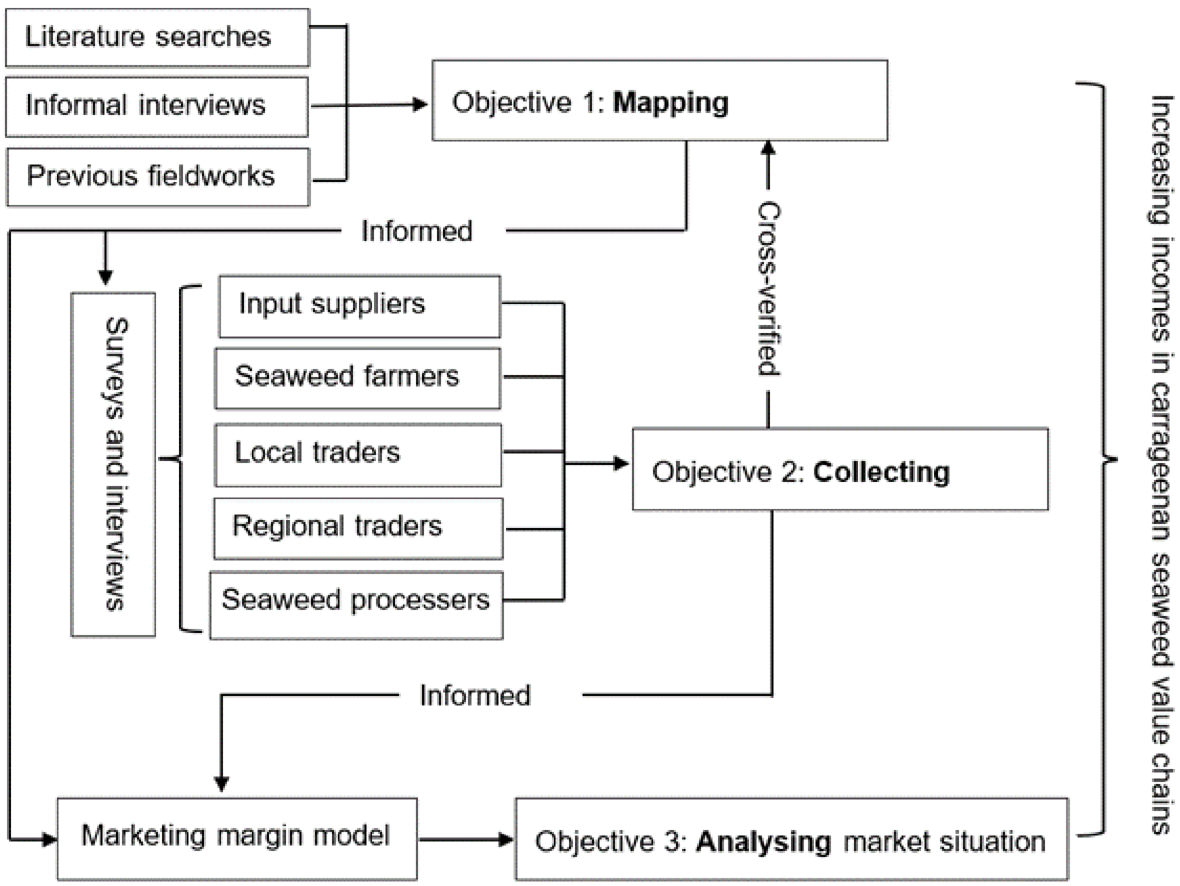

Figure 1: Overview of methods used

3.0 ANALYSIS AND RESULTS

Value chain mapping results

To understand how seaweed is transformed into carrageenan, we created a visual guide called a value chain for Takalar Regency (see Figure 2). It starts with the suppliers - seaweed farmers who produce the seedlings and then local collectors and traders who buy directly from farmers. Regional traders buy from local collectors and traders, mostly in Makassar. Seaweeds are exported overseas or sold to domestic processors, which further process them into carrageenan. Processed carrageenan comes in three forms: alkali-treated *Cottonii*, semi-refined carrageenan and refined carrageenan. carrageenan is used to make food, pharmaceuticals and industrial products in Indonesia and abroad. Different players in the value chain often have overlapping roles. For example, seaweed farmers in a village can also act as seedling providers and village collectors may work for traders or processors. Regional traders may also export products, while some exporters are involved in processing as well as exporting dried seaweed and carrageenan.

The next section in this report explores a typical seaweed carrageenan value chain involving suppliers, local traders, regional traders and processors.

Seedling suppliers

Most seedling suppliers are seaweed farmers, who privately run their seedling businesses at village level. They do not receive financial assistance. Small-scale suppliers sell only a few tonnes of seedlings per cycle, while large suppliers usually collect seedlings regularly from different areas or exchange them between areas for genetic quality. For example, one supplier in Laikang village collects seedlings from local collectors in Jeneponto and brings them to Laikang for sale. This supplier also collects wet form seaweed from farmers in Laikang village and sells it to farmers in Jeneponto. Similarly, another sources seedlings from Punaga and Laikang village and sells them to other districts. They generally have no difficulty sourcing seedlings as farmers in Laikang can farm and harvest year-round. Sales quantities can reach 30 tonnes per month, with the largest sales occurring at the beginning of the peak season in November and December. Seaweed seeds are relatively easy to obtain in every area due to differences in production cycles between regencies. Seedling providers and buyers assess seedling quality based on colour and cleanliness, with good quality seedlings appearing greenish or brownish in colour and free from dirt, moss and barnacles.

Some farmers in Takalar consider small thallus that have been planted for about three weeks to be good seeds compared with seaweed that has been planted for more than 30 days. They explain that a three-week-old seaweed lump weighing 100 grams can be cut into four to five seedlings, while the same weight of seaweed that is more than three weeks old can only be cut into three pieces. Farmers either check the seed quality themselves or have their relatives do it when buying from other farmers. Demand for seaweed seeds in Takalar depends not only on quantity but also the types of kappaphycus seaweed. The demand for brown *Cottonii* seeds is higher in the rainy season than for green sacol seeds because *Cottonii* grows faster. In the dry season, demand for green sacol is higher because it grows faster than brown *Cottonii*. The production cycle of seaweed seedling is about 25 to 30 days after planting and is shorter than the output production cycle. The price of wet seaweed for seedling and for drying differs. For example, one farmer sold seed for 8,000 rupiah/kilogram in March 2022 but sold wet seaweed to other farmers for 7,000 rupiah/kilogram in the same month because it was dirtier. Seaweed seedling harvest is determined by the seaweed growth rate and the price of seeds is based on an agreement between the seller and the buyer. Discounts or bonuses may be negotiated for large orders. The average price of seaweed seeds in Takalar is 5200 rupiah/kilogram for *Cottonii* and 4833 rupiah/kilogram for sacol with some variation depending on quality.

The price of seaweed seeds increased in 2022 due to the rising price of raw dried seaweed. At the end of 2021 the price was around 4500 rupiah/kilogram but by March it had reached 8000 rupiah/kilogram and in October it was 10,000 rupiah/kilogram. This increase also affected the cost of binding seaweed, which rose from 3000 rupiah/line to 4000 rupiah/line. The rapid price increases over the year caused changes in seed pricing norms and seed prices now appear to increase with sale prices, as do the labour costs of binding (tying). Seedling providers typically do not sell any other seaweed-related inputs.

Farmers

Seaweed farms in Laikang village are located at varying distances from the shoreline. Farmers have specific plots that they have exclusive rights to farm and often have several plots in different locations to manage production risks such as unsuitable salinity or water temperature. These different locations could be other villages around Laikang, such as Payakkalang and Punaga, as well as the nearby district of Jeneponto. Farmers define their plots using anchors and local governance systems with varying degrees of formality protect individual property rights over these areas. Seaweed can be grown year-round, with an average of seven or eight cycles per year. Respondents reported that the high season had a greater average number of lines per cycle compared with the low season (see Table 1). All lines, which are made of rope, were 40 metres long.

Farmers in Takalar engage in various seaweed production activities, including sourcing seedlings, planting, maintenance, harvesting, drying and selling. At the beginning of the peak season, farmers usually obtain around 90 percent of their seedlings from suppliers for the first cycle. The

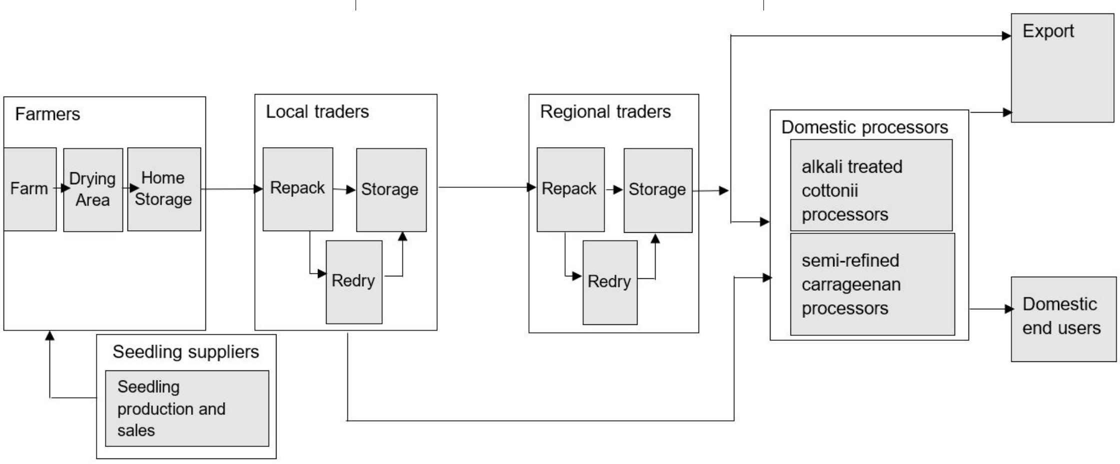

Figure 2: Typical value chain for seaweed-kappa carrageenan originating from Laikang village, Takalar, South Sulawesi, August 2022. Some processors transform seaweed into refined carrageenan in South Sulawesi but we only consider alkali treated cottonii and semi-refined carrageenan in this study. The local traders are called collectors in the village and regional trader in the Takalar regency. Exporters are part of the regional traders.

Season	Item	Average	Minimum	Maximum	Sample size
High season	Number of production cycles	3.73	3	5	15
	Average number of lines per cycle	216	40	600	15
	Standard length of a line (m)	40	40	40	15
Low season	Number of production cycles	3.61	3	4	14
	Average number of lines per cycle	129	20	500	14
	Standard length of a line (m)	40	40	40	15

Table 1: number of cycles and lines per cycle reported by Laikang farmers in high season and low season in year 2021–2022

average survey respondent stores 88 percent of their total production from the first high-season cycle as seed, ranging from 25 percent to 100 percent. The first cycle is typically shorter as its primary purpose is to produce seeds. The peak season for planting seaweed in Takalar is between December and April, which corresponds to the 'west' or rainy season. The water conditions in Takalar Regency are optimal for seaweed production, particularly during the west and first transition seasons[1]. The west season has the greatest carrying capacity compared with the other seasons, followed by the first and second transition seasons and the east season[2]. However, the suitability of the east season has significantly improved since farmers began using sacol in the east season recently. The seaweed from the first cycle is typically grown for a shorter period than the regular farming cycle and used to seed new longlines. After producing enough seeds to fill their farming plots, farmers usually purchase some seed from neighbouring farmers while cutting off some of their existing plants to become a portion of seedlings for the next farming cycle. The rest are dried and sold.

Farmers primarily use their household savings and trader loans to purchase seedlings, followed by borrowing from relatives. These loans are typically unsecured and undocumented. In exchange, farmers commit to selling their harvested seaweed exclusively to the lender at a lower sales price of 1000-3000 rupiah/kilogram than the market average. If the money was borrowed from relatives, farmers can sell to any collector at the market price on the condition that the loan is paid off immediately after the sale.

Farmers in Takalar typically use the longline production method which is suitable for deeper waters. This method involves tying seaweed cuttings of about seven to eight kilograms in weight to a 40-metre-long line using plastic string. The ropes are attached to permanent anchors on the ocean floor, hung at approximately one-metre intervals and floated to the surface using plastic bottles. During the high season production cycle, farming work is mainly done by two family members, typically the father and mother, who work an average of seven hours per day and 3.5 days per week. Paid labourers primarily work on tying seedlings to the ropes, with less demand for installing the ropes and harvesting the seaweed. The task of tying seedlings to the ropes is time-consuming and labour-intensive, often requiring a group of helpers within a concentrated time period as the ropes must be returned to the ocean on the same day to prevent seedling damage. To plant 500 kilograms of seedlings, farmers typically require about four labourers to work twice a day. Paid labourers usually work an average of two days per week and seven hours per day but the number of labourers employed varies widely depending on the farming size, ranging from a minimum of zero to a maximum of 14 non-family labourers. After deploying the ropes with seedlings, farmers constantly visit and check their farms to ensure better growth, perform activities such as fastening detached lines, installing and removing the bottles, replacing lost or diseased plants and removing clinging debris such as epiphytic algae.

Seaweed is typically harvested about 30 to 50 days after planting, which varies depending on the season and the farmer. Boats, often equipped with boat engines, are widely used during planting, maintenance and harvesting to transport wet seaweed from the farm to the drying platform. A single boat with a capacity of 500 kilograms can carry about eight lines of wet seaweed during the high season. Farmers bring in the longlines from the ocean with bottles (Figure 3) attached and remove the seaweed from the longlines by running the line between two pieces of wood to break off the seaweed.

The seaweed selected as seedlings is replanted immediately for the next farming cycle, while seaweed prepared for sale is sun-dried by spreading it on a bamboo platform (para-para), usually for two days on the para-para and between three to five days on the ground. Dried seaweed is tightly packaged

1 A. Rahadiati., K. Soewardi., Y. Wardiatno and Dewayani., 'Spatial pattern and temporal variation of water quality and carrying capacity for seaweed mariculture in Takalar, Indonesia. Aquaculture, Aquarium, Conservation & Legislation', International Journal of the Bioflux Society, 2017;10(4):894-910.
2 As above

in unified plastic sacks, which are usually provided by local traders and can weigh 100 to110 kilograms per sack. Farmers often have a storage area under their house for dried seaweed, although some have larger storage spaces of up to two tonnes. Farmers sometimes save their seaweed to wait for higher prices or manage their income flows, but small farmers typically do not store seaweed for long periods due to their need for cash income.

Farmers reported having five to 15 collectors and traders in the village available to purchase seaweed. Farmers who received credit from local traders sell at the market price, but the actual price received is reduced for those with outstanding loans. This is the main reason why farmers sell seaweed to certain collectors/traders as well as the existence of family relationships with local collectors/traders. In addition to these reasons, farmers can call for a price quote if they have more than two pikul (around 200 kilograms) of dried seaweed stocked at home and can sell to anyone at the highest price. The moisture content is the main factor determining the price of dried seaweed, with some farmers estimating that the selling price may drop by 2000 rupiah/kilogram for every one percent increase in moisture content. At the national level, there was no statistically significant correlation between national seaweed prices and moisture content[3]. However, farmers do not receive an increased price for exceeding quality standards, so many avoid excessively drying seaweed as this would reduce its price. Farmers also mentioned that while dirt content and the colour of dried seaweed do not affect the selling price, collectors and traders may deduct one kilogram from each bag of seaweed once they estimate that the dirt content of a bag is heavier than normal through visual observations.

Local traders

Local traders are independent buyers with backgrounds in seaweed farming. They purchase dried *Cottonii* and/or sacol from small farmers and often repackage it for resale. They may also purchase additional dried seaweed from other areas, but they often encounter problems with externally sourced seaweed quality. Farmers are expected to meet quality requirements, with moisture content between 35 percent and 38 percent. In Laikang, there are seaweed collectors/middlemen who operate at the village or sub-village level. They can be paid employees of regional traders and processing companies or private individuals who wait for information from farmers willing to sell. Their job is to procure raw materials and charge a commission based on transaction volume, usually 500 rupiah/kilogram for transactions below one tonne and 1000 rupiah/kilogram for transactions above one tonne. They are intermediaries rather than buyers. Farmers or village collectors usually deliver small quantities of seaweed, about 100 kilogram per transaction, to the local traders' bases. The village traders weigh the seaweed using scales that farmers trust for their accuracy. The farmers receive net proceeds in cash at agreed or contracted prices without any additional costs. Local traders may also pick up the seaweed from the farmers' houses based on personal contacts and contracts. However this incurs additional operating costs such as labour, transportation, accommodation and levies. Each trip requires a variable number of male labourers and takes three to four days to travel within the village and surrounding areas. According to the local trader, there is no minimum quantity required to collect from farmers, it could be as low as one kilogram.

Marketing collected seaweed is simple because there is only one product that is in high demand for use in the carrageenan industry. Local traders focus on achieving optimal pricing and building mutual trust. When they have large quantities (eleven tonnes or more), they usually deliver and sell directly to exporters in Makassar. If they don't have enough product to fill the truck, they may call larger local traders to pick up the seaweed. However, most local traders

Figure 3: Farmers use boats to bring in seaweed longlines from the ocean with bottles attached. Image credit: Imran Lapong.

3 A. Langford., J. Zhang., S. Waldron., B. Julianto., I. Siradjuddin and I. Neish., et al, 'Price analysis of the Indonesian carrageenan seaweed industry', Aquaculture. 2022;550:737828.

have facilities for storing their purchased seaweed to benefit from economies of scale and future price considerations. They can construct warehouses with the assistance of the Department of Marine and Fisheries in Takalar. Overall, local traders can adjust their buying and selling to wait for a suitable or higher price by accommodating the seaweed.

The ability to buy seaweed is largely dependent on a trader's own capital. Some traders also use the government-sponsored KUR program from Bank Rakyat Indonesia to borrow funds at lower interest rates, although the loan amount is usually smaller than their own capital. Some traders may only borrow money from banks at the beginning of their business due to various reasons such as limited access to the program. When they lack cash reserves, they prefer to pay farmers after selling seaweed to regional traders in Makassar within one to four days of delivery. Farmers trust local traders more than financial institutions and while their satisfaction with financial services provided by traders is generally low, it is higher than with financial institutions. Therefore, loans from financial institutions are unnecessary and uneconomical.

Regional traders

Regional traders who operate in Takalar City and Makassar buy seaweed from local collectors/ traders and then repackage the seaweed for export or sale to processors after drying and cleaning if needed. The Makassar-based seaweed research organisation Jasuda has identified 15 to 20 buyers at this level. Increased competition among traders in recent years has seen pricing improvements for farmers who had previously faced a stagnating market price. Regional traders have large capital reserves and can therefore trade in both fishery products and seaweed. Even traders who specialise only in seaweed are able to receive a wide variety of species, including dried *Cottonii*, sacol, spinosum and gracilaria from different regencies in South Sulawesi including Takalar, Pangkep, Wajo, Bone, Bantaeng and Janeponto. Additionally, they also source seaweed from outside of South Sulawesi in areas such as North Kalimantan, West Nusa Tenggara, East Nusa Tenggara (though there is currently an export ban in place) and Bali. The seaweed is shipped to their warehouses in Makassar. The purchasing price is received on a weekly basis (every Monday) from the processor or overseas importer and is directly transmitted to the local collectors or traders (existing suppliers) as a benchmark for trading during the week (Monday to Sunday).

When dried seaweed arrives at the warehouse, it is held in an area for incoming materials until a quality control inspector in the laboratory checks for moisture and dirt content. If the seaweed does not meet quality standards the buyer may reduce the offer price or reject the seaweed. Some traders provide a drying platform to suppliers whose seaweed has a high moisture content so that the price is not deducted or the product rejected. Regional buyers transfer payment to the bank account of local traders about three days after quality inspection, though some may transfer payment immediately and this can influence the choice of buyer for local traders. Seaweed quality varies based on geographic location, growing conditions and moisture content and traders prefer to buy seaweed with high moisture content at a cheaper price for more profit. This did not apply during our period of investigation and for most of 2022 due to difficulties in sourcing dried seaweed. According to regional traders, they paid the same price for all seaweed with moisture content ranging from 40 percent to 45 percent. Previously, the moisture content standard was 35 percent to 38 percent and buyers would drive down prices due to excess moisture content.

Traders typically have established customers to whom they regularly sell such as processors both in Indonesia and abroad

Regional buyers are responsible for organising shipments which always use third-party logistics (containers, ships). The biggest buyers in Indonesia are two foreign-invested companies,

Figure 4. Truck used by local traders transporting dried carrageenan seaweed from farmers or to regional traders. Image credit: Risya Arsyi.

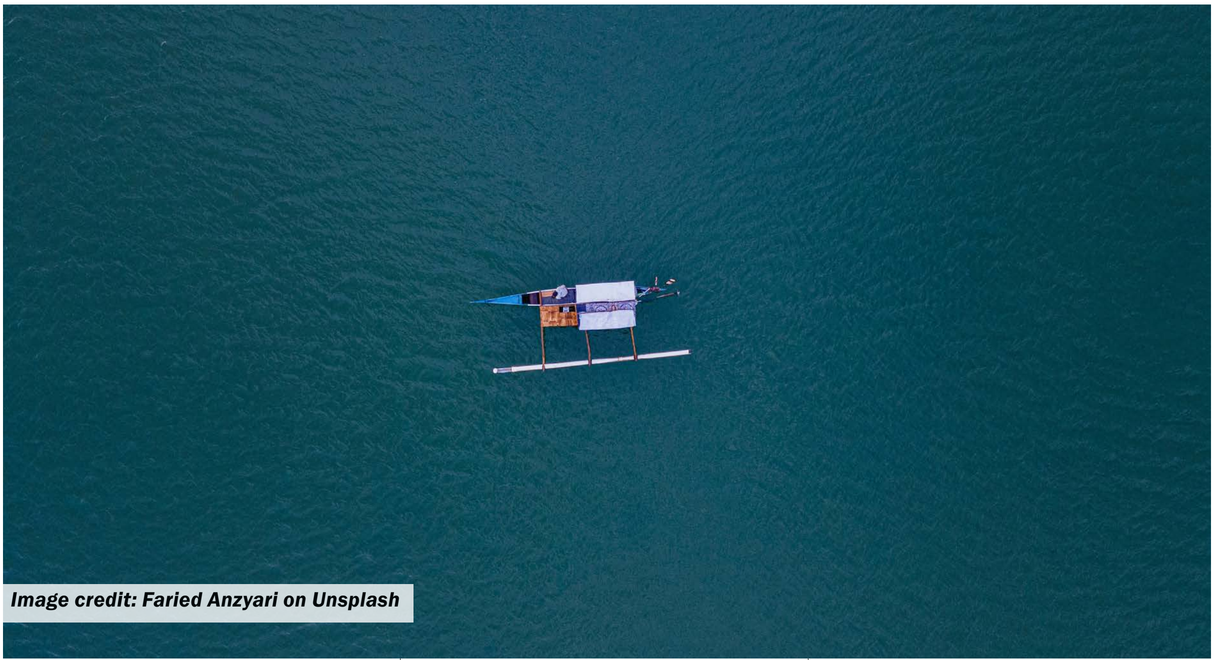
Image credit: Faried Anzyari on Unsplash

BLG and Green Fresh from China which operate in Pinrang, South Sulawesi and Situbondo in East Java. Major export destinations include China, the Philippines, Spain and Denmark, each with different requirements for product quality and packaging. For example, a registration number is required for exporting seaweed to China, while Spain requires the packaging to be pressed for shipment but China does not. Established and large-scale exporters typically have HACCP (hazard analysis and critical control point) systems and phytosanitary and warehouse receipt licences. Some larger exporters are developing corporate farming to secure seaweed supply. An example of this is an exporter from Maros in South Sulawesi who is developing seaweed farming on Salemo Island. This farming is expected to supply 100 tonnes of raw dried seaweed per week, making Pangkep district a substantial supplier of raw dried seaweed in the future.

Processors

Local processors purchase dried carrageenan seaweed from large local traders or regional traders across the country and not exclusively from South Sulawesi. Processors perceive that seaweed from East Nusa Tenggara (NTT) is generally of better quality than seaweed from Kalimantan and Sulawesi due to the province's suitable geographical conditions for seaweed farming, including cleaner water, adequate sunlight, suitable sea currents and water salinity levels that support seaweed growth.

The province has banned the export of raw dried seaweed so that higher quality seaweed can only be obtained at an increased cost. A common strategy applied by most processors, due to a price-quality trade-off, is to mix high-quality seaweed from East Nusa Tenggara with a more accessible and affordable seaweed sourced from south and southeast Sulawesi. They prefer to buy from their partner traders to ensure the supply of high-quality seaweed that meets three main parameters: gel strength (900), moisture content (previously 35 to 38 percent, now 35 to 40 percent due to difficulties in sourcing dried seaweed) and dirt content (five percent). The quality parameter of raw dried seaweed from traders refers to the Indonesia National Standard (SNI 2690:2018) with a maximum moisture content of 38 percent and maximum impurity of three percent. Farmers who are found to be applying inappropriate practices will find that they are no longer trusted and processors will stop buying from that region. For example, some Takalar farmers used salt to speed up the drying process which reduced the gel strength, one of the main quality parameters in the processing stage. As reported by one processor, they will no longer buy from Takalar because the gel strength of dried seaweed from Takalar was only 700g/cm2 during 2016-2018 while it is usually required to be 900g/cm2.

Purchased seaweed can be processed into alkali-treated *Cottonii*/spinosum chips, semi-refined carrageenan and refined carrageenan. Alkali-treated *Cottonii* and semi-refined carrageenan require simpler technology and cheaper costs and are more locally produced, while refined carrageenan is only for some high-tech Java processors and foreign-invested processors. The level of carrageenan refinement during extraction can influence key properties, with alkali-treated *Cottonii* and semi-refined carrageenan containing more impurities than more refined carrageenan. Semi-refined carrageenan (E407a) contains higher dietary fibre (acid in a soluble matter) than refined carrageenan (E407). The semi-refined carrageenan is eight to fifteen percent fibre and the refined carrageenan is less than two percent fibre, as stated by the Joint FAO/WHO Expert Committee on Food Additives.

Alkali-treated *Cottonii* processing involves washing the seaweed to remove impurities like sand and salt, treating with hot alkali to increase the gel strength and drying and chopping/pressing into chips around one centimetre in length. If these chips are fed into a mill for grinding into powder the product can be sold as semi-refined carrageenan. If further treatments such as filtration and purification processes can be applied to remove residual substances such as cellulosic materials before milling and grinding, the product will be sold as refined carrageenan. Further refinement steps result in higher costs associated with the production of refined carrageenan.

All three products can be used in both food and non-food industries, but locally produced alkali-treated *Cottonii* and semi-refined carrageenan are mainly used in the pet food industry as well as the dairy and meat industries where carrageenan clarity is not an important issue. The products are exported to South Korea, Japan, China and European markets. These products also leave behind some waste products which reduce the waste treatment costs of buyers. Some local processors have suspended or permanently closed their production of alkali-treated *Cottonii* or semi-refined carrageenan due to the market uncertainty caused by COVID and the sharp rise in dry seaweed prices over the last two years (figure 5). According to one processor, three out of seven semi-refined carrageenan producers in South Sulawesi stopped producing semi-refined carrageenan during the rise of seaweed prices. Two producers completely stopped their operation, while one producer stopped producing semi-refined carrageenan when the price of raw dried seaweed surpassed 22,000 rupiah/kilogram in November 2021. Another company produced shrimp feed from fresh seaweed and did not buy the dried seaweed due to high prices. They stressed that stable raw material prices, which account for 75 to 80 percent of production costs, are crucial for local producers to manufacture semi-refined carrageenan. Due to different economies of scale and start-up/shut-down costs the foreign-invested processing facilities continued to process and expand. They appear to be the price setters for the region after gradually establishing themselves from 2017 to 2021.

Costs and prices results

Farmers

During the high season of 2021-2022, the price received by farmers for dried seaweed with moisture content of 37 to 38 percent fluctuated between 34,000 rupiah/kilogram and 37,000 rupiah/kilogram with an average of 34,500 rupiah/kilogram. One independent farmer sometimes sells wet seaweed at 5,500 to 6,000 rupiah/kilogram, presumably as seeds to another farmer. Kappaphycus alvarezii (*Cottonii*) and Kappaphycus striatus (sacol) have the same carrageenan type (kappa) so they are often mixed, bought, planted and sold. The farmers reported no difference between them not only in the prices of seedling buying and seaweed selling but also in the series of costs paid during the production cycles. The components of costs paid by the farmers during seaweed cultivation include seedlings, labour, non-labour variable costs (including fuel, repairs, plastic bottles, tools like knives and gloves and other items such as tali rafia and minyak tanah) and fixed costs (including costs of para-para, boat and engine, ropes, tarpaulin, waring, loops/ties, anchor and shelter). More details about the cost paid per cycle on an average size of 216 ropes of seaweed cultivation based on the longline system can be seen in Table 2. The average cost of 216 ropes of seaweed farming in the main production season amounted to 10,593,536 rupiah/cycle.

The average total cost for an average farmer to produce raw dried seaweed was 6,869 rupiah/kilogram. However, this total cost excludes shrinkage or loss during post-harvest handling and packaging and consumable costs such as food and drink that are incurred while binding seedlings to the nylon rope. With the average selling price of 34,500 rupiah/kilogram this generates a revenue cost ratio of five (table 2). There were no reported government subsidies/aid in the form of boats, boat engines or other equipment in the survey conducted in Laikang Village. The cost of seedlings accounts for the largest proportion of the total cost at an average of 66 percent (range 42–79 percent). Labour costs account for six to 36 percent with an average of 17 percent, cash fixed costs account for four to -21 percent with an average of 10 percent and other non-labor variable costs account for four to 13 percent with an average of eight percent. According to Ferdinandus, Risambessy and Alin and Eranza, the revenue cost ratio at the seaweed farm level is different across regions[4] . For example, the ratio is 10 for Ambon city and Western Southeast of Maluku, but only 2.38 for Pajukuang Rappoa Bantaeng, South Sulawesi. This difference is related to farm

4 S.J. Ferdinandus., A. Risambessy and R.B.D Sormin., 'Business Analysis on Seaweed Processing and Marketing (Case Study in Ambon City and sub District of Western Southeast of Maluku-Indonesia)', IOSR Journal of Research & Method in Education, 2016;6:10-4 and J.M Alin and D.R.D. Eranza., 'Economic returns from seaweed Euchema cottonii cultivation in Amal beach old village Tarakan, North Kalimantan province of Indonesia', International Journal of Development and Sustainability, 2018;7:2716-30.

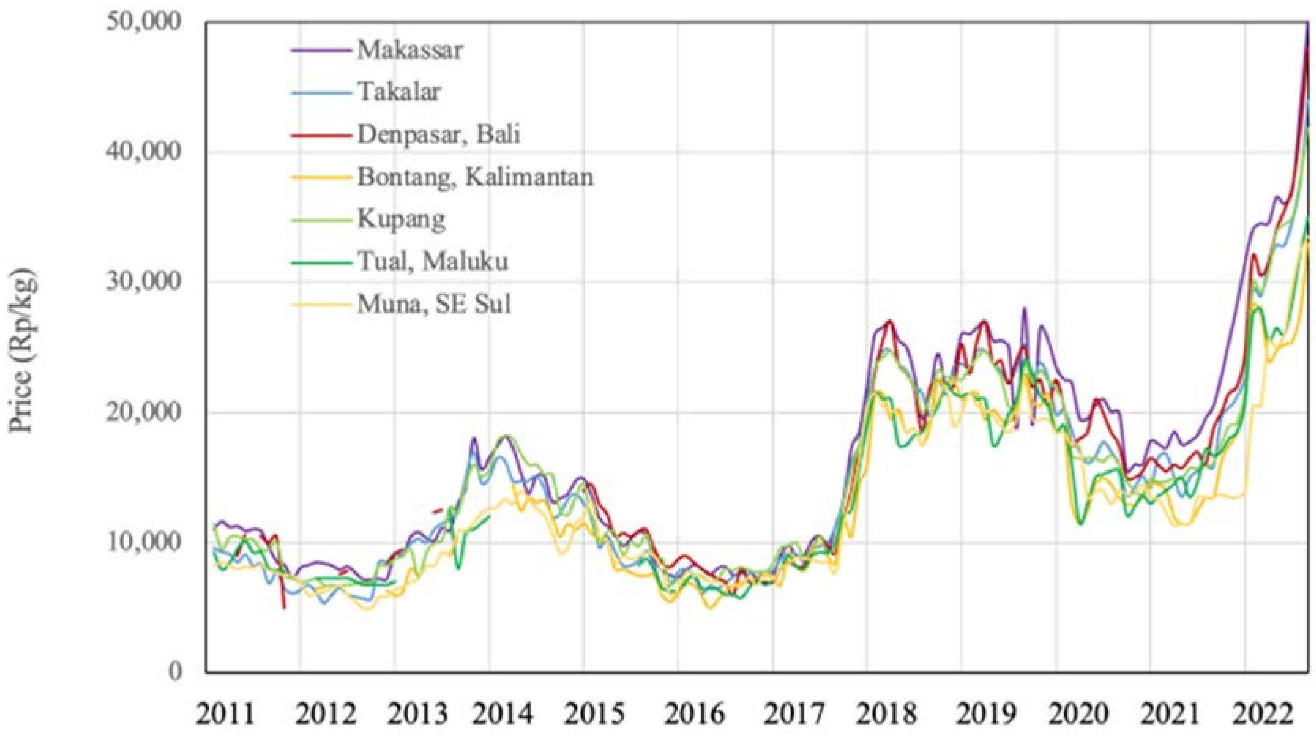

Figure 5: Seaweed prices in major seaweed buying hubs across Indonesia.[5]

scale, farmers' skill and market price. The market price in 2022 is about five times greater than it was in 2017 (figure 5)[5].

Traders

During the May-August 2022 period, local traders bought raw dried seaweed from farmers at 30,000 to 48,500 rupiah/kilogram with the price depending on the seaweed quality (see table 3). The local trader's biggest cost is the fee for the local collector/middleman at 500 rupiah/kilogram, increasing to 1000 rupiah/kilogram if the collector collects more than one tonne. Labour costs follow at around 220 rupiah/kilogram for handling, cleaning, drying and packing. Transportation costs to the point of purchase are low because farmers deliver their products to nearby traders. The small trader usually delivers the product to the large trader, resulting in transportation costs of 118 rupiah/kilogram to the selling point.

The buying price for large traders of dried seaweed is influenced by various factors, such as environment, seasonal and market changes and moisture content

Tarakan and Nunukan in particular have lower prices due to higher moisture content (45 to 50 percent) with the price being 27,000 to 28,000 rupiah/kilogram and 30,000 rupiah/kilogram respectively. The transport and shipment cost from Nunukan to Makassar is covered by the large trader. For other regions, the price to the Takalar warehouse is 42,000-45,000 rupiah/kilogram. Some companies report that they earn more profit by purchasing high moisture content dried seaweed and re-drying it properly with a profit of about 1,000 rupiah/kilogram for Tarakan and Nunukan and 500 rupiah/kilogram for other regions. The main costs paid by large traders/exporters are labour costs (100 rupiah/kilogram) and warehouse construction costs.

Processors

Local processors usually buy raw dried seaweed for 40,000 to 50,000 rupiah/kilogram. Alkali-treated *Cottonii* sells for 103,749-163,033 rupiah/kilogram, while semi-refined carrageenan sells for 177,855-192,676 rupiah/kilogram. The processing technique and raw material quality can affect both prices and costs. The yield for alkali-treated *Cottonii*, semi-refined carrageenan and refined carrageenan extracted from

5 Jaringan Sumber Daya Informasi dan Teknologi Rumput Laut Indonesia', Jasuda, 2022: https://jasuda.net/

Category	Category item	Unit	Average	Minimum	Maximum
Price received		rupiah/kg raw dried seaweed	34500	33000	37000
Variable cost	Seedling planted (1st cycle)	Kg/cycle	1327	400	4800
	Seedling price from seedling provider	rupiah/kg seedling	5200	4000	7000
	Seedling price from seaweed farmer	rupiah/kg seedling	5273	4000	6000
Variable cost	Total seedling costs	rupiah/cycle	6969697	2000000	24000000
Labour time	Family (full time non-paid)	person-days/week	7	3	12
Labour time	Non-family (paid)	person-days/cycle	15	0	42
Labour time	Wage rate for hired labour	rupiah/day	31000	25000	40000
Variable cost	Cost of paid labour	rupiah/cycle	454667	0	1260000
Non-cash fixed cost	Opportunity cost of family labour	rupiah/cycle	1308000	540000	2160000
Variable cost	Fuel	rupiah/cycle	16667	0	40000
Variable cost	Repairs	rupiah/cycle	145333	0	1000000
Variable cost	Plastic bottles	rupiah/cycle	612445	250000	2000000
Variable cost	Tools	rupiah/cycle	9933	5000	25000
Variable cost	Other (tali rafia)	rupiah/cycle	14000	0	150000
Variable cost	Other (minyak tanah)	rupiah/cycle	1333	0	20000
Variable cost	Total non-labour variable costs	rupiah/cycle	799712	282000	3035000
Cash fixed cost	para-para	rupiah/cycle	105611	0	375000
Cash fixed cost	boat	rupiah/cycle	143621	56250	300000
Cash fixed cost	boat engine	rupiah/cycle	91553	0	200000
Cash fixed cost	rope (main line)	rupiah/cycle	288304	133333	575000
Cash fixed cost	tarpaulin	rupiah/cycle	29318	8929	83333
Cash fixed cost	waring	rupiah/cycle	12738	8333	26667
Cash fixed cost	loops/ties	rupiah/cycle	347114	259259	447222
Cash fixed cost	anchor	rupiah/cycle	16118	3750	50000
Cash fixed cost	shelter	rupiah/cycle	27083	0	90000
Cash fixed cost	Total cash fixed costs	rupiah/cycle	1061460	623426	1642917
Variable costs	Total variable costs	rupiah/kg raw dried seaweed	5335		
Fixed costs	Total fixed costs (cash and non-cash)	rupiah/kg raw dried seaweed	1532		
Total costs	Total costs	rupiah/kg raw dried seaweed	6867		
Gross margin		rupiah/kg raw dried seaweed	29165		
Operating profit		rupiah/kg raw dried seaweed	27633		
Revenue-to-cost ratio			05.02		

Table 2: Prices and costs for seaweed farmers in the first production cycle in the year 2022 high season

Notes: Non-family paid labour is assumed to work one week per cycle. The cycle is six weeks with 216 lines used per cycle (table 1). Assume each 40 metre line produces 50 kilograms of fresh wet seaweed (16). One kilogram of raw dried seaweed requires seven kilograms of fresh wet seaweed. Fixed costs were based on the service life of the item. The sample size was 15 farmers.

	Unit	Average	Minimum	Maximum	Sample size
Seaweed purchase cost	rupiah/kg	37150	30000	48500	10
Payment to collector	rupiah/kg	750	500	1000	10
Transportation to purchase point*	rupiah/kg	10	5	25	7
Labour*	rupiah/kg	220	68	477	7
Transportation to selling point	rupiah/kg	118			
Costs in total	rupiah/kg	1098			
Seaweed sell price	rupiah/kg	43320	30000	47000	10

Table 3: The prices received and costs paid by local traders for seaweed

Note: *depends on trip distance, fuel cost 10,000 rupiah/litre; regional levies on the way to the warehouse 10,000 rupiah/trip, around 1 rupiah/kilogram; communication fee is 100,000 rupiah/month, equals to around 1 rupiah/kilogram.

raw dried seaweed is reported as 12:4:3:2.4. This means that processing 1200 kilogram of raw dried seaweed would result in 400 kilogram of alkali-treated *Cottonii* which equals 300 kilograms of semi-refined carrageenan or 240 kilogram of refined carrageenan[6].

Marketing margin results

Table 4 and figure 6 present the price and cost data collected as well as the assumptions used in the marketing margin framework. This data shows the changes in price as the commodity is transformed from a seedling to alkali treated *Cottonii* over time, space and form. The price elasticity of supply, estimated using the United Nations Comtrade database, was 0.52. Figure 6 illustrates the interaction between supply and demand and at equilibrium, the marketing margin is 98,891 rupiah/kilogram. This margin represents the difference between the average sales price of alkali treated *Cottonii* for the processor and the average price the farmer receives for raw dried seaweed. It includes all the costs associated with transforming the raw dried seaweed into alkali treated *Cottonii* over time and space, as well as the profit attributed to each actor. The processor incurs the largest margin since they are responsible for the product transformation, while most of the trader costs are related to logistics.

Actor	Commodity purchased	Commodity sold	Average cost to buy (rupiah/kg)	Average price to sell (rupiah/kg)
Seedling supplier	NA	Seedling	NA	5,273
Farmer	Seedling	Raw dried seaweed	5,200	34,500
Local trader	Raw dried seaweed	Raw dried seaweed	37,150	43,320
Regional trader	Raw dried seaweed	Raw dried seaweed	43,000	48,500
Processor	Raw dried seaweed	alkali treated cottonii	45,000	133,391
Processor	Raw dried seaweed	semi-refined carrageenan	45,000	185,265

Table 4: Buying cost and selling price for actors along the seaweed-carrageenan value chain in Takalar, South Sulawesi in 2022 high season.

Note: alkali treated cottonii and semi-refined carrageenan sold in USD, average exchange rate of USD to rupiah was 14821.22 in August 2022 (interview time). The carrageenan content of dried seaweed is around 30%.

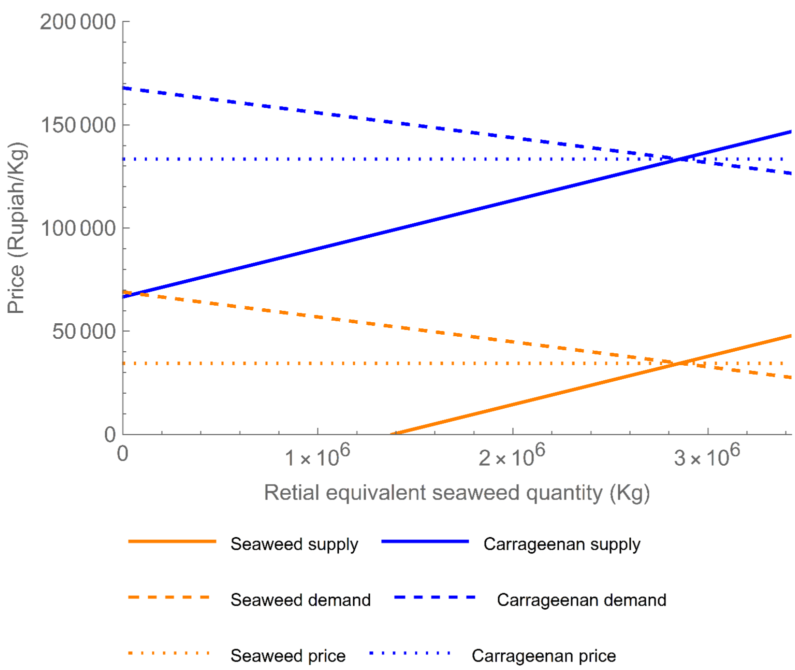

Figure 6: Annual supply and demand of seaweed and carrageenan in Takalar Regency, South Sulawesi. The units on the horizontal axis are the kilograms of carrageenan the seaweed will produce. The units are the retail-equivalent farm production of seaweed where the 'retail product' is carrageenan.

6 Nurmiah Sitti., R. Syarief., Sukarno., R. Peranginangin., B. Nurtama and I. Jaswir, 'Production of refined carrageenan from Kappaphycus alvarezii on pilot plant scale: optimization of water extraction using Response Surface Methodology', International Food Research Journal, 2017;24, pp. 522-8.

4.0 FINDING AND RECOMMENDATIONS

It has been noted that thousands of farmers and traders in South Sulawesi depend upon seaweed for their livelihoods and that the value chain is notoriously complex. Clearly there is much work to be done to maximise success in this industry. From our collected data and value chain mapping it is possible to make a number of recommendations. These recommendations are designed to assist in progress towards creating an economically sustainable and profitable industry for all stakeholders:

Extension services and inancial support: It is apparent that some Laikang farmers know the seaweed quality demanded by traders and processors and are willing to maintain stable product quality within a specific range. To improve farmer incomes, possible options include extension services for disease control and financial support for drying and storing facilities to ensure low moisture and dirt content.

Establish cooperatives and micro-credit programs: There is one point of contact for seaweed farmers with the market and that is through a local trader. The traders or 'middle men' often have a close relationship with the farmers based on family, friendship or financial support. These relationships can have both positive and negative implications. While farmers may gain a secure marketing channel they may also be obligated to sell to the trader who provided credit for seedlings and traders may pressure farmers over prices and product quality.

The traders charge a commission for their services and have the ability to collect and store seaweed in a way that covers their costs and achieves optimal pricing in negotiations with buyers.

We recommend that the commission being paid to traders could be better channelled into farmer groups, cooperatives and micro-credit programs which provide solutions to overcome the issues around financing and offer more selling options. When farmers join a cooperative or farmer group they can negotiate better with traders or processors and store seaweed to hedge against price volatility and attract higher prices.

Governments to provide market price information: Price information in the seaweed value chain flows from processors to traders to farmers, which can make it difficult to understand due to the length of the chain. Seaweed processors are struggling to make a profit due to price volatility and rising costs of raw dried seaweed. Price volatility is not a new phenomenon and it is up to processors to find ways to mitigate costs or pass on increases to carrageenan buyers. While passing on the cost increases to carrageenan buyers may be the solution, it may not be feasible in the long term since carrageenan has substitutes in the manufacturing sector. The ability of carrageenan users to shift into substitute hydrocolloids depends on the product's nature and application. The government can help by providing market price information to all actors, particularly farmers.

Evaluate market displacements: We recommend using our marketing margin framework to help evaluate options for boosting profits along the value chain by looking closely at scenario-based displacements and distortions. These displacements could be caused by supply and demand factors or other factors that influence marketing margins. One should also study the overall benefits to society and how incomes may be affected by these changes, taking into account important factors like the yearly amount of dried seaweed produced in Takalar Regency, how changes in seaweed prices affect its supply, how changes in carrageenan prices affect its demand and the competition among businesses involved in the process as well as their control over the market.

APPENDIX A: MARKETING MARGINS MODEL

We used a marketing margin model to explore the relationship between the supply of seaweed, demand of carrageenan and the marketing margin. The marketing margin includes all the services and activities that connect the producers of seaweed seedlings to the businesses that demand carrageenan. The marketing margin is the difference between price received by farmers and the price paid by consumers for an agricultural commodity. In the model there are two inputs used by the carrageenan manufacturer to produce their final product of carrageenan: raw dried seaweed and a "conglomerate" marketing input. The conglomerate marketing input includes all the costs associated with processing, transport, marketing and trading along the value chain between the time seaweed is sold by the farmer and the carrageenan is produced. The framework is described in existing studies[7] and has been applied to study agricultural commodities such as beef and pork[8], wheat[9], bananas[10], vegetables (onion, tomato, green pepper, cabbage, Ethiopian kale)[11] and rice[12].

We used a series of standard simplifying assumptions in the marketing margin model: a long-run perfectly competitive seaweed-carrageenan industry, fixed proportions meaning every kilograms of seaweed produced is equal to a constant fraction of carrageenan demanded and therefore a constant absolute marketing margin, constant returns to scale, linear supply curves for seaweed and carrageenan with the same slopes. Fixed proportions means that there is zero substitution between seaweed and other non-seaweed inputs in the production of carrageenan and that the supply of marketing inputs is perfectly elastic. Under the fixed proportions assumption farm output is a fraction of retail output and the quantity demanded of a retail product (say carrageenan) exactly equals the quantity supplied of the farm product (say seaweed), where seaweed quantity is expressed in retail equivalent units (i.e., as the kilograms of carrageenan the seaweed will produce).

Data required to develop our marketing margin model included:

- The average price of seaweed sold by farmers. This data was sourced from the surveys of farmers in Laikang.
- The price of carrageenan sold by processors (assumed to be equal to price of carrageenan demanded by the processors who use carrageenan as a gelling agent). This data was sourced from the surveys with two businesses in Makassar and Surabaya who transformed raw dried seaweed into carrageenan. We used only data for alkali treated cottonii in our model.
- Total quantity of raw dried seaweed produced per year in Takalar regency. This quantity was assumed to be 10,000,000 kilograms. This quantity is based on the authors' data reporting fresh seaweed production in the year 2017 for Takalar of 891,000 metric tonnes, which gives 111,000 metric tonnes of raw dried seaweed assuming eight kilograms of wet seaweed is required to generate one kilogram of dry seaweed and that the 891,000 metric tonnes is overestimated by a factor of about 10.
- Price elasticity of seaweed supply. We used data from the United Nations Comtrade database to estimate the price elasticity of export supply in Indonesia. We used this price elasticity of export supply in Indonesia in our model as a proxy for the price elasticity of raw dried seaweed production in Laikang. We estimated the elasticity using a log-log statistical model. We used natural logarithms in the model for both the dependent variable of quantity of seaweed exported per year (kilogram) and the explanatory variable of the price of seaweed in the same year (US$/kilogram). The price was calculated as the value of exports (US$) divided by the mass of exports (kilogram). The available data were for the years 2012 to 2021 and we used Commodity Code 121221, which is for the trade product "Seaweeds and other algae, fresh, chilled, frozen or dried, whether or not ground, fit for human consumption".
- Price elasticity of carrageenan demand was assumed to be −1.
- As we assumed a constant absolute marketing margin, the demand curves are assumed parallel.

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6.0 STAKEHOLDER DETAILS

Indonesian Coordinating Ministry for Economic Affairs

South Sulawesi Marine and Fisheries Office

Takalar Marine and Fisheries Office

BPBAP (Balai Perikanan Budidaya Air Payau) in Takalar.

Jasuda (seaweed data and information network)

Makio Dalle cooperative

ASTRULI (Indonesian Seaweed Industry Association)

PT WPB (manufacturer of semi-refined carrageenan) located in Makassar

PT Bantimurung Indah (seaweed manufacturer) located in Maros District

Local collector in Takalar

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