# Institutional arrangement for quality improvement of the Indonesian *Gracilaria* seaweed

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**Abstract**. Indonesian *Gracilaria* production is high, but the quality is low. This research, a case study carried out in 2018, aimed to identify problems and formulate relevant solutions. Cases where seaweed industry managed to maintain the product quality were used as a benchmark for the less performing cases. The former cases were represented by Luwu and Makassar (South Sulawesi) while the latter were represented by Serang & Brebes (Java). Parameters, consisting of seaweed quality, handling, and distribution, were collected through surveys and literature reviews. Data were analysed descriptively to build a sketch of the problem structure and remedial options, which were then brought to a focus group discussion for feedbacks. Main findings: (i) quality of dried *Gracilaria* from Java ranged between grade 3 and grade 4 (4 representing the lowest grade), while Sulawesi products were graded 1 to 3, (ii) apart from natural determinants, there is an institutional arrangement where Java seaweed industry can adopt from Sulawesi case, (iii) good handling practices in Sulawesi are related to the implementation of warehouse receipt systems, by which global market effects are minimized so that farmers and buyers can secure fair prices, (iv) in order to improve quality, technological interventions can be introduced in this system.

**Key Words**: Indonesia, dried *Gracilaria*, technological intervention, warehouse receipt system.

**Introduction**. Seaweed has become a leading commodity in Indonesia's national economy. The country's climate is favourable to the growth of various species of seaweed, both naturally wild harvested and cultured. Among the ones that have been developed commercially, *Gracilaria* is one of the most important due to the large market potential (Ahyani et al 2014; Srihidayati et al 2018). *Gracilaria* is one of the seaweed species producing agar, that has been successfully cultivated in several provinces in Indonesia, such as South Sulawesi, West Nusa Tenggara, West Java, Central Java, East Java and Lampung (Ahyani et al 2014).

Early initiatives of seaweed farming in Indonesia were recorded in 1975, where the Indonesian Institute of Science began a cultivation project, but it was unsuccessful and then stopped (Saleh & Sebastian 2020). Later, in the 1980s extensive efforts of seaweed farming took place (Blankenhorn 2007). The efforts succeeded, focusing on two species, namely *Eucheuma cottonii* and *Gracilaria* sp., for which Indonesia was ranked the second among the world prominent seaweed production in 2000, but took the lead in 2010 (Salim & Ernawati 2015). *Gracilaria* farming activities attracted many people because of the relatively short planting time, simple technology, relatively small investment, and big profits. The high production potential of *Gracilaria* and its simple cultivation technology are opportunity for its utilization, both for food and non-food purposes, to satisfy both domestic and international market demand (Priono 2013).

A high proportion of the seaweed production in Indonesia is exported in the form of dried seaweed, as an industrial raw material (Priono 2013). As a result, Indonesian seaweed added value stands more in the processing by the importing countries than the production in Indonesia (Priono 2013). Efforts to process *Gracilaria* domestically into higher-value products have not yet been done (Kumala et al 2013). An obvious challenge in doing such efforts is the low incentive of upstream market players to produce better quality seaweeds and this is believed to have created the existing market structure. In this structure, quality is not as determining as supply fluctuation in the formation of seaweed market price (Syahrir 2017). This suggests that market institutional arrangement should be improved.

Coping with problems regarding cultivation, post-harvest handling and processing, as well as marketing systems, there are both technical and non-technical aspects are an economic priority. If quality improvements are not made, processing factories will experience a shortage of raw materials that meet the requirements, the small-medium scale processing industry will stagnate, and seaweed exports will be hampered. The success of addressing these problems will guarantee the production of good quality seaweed, continuous supply of raw materials, and stable prices.

Given this background, the following research questions were formulated: (i) what is the nature of problem of Indonesian dried *Gracilaria* quality, and (ii) how can an alternative institutional arrangement be adopted to solve problems. Following these questions, the purposes of the present research were: (i) to analyse the nature of problem of Indonesian *Gracilaria* seaweed quality and the existing alternative arrangements, (ii) to formulate a strategy to improve the quality and stabilize the price of seaweed, both to meet the needs of domestic raw materials and for exports.

**Material and Method**. This research was based on the case study approach, according to which a case is used as reference for other cases sharing the same variables. Candidate success factors of Luwu and Makassar (South Sulawesi) in maintaining the quality of dried *Gracilaria* were studied and used as a benchmark framework for the case of Serang and Brebes (Java) optimization. Observed factors included those found in practices of the so called warehouse receipt system, namely: quality assurance, price assurance, purchase assurance and insurance, handling mechanism, institutional arrangement, distribution, etc. Data of these factors were collected through surveys, consultations and literature reviews, then analysed descriptively to build a sketch of the problem structure and remedial options, which were then brought to a focused grup discussion (FGD) for feedbacks. FGD participants were asked to comment on the sketch and provide any clarification which the authors perceive as wrong. Modification or improvements on the sketch prepared prior to FGD was done accordingly.

## Results

***Quality measurement of Gracilaria in Indonesia: regulation and practices***. Officially, Indonesia has a documented reference for the quality of *Gracilaria*, namely the Indonesian National Standard No. 2690:2015 (National Standardization Agency 2015). According to this document, quality parameters for *Gracilaria* include moisture content, impurities, clean anhydrous weed (CAW), yield, gel strength, viscosity, and heavy metals content. The standard requires that the moisture content of *Gracilaria* seaweed does not ecxceed 12% while impurities should not be greater than 3%. Five types of heavy metal are covered by standard, namely the: arsenic (1 mg $kg^{-1}$), cadmium (0.1 mg $kg^{-1}$), mercury (0.5 mg $kg^{-1}$), tin (40 mg $kg^{-1}$) and lead (0.3 mg $kg^{-1}$). Meanwhile, the minimum standard for organoleptic acceptance score is 7 according to a sensory scale of 0 to 10.

However, the provisions of this Indonesian National Standard (SNI) are not fully followed by market players in the industry. Although parameters have been listed in the SNI, only two of them are normally referenced in domestic *Gracilaria* trade. The two operational parameters are moisture and impurities, where the numbers are determined by the buyers. Based on the buyers' standard, the maximum moisture content of the seaweed varies from 16 to 18%, impurities should not be greater than 3% and it must be ensured that dried seaweed must be of uniform black color and have a large thalus size. Other requirements as mentioned in SNI, namely heavy metals and CAW, are applied only in trading, at the downstream level, including the export activities, together with a number of other parameters, for example: yield, gel strength and viscosity of the extracted agar. At this level, some buyers required that seaweed has an agar yield greater than 10% and a gel strength greater than 1000 g $cm^{-2}$. In some developing countries, poor agricultural producers have successfully applied warehouse receipt to solve fundamental marketing problems. However, such systems have not been easily applied in Indonesia (IFC 2015), as also stated by Hidayah et al (2019): in Indonesia, using warehouse receipt as a guarantee could not practically improve the credit amount of banking though the regulation Law No. 9/2011. Therefore, a warehouse receipt system (WRS) has been accomodated.

***Formation of Gracilaria quality in Indonesia: determining factors***. From field observations in this study, it was learned that in general the quality of Indonesian seaweed reflects the resultant of a number of external variables and internal variables. External ones are not easily controlled, while the internal ones can be enhanced. Variables that cannot be controlled are natural/environmental factors and the seaweed species, while factors that can be controlled are farming technology, harvesting system (technology and wages), post harvest practices (drying, sorting, cleaning, storage, and packaging techniques), and price (Haryanti & Munifatul 2008; Paul & Chen 2008).

The contribution of natural factors and species of seaweed is attributed to their effect on growth, resistance to disease during cultivation and influence on innate quality characteristics. For example, a long dry season caused an increased pond water salinity up to 30 to 40 $mgL^{-1}$, which resulted in a slower growth of farmed seaweed and in decrease product quality. High salinity is favorable to the growth of epiphyte, which exacerbates the seaweed quality degradation; seawed whose epiphyte is entangled in the thallus are difficult to clean, making it falling into a rejection quality category. The side effect of long droughts and high salinity are also associated with small thalus size, which also contributes to a decrease in quality.

Among the internal (controllable) factors that shape the quality of Indonesian seaweed, the first is the technology applied for cultivation, comprising: good quality seed (loc: bibit), handling water quality, fertilizing, density of intercropping commodity (for example seaweed and milkfish polyculture) and harvest timing. Among the technology components, the one that most frequently causes the low quality of Indonesian *Gracilaria* is early harvesting, which produces small-sized seaweed with a low agar content and quality. While *Gracilaria* is ideally harvested at the age of 50 to 60 days, many farmers harvest at 30 to 40 days. Early harvesting is often applied also to fish (milkfish), in the polycultures, which leads to thick epiphyte cover as it is no longer consumed by fish.

The next internal factors identified through this research are related to the harvesting process. At the harvesting stage, there are two important things that influence the quality of seaweed, which are washing/cleaning and harvesting wage systems. There are only a few farmers who properly wash the seaweed. They often use dirty water from the pond, mixing the seaweed with mud from the bottom of the pond. The importance of the harvest wage system is related to the motivation of workers to handle seaweed well in order to enhance the product quality. Many cases were found in this study where harvesting systems were based on the yield (i.e. weight) of seaweed and ignored the quality aspects (e.g. impurities attached to the seaweed).

In the post-harvest handling stage, 3 factors were identified as affecting the quality of Indonesian seaweed, namely the drying, cleaning and storing methods. Some farmers perform drying directly on the pond's embankment without any covering mat, causing high impurity content, high moisture content, normally in the range of 25 to 30%, far from the required level of 16%. Another cause of low quality seaweed is the absence of top covers needed to prevent water reabsorption by dried seaweed after rainfall (for example), which increases the risk of damage by bacterial and fungal activity. The next critical post-harvest handling stage is storing in the on-farm warehouses; at this stage, the decrease in the quality of seaweed is attributed to poor existing facilities; on-farm warehouses are not normally equipped with light and rain protection, and the average humidity remains high. Although these warehouses are supposed to be temporary, the storage period is often extended for a long time, i.e. in cases where seaweed collectors/middlemen already have sufficient stock. The required quality of the stored goods (dry *Gracilaria* in this case), can be obtained through the appropriate warehouse technical design and operational management, as comprehensively discussed by Shah & Khanzode (2017). As mentioned by Mapunda et al (2018), the WRS offers an opportunity by providing collateral guarantees to financial institutions to provide credit to smallholder farmers for their agricultural products stored at the warehouses.

The next controlable factor is the on-farm price. It is undeniable that the price of Indonesian seaweed is strongly influenced by the dynamics of the global market. Domestic stakeholders can only intervene to a limited extent. However, there is still enough room to engineer prices in order to secure fair revenue levels for the industry upstream players, which are expected to play roles in the quality improving of Indonesian seaweed. This research found that in 2014, when the price of dried *Gracilaria* reached 0.50 USD to 0.70 USD $kg^{-1}$, farmers had a strong motivation to maintain their product quality, throughout cultivation, harvesting and post-harvest handling. When the seaweed selling price from farmers is too low, the profit margin becomes very small. To reduce expenditure, only a minimum treatment is carried out in the cultivation, harvesting and post-harvest handling, and these practices inevitably affect the quality.

## Discussion

***Synthesis of the problems and the search for relevant solution***. A FGD confirmed that the case of Indonesian *Gracilaria* low quality can be linked to the decrease in the motivation of actors to strive for quality products that meet national and industrial standards. Over recent decades, seaweed warehouse design and operations have undergone major changes (De Koster et al 2017), such that technology is not a problem for seaweed farmers to implement better post-harvest handling, as long as it is worthwhile for them to do so. However, greater control and monitoring of the warehouse operations could still be achieved by developing innovations such as Warehouse Management Systems (WMSs), because traditional technology systems have become obsolete and unsuitable to new market requirements (Hamdy et al 2018). FGD participants confirmed that in the past, when the price of seaweed was high, traders and middlemen found no difficulty in encouraging farmers to practice good harvesting and handling. At that time, harvesting at an adequate age, cleaning and drying were carried out with the aim of obtaining the best quality. At present, when seaweed prices are down, the farmers perceive that the received additional profits created from such improvement are not proportional to the subsequent costs. The lack of motivation also makes farmers neglect good managing practices in the harvest operations. This is particularly true in the case of piece harvest workers who are paid by farmers based solely on the volume, without any incentivisation mechanism based on the product quality parameters,  such as the dryness and impurities of the seaweed.

Furthermore, a lesson learned from this study shows that the decline in price of *Gracilaria* has raised the loan burdens: fresh funds are a necessity for investments, working capital and personal needs forced farmers to get tied to high interests. Providers of these loans are mostly seaweed buyers; consequently, farmers must accept the price set by the buyers, which is usually too low for maintaining the traded seaweed quality.

Similar problems occur downstream the seaweed supply chain. This condition is aggravated by the absence of independent institutions performing objective measurements related to the quality of transacted seaweed. The quality of the farmers' seaweed is assessed only by collectors, while the quality of the collectors' seaweed is determined based on the assessment carried out by the processing plants, with a large exposure to conflicts of interest. Also, upstream business players are facing serious risks due to a lack of assurance that their seaweed would be accepted by the processing plant.

This unconducive context determined by the price drop is exacerbated by unhealthy physical and social environments. Regarding the infrastructure, this research identifies a lack of volume capacity of warehousing facilities, a situation which makes farmers unable to keep their seaweed stored in the warehouse, waiting for a reasonable price. In almost all production centers, seaweed storage facilities that meet the standards were missing. At some farmers' ponds, seaweed transit warehouses with a capacity of 5 t were built to store seaweed for 1 to 5 days prior to delivery to a middleman's warehouse. In other places, transit warehouses are seen as unnecessary as the middlemen warehouses are located not too far from the pond.

Alternative solutions should address the aforementioned problems. In general, such solutions should cover a number of important objectives, namely: (i) stable and fair price for every market play-actor, (ii) standard-complying quality, (iii) maintained productivity and (iv) supply adequacy for the domestic processing industry. Although necessary, these solutions are not sufficient. For example, to address the issues of the volume-based harvesting payment scheme, the alternative is integrating harvest activities with cultivation works; but this solution will face financial constraints due to a higher spending for harvest, which hasto be adjusted, in this case, to the cultivation period (harvest age). Another enhancement solution would be to build warehouses in the production centers, butfinancial and management prerequisites are challenging.

Adopting the so called WRS would overcome all the issues mentioned above. Warehouse receipts are documents/proofs of ownership for the stored goods, issued by a warehouse manager who has been certified by the Commodity Future Trading Regulatory Agency and the Ministry of Trade (BAPPEBTI 2014). The definition of this system refers to the Ministry of Trade Regulation No. 33 of 2018 concerning goods compatible with the warehouse receipt systems, including the seaweed. According to the regulation, the warehouse receipt system includes a variety of activities related to the issuance, transfer, guarantee and settlement of warehouse receipt transactions. Determination of goods in the WRS is carried out by considering recommendations from the regional government, relevant agencies or commodity associations while taking into account the requirements of Article 3 of the Minister of Trade Regulation No. 37 of 2011, regarding: power saving, quality standards, minimum quantity of goods stored.

Among the features qualifying WRS as a strategic solution are: quality guarantee, standardized warehousing facilitation and fostering receipt-holding farmers and groups that coordinate them (cooperatives/collectors) (Putri 2015). Lessons learned from the implementation of warehouse receipt systems imply the need to consider the application of this system more broadly. A comparison of the seaweed management practices' performances and challenges between adopters of warehouse receipt systems and adherents to conventional systems are presented in Table 1 and Table 2.

Table 1

Advantages of warehouse receipt systems over non-warehouse receipt systems

| *WRS* | *Non-WRS* |
|---|---|
| Quality assurance | |
| Independent quality measurement by a BAPPEBTI-certified analysis institution | Performed by processing plant staff<br>QC exists, but measurements are mostly done using subjective ways |
| Price assurance | |
| When the market price < the receipt's basic price, seaweed is purchased by the cooperatives at the receipt's basic price<br>First payment is 70 % of the total sales<br>Second payment is paid after seaweed is sold by cooperatives, following a profit sharing scheme as previously agreed by both parties | Price follows the market dynamics |
| Purchase assurance | |
| The volume of purchases from farmers is almost unlimited, depending only on warehouse capacity | The volume of of purchases depends on processing plant capacity |
| Insurance | |
| Stored seaweed is insured | Seaweed is not insured |

Table 2

Advantages of non-warehouse receipt systems over warehouse receipt systems

| *WRS* | *Non-WRS* |
|---|---|
| Needs a financial institution; banking is not normally interested | Does not require financial institution support |
| Rigid banking regulations: too many conditions apply to warehouse receipt requests | More flexible because it does not involve funding institutions |
| Banks often take too long to process warehouse receipt credit disbursement | Payment of goods is often delayed |

***Opportunities and challenges for the development of warehouse receipts***. The expansion of the implementation of warehouse receipt systems in other regions has a number of opportunities and constraints that must be considered.

Table 3

Opportunities and constraints for the wider application of warehouse receipts

Opportunities:

- Production: very large production potential
- Marketing: mechanism of seaweed movement from the pond to the collectors' warehouse is established
- Institutional: best practices from an institution implementing the WRS system in one location can be transposed in other contexts
- Warehousing: There are several examples of warehouses hat have met the warehouse quality standards that are integrated with the cultivation and handling systems, which can be used as a model for the construction of new warehouses elsewhere
- There are examples of integrated warehousing models accommodating various commodities for efficiency purposes (Cottonii seaweed, tobacco, etc.).
- Warehousing networks for other commodities are well-established:
  (1) private warehouses with a capacity of 100-200 t each
  (2) public warehouses owned by the trade ministry, that are currently not properly utilized.

Constraints:

- Most existing warehouses do not meet standard requirements
- Non technical aspects:
  - Price increases are not in line with quality improvements
  - Farmers in general have been tied to loans to collectors
  - Small-scale collectors depend on larger-scale collectors for their business operations
  - There are potential areas for *Gracilaria* cultivation thathave good warehousing facilities, but are constrained by non-technical aspects related to contracts with landowners
  - Many farmers harvest seaweed before the optimal time necessary to produce quality seaweed of 50 days
  - Among the three value chain sections concerned by the WRS implementation (farming, post-harvest and processing industries), the post-harvest section has the least problems
  - Opportunities and constraints related to the application of warehouse receipts are localistic, however, their application cannot be generalized
- Warehouse management costs are relatively high
- WRS requires large receipt warehouses (capacity of 2,000 t) and are certified to accommodate products from the surrounding areas
- Funding institutions: constrained by (i) lack of human resources specialized in the WRS field and (ii) lack of quality test officers

Table 3 summarizes the results of identification of these potentials and challenges, which are based on research in 6 *Gracilaria* namely Palopo, North Luwu, Serang, Bekasi, Brebes and Pamekasan (potential locations).

Warehousing systems in the WRS can still be improved, for example by incorporating seaweed storage technologies that take into account the Moisture Sorption Isotherm (MSI) equilibrium curve pattern. MSI curves describe the relationship between the equilibrium relative humidity (RH) of air and the moisture content of a material during the storage (Adawiyah & Soekarto 2016; Somantri 2003). By comparing the initial seawater moisture content data with the equilibrium moisture content at the storage location, evolution of the material's moisture can be predicted and adjusted to remain within the standard reference range (16 to 18%). Due to differences in RH conditions in each region, the seaweed equilibrium humidity value must be considered and used as a reference in determining seaweed storage conditions (Supriadi et al 2015). The shelf life of agricultural products is greatly affected by the water content, which is determined by the RH of the storage environment (Histifarina 2004; Fitriani et al 2015). In areas with a high RH, special handling, such as certain packaging techniques, can be applied in order to prevent an increase in the moisture content of dried seaweed stored in the WRS warehouse.

**Conclusions**. This study concluded that an innovative institutional arrangement in the form of WRS can be expected as a strategy to deal with complex problems involving price stability, quality measurement, processing industry raw material supply and fair pricing. Through the WRS, several post-harvest technologies can be introduced to further improve the quality of seaweed, for example the storage technology based on the water sorption isotherm curve. To support such a WRS program, there is a number of prerequisites, such as: seaweed quality improvement to meet the industry and warehousing standards, building standardized warehouses and preparing a cooperation institutional framework among the related parties.

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