Seaweed Nation:
Indonesia’s new growth sector

Connectivity, People and Place

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PAIR

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INTRODUCTION

The AIC’s PAIR researchers recently visited the small coastal village of Pitue, in Pangkajene dan Kepulauan (Pangkep) district, South Sulawesi. Seaweed farming has become a key business for communities here, though the local industry needs to further develop if it is to lift more people out of poverty.

Studies suggest the industry has the potential to provide much higher household incomes than fishing, but opportunities are limited by a lack of downstream processing and, for many, imbalanced access to the industry (La Ode et al.)

As an archipelagic nation, Indonesia has more than 17,000 islands. Its coastline is the second-longest in the world after Canada. Its marine area spans 1792 million hectares, three times the size of its landmass. The potential production of fisheries and aquaculture is enormous. It is about 100 million tons per year, compared to the current output of 20 million tons per year. (Subjakto S, 2019)

Seaweed can boost the economy and improve the livelihood of coastal communities. Indonesia is already the largest seaweed producer in the world. It accounts for more than a third of global seaweed production. In 2014, its exports were A$300 million, with production increasing by about 30% per year. (Sedayu, B.B., 2018)
**SEASWEED IN INDONESIA**

Seaweed was first documented in the Indonesia archipelago (Nusantara) in 1890. As an industry, it only started to flourish in the 1980s. Below (Figure 1) is an overview of its history (Zamroni and Salim, 2015; news from industry.co.id, 2017; Qing, 2018):

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1899</td>
<td>Sibolga Marine Expedition (1899 - 1900) led by Max Weber and Anna Weber-von-Bosse identified 782 types of seaweed in the archipelago.</td>
</tr>
<tr>
<td>1967</td>
<td>The first seaweed symposium held on seaweed cultivated in Indonesia (Thousand Islands District). In the same year, Spinosum was first cultivated in Tikus Island, Jakarta Bay.</td>
</tr>
<tr>
<td>1968</td>
<td>Seaweed categorised as Eucheuma, Gracilaria, Gelidium, Hypnea, and Sargassum by the Food and Agriculture Organisation (FAO).</td>
</tr>
<tr>
<td>1974</td>
<td>Cotton ii type seaweed originating from the Philippines is cultivated in Indonesia.</td>
</tr>
<tr>
<td>1975</td>
<td>LIPI, the Indonesian Institute of Sciences, a governmental authority for science and research in Indonesia, begins a cultivation project in Samaringga and Rio Island (Sulawesi). The project fails and is stopped.</td>
</tr>
<tr>
<td>1981</td>
<td>Indonesia makes exports 81 tons of dried seaweed.</td>
</tr>
<tr>
<td>1986</td>
<td>Experiment for Cottonii cultivation is conducted in Bali. It results in good yield the following year.</td>
</tr>
<tr>
<td>1994</td>
<td>Indonesian Seaweed Industry Association (AP-BIRI/Asosiasi Pengusaha Budidaya dan Industri Rumput Laut Indonesia, office in BPPT, Jakarta) conducts seaweed symposium in Bali.</td>
</tr>
<tr>
<td>2014 - 2019</td>
<td>President Jokowi makes seaweed cultivation a priority. The Ministry of Maritime Affairs and Fisheries (KKP) responsible for improving the welfare of Indonesian coastal communities.</td>
</tr>
</tbody>
</table>
NOT JUST SUSHI

Seaweed is a marine plant that occurs in salt and freshwater. It has no roots, no stems and no leaves. There are four colours: blue algae (Cyanophyceae), green algae (Chlorophyceae), red algae (Rhodophyceae), and brown algae (Phaeophyceae). All four types of seaweed are in Indonesia, with red seaweed the most found in Indonesian waters.

Though seaweed is harvested around the world, eight countries in Asia produce a staggering 99%. China and Indonesia are, by far, the most significant producers. According to the Food and Agriculture Organisation, China’s holds a 47% share of the total production of 30.05 million tons, while Indonesia’s share is 38%. But up to 80% of seaweed exports are in the form of low value-add - dried raw materials - sent to China, South Korea and Vietnam.

Indonesia’s seaweed production increased by almost three times between 2010 and 2015 (see Figure 3). Its rapid growth is due to the development and cultivation of Kappaphycus alvarezii and Eucheuma spp. - these are the primary raw materials for carrageenan extraction, used to thicken, emulsify, and preserve foods and beverages (Suadi and Eiichi Kusano, 2019).

A 2016 report from the World Bank estimates that the annual global seaweed production could reach 500 million dry tons by 2050 if the market can increase its harvest 14% per year. Reaching 500 million would boost the world’s food supply by 10% - from the current level - create 50 million direct jobs in the process and, as a biofuel, replace about 1.5% of the fossil fuels used to run vehicles (World Bank, 2016).

Seaweed is the most significant contributor to Indonesia’s total aquaculture production. It is also a growing economic driver. Up to 80% of seaweed exports are in the form of low value-add dried raw materials sent to China, South Korea and Vietnam.

Seaweed is a versatile product. It is in fertilisers, food additives and animal feed ingredients, or extracted for carbohydrates such as agar or Carrageens. Recent developments in bio-refining are turning seaweed into biofuels, chemicals, cosmetics and pharmaceuticals. Australia’s national laboratory, CSIRO, is even looking at a way to feed seaweed to cattle to reduce greenhouse gas emissions from Australia’s $17 billion livestock sector. Indonesia’s start-up, Indonesia Evoware, has invented cups and food containers made from farmed seaweed as an alternative to plastics. The company also designed food wrappings and sachets for products such as instant coffee or flavouring for noodles to dissolve and eaten.

Figure 3. Indonesia seaweed production

Source: Food and Agriculture Organisation (2018)
As an aquaculture sector, seaweed employs approximately 3.3 million workers (Packard Report, 2018). It does not need significant capital investments nor sophisticated technology. Its harvest age is short, between 1.5 to two months, making cultivation a more reliable source of income for fishermen and farmers (Cumming V, 2016).

Sixty-five per cent of total seaweed production is consumed. While edible seaweed is a nutritious food source with high fibre, carbohydrates, proteins, minerals and low fat, yet Indonesia consumes only 1%, in contrast to Japan’s 20%. About 15% is hydrocolloid ingredients, and 20% turned into fertiliser, paper and biofuel. (Dahuri, 2011)

Seaweed is also turned downstream into high value-added products. Carrageenan, for instance, is a strong binder for food proteins. It’s gelling, thickening, and stabilising properties applies in the food industry, especially dairy and meat products. Carrageenan is also a vegetarian and vegan alternative - used to replace gelatin in confectionery. Alginate, on the other hand, is a marine biopolymer used to thicken solutions, to make gels, and to form films and several industrial applications. The textile industry uses it as thickeners for the paste containing dye (Babel et al. 2015). The food and beverage industry uses Alginate in ice creams and sauces (Kim, 2012).

Figure 4 provides an overview of the three post-harvesting processing pathways of seaweed - from pharmaceutical grade to industrial and food-grade products.

**SEAWEED PROCESSING**

Seaweed processing is in three stages: i) cultivation; ii) post-harvest processing and iii) collection, distribution and downstream processing into industrial products.

Harvesting takes place every 45-60 days or about four times a year. Cultivation techniques involve ropes and nets. But, bringing seaweed to land is labour intensive and can be a costly aspect of sea farming.

Once it is onshore, seaweed is washed and impurities removed. Fouling, fauna, tying strings and a variety of other contaminants are removed by hand, as are unwanted and damaged parts. Once washed, the product is then ready for consumption, processing or packaging for storage (See Radulovich, R. et al. 2015).

Below (Figure 5) is an example of seaweed cultivation, processing and interactions between seaweed farmers and other actors (Zamroni & Yamao, 2012).
SEAWEED SUPPLY CHAIN

Indonesia’s seaweed supply chain is a vertical collaboration. It involves farmers, traders, manufacturers and exporters. (Mulyati, H. & Geldermann, J., 2017). A 2019 report produced by the Centre for the Promotion of Imports from Developing Countries (CBI) maps in detail the five important actors in Indonesia’s seaweed value chain: a) input suppliers; b) seaweed farmers; c) collectors, traders and cooperatives; d) exporting traders; and e) processors. (CBI, 2019) The section below outlines the value chain based on the CBI report. (Figure 6)

i) Input suppliers involve seaweed collectors and local government agencies. Both play a role in supporting farmers with farming inputs such as lines, ties, buoys, anchors and seedlings. Collectors often finance such inputs, while local government agencies often assist with seedlings.

ii) Seaweed farmers are usually smallholders from coastal communities. A farmer tends to have other sources of income, outside the seaweed growing season. Some seaweed farmers form legal entities, such as cooperatives, or informal farming groups. Farmers sell their seaweed to collectors in cash-based transactions. The sale price at the farm level is set by local collectors, who in turn get their prices from district traders or export traders. Farmers lack information on sharp price fluctuations on the market or margins in the value chain. If farmers face cash shortages, they sell it even when crops have not matured.

iii) Collectors, traders and cooperatives exist in different sizes. Smaller collectors often operate in the same village as farmers. Often, collectors are also leading or large farmers. These collectors finance farmers by purchasing the necessary inputs such as lines and seedlings. In return, they get all the harvest. These types of arrangement make farmers dependent on collectors.

District traders often work with traders. They arrange transport from collectors to warehouses where the quality, moisture and impurities contents are checked, packed and delivered to exporters or local processors.

Cooperatives are also involved in seaweed collection, drying and trading. Cooperatives engage in financial loans, technical help, supplying input to members, selling to traders or exporters and local processors. Kospermindo is an example of a cooperative that operates in 11 districts in Sulawesi.

iv) Export traders supply to foreign markets and domestic processors. About 100 exporting traders are operating in Indonesia. They tend to use different models to source seaweed. Some source from five to ten district traders, while others work with collectors and have up to 200 suppliers. Traders source seaweed from different areas to ensure that there is an ongoing supply based on seasonal or weather variations. Exporters buy dried seaweed based on spot purchasing orders from China or buyers in other parts of the world. Based on these orders, they give short-term contracts to suppliers to deliver specific amounts, at a certain quality in one or two months at a particular price. Prices change every week, based on rates provided by buyers in China.
v) Processors - Many processors operate with government support and are considered uncompetitive. In 2007, there were an estimated 150 seaweed processing companies in Indonesia, with a majority located in East Java. There are at least three types of processing companies:

Highly effective companies with modern technology and good connections to the market such as Java Biocolloid for carrageenan and AgarIndo for agar-agar.

Companies that have developed slowly and face issues in access to finance, human resources, technology and markets;

Struggling companies that face challenges to remain active in the market. Some seaweed factories in eastern Indonesia are government-owned and generally not well managed.

No processor operates at full capacity. Some use as little as 30% to 40% of their productive capacity. Low capacity is most likely due to a lack of access to seaweed or a lack of market access (CBI, 2019).

Processors face three challenges—first, the need to upgrade technology. About 60% of seaweed companies only have access to outdated machinery. Second, the need to improve human resources. Sixty per cent of companies interviewed pointed to the lack of staff experience as an obstacle. The third challenge is the need to improve quality assurance. About 40% of the companies interviewed indicated difficulties to ensure stability in quality and microbiology. (CBI, 2019).

Figure 7 shows a typical seaweed supply chain model in South Sulawesi. The leading players in the business are farmers, collectors, processors (companies), and buyers.

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Figure 7. Seaweed supply chain model in Makassar, South Sulawesi

Source: Mulyati, H. & Geldermann, J., 2017
To sustain the supply of dried seaweed, the processors collaborate with producers (seaweed farmers) on technical assistance, seaweed farmers’ training, and financial capital support. Seaweed farmers are, however, not well organised. As such, there are opportunities to strengthen collective-based seaweed production to fulfil the need for standardised seaweed products from farmers and to facilitate empowerment and cooperation (Suadi and E. Kusano 2019).

Both internal and external risks can threaten supply chains (Mulyati, H. & Geldermann, J., 2017). Internal hazards include coordination problems within the supply chain, which occur in processing and manufacturing. External risks are risks outside of companies and supply chains, which include financial, policy and infrastructure risks. Figure 8 maps the sources of seaweed supply chain risk.

Figure 8. The sources of seaweed supply chain risk

Source: Mulyati, H. & Geldermann, J., 2017
SEAWEED AS A NATIONAL PRIORITY

Indonesia has ambitious plans to boost its seaweed sector. In 2015, President Joko “Jokowi” Widodo announced a Roadmap to make Indonesia a world leader in carrageenan and agar-agar (jelly) industries by 2021. President Jokowi called for the development of the industry to process all seaweed. “We have to develop the downstream industry to be able to export finished goods. We must not continue to be a supplier of raw material”, he said. (Republika Online, 2015)

The plan focused on three particular priorities: double seaweed production from 10.6 million tons to 19.5 million tons by 2019; process half of it domestically by 2020; and reach a target of seaweed mix (5% content) in the feedstock for fisheries and animal farms (KKP, 2015).

Some critical points identified in the national seaweed roadmap include:

- Five of Sulawesi’s six provinces (all except West Sulawesi) offer prospects for two essential groups of seaweed species (Eucheuma and Gracilaria)
- Key factors in fulfilling the roadmap:
  - Improving the sub-optimal practices of seaweed cultivation;
  - Optimising the use of land/seaways for seaweed cultivation;
  - Engaging the ASEAN Economic Community as a means to boost efficiency and competitiveness;
  - Maximising the use of domestic seaweed produce for downstream production;
  - Raising competitiveness of domestic seaweed manufacturing sector; and
  - Increasing the pace of investment in seaweed manufacturing sector.

- Key challenges to fulfilling the roadmap:
  - Delineate the allocation of space for seaweed cultivation within the various spatial related plans;
  - Availability of quality and quantity of human resources for cultivation and processing;
  - Application of Indonesian National Standards in both cultivation and processing stages;
  - Availability and supply of quality produce for processing on a sustainable basis;
  - The fluctuation of prices for raw seaweed;
  - Expensive transport and logistics costs;
  - Sub-optimal rates of utilisation of processing facilities;
  - Insufficient supporting infrastructure (roads, clean water, electricity and gas);
  - Government fiscal policies that are not internationally competitive;
  - Upstream and downstream databases that are not synergistic;
  - Limited market access for seaweed producers and processors.
The government has identified several constraints in developing the seaweed industry.

1) lack of coordination between central government, regional, business and communities.

2) no seaweed processing companies in eastern Indonesia - all companies are located in Java - even though most seaweed production is in the east. According to the Centre of Excellence for Development and Utilisation of Seaweed at Hasanuddin University, the 14 Indonesian companies producing agar are all located in Java's big cities: Medan, Tangerang, Sidoarjo, Surabaya and Malang, and none in South Sulawesi.

3) the poor logistics and supply chain system is a constraint, as it fails to move seaweed from farms to ports and across islands in a timely, efficient and cost-effective way.

4) the lack of innovation in the seaweed value chain is holding back the sector (Mongabay, March 2019). Seaweed development is lacking adequate investment in science and downstream innovation.

There are already several strategies underway to develop seaweed industry, including:

- A focus on increasing productivity and quality of seaweed (Hikmah, 2015).

- The development of the processing industry for semi-refined seaweed near the centres of seaweed production (Hikmah, 2015).

- The development of consumable seaweed businesses from micro-scale into industrial scale. Indonesia is investing significant effort into cultivating more seaweed and expanding its global market. But this effort is not matched by the development of adequate post-harvest processing and downstream industries.

- A digital platform called Tropical Seaweed Innovation Network (TSIN, https://www.seaweednetwork.id/) that was created to connect all seaweed stakeholders. The platform facilitates a network, promotes cooperation and synergy, and encourages innovation.

- The initiation of a number of activities that involve government (central and regional), academics and the private sector coming together to collaborate. (Perpres No. 33/2019). The Perpres is expected to be a guide, both in increasing the production of seaweed value-added products and more broadly in the development of a reliable, competitive and sustainable seaweed industry, so that Indonesia’s large seaweed potential can be further expanded.
ACTORS IN THE SEAWEED INDUSTRY

The seaweed industry is managed directly by the central government through the Ministry of Marine Affairs and Fisheries (Kementerian Kelautan dan Perikanan/KKP) - under the Directorate General of Aquaculture (Direktur Jenderal Perikanan Budidaya) and Directorate General of Marine and Fisheries Product Competitiveness (Direktur Jenderal Penguatan Daya Saing Produk Kelautan dan Perikanan).

Below is a list of key seaweed actors in Indonesia:

1. Government
   - Ministry of Marine Affairs and Fisheries (KKP)
   - Coordinating Ministry for Marine Affairs (Kemenkomar)
   - Ministry of Finance
   - Ministry of Industry
   - Ministry of Trade
   - Supporting Ministries and Agencies
   - Ministry of Cooperatives, Small and Medium Enterprises
   - Ministry of Villages and Underdeveloped Regional Development
   - Investment and Coordination Board

2. Business and Business Associations
   - ARLI (Indonesian Seaweed Association, Asosiasi Rumput Laut Indonesia, led by Safari Azis)
   - ASTRULI (Indonesian Seaweed Industry Association/Asosiasi Industri Rumput Laut Indonesia; led by Mc Donny W Nagasan)
   - ASPERLI (Seaweed Farmers Association/Asosiasi Petani Rumput Laut; led by Arman Arfah)
   - MAI (Indonesian Aquaculture Society/Masyarakat Akuakultur Indonesia, led by Safari Azis)
   - Celebes Seaweed Group (CSG, local level in South Sulawesi; led by Mursalim)

3. Research
   - BPPT (Agency for the Assessment and Application of Technology/Badan Pengkajian dan Penerapan Teknologi) - BPPT has its own seaweed research focus. Among them is the development of seaweed-based capsules by Pusat Teknologi Agroindustri (Agro-Industry Technology Centre)
   - Balitang KKP (The Centre for Marine and Fisheries Research and Development/Badan Penelitian dan Pengembangan Kelautan dan Perikanan) which operated the following centres:
     - Centre for Research and Development of Marine and Coastal Resources (Pusat Penelitian dan Pengembangan Sumber Daya Laut dan Pesisir);
     - Centre for Research and Development of Marine and Fisheries Products and Biotechnology Competitiveness (Pusat Penelitian dan Pengembangan Daya Saing Produk dan Bioteknologi Kelautan dan Perikanan);
     - Centre for Marine Socio-Economic and Fisheries Research (Pusat Penelitian Sosial Ekonomi Kelautan dan Perikanan);
   - LIPI (Indonesian Institute of Science) - Seaweed research in LIPI is undertaken by the Centre for Oceanography Research (Pusat Penelitian Oseanografi), which also has a Centre of Excellence on Marine Bioprospecting. Seaweed downstreaming research development is also conducted by LIPI as a potential cure for cancer.
   - Universities - Seaweed experts are scattered in Indonesian universities, especially those that are autonomous state universities (PTNBH). It is worth noting that Ristekdikti has established the Centre of Excellence Seaweed at Hasanuddin University (PUI-P2RL) in 2016, the only one in Indonesia. However, there seems to be no clear divisions of focus among the various institutions involved in seaweed research.

In 2006, the Minister of Marine and Fisheries established the Indonesian Seaweed Commission (Komisi Rumput Laut Indonesia) - consisting of various ministries. The commission no longer exists with its last news dated back in February 2018.
NATIONAL SEAWEED RESEARCH & DEVELOPMENT

The National Seaweed Development Programs for 2018-2021 as listed in Perpres No. 33/2019 are as follows:

1. Development of seaweed cultivation and post-harvest in the cultivation development area.
2. Development and organisation of seaweed-based processing industries.
3. Market development of raw materials, semi-finished products (by-products) and final products of seaweed both at domestic and international levels.
4. Research and development of new seaweed (species and/or variety), cultivation and technology innovation of semi-finished and final products and the development of domestic and global markets.

The National Seaweed Research Programs 2018-2021 (Perpres No. 33/2019) focus on two aspects: cultivation of new species or new varieties and innovations in seaweed downstreaming.

Utilisation and development of new seaweed species (species and/or varieties) cultivation focuses on:

- Research and development of seaweed bioprospecting types and procedures for utilisation (Sargassum sp., Ulva sp., and Gelidium sp.).
- Increasing research and development of seaweed cultivation technology, including quality seeds, production, post-harvest, and seaweed marketing.
- Research on the development of tissue culture seedlings and supervision of tissue culture laboratories in each region.
- Research on new species and/or varieties to pilot the development of aquaculture and diversification of processed seaweed products.
- Research and development of new types (species and/or varieties) of seaweed for herbal products.
- Innovative development through technology transfer of semi-refined products and final products and seaweed markets focuses on:
  - Research into the development of innovation through technology transfer and diversification of semi-refined (intermediate) products and seaweed end products.
  - Research on management and utilization of seaweed industry waste for fertilizer products and other products.

The study of raw materials, semi-finished products, and seaweed-based final products.

CONCLUSION

Seaweed can significantly boost Indonesia’s economy and markedly improve the welfare and livelihood of its people, especially in coastal and island communities. With more investment into the sector, huge opportunities will flow from the development of a healthy, sustainable and globally competitive industry.
ABBREVIATIONS AND ACRONYMS

**ASEAN:** Association of Southeast Asian Nations

**ARLI:** Indonesian Seaweed Association (Asosiasi Rumput Laut Indonesia)

**ASPERLI:** Seaweed Farmers Association (Asosiasi Petani Rumput Laut)

**ASTRULI:** Indonesian Seaweed Industry Association (Asosiasi Industri Rumput Laut Indonesia)

**Ballitang KKP:** Centre for Marine and Fisheries Research and Development (Badan Penelitian dan Pengembangan Kelautan dan Perikanan)

**BPPT:** Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi)

**CSG:** Celebes Seaweed Group

**CSIRO:** Commonwealth Scientific and Industrial Research Organisation

**CBI:** Centre for the Promotion of Imports from Developing Countries

**DKP:** Office of Marine Affairs and Fisheries (Dinas Kelautan dan Perikanan)

**EIBN:** EU-Indonesian Business Network

**FAO:** Food and Agriculture Organisation

**IDR:** Indonesian Rupiah

**Kemenkomar:** Coordinating Ministry for Marine Affairs (Kementerian Koordinator Bidang Kamaritiman dan Investasi)

**KKP:** Ministry of Maritime Affairs and Fisheries (Kementerian Kelautan dan Perikanan)

**LIPI:** Indonesian Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesia)

**MAI:** Indonesian Aquaculture Society (Masyarakat Akuakultur Indonesia)

**Pangkep:** Pangkejene and Kepulauan district

**Perpres:** Presidential Regulation (Peraturan President)

**PTNBH:** Penguruan Tinggi Negeri Badan Hukum (autonomous university)

**PUI-P2RL:** Centre of Excellence Seaweed at Hasanuddin University (Pusat Unggulan Ipteks – Pengembangan dan Pemanfaatan Rumput Laut)

**RENIJA:** Work Plan (Rencana Kerja)

**RENSTRA:** Strategic Plan (Rencana Strategis)

**SRG:** Warehouse Receipt System (Sistem Resi Gudang)

**TSIN:** Tropical Seaweed Innovation Network

**UNIDO:** United Nations Industrial Development Organization
REFERENCES


Tropical Seaweed Innovation Network (TSIN), available at: https://www.seaweednetwork.id/.


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