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A diagnostic analysis of seaweed value chains in Sumenep Regency, Madura Indonesia

Kabupaten
Sumenep

United Nations
Industrial Development
Organization

This document has been prepared by Iain C. Neish in fulfilment of UNIDO project No. 140140.

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Executive summary

The present study was conducted during March and April, 2015 as a component of UNIDO Project no 140140 as preparatory assistance to develop a seaweed value chain development project for the Regency of Sumenep on the island of Madura. Substantial seaweed biomass had been produced in Sumenep for more than twenty years. The study was motivated by goals of the government to generate opportunities for businesses and decent work for farmers in sustainable seaweed production, processing and marketing.

Sumenep produces about 5 percent of Indonesian seaweed raw material and has the capacity to produce much more. Sumenep has comparative advantage as a seaweed raw material source due to a combination of generally favorable weather; fertile sea water; abundant human resources; and close proximity to the major hub region of Surabaya.

With respect to farm productivity issues it was found that in several Madura main island areas farmers used small bibit (cuttings) on raft modules in order to create piecework opportunities that, in turn, led to domestic harmony due to distribution of farm revenues among village populations. However the piecework system institutionalized a low-productivity approach to seaweed farming. By contrast, in the Kangean and Sapeken Islands farmers used larger bibit on longline systems to achieve higher farm productivity. Means should be sought to increase farm productivity and market competitiveness in ways that still realize income distribution objectives.

With respect to value adding opportunities it was found that despite prior failures, there may be modest opportunity to operate alkali-treated chips (ATC) capacity in Sumenep provided that contractual relationships are formed with anchor buyers. especially Chinese refined carrageenan producers. A far greater opportunity lies with development of new products from multi-stream, zero-effluent (MUZE) technology. MUZE requires that value addition commences with live seaweeds at farm areas. A first step toward MUZE processing can be production of cottonii/sacol white RDS that is being sought by SRC processors.

Development of new products from MUZE technology will enable proliferation of agricultural nutrient products and other products from seaweeds that can get the Sumenep seaweed industry out of the ‘zero-sum carrageenan game’ and into a ‘development for growth’ game as new, large markets develop both domestically and internationally. Innovation is the key to future Sumenep seaweed market opportunities.

At the farm level almost all seaweed farmers in main-island Madura areas and some farmers in the Kangean and Sapeken Islands belonged to more or less formal groups (Kelompok). Benefits and costs from farmers aggregating into groups lean toward benefits outweighing costs. Based on experience from one existing co-op in Sumenep it seems that development of co-ops should be examined as a feasible way for farmers to maximize the benefits of aggregation.

Glossary

Note: (B) is Bahasa Indonesia

ATC: alkali-treated chips made from *Kappaphycus*.

Bibit: (B) Cuttings or propagules used to inoculate planting lines on farms.

Cottonii: *Kappaphycus spp*.

Cultivar: A clone derived from vegetative propagation originating from a single seaplant thallus.

Eucheuma spp.: A red algal genus that is called "spinosum" of the trade; source of iota carrageenan.

***Gracilaria spp*.**: A red algal genus also called "gracilaria" in the trade; source of agar.

Kappaphycus spp.: A red algal genus that includes both "cottonii" of the trade and "sacol" of the trade; sources of kappa carrageenan.

MSME: Micro, small and medium enterprises.

MT: metric ton.

Para-para: (B) drying rack for seaweed

RAGS: Red Algal Galactan Seaweeds including *Eucheuma*, *Gigartina* and *Kappaphycus*.

Sacol: A cultivar of *Kappaphycus striatus*

Spinosum: *Eucheuma* spp.

SRC: semi-refined carrageenan (a.k.a. processed eucheuma seaweed, PES or E407a).

USD: United States Dollar.

Value Chain: A mechanism that allows producers, processors, and traders - separated by time and space – to add value to products and services as they pass from one link in the chain to the next until reaching the final consumer (after UNIDO, 2011).

VAT: Value-added tax.

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Introduction

The present study was conducted during March and April, 2015 as a component of UNIDO Project no 140140. The study was a component of UNIDO financed preparatory assistance to develop a seaweed value chain development project for the Regency of Sumenep on the island of Madura where substantial seaweed biomass had been produced for more than twenty years and conditions of seaweed production called for renewed Government investment. The preparatory assistance was organized in response to a request from the local Government in Sumenep and was supported by the central planning Ministry.

The study was motivated by goals of the government to generate opportunities for businesses and decent work for farmers in sustainable seaweed production, processing and marketing. Drawing from technology that is already in use of under development in Indonesia and elsewhere and collaborating with private sector entities that have pioneered the seaweed sector the idea was to bring value addition closer to the poor and help local seaweed farmers to benefit from the value that is added to seaweed as it gets processed and marketed.

1. Geographic & demographic context

1.1. Location and overview

Sumenep is a Regency (Kabupaten in Bahasa Indonesia) of East Java province, Indonesia. It has a population estimated at 1,071,591 (2014). Sumenep occupies the eastern end of Madura Island and also includes 126 scattered islands located between 113 ° 32'54 "-116 ° 16'48" East Longitude and 4 ° 55'-7 ° 24 'South latitude. Forty eight of the islands are inhabited. The islands extend as far as 305 kilometers from Kalianget Port. Sumenep is bordered to the south by the Strait of Madura and Bali Sea; to the north by the Java Sea; to the west by Pamekasan Regency (the only land border); and to the east by the Java Sea and Flores Sea.

The total area of Sumenep Regency is 1,998.5 km². This comprises 179.32 km² of settlements; 423.96 km² of forest; 14.68 km² of grassy areas or vacant land; 1,130.19 km² of farms and moors; 59.07 km² of water bodies including aquaculture ponds; and 63.41 km² of "other" areas. Sumenep has about 50,000 km ² of territorial sea that includes an estimated area deemed suitable for seaweed farming of almost 250,000 hectares.

Figure 1.1. Locator map for Sumenep Regency. Note that the island groups to the east of Madura and north of Bali comprise more than half of the shoreline suitable for seaweed farming. (Screenshot from Google Earth)

Most seaweed grown in Sumenep is trucked across the Suramadu Bridge to Surabaya before delivery to domestic processors or exporters. Some goes by sea to Bali or East Java prior to onward shipment to Surabaya.

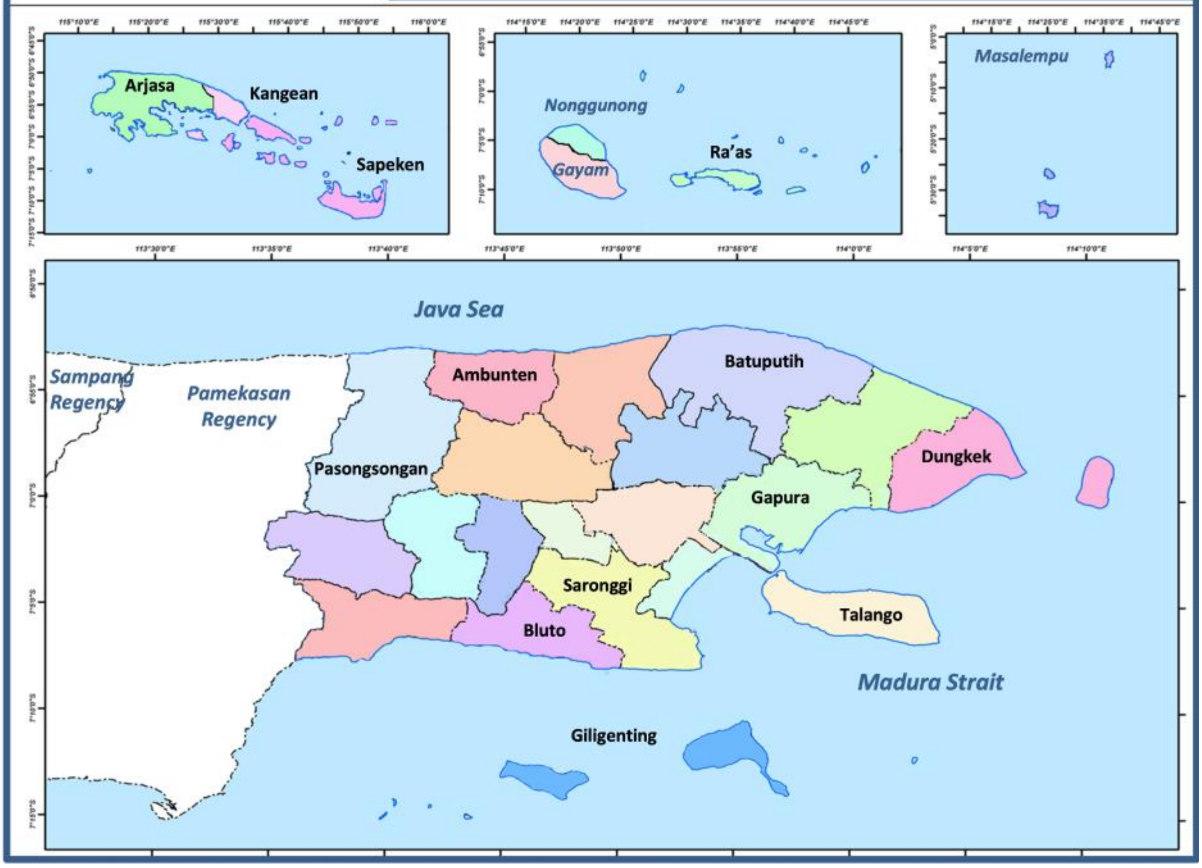
Figure 1.2. Map of Sumenep showing distribution of seaweed farming activity among municipalities. (Data from BPSKS, 2014).

Sumenep Regency (Kabupaten), Madura, Indonesia

Showing municipalities (kecamatan) with seaweed farming activity as of 2014. Hectares planted calculated assuming that one raft or longline unit has planted area of 48 squares meters (raft size 6 x 8 meters).

(Data from Dinas Kelautan dan Perikanan, Kabupaten Sumenep).

Municipality	Hectares total	Hectares planted	% hectares	No. farmers	No. rafts	No. longline
Giligenteng	12,927	26	5.3	551	5,485	0
Bluto	8,917	114	3.7	1,629	23,658	0
Saronggi	6,728	104	2.8	1,593	21,627	0
Talango	17,167	40	7.1	635	8,335	0
Masalembu	3,409	0	1.4	0	0	0
Gapura	3,307	26	1.4	375	5,438	0
Dungkek	11,690	25	4.8	390	5,265	0
Ra'as	8,492	4	3.5	271	0	815
Sapeken	137,387	32	56.5	1,241	0	6,648
Kangean	17,100	0	7.0	0	0	0
Arjasa	15,080	7	6.2	365	0	1,460
Pasongsongan	280	0	0.1	0	0	0
Ambunten	520	1	0.2	40	0	235
Batuputih	250	0	0.1	0	0	0
Total	**243,254**	**379**		**7,090**	**69,808**	**9,158**



Mineral Resources in Sumenep include phosphates, limestone, calcite, gypsum, quartz sand, dolomite, kaolin clay and stone. Some islands of Sumenep show indications of gas and petroleum. Since 1993 the Kangean islands have been a site of natural gas mining production which is now operated by PT Energi Mega Persada. The islands are connected to East Java via a 430 km pipeline, most of which runs underwater.

1.2. Population structure, employment and GRDP

Numerous tables and graphs concerning the demographics of Sumenep can be found in BPSKS (2014). The following narrative and table summarize key data from that source.

As of 2014 the total population of 1,061,211 people comprised 504,712 male and 556,499 female within 322,393 households. About 7,000 households were engaged as owners of seaweed farms. About 21 percent of people were below the poverty line. The population was mostly Muslim. Worship facilities comprised 1,592 mosques; 2,358 prayer houses (musholla); 3 churches and one Buddhist nunnery.

BPSKS data for 2013 (Table 1.1) indicated that agriculture accounted for over 40 percent of the Gross Regional Domestic Product (GRDP) of Sumenep. Fisheries, including seaweed farming, accounted for almost three percent of GRDP.

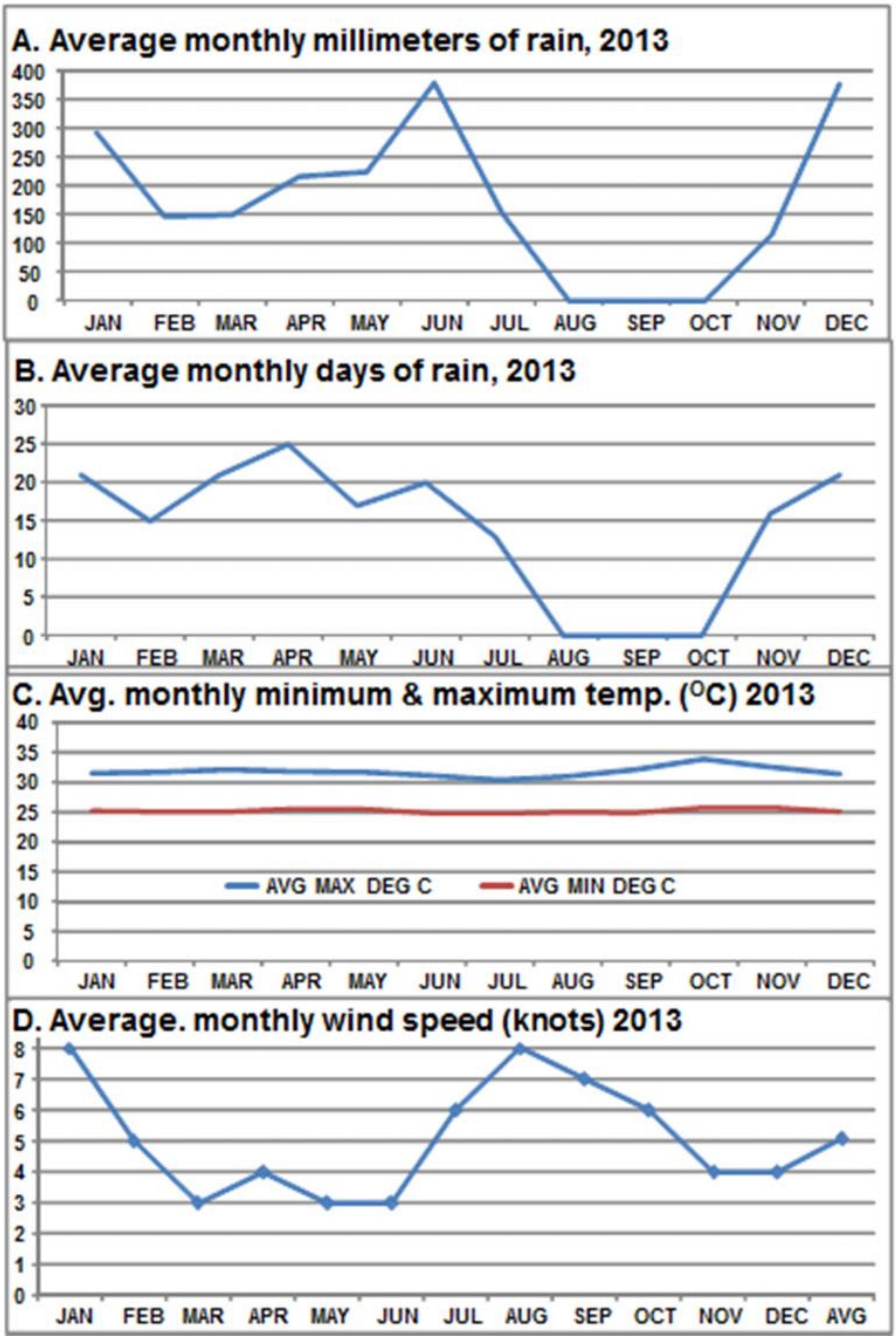
Table 1.1. Gross Regional Domestic Product (GRDP) of Sumenep (2014) at current market prices. FOREX was assumed at an average of 10,000 IDR/USD.

Sector	M Rp	M USD	Percent
Agriculture	7,010,806.83	701.08	41.4
Fisheries	497,230.05	49.72	2.9
Mining & quarrying	1,523,801.25	152.38	9.0
Manufacturing industries	355,086.33	35.51	2.1
Electricity, gas & water supply	31,946.46	3.19	0.2
Construction	355,528.90	35.55	2.1
Trade, hotel & restaurant	3,676,276.87	367.63	21.7
Transport & communication	410,568.50	41.06	2.4
Finance & business services	758,187.40	75.82	4.5
Services	1,483,298.43	148.33	8.8
TOTAL	16,102,731.02	1,695.02	100.0

1.3. Climate and seasonality

Sumenep is located at coordinates 7°01’S 113°52’E, well within the tenth parallels. This region is generally between the 21-24 degree Celsius winter isoclines where most *Kappaphycus* and *Eucheuma* biomass occurs (Neish, 2013b in Valderrama *et al*, 2013). Sumenep has a tropical marine climate. Seashores are typified by fairly uniform air and sea temperatures averaging in the range of 25-35 degrees Celsius. There is high humidity and moderate rainfall that is distinctly seasonal. There are no typhoons but seismic activity in the region can produce tsunamis and earth tremors. Weather changes are driven by the West Monsoon (generally from October to March) and the East Monsoon (generally from April to September).

Figure 1.3. A,B. Sumenep monthly rainfall in mm and days (2013) showed a distinct annual pattern with little rain during the east monsoon (about July-November) and moderate rainfall during the rest of the year. **C.** Sumenep monthly air temperature (^oC, 2013) indicated little variation within years or between years. **D.** Sumenep monthly average wind speed (2003-2010) was fairly consistent throughout the year. Strongest winds occurred during the east monsoon. (Data from BPSKS, 2014).



Seasonal variations in wind patterns and rainfall are a fact of life that has great impact on Sumenep seaweed farmers. Most farmers refer to "good" or "bad" farming conditions with reference to rainfall. In some locations production is best during the "rainy season" and in others during the "dry season". Some locations are good for seaweed farming all year around although there may be seasonal variations in productivity. Many locations can only support seaweed farming during a limited season of the year.

For the present analysis 2013 data were obtained from BPSKS (Fig.1.3). Data indicated that Sumenep had a very distinct rainy season when winds were coming predominantly from the northwest (the west monsoon) and a dry season when winds were coming predominantly from the southeast (the east monsoon) and some months had no rainfall at all. The west monsoon occurred from about December until March and the east monsoon from about May through October. June and December were transition months with inconsistent weather.

2. Value chain mapping

2.1 Value chain contexts and diagnostic dimensions

UNIDO (2011) defines a value chain as "*a mechanism that allows producers, processors, and traders—separated by time and space—to gradually add value to products and services as they pass from one link in the chain to the next until reaching the final consumer (domestic or global). Main actors in a value chain are firms from the private sector. The private sector draws from a range of public services and private technical, business and financial service providers. They also depend on the national and global legislative context and sociopolitical environment. In a value chain the various business activities in the different segments become connected and to some degree coordinated*."

The present study was undertaken within the following seven diagnostic dimensions (after UNIDO, 2011):

1. **Sourcing of Inputs and Supplies**: Emphasis was placed on understanding sources of goods and services that seaweed industry players use in production. Their relationships with providers of primary materials and inputs were examined. Sourcing steps were examined from the farm to the offshore processors.
2. **Production Capacity and Technology**: Here the study examined Sumenep seaweed industry players' capabilities to manufacture and transform goods, including the means of production (machinery), human capital and the knowledge and technologies used in production. Indicators of technical productivity, cost-efficiency and profit margins were used in the analysis.
3. **End-Markets and Trade**: The study examined markets that ultimately absorbed Sumenep seaweed products and the seaweed quality demands of those markets. There was emphasis on understand existing capacity of the Sumenep seaweed value chain to meet demands and access existing and potential markets.
4. **Value Chain Governance**: Relationships among seaweed farmers and buyers were examined in light of the complex interdependencies between value chain players. The focus on value chain governance was on rules and regulations that determine the functioning of and coordination in Sumenep seaweed value chains, existing barriers to entry and the dominance of certain value chain players such as carrageenan processors and exporters.
5. **Sustainable Production and Energy Use**: The seaweed industry is generally regarded as a sustainable, environment friendly industry. The study examined how value chain actors complied with standards of environmentally sustainable production.
6. **Finance of Value Chains**: The emphasis here was to understand how the various actors in the value chain finance their operations, the appropriateness and sufficiency of available finance mechanisms and how delivery can be made more

efficient. A distinction was made between credits provided by formal financial institutions and informal financing through buyer-supplier relationships

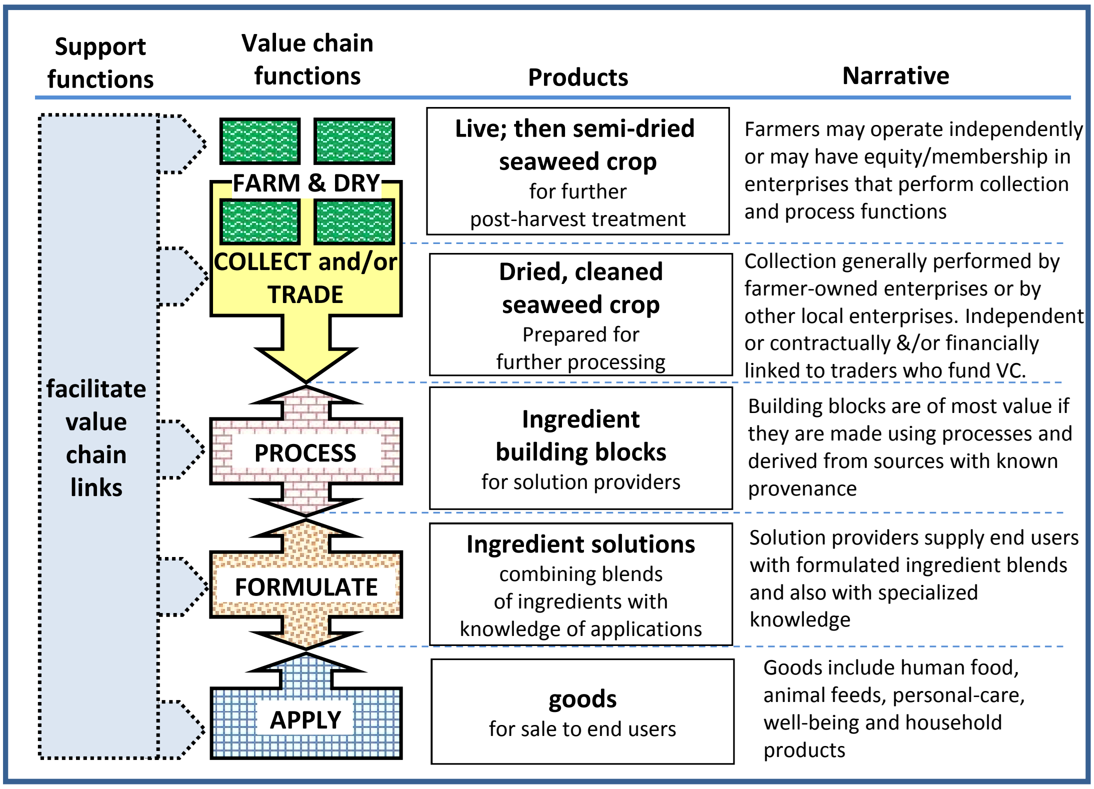
7. **Business Environment and Socio-Political Context**: The aim of the analysis here was to understand how policies and institutions may have impacted on Sumenep seaweed value chains and what public institutions can do to support the development of the value chain. The study also examined the availability of public and private support services, and the business culture of public and private actors.

2.2. A generalized seaweed value chain structure

Basic value chain functions are shown in association with the products they make in Figure 2.1. A detailed value chain map specific to Sumenep is shown in Figure 2.3. The essential feature of value chain functions is that each step adds value to products as they move geographically and economically from the original sources of raw materials to end users.

It is an important feature of carrageenan that it is a product with 'derived demand'. It is not sold directly to end users; rather, it is a 'building block' performance chemical that is blended with other ingredients as a component of 'ingredient solutions' that are applied in end products such as foods and personal care products. **Alkali-treated 'chips' (ATC) are not a 'product' *per se*; their production comprises an intermediate step in carrageenan manufacture**

Figure 2.1. Generalized value chain structure for carrageenan made from *Kappaphycus* seaweeds.



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2.3. Value chain actors

2.3.1. Seaweed farmers in Sumenep

Based on interviews with seaweed farmers in Sumenep the predominant model for farm management was the 'lead farmer' model where one person or a small team of people own the enterprise; are actively involved in day-to-day operations; assume responsibility for managing the farm enterprise; and undertake marketing and selling of the crops produced. Much of the farm labor was supplied by piecework laborers who performed tasks including attaching cuttings to lines and drying the seaweed. It seemed that most such labor was supplied by members, relatives and friends of farm-owning households.

Less common in Sumenep was the 'nuclear family' model where spouses shared work and shared income between themselves, their children, their parents and/or other first-degree blood relations.

According to BPSKS estimates (Fig. 1.2) Sumenep was home to over 7,000 farm households in 2013 and they operated almost 80,000 raft or longline farm modules in 14 municipalities. About 40 percent of farmers were island-based. Over 80 percent of seaweed farmable area and about 27 percent of area already planted was in island areas so there was plenty of scope for expansion around the islands.

2.3.2. Seaweed collectors and intermediate traders in Sumenep

Most seaweed farmers in Sumenep sold directly to collectors that, in turn, sold to Indonesian domestic traders or processors (Table 2.2). Traders then sold to national or international carrageenan processors (Table 2.3). During interviews Sumenep collectors indicated that funds from buyers were commonly used to finance seaweed purchases. It was reported that two or more collectors generally operated in proximity to all seaweed farming areas.

2.3.3. Seaweed national traders/exporters in Indonesia

At the time of writing Sumenep collectors sold their seaweeds with little or no processing to Indonesian national traders or processors. Some national processors were also exporters of raw seaweeds. Traders sold to national processors or exported to international processors (Table 2.2). Collectors generally used funds from national traders or processors to finance seaweed purchases. It is significant to note that traders and exporters/processors were not just 'middlemen' who simply bought and sold seaweed. They had several important value chain functions, including:

A. Provision of capital to farmers and collectors in the form of cash advances or rapid payments;
B. Logistic arrangements for transporting seaweeds from sources to processors;
C. Technical and information exchange with farmers and collectors;

D. Simple processing needed to make farmer-delivered seaweed meet buyer specifications including (a) sorting and cleaning; (b) drying to a uniform, low moisture content (e.g. about 35-38% moisture); and (c) pressing seaweed into compact, wrapped bales for export shipment.
E. Absorption of foreign exchange risk or rewards and provision of working capital to cover holding of inventories and work-in-progress.

From this list it can be seen that trader/exporters bore several risks and cost burdens. For example, exporters normally bought seaweed in Indonesian rupiah and sold in US dollars. Many buyers withheld as much as 20% of the purchase price pending testing at their factories. Final payment was adjusted by moisture content on a pro-rata basis to take a penalty or award a bonus. Payment of the balance often took several months. They were exposed to foreign exchange risk and they carried the cost of financing seaweed as it moved from sources to processors (often taking several months). They also absorbed processing and transportation costs and most significantly of all they absorbed shrinkage losses often in the range of 15-20% (Table 4.1).

By 2015 there were no direct exporters known to be operating from Sumenep. Exporters active in Indonesia included those shown in Table 2.1.

Table 2.1. Some major seaweed exporters in Indonesia as of 2015. Many companies get involved in seaweed exporting for more or less time so the roster is constantly changing. (Source: PT Jaringan Sumber Daya [Jasuda])

Company	Address	Email	Contact person
Berkatu Sinar Makmur (PT)	The Belezza GP Tower lt 15/8 Jl. Jend Supeno No 34 , Arteri Permata Hijau, Jakarta		Ign Braminto WA
Bina Makmur Sejahtera	Raya Tanjungsari 44 Kompleks Pergudangan dan Industri Permata Tanjungsari Blok B26 Surabaya - Jawa Timur	bina@sby.dnet.net.id	Dewi Kumala Sari (Ay Lie)
Bintang Mandiri Waskito (CV)	Jl Tanjung Sari No. 44 B20, Surabaya	willysutanto2006@gmail.com	Willy Sutanto
Citra Mandala (PT)	Makassar		Ali Thalib
Delapan Sembilan (UD)	Jl. Kombes Pol M. Duryat 14 - 16 (B-19) Surabaya 60262	ud_89@yahoo.com	Go Junaidi (Ahong), Harry Sapudi
Indomarin Niaga (CV)	Head Office:Jalan Bung Tomo 26 Surabaya 60245 Indonesia, Warehouse: Komplek Bumi Maspion Blok 6 No. D-3, Romokalisari, Gresik	info@indomarin.com	
Jaya Laut Internasional (PT)		alvinbhatara @gmail.com	Alvin Bhatara
Kali Mas Seaweed Co. (PT)	Makassar		Lie Tjep Njan
Lokanindo Pratama (CV)	Jl. Margomulyo Permai Blok N/2, Surabaya 60188	lip.seaweed@gmail.com; wllstan@gmail.com	Tan William Sutanto
Persada Semesta (CV)	Jalan Topaz Raya F53, Panakkukang Mas, Makassar 90231	N/A	Sani Azis Husain
Phoenix Food (CV)	A.A Gde Ngurah Street Cakranegara - Mataram 83234	phoenix.food@yahoo.co.id ; phonixmas@yahoo.com	Tjahya Setiawan
Rahmat Bahari (CV)	Jl. G. Agung Gg. Bumi Ayu B No. 7 Denpasar, Bali		Komang Ribek
Rapid NiagaInternational (PT)	Jl. Teuku Umar X No.46 Makassar PO BOX 1295 Sulawesi Selatan		Noor Rahma Amier
Sentosa (UD)	Makassar	sbl_seaweed@yahoo.com	Darwis
Setia Utama (UD)	Makassar		Haji Sakka
Simpul Agro Globalindo (CV)	Jalan Anggrek AA/1, Palopo, Sulawesi Selatan	celebesseaweed@celebesseaweed.com	Mursalim
Sumber Rejeki (CV)	Jl. Mahawu No.156 A Manado - Sulawesi Utara (HO), Jl. Kakatua No.49A Makassar - Sulawesi Selatan	sumber_rejeki@hotmail.com , marcel_taher@yahoo.com	Marcel Julius Taher
Sumberguna Makassarnusa (PT)	Jl. Ujung Pandang Baru No.17 Makassar - Sulawesi Selatan	sabina@indosat.net.id	Utama Rusli

2.3.4. Seaweed processors in Indonesia and the rest of the world

In the dynamic seaweed industry companies are frequently opening, closing, merging and otherwise changing their identities. The list in Table 2.2 was not totally comprehensive but it included most major processors known to be in business at the time of writing.

Table 2.2. Prominent carrageenan processors in business worldwide (April, 2015). Estimated production capacities are shown as MT per annum. Process methods indicated are alcohol precipitation, hybrid alcohol/KCl methods, gel-press, semi-refined food grade and semi-refined technical grade. (Source: PT Jaringan Sumber Daya [Jasuda])

Country	Company	Alcohol	Hybrid	Gel press	SRC FG	SRC TG	Total
Brazil	Griffiths				750		750
Chile	Dupont		2,000		1,500		3,500
	Gelymar	1,000	2,000	1,000			4,000
China	Lubao Bio (Greenfresh)			3,000			3,000
	Shanghai Brilliant Gum (BLG)	1,000		4,000	8,000		13,000
	Sheli Foods			2,000	500		2,500
	Other China			2,500	2,500	1,000	6,000
Denmark	CP Kelco	4,000					4,000
France	Cargill	4,500					4,500
India	Aquagri Processing Pvt. Ltd.				600	600	1,200
Indonesia	PT Algalindo Perdana				1,000		1,000
	PT Amarta Carragenan Indonesia				600	1,200	1,800
	PT Bantimurung Indah				600	600	1,200
	PT Cahaya Cemerlang				600	1,200	1,800
	PT Centram			1,000			1,000
	PT Galic Arthabahari				1,000	1,000	2,000
	PT Giwang Citra Laut				1,000		1,000
	PT Gumindo Perkasa Indistri				500	1,000	1,500
	PT Hydrocolloid Indonesia				1,200		1,200
	PT Indonusa Algaemas Prima				3,000		3,000
	CV. Karaginan Indonesia				1,000		1,000
	PT. Sansiwita				500		500
	PT Phoenix Mas				180		180
	PT Seamatec			1,000			1,000
	PT Wahyu Putra Bimasakti					600	600
Japan	Mitsubishi	1,250					1,250
	Nippon Carrageenan			500			500
Korea	MSC Co. Ltd.	1,500					1,500
Malaysia	Omnigel				600	600	1,200
	Tawau Carrageenan (Takara)					600	600
Philippines	CP Kelco			2,000	1,000		3,000
	FMC Biopolymer				4,000		4,000
	Kerry				2,000		2,000
	Marcel				1,500	4,000	5,500
	Martsons Food Corpn.				1,200		1,200
	MCPI/Datingbayan				600	600	1,200
	Philippine Bioindustries			1,800			1,800
	Polysaccharide (Shemberg)					2,400	2,400
	W Hydrocolloids Co.			500	1,500		2,000
	Shemberg Marketing			1,220	5,400		6,620
	Shemberg Biotech	1,200					1,200
	TBK				1,000	500	1,500
	CEAMSA				2,000		2,000
Spain	CEAMSA	1,750			1,000		2,750
USA	FMC	6,000					6,000
Other	Other producers worldwide			2,000	1,000	1,500	4,500
		22,200	**4,000**	**22,520**	**47,830**	**17,400**	**113,950**

It was notable that total plant capacity of almost 114,000 MT/yr. was more than double the known total carrageenan market of about 50,000 MT/yr. This was an industry that had large under-utilized processing capacity. The magnitude of over-capacity was inflated even further by the fact that several ATC and SRC factories were known to be inactive at the time of writing.

2.3.5. Organizations with impacts on Indonesian seaweed value chains

At least six government ministries impact on seaweed value chains in Indonesia and so do many other organizations. The list in Table 2.3 included most known at the time of writing.

Table 2.3. Organizations with impacts on Indonesian seaweed value chains. (Source: PT Jaringan Sumber Daya [Jasuda])

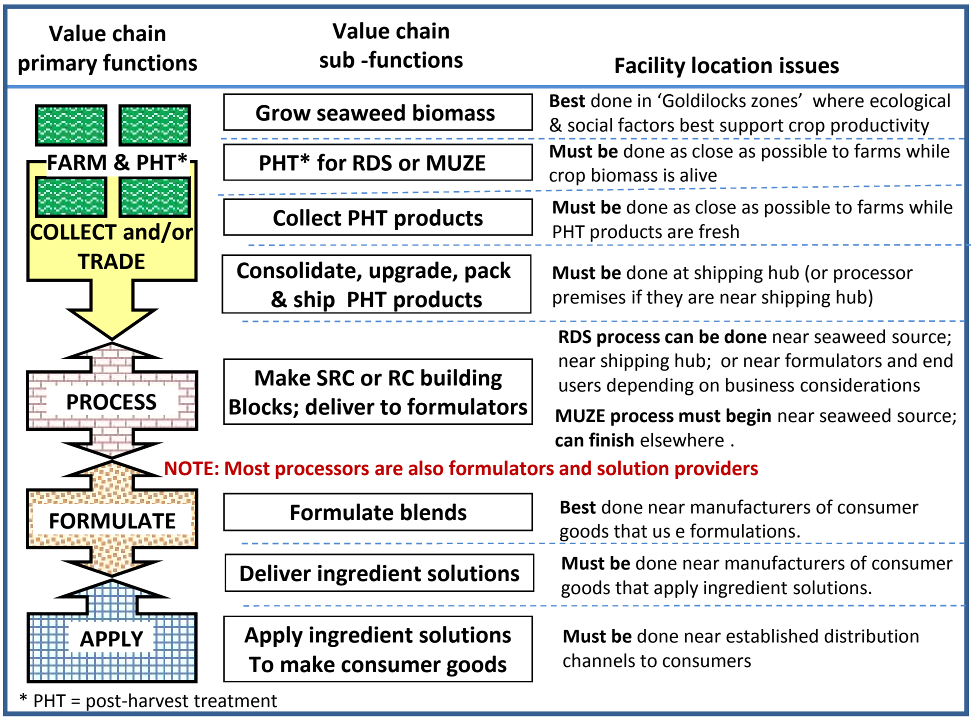
ACRONYM	ORGANIZATION	URL
ACIAR	Australian Centre for International Agricultural Research	www.aciar.gov.au
ADB	Asian Development Bank	www.adb.org
ARLI	Asosiasi Rumput Laut Indonesia (Indonesian Seaweed Association)	n/a
ASKRINDO	P.T. Asuranis Kredit Indonesia	askrindo.co.id
ASPERLI	Asosiasi Petani dan Pengelola Rumput Laut Indonesia (Association of Farmers and)	aspperli.ning.com
BAPPEDA	Badan Perencanaan Pembangunan Daerah (Regional body for planning and development)	www.bappedaprovsi.net
BPPT	Badan Pengkajian Dan Penerapan Teknologi (The Agency For the Assessment and Application Technology)	www.bppt.go.id
CIDA	Canadian International Development Agency	www.acdi-cida.gc.ca
COREMAP	Coral Reef Rehabilitation and Management Project	www.coremap.or.id/
DFAT	Australian Department of Foreigne Affairs and Trade	www.dfat.gov.au
ILO	International Labour Organization	www.ilo.org
ISSA	Indonesian Seaweed Society Association	c/o www.bppt.go.id
JAMKRINDO	Perusahaan Umum Jaminan Kredit Indonesia	www.jamkrindo.com
JICA	Japan International Cooperation Agency	www.jica.go.jp
kKP (MOMAF)	Kementerian Kelautan dan Perikanan Indonesia (Indonesian Ministry of Marine Affairs and Fisheries)	www.dkp.go.id
KUKM	Kementerian Negara Koperasi dan Usaha Kecil dan Menengah Republik Indonesia (National Ministry of Cooperatives and Small to Medium Enterprises in Indonesia)	www.depkop.go.id
LIPI	Lembaga Ilmu Pengetahuan Indonesia (Indonesian Institute of Sciences)	www.lipi.go.id
Marinalg	Marinalg International.	www.marinalg.org
PKBL	Program Kemitraan & Bina Lingkungan	pkbl.bumn.go.id
PNM	PT Permodalan Nasional Madani is a state-owned investment firm	www.pnm.co.id
Swiss Contact	Entwicklungsorganisation der Schweizer Privatwirtschaft - Indonesia	www.swisscontact.or.id/
TNC	The Nature Conservancy	www.nature.org
UDAYANA	Udayana University in Bali	www.unud.ac.id
UNHAS	Hasanuddin University in Makassar	www.unhas.ac.id
UNIDO	United Nations Industrial Development Organization	www.unido.org
UNPATTI	Pattimua University in Ambon	www.unpatti.com
UNSRAT	Sam Ratulangi University in Manado	www.unsrat.ac.id
USAID	United States Agency for International Development	indonesia.usaid.gov

2.3.6. Facility location issues

Functions relevant to the Sumenep value chain are listed on the left side of Fig. 2.3. These include not only value chain steps undertaken in Sumenep but also steps that pass through processing of seaweed into carrageenan; sale of carrageenan blends; and manufacture, marketing or sale of consumer products from the blends. In future all value adding steps may occur in Sumenep as the seaweed industry develops. Locations of facilities for undertaking value chain functions can have a profound impact on the costs of adding value (Figure 2.2). In the last analysis value chains that prevail tend to be those that deliver best value to customers. In the case of performance ingredients such as carrageenan services and blends provided by formulators and solution providers are crucial links in the value chains that are best performed by facilities in close proximity to facilities where carrageenan in blends is applied to the manufacture of consumer goods such as food products, personal care products and other applications where carrageenan adds functionality and value.

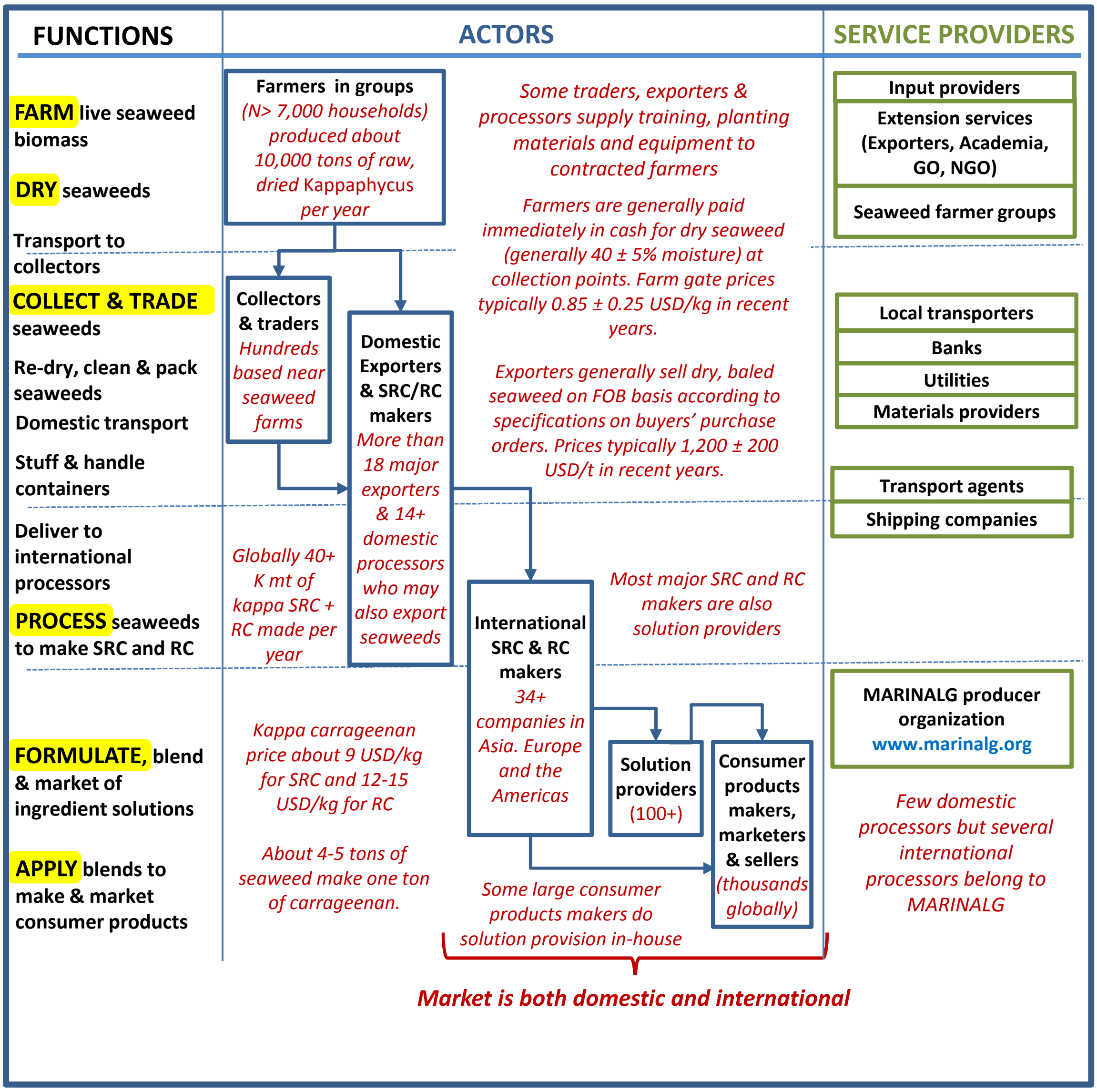
Most carrageenan processors are also blenders and solution providers so historically process plants have tended to locate near to end users unless cost considerations were over-riding. During the past three decades cost considerations have caused some process capacity to migrate toward transportation and logistics hubs that are close to seaweed production areas. For example major European plant capacity has closed down and moved to Asian hubs including Surabaya, Makassar, Jakarta, Cebu City and Manila. On the other hand China is an example where cost factors (including ready access to process chemicals) have enabled process plants to remain near major markets rather than shifting toward seaweed sources. The recent announcement of a large Chinese-owned SRC factory in South Sulawesi may be a move away from that tendency (see Section 5.6.4).

Figure 2.2. A summary of facility location issues for value chain functions involving carrageenan made from *Kappaphycus* seaweeds.



2.3.7. Map Value chain map for *Kappaphycus* farmed in Sumenep

Figure 2.3. Map Value chain map for *Kappaphycus* farmed in Sumenep. Yellow highlights refer to VC functions in Figure 2.1. (Format from UNIDO, 2011 and Neish & Msuya, 2013).



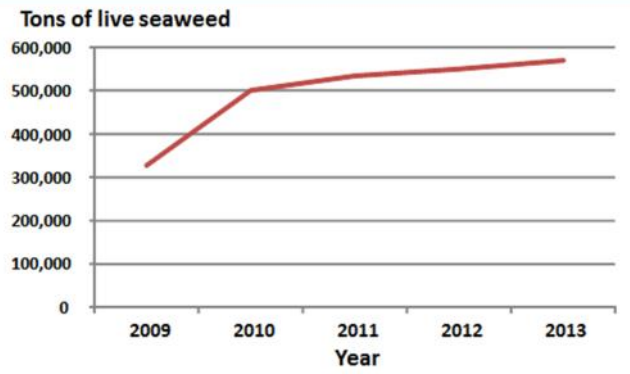
A small range of actors is involved in Sumenep seaweed value chains. Overlay notes on the VC map indicate how some actors can cover more than one function. For example processors/exporters are commonly involved in functions extending all the way from picking up seaweed at farms to stuffing and handling export containers and many carrageenan makers are also solution providers. Arrows in the map represent the flow of products from one actor to the next. Overlay notes include information on types of contractual arrangements. Arrows indicate market channels, with end-markets at the end of the map. Generic categories of support services are indicated on the right side of the map including extension services, financial services, transport, materials, etc. Data overlays indicate information that is available, relevant and helpful for the chain analysis and they make reference to specific content in the report.

3. Seaweed production

3.1. Seaweed production volume

From 2009 until 2013 BPSKS estimates showed production of live seaweeds rising from 328,101 to 565,651 wet tons (Table 3.1). During that time BPSKS estimates showed the number of farm rafts + longline systems rising from 52,346 to 78,342 units and the number of farmers rose from 6415 to 7,029 households.

Table 3.1. Estimated seaweed production figures for the regency (kabupaten) of Sumenep, Madura, Indonesia as of 2013 (from Dinas Kelautan dan Perikanan, Kabupaten Sumenep).



Year	Live Tons	Farmers	Units	Live tons /farmer	Live tons /unit	Live kg/cycle per unit
2009	328,101	6,415	52,346	51	6.27	783
2010	500,775	6,591	56,226	76	8.91	1,113
2011	533,706	7,029	78,342	76	6.81	852
2012	549,718	7,029	78,342	78	7.02	877
2013	569,651	7,029	78,342	81	7.27	909

Production estimates of dry seaweed production based on interviews with farmers were extrapolated as shown in Table 3.2. These were based on wet-to-dry ratios consistent with those shown in Figure 3.9. Dry yields were calculated in terms of a 6:1 wet-to-dry ratio ('local quality' moisture content about 42% and above) and an 8.5:1 wet-to-dry ratio ('export quality' moisture content at 35 percent).

Table 3.2. Estimated seaweed production figures for the regency (kabupaten) of Sumenep, Madura, Indonesia as of 2013 comparing estimates from Dinas Kelautan dan Perikanan, Kabupaten Sumenep with estimates based on farmer interviews.

2013 DKP estimate	7,029	farmers	
2013 DKP estimate	78,342	planting units	
Scenario	**Tons**	**Tons /unit/yr**	**Kg/cycle per unit**
DKP estimate live weight	569,651	7.27	909
DKP RDS W:D 6:1	94,942	1.21	151
DKP RDS W:D 8.5:1	67,018	0.86	107
Farmer estimates live weight	78,342	1.00	125
Farmer est. RDS W:D 6:1	13,057	0.17	21
Farmer est. RDS W:D 8.5:1	9,217	0.12	15

Production estimates based on farmer interviews (Table 3.2) assumed that 78,342 units were being operated by 7,029 farmer households and that farm yields were consistent with the scenario presented in Figure 3.3. The RDS production levels calculated from farmer interviews were consistent with numbers obtained during interviews with collectors, traders and exporters. They claimed that their data indicated Sumenep production on the order of 7,000-10,000 tons RDS per year.

During the present study raw seaweed production data were not available either from private or from public sources so it was not possible to reconcile the spread in estimated production figures based on different sources. Information from interviewed value chain actors indicated that live seaweed weights were generally not recorded at the point of harvest because the crop is immediately placed on drying devices. The first weighing point was reported to be for 'locally dry' RDS at the point where collectors or traders purchased seaweeds from farmers. Those numbers were proprietary and in most cases moisture content was estimated; not measured at the point of sale. Further weighing was done as seaweeds were delivered to exporters or domestic processors but weights and shrinkage-loss data were proprietary. In exporter and processor facilities RDS from Sumenep is mixed with seaweeds from other sources so it was not feasible to track Sumenep seaweeds using trade data. Theoretically it should be possible to get accurate production data from Sumenep because most RDS production is shipped by truck across the Suramadu bridge through Surabaya to buyers or is shipped to Bali and East Java ports through a few ports in the Kangean and Sapeken Islands region.

3.2 Farm tenure

Entry to seaweed farming is essentially unrestricted. Any inhabitant from a coastal village can establish a farming location wherever space is available. As long as this person continues to farm its selected space, the area will belong to that person. Protection of property is based primarily on 'rural modesty' whereby farmers protect each other's farming areas against external intruders. People usually farm near to areas where they live and a villager can grant a farming space to a fellow villager from the same village/area. For villagers from other areas, entry is achieved by requesting space from local farmers. Respondents during the present study asserted that no licenses or purchase of property were involved in seaweed farming in Sumenep. Furthermore it was reported that farm sites varied during the year as farm modules are moved among locations seasonally.

3.3. Farm enterprise structures

Seaweed farming in Sumenep tended to follow either of two models:

A. A **'nuclear family' model** where spouses shared work and shared income between themselves, their children, their parents and/or other first-degree blood relations. An example is shown in Figure 3.1.
B. A **'lead farmer' model** where one person or a small team of people such as a household owned the enterprise; were actively involved in day-to-day operations; assumed responsibility for managing the farm enterprise; and undertook marketing and selling of the crops produced. An example is shown in Figure 3.2.

Figure 3.1. The 'nuclear family' farm of Pak Ahmad and Ibu Nurhasana on the large reef area near Desa Saseel, Sapeken Islands, Sumenep. **A.** Their 14 x 2 meter diesel powered boat served as a platform for planting and harvesting. **B.** There was space to accommodate extra hands paid to assist with farm chores when extra labor is needed. **C.** Pak Ahmad re-plants a line while Ibu Nurhasana attaches cuttings to lines. Most farm work and revenue is shared by husband and wife.

In Sumenep the 'lead-farmer' model predominated especially on the main island of Madura. In island regions farmers appeared to operate more independently and nuclear farms were encountered.

3.4. Farm enterprise real property ownership

Real property ownership in Indonesia generally conforms to one of four models as follows:

A. A '**proprietary**' model where the farm enterprise directly owns physical farm assets and holds the rights to farm in the locations where it operates.

B. A ‘**tenant**’ model where the farm enterprise pays some cash rent for the right to use physical farm assets and/or to farm in the locations where it operates.
C. A ‘**share-cropper**” model where the farm enterprise pays rent as a percentage of crop yields for the right to use physical farm assets and/or to farm in the locations where it operates.
D. An ‘**estate-farm**’ model where the farm is managed and operated by people on salary.

In Sumenep during the present survey only the ‘proprietary’ model was encountered although large ‘lead-farmer’ operations approached an ‘estate-farm’ structure.

Figure 3.2. Images of ‘lead-farmer’ operations for bamboo raft systems of Kelompok Maju in Saronggi municipality, Sumenep, Madura (ICN photos). **A.** *Kappaphycus* seaweeds drying in the foreground and growing on rafts in the background. Rafts are moved further offshore during the East Monsoon. **B.** Harvesting seaweeds from rafts brought close to shore. **C.** Several tons of harvested seaweed being dried prior to sacking and selling. **D.** Iain Neish interviewing Pak. Jumani, the head of Kelompok Maju and Pak Masruri, head of Koperasi Anika Usaha; a cooperative to which this farmer group belongs.

3.5. Agronomy systems

Two types of agronomy systems predominated in Sumenep as follows:

A. **Bamboo rafts** ('raket bambu' in Indonesian) were the predominant agronomy system reported and observed at Sumenep farm areas on the main island of Madura. Overall, estimates from BPSKS indicate that almost 90 percent of Sumenep seaweeds were produced using rafts. Figure 3.3 shows features of a typical raft system. Images from the site of a large farmer group are shown in Figure 3.2. Seaweed rafts are large enough to be seen on Google earth as shown in figures 3.5 and 3.6.
B. **Longline agronomy systems** were more commonly used than raft systems in island areas of Sumenep. The main reasons given were (a) that longline systems were less prone to breakage during heavy wave action; and (b) they are more easily tended line-by-line at sites distant from the home village (e.g. Fig. 3.1). Logline systems are shown in Figures 3.4 and 3.5.

3.6. Crop species, nursery systems and replanting

Bibit (a.k.a. 'cuttings', 'propagules or 'seed') were typically vegetative clones developed as cultivars. Bibit biomass was sourced from exporters, from other farmers or from buyers. Section 3.8 explains impacts of seasonality on biomass sourcing and emphasizes the importance of seasonal 'nursery' areas.

The predominant species of seaweed observed on farms on Madura main island areas of Sumenep appeared to be *Kappaphycus striatus* of the 'sacol' cultivar. The prominent species seen on farms in the Kangean and Sapeken Islands was cottonii seaweed (*Kappaphycus alvarezii*) and the cultivar appeared to be of the 'tambalang' type. Both cultivars were originally of Philippines origin and were introduced to Indonesia in the mid-1980s by development teams of major carrageenan processors (*pers. obs.*) Definitive identity of cultivars must be by methods of molecular biology but outward appearances and industry interviews indicated these provisional identifications.

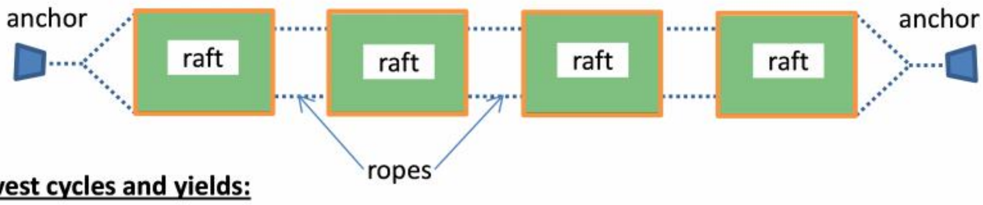
During farmer interviews (e.g. members of Koperasi Anika Usaha) it was revealed that sacol cultivar was introduced to Sumenep from Bali during the early 2000s with participation by traders and processors. The introduction was prompted by frequent diebacks of *K. alvarezii* cultivars that were associated with seasonal 'ice-ice' malady. It was reported that these introductions were facilitated at least in part by Mr. Made Simbik and that was confirmed during interviews with him.

During most of the year farmers accomplished replanting by immediately using biomass from the previous harvest. However, several farmers interviewed during the present study all stated that seasonal die-backs in their farm areas required that they purchase bibit from other areas that served as nursery sites. Most farmers interviewed belonged to member groups of Koperasi Anika Usaha, a cooperative that coordinated trades in the trade of cuttings for replanting. Cuttings were sold at a reported price of about 2,000 - 3,000 IDR/kg.

Figure 3.3 Configuration and operating parameters for a bamboo raft system in Bluto municipality, Sumenep, Madura (from farmer interviews).

- Farmers stated that the average dimensions of a bamboo raft were 6 x 8 meters for a total area of 48 square meters.
- Each raft supported 50 lines each 8 meters long.
- Cuttings were spaced at 15 cm.
- Initial planting was said to be 250 cuttings with a total weight of 50 kg. hence individual weight about 20 grams

Farmers stated that they plant eight harvest cycles per raft per year with each cycle being about six weeks (42-45 days). Each raft used six lengths of bamboo costing 25,000 IDR each for a total of 150,000 IDR/raft. Rafts could be used for 3-5 harvests. Rafts were anchored in clusters; for example four rafts with one stone + wood anchor at each end as shown below:



Harvest cycles and yields:

The 'worst' season at Bluto was said to be during January and February when there were winds strong enough to damage rafts. During six-week harvest cycles from January-September it was said that 50 kg grew to about 100 kg. From August until December 50 kg grew to about 250 kg (fivefold increase). That averaged out to a net harvest of 125 kg live seaweed per raft per cycle or 1,000 kg (one ton) of live seaweed per raft per year. **Assuming a wet:dry ratio of 8.5:1 from live weight to export quality dry weights (35% moisture) estimated harvests were 118 kg raw, dried seaweed (RDS) per raft per year worth about 1,180,000 IDR at a typical 10,000 IDR per kg farm gate price.**

A variety of planting and harvesting strategies were observed for both raft and longline systems in Sumenep. The examples of Figures 3.3 and 3.4 were from two of the larger and more successful farm operations.

Figure 3.4. Longline systems uses to grow *Kappaphycus alvarezii* (cottonii) at Desa Sadulang, Sapeken, Sumenep Regency (lead farmer: Pak Anas). **A.** Lines 40-50 meters long with Styrofoam floats. **B.** Lines clustered on bamboo spreaders and moored to stakes driven into the sea floor. **C**. A line planted for about 15 days.

- Farmers stated that a typical farm unit was 100 lines each about 40-50 meters long so total line length was 4-5 kilometers of line per unit.
- Cuttings were spaced at about 20 cm and weighed about 80-100 grams each so initial inoculum was about 0.4–0.5 kg/meter or 1.6–2.5 tons live biomass per unit.

Farmers stated that they plant 8-12 harvest cycles per raft per year with each cycle being about 30 to 45 days in length. Five kilometers of line (one example unit) cost about 7,200,000 IDR. Lines could be used for about 8-10 harvests. Units were commonly moored in shallow water over seagrass beds using long wooden stakes. Lines were floated using scraps of Styrofoam about each two meters along their length.

Harvest cycles and yields:

The 'worst' season in the Kangean and Sapeken regions was said to be during August and September.

During 30-day harvest cycles from it was said that biomass increased from two-fold to four-fold depending on the season. An average of three-fold would result in a net harvest of 4.8-7.5 tons of live seaweed per unit per cycle or an average of about 74 tons of live seaweed per unit per year. **Assuming a wet:dry ratio of 8.5:1 from live weight to export quality dry weights (35% moisture) the estimated harvest was 8.7 tons of raw, dried seaweed (RDS) per raft per year worth about 87 million IDR at a typical 10,000 IDR per kg farm gate price.**

Figure 3.5. Seaweed rafts next to a shore station in Saronggi in this Google Earth imagery from August 18, 2013. At the shore station recently harvested rafts can be seen and seaweed was drying (inside oval). **B.** Longline raft systems in Bluto municipality can be seen inside the oval. (Google Earth imagery Oct. 2013). Closer views are seen in photos from March, 2015 (ICN photos inside squares).

Figure 3.6. A. Seaweed rafts are clearly visible in this Google Earth imagery dated August 18, 2013. This stretch of coastline was near to Tanjung village in Saronggi municipality, Sumenep. About 1,100 rafts were counted per kilometer of shoreline in this vicinity. When interpreting satellite imagery one must be careful to differentiate fish traps **B.** from seaweed rafts **C.** because they are of similar size and have similar appearances when viewed from above.

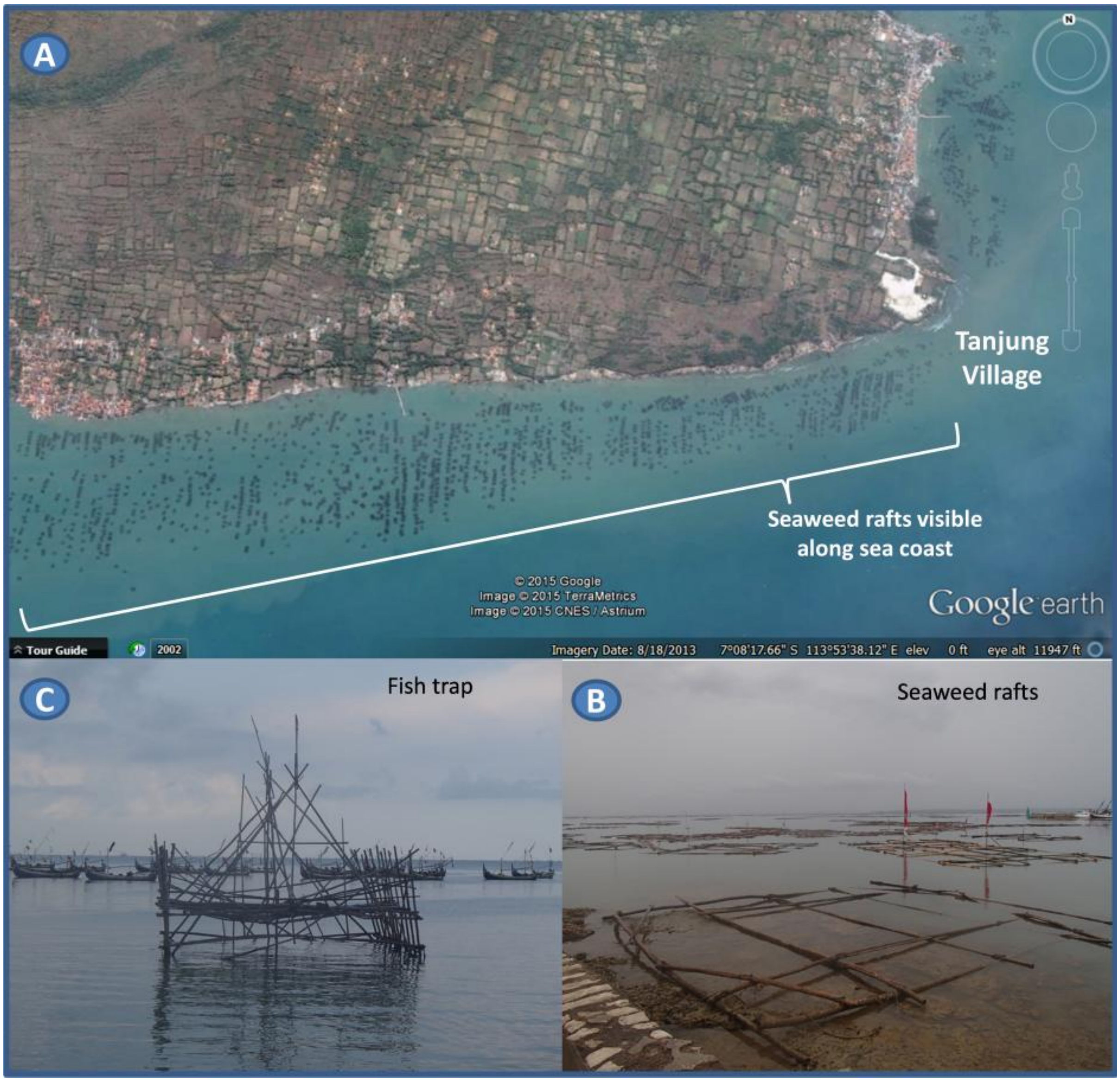


Figure 3.7. A. Large cuttings (bibit) about 80-100 grams being attached to lines by workers paid 2,500 IDR per line. **B**. Biomass brought to shore, split and replanted for farm expansion. **C**. Members of farmers, families attaching cuttings to lines on a piecework basis. **D**. Lines ready for immediate replanting on rafts.

Farm productivity can be ten times greater where the larger bibit are planted. It takes the same amount of labor and the same size of ocean systems to handle 20 gram bibit as it does to handle 200 gram bibit but in good seasons when fivefold growth is common during six week growing cycles a 20 gram bibit grows to become 100 grams and a 200 gram bibit grows to become 1,000 grams.

Figure 3.8. A. In Bluto, Saronggi and Talango very small 'bibit' of about 20-40 grams are planted. **B.** These bibit near Zamboanga, Philippines are about 200 grams each; bigger than the size of many harvested plants in Sumenep. Bibit seen in Sapeken were intermediate in size (Fig. 3.7). **C.** Sacol bibit on an outgrower system initially planted in a tubenet at one kilogram per meter of net.

3.7. Harvesting post-harvest handling and transport

Sumenep seaweed was generally harvested about 4-6 weeks after planting according to interviewees. In the case of rafts, individual units were towed close to beachside work areas where they were stripped and replanted. In the case of longline systems harvesting commonly involved untying lines from raft units, then transporting lines to shore by boat for harvesting and replanting. Lines were then transported back to longline units and re-attached. An alternative method was for harvesting and replanting to be done on purpose-built boats (Fig. 3.1).

Farmers generally delivered their dried crop to exporters' collection stations that are located near to drying areas or collectors may pick up seaweeds from farmers. Collected seaweeds are transported to exporters' warehouses for sorting, re-drying, cleaning and packing as needed to meet specifications in buyers' purchase orders. Typically seaweeds in Sumenep were dried under the sun on tarpaulins or bamboo platforms (known as para-para) as shown in Figure 3.10. Crops took from two to three days to dry in sunny weather, but could take up to seven days during rainy months. Upon drying, seaweed was sorted and shaken to remove dirt and sand; then stored at home or sold directly depending on the harvest volume. Before sale to collectors or traders RDS was stuffed into woven plastic sacks (Figures 3.10 and 3.11).

Both species of *Kappaphycus* are notable for having high water content on the order of 88 percent (Fig. 3.1). During sun drying to 'local quality' levels near to farms the wet-to-dry ratio may be as low as 6:1 but by the time the RDS is dried to the export-quality level of 35 percent moisture the wet-to-dry ratio is about 8.5:1. Numbers may vary between cultivars, farm locations and season. Moisture content is a matter of ongoing negotiation between buyers and sellers and it is the single largest contributor to 'shrinkage' absorbed by collectors, traders and exporters (Table 4.1). *Kappaphycus* naturally concentrates potassium chloride (KCl) salt so its presence is accepted by buyers. 'Salting' of *Kappaphycus* by soaking it in sodium chloride (NaCl) or broadcasting salt over drying seaweed are controversial post-harvest treatments (PHT) practiced by some famers in Madura (Fig. 3.8). Some processors and exporters stated that they avoid buying Madura seaweeds because salted seaweed is not acceptable for processing. However, those practicing salting stated that it accelerates drying and is requested by some buyers.

Figure 3.8. A. Effluent from soaking *Kappaphycus* in NaCl prior to discharge into the sea. **B.** Salted seaweed tends to have dark pigmentation after sun-drying. (ICN photos).

Figure 3.9. Drying curve and comparison of wet and dry compositions of typical *Kappaphycus spp.* Seaweed. These proportions vary somewhat between cultivars, farm locations and seasons. (Source: PT Jaringan Sumber Daya [Jasuda]).

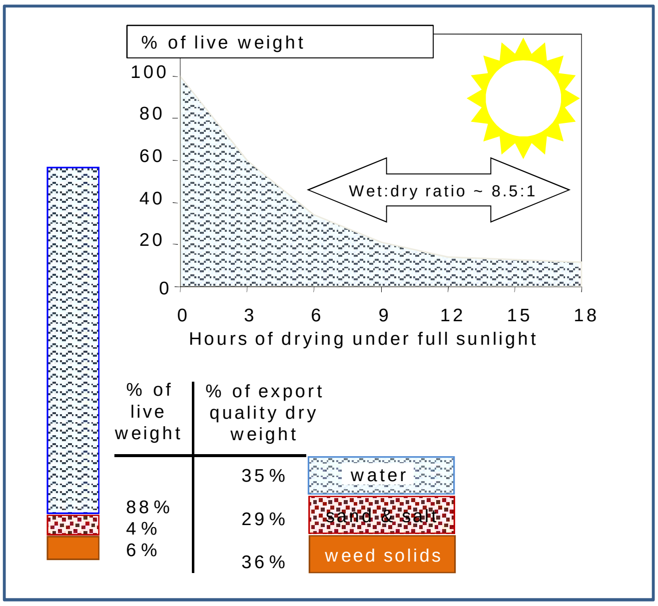


Figure 3.10. A. Freshly harvested seaweed thought to be sacol cultivar of *Kappaphycus striatus*. **B.** Harvested seaweeds drying on a platform (para-para at Bluto). Light color of seaweed in the foreground is typical of seaweed that has been rained on while drying **C.** Iain Neish interviewing Pak. Rialdi, the head of Kelompok Karang Baru (left) and Pak Mohd. Ratam a group member as they provide information shown in Figure 3. **D.** Dried sacol seaweed in a sack ready for sale.

Figure 3.11. **A & C**. A 70 ton vessel loads raw, dried cottonii (locally called agar kotoni) at Desa Saseel. **B.** This lot was very well dried. Such vessels carry dried seaweeds to ports in Sumenep, Bali and the Surabaya area.

3.8. Seasonality

No seasonality survey was possible during the present brief study but available weather data (Fig. 1.3) revealed strong seasonality during 2013 and all interviewed farmers stated that their seaweed production had a strong seasonal pattern with best-season harvests being as much as four times greater than worst season harvests. In some cases, such as at Talango Island, farmers reported total crop failure by January, 2015 and total re-planting was being undertaken during March. As in Bluto, the worst season was deemed to be from about December-January until August-September. On the other hand in Saronggi farmers that February until August was the best season. The situation in Sumenep was apparently similar to the situation in Maluku Tenggara where farmer surveys indicated seasonality patterns as shown in Figure 3.4. Both in Maluku Tenggara and at Sumenep farmers reported that seasonality varied between sites such that at least a few areas had good or acceptable growing conditions at most times of the year and these can serve as nursery areas.

Figure 3.4. No seasonality survey was possible during the present brief study but this matrix shows an example of farmer evaluations of seasonal crop production for seven prominent seaweed farm locations in Maluku Tenggara. Green = best growth. Yellow = sub-optimal growth. Red = poor growth and/or presence of ice-ice. (From Neish, 2012a).

Village	Exposure	Cottonii seasonal growth patterns for seven villages in MalRa											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dullah Laut	N	↓	↓	↓	↑	↑	↑	↑	↑	↑	↑	→	↓
Ohoidertawan	NW	↓	↓	↓	→	↑	↑	↑	↑	↑	↑	→	↓
Ohoililir	NW	→	→	→	↑	↑	↑	↑	↑	↓	↓	↓	↓
Debut	W	↑	↑	↑	↑	→	↓	↓	↓	↓	↓	→	↑
Evu	W	→	↑	↑	↑	↑	↑	↑	→	→	↓	↓	↓
Sathean	E	↓	→	→	↑	↑	↑	↑	↑	↑	↑	↓	↓
Revav	E	↓	→	↑	↑	↑	↑	↑	→	↓	↓	↓	↓
GROWTH:	BEST	↑		MIXED	→		WORST	↓					

Seasonal reductions in crop growth are commonly associated with loss of plant color and high incidence of 'ice-ice' malady (Fig. 3.5). Both phenomena are probably related to plant malnutrition (especially low nitrogen levels) and high metabolic rates associated with still, warm seawater but there is a dearth of scientific evidence that tests seasonality hypotheses.

Figure 3.5. A. Seasonality is commonly related to: A & B. loss of color by crops and C. ice-ice malady.

4. Carrageenan process systems

4.1 Seaweed and carrageenan product characteristics

4.1.1 Raw seaweeds

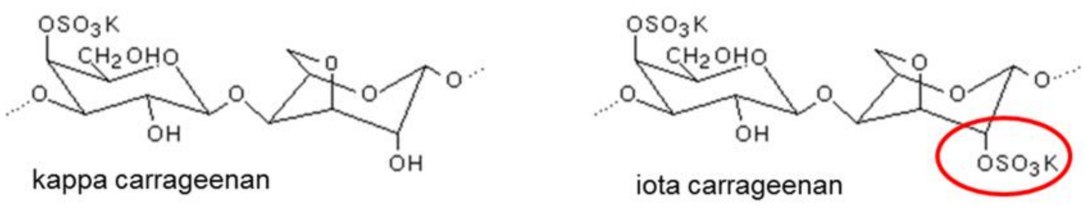
At the time of writing Sumenep seaweed production from the main island of Madura appeared to be mainly as dried *Kappaphycus striatus* (sacol of the trade; often identified as cottonii) while *Kappaphycus alvarezii* (cottonii of the trade) predominated in the Kangean and Sapeken Islands. There was no observed production of *Eucheuma denticulatum* (spinosum seaweed of the trade) but some farmers stated an interest in planting it in the future. Most, if not all Sumenep seaweeds were sold as raw, dried seaweed (RDS) that was used as raw material for the manufacture of either semi-refined or refined carrageenan. A minor proportion was made into alkali-treated cottonii chips (ATC). National Indonesian Product Standards for RDS exist but in the trade standards are set by specifications in purchase orders between buyer and seller (section 5.2).

4.1.2 Differences between kappa and iota carrageenan

Although *Kappaphycus* and *Eucheuma* have a similar appearance they contain different types of carrageenan. *Eucheuma* contains iota carrageenan and *Kappaphycus* contains kappa carrageenan. Differences in the kappa carrageenan from *K. alvarezii* and *K. striatus* can be detected in infrared spectrographs. They are generally considered to be functionally equivalent in the carrageenan trade but some processors prefer one over the other for particular products.

Kappa and iota carrageenan are performance chemicals that are utilized in food, personal care and industrial applications. They behave in radically different ways due to sulfation patterns of the carrageenan molecules (Fig. 4.1). They can have complementary uses but they cannot replace each other.

Figure 4.1. Structures of kappa and iota carrageenan. The ester sulfate at the 6 position of the 3,6 anhydrogalactose unit causes iota carrageenan to perform in a radically different way than kappa carrageenan in food, personal care and industrial applications.



Iota carrageenan forms soft, elastic gels in the presence of calcium salts. Refined iota carrageenan forms clear gels with no bleeding of liquid (no syneresis). Gels are freeze/thaw stable and can form in the presence of high salt concentrations. Major applications include dentifrice gels (toothpaste), capsules, industrial slurries and food texturization.

Kappa carrageenan forms strong, rigid gels in the presence of potassium salts and brittle gels with calcium salts. The slightly opaque gels become clear with sugar addition. There is some syneresis. Major applications include stabilization of dairy products, gelled pet foods, meat processing and water gels such as jelly desserts and candies. Kappa carrageenan is generally applied with other vegetable gums such as galactomannans and glucomannans.

4.1.3. Differences between semi-refined carrageenan (SRC) and refined carrageenan (RC)

The global standard for carrageenan is set forth under the FAO/WHO Codex Alimentarius which was updated at the 37th Session of the Codex Alimentarius Commission (2014). The definitions were prepared at the 68th JECFA (2007) and published in FAO JECFA Monographs 4 (2007) where refined carrageenan was identified as 'carrageenan INS No.407' and semi-refined carrageenan was defined as 'processed eucheuma seaweed PES with INS No. 407a. The definition is lengthy and can be downloaded from the Internet www.codexalimentarius. The key paragraph in the definition is that SRC (PES) is *"a substance with hydrocolloid properties obtained from either Eucheuma cottonii or E. spinosum (from the Rhodophyceae class of red seaweeds). In addition to carrageenan polysaccharides, processed Eucheuma seaweed may contain up to 15% of insoluble algal cellulose and minor amounts of other insoluble matter. Articles of commerce may include sugars for standardization purposes or salts to obtain specific gelling or thickening characteristics.* ***It is distinguished from carrageenan (INS No. 407) by its higher content of cellulosic matter and by the fact that it is not solubilized and precipitated during processing."*** *[emphasis added]*

Note that this definition identifies *Eucheuma cottonii* and *Eucheuma spinosum* as sources of INS No. 407 and 407a although such identifications are incorrect from a taxonomic perspective. On food labels RC is typically referred to as E407 and SRC as E407a**. In terms of chemical composition the key difference is that RC contains less than two percent by weight of cellulosic matter and SRC contains more than two percent.**

4.1.4 Differences between food grade and technical grade ATC/SRC

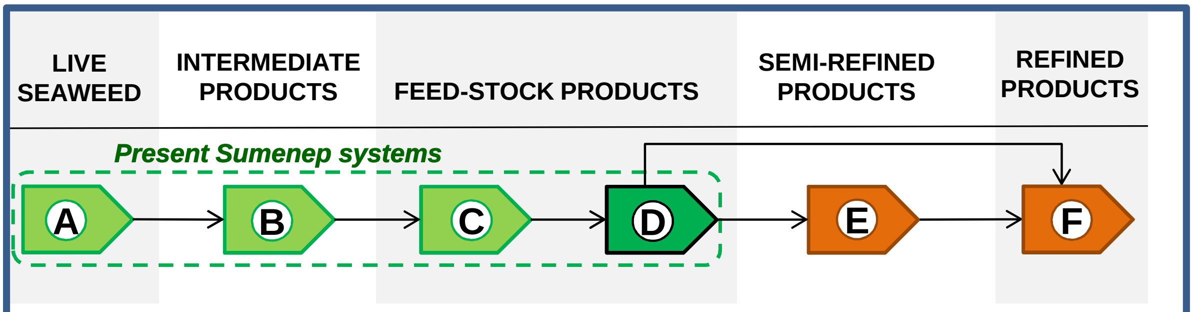
During processing (Figs. 4.2 and 4.4) ATC is a precursor to SRC. The only difference between ATC and SRC is the particle size. SRC is ATC that has been ground finely enough to be considered as a powder for commercial purposes. The defining difference between technical grade (also referred to as petfood grade) ATC/SRC and food grade ATC/SRC is the cleanliness of the product. Microbial criteria that must be met in order to qualify as food grade (FAO JECFA Monographs 4 [2007]) are:

"Initially prepare a 10-1 dilution by adding a 50 g sample to 450 ml of Butterfield's phosphate-buffered dilution water and homogenizing the mixture in a high speed blender. Total (aerobic) plate count: Not more than 5000 cfu/g. Salmonella spp.: Negative per test E. coli: Negative in 1 g." Buyers of carrageenan building blocks often require that more stringent standards be met and they generally specify a low mold and yeast content.

4.3 Conventional process technology

Present Sumenep seaweed value chains are simple in form (Fig. 4.2) Farmers grow seaweed that gets dried, then is exported to international processors that use the seaweed as raw material for manufacture of carrageenan. Although some ATC has been made in at least three facilities in Sumenep there is no record of substantial market volumes being achieved. One example of a Sumenep ATC factory is shown in Plate 4.1. That factory never achieved commercial production. Another ATC factory owned by Haji Khalis Esbe is about to commence production in Sumenep, however (Khalis, *pers. comm*).

Figure 4.2. *Kappaphycus* seaweed process flow characteristic of current Sumenep seaweed markets. Only the first three steps (A, B & C) commonly take place in Sumenep although some ATC has been made there.



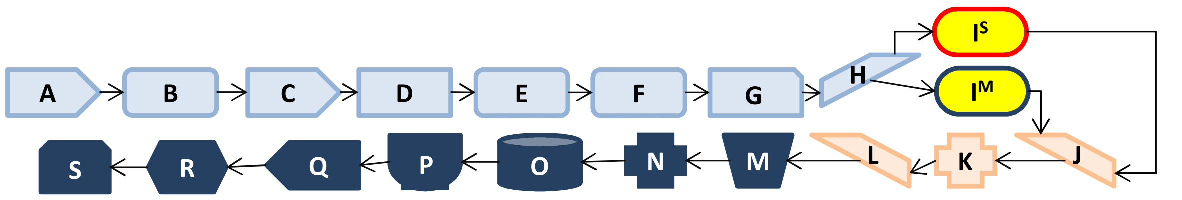
#	SYSTEMS	ACTIONS	PRODUCTS
		PRESENT SUMENEP SYSTEMS	
A	Seaweed agronomy	Plant and grow seaweeds in agronomy systems that include nursery, grow-out and logistics sub-systems	Fresh seaweed (FS)
B	Whole seaweed drying	Live seaweed sun dried on appropriate surfaces and bagged for sale	Raw-dried seaweed (RDS) – farm gate
C	Logistics & baling	Sacked seaweeds picked up from farmers, moved to warehouse, cleaned, re-dried, baled and shipped	Raw-dried seaweed (RDS) – export grade
		OLD CARRAGEENAN TECHNOLOGY OF CURRENT PROCESSORS	
D	ATC plant	Seaweed is treated with alkali to stabilize & modify the carrageenan then is dried & packed for sale	Alkali-treated chips – (ATC)
E	SRC plant	ATC or ATP is sanitized, treated, further-dried, milled, blended to specifications & packed for sale	Semi-refined carrageenan – (SRC)
F	RC plant	Acid insoluble matter (AIM) removed from ATC/ATP; dried, milled, blended & packed to specifications	Refined carrageenan (RC)

The conventional process for making kappa SRC using *Kappaphycus* RDS as raw material is shown in Figure 4.3. Variable production costs typical of this process are shown in Table 4.1. That example assumed RDS consumption of four tons per ton of food grade SRC produced. RDS price CNF factory gate was assumed to be 15,000 IDR/ton and the FOREX rate was assumed to be 13,000 IDR per USD. As of April, 2015 the price of food grade SRC was generally in the range of 8.00 ± 0.5 USD so the gross margin of a kappa carrageenan building block maker would have been about one to two USD/kg or about 13-24 percent. This level of gross margin was barely able to cover fixed costs for most processors.

Table 4.1. Example summary of major variable production costs for food grade SRC in USD per ton. (Source: Neish *pers. Comm.*)

Component	USD/Ton of SRC	%
RAW, DRIED COTTONII	4,600	71.4
OTHER MATERIALS	700	10.9
FUEL CONSUMPTION	540	8.4
ELECTRICITY CONSUMPTION	350	5.4
VARIABLE LABOR	160	2.5
WASTE DISPOSAL	90	1.4
Total USD	6,440	100.0

Figure 4.3. Example schematic diagram of a conventional process for making semi-refined carrageenan (SRC).



STEP	EQUIPMENT/ACTION
A	**Forklift**: moves RDS to pre-washer
B	**Pre-wash conveyor**: RDS washed & conveyed to baskets (uses waste wash water)
C	**Forklift**: move baskets to hoist
D	**Cooker**: hoist places baskets in cooker and alkaline modification takes place
E, F	**Wash 1**: hoist moves basket to wash 1 (uses wash 2 water from previous batch); **Wash 2**: (uses clean fresh water)
G	**Unloading hopper:** baskets unloaded into hopper, gets sorted & dewatered;
H	**Conveyor 1**: cottonii is conveyed to dryer
I	**I^S sun dryer for technical grade**; **I^M** mechanical dryer for food grade
J	**Conveyor 2**: lifts dried cott to cutting mill
K	**Cutting mill**: chops dried cottonii to ATC size;
L	**Conveyor 3**: moves ATC to mill feed hopper
M	**Mill feed hopper**: meters ATC into attrition mill
N	**Attrition mill**: reduces ATC to SRC with desired mesh size
O	**Bag-house/dust collector**: prevents loss of dust during milling
P	**Blender**: mixes powder produced from mill
Q	**Forklift**: moves SRC from milling system to storage areas, blender & packing
R	**Blender**: makes pre-blends and final blends
S	**Packing system**: packs SRC in bags for shipment

Plate 4.1. A factory built for manufacturing alkali-treated chips (ATC) from *Kappaphycus* seaweed in Sumenep in 2008. **A.** The processing building. **B.** Wastewater treatment system. **C.** The cooking system. **D.** Racks (para para) for drying ATC chips. **E.** The chipping mill. **F.** Storage shed and office building. There apparently was no laboratory. This factory never produced ATC at commercial scale but there is another Sumenep factory commencing ATC production near Desa Lobuk (Haji Khalis Esbe, *pers. comm*).

4.4 Advanced processing options for future development

Present Sumenep seaweed value chains are placed in the context of future value chain development options in Figure 4.4. There are two distinctly different paths to take, namely:

1. **Utilize conventional (old) technology** to make semi-refined carrageenan (SRC) or refined carrageenan (RC) from raw, dried seaweed (RDS) in Sumenep-based production facilities;
2. **Employ newly developing multi-stream, zero-effluent (MUZE) technology** that commences processing using live, fresh seaweed (FS) to produce not only SRC and RC but also agricultural nutrient products and various other products that are becoming possible from developing bio-technology.

Predominant current carrageenan processes (Figs. 4.2 and 4.3) employ decades-old single-stream technology that yields a narrow product range and wastes much, if not most of biomass value. Such processes require large amount of fresh water and can generate high-chloride effluents in amounts of tens of cubic meters per ton of carrageenan produced. Such technology serves global markets worth about seven hundred million USD/yr.

Emerging multi-stream, zero-effluent biotechnologies produce not only carrageenan but also a wide range of products beyond hydrocolloids. It can serve global markets worth multi-billion USD/yr. Fresh seaweed biomass is fully utilized and fresh water is recovered so there is little or no waste. (Fig. 4.4)

Figure 4.4. A comparison of product profiles and waste generated by conventional single-stream and developing MUZE process systems.

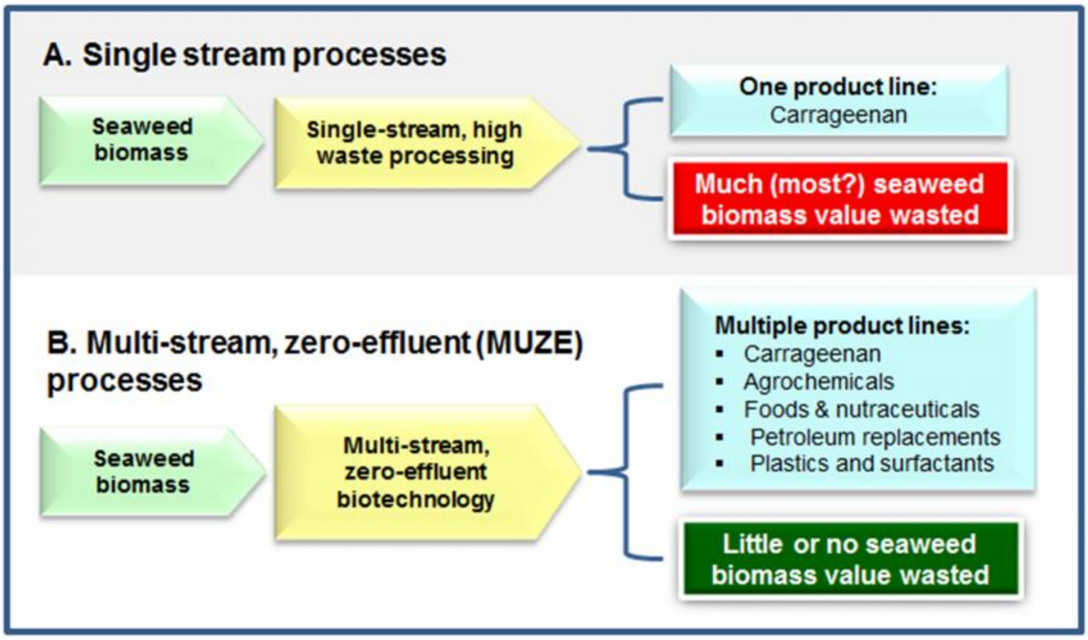
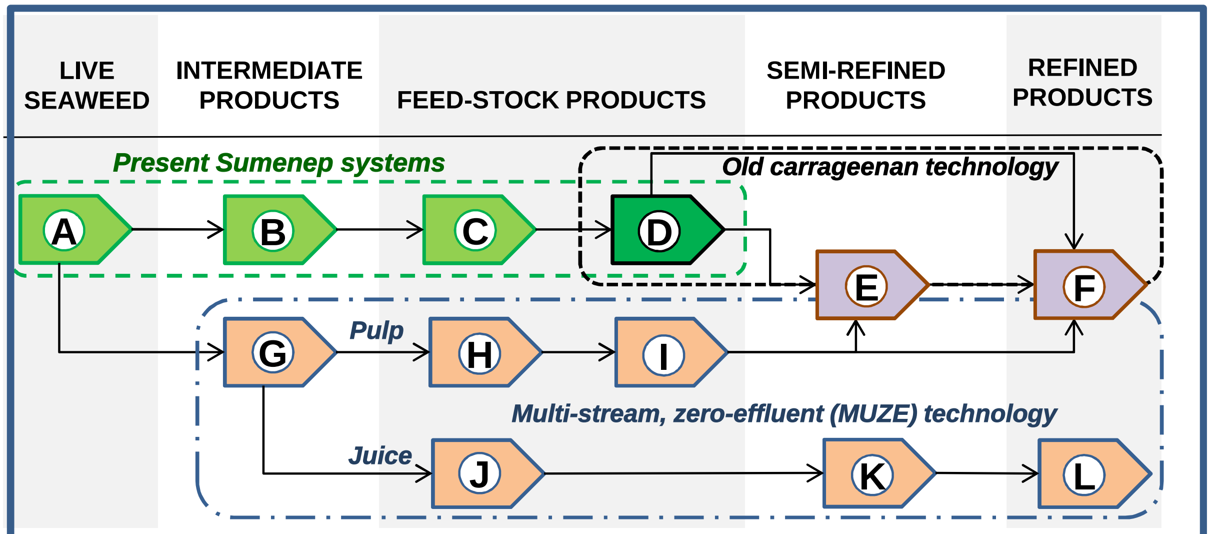
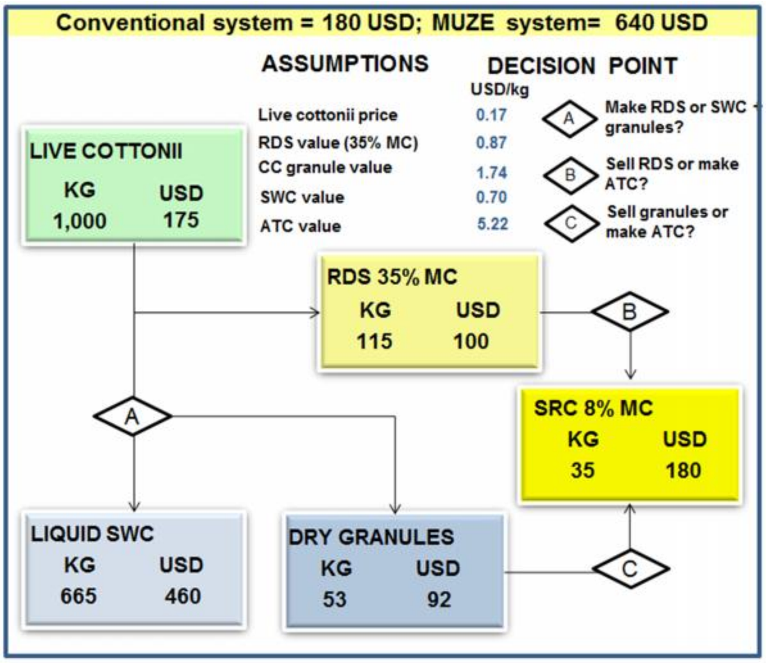


Figure 4.5. Seaweed process flow options for Sumenep.



#	SYSTEMS	ACTIONS	PRODUCTS
		PRESENT SUMENEP SYSTEMS	
A	Seaweed agronomy	Plant and grow seaweeds in agronomy systems that include nursery, grow-out and logistics sub-systems	Fresh seaweed (FS)
B	Whole seaweed drying	Live spinosum sun dried on appropriate surfaces and bagged for sale	Raw-dried seaweed (RDS) – farm gate
C	Logistics & baling	Sacked seaweeds picked up from farmers, moved to warehouse, cleaned, re-dried, baled, moved to port and shipped	Raw-dried seaweed (RDS) – export grade
		OLD CARRAGEENAN TECHNOLOGY	
D	ATC plant	Seaweed is treated with alkali to stabilize & modify the carrageenan then is dried & packed for sale	Alkali-treated chips – (ATC)
		OLD AND/OR MUZE CARRAGEENAN TECHNOLOGY	
E	SRC plant	ATC or ATP is sanitized, treated, further-dried, milled, blended to specifications & packed for sale	Semi-refined carrageenan – (SRC)
F	RC plant	Acid insoluble matter (AIM) removed from ATC/ATP; dried, milled, blended & packed to specifications	Refined carrageenan (RC)
		NEW MULTI-STREAM, ZERO-EFFLUENT (MUZE) TECHNOLOGY	
G	Juicing units	Juicing systems mill live seaweed near farm sites then separate juice from pulp	Seaweed juice & pulp
H	Wet pulp	Wet pulp in vessels transported to process plant	Wet seaweed pulp (WSP)
I	ATP plant	Wet pulp is treated with alkali to stabilize & modify the carrageenan then pulp is semi-dried or dried	Dry or semi-dry alkali stabilized pulp (ASP)
J	Raw juice	Raw juice in vessels transported to process plant	Raw seaweed juice (RSJ)
K	Juice concentrate	Juice is concentrated, preserved, blended & packed	Seaweed juice concentrate (SJC)
L	Juice powder	Concentrated seaweed juice (CSJ) is dried to powder, blended & packed for sale	Powdered seaweed juice (PSJ)

Figure 4.6. Schematic view of materials and values partitioning for cottonii comparing a conventional approach to a MUZE approach. CG = carrageenan granules; MC = moisture content; RDS = raw, dried cottonii seaweed; SRC = semi-refined carrageenan. (Source; Sea6 Energy).



Pertinent features of MUZE technology include:

1. MUZE processing produces several value-added products and zero-waste.
2. Pulp from MUZE processing can be used to make SRC or can be used to produce agricultural nutrient products or chemical feedstock.
3. Juice from MUZE processing can be used as a basis for several agricultural nutrient products than can benefit both plants and animals.
4. Agricultural nutrient products have large local and regional markets in Asia.
5. According to the comparison shown in Figure 4.6 total product value derived from 1 000 kg of live cottonii would be on the order of 180 USD from a conventional system and 640 USD from MUZE system. These numbers are estimates but the principle holds true; more value streams and zero waste lead to more added value.
6. MUZE processing lends itself to adaptation to new process technology being developed by the biotechnology industry.

4.5. Opportunities for future development in Sumenep

Both public and private sector stakeholders in Sumenep have stated clear intent to see value added to farmed seaweeds within the Regency rather than having Sumenep remain only as a provider of raw seaweeds. The plus side of MUZE processing from that standpoint is that it commences with live seaweeds as raw material; therefore value addition is compelled to take place near to farm areas.

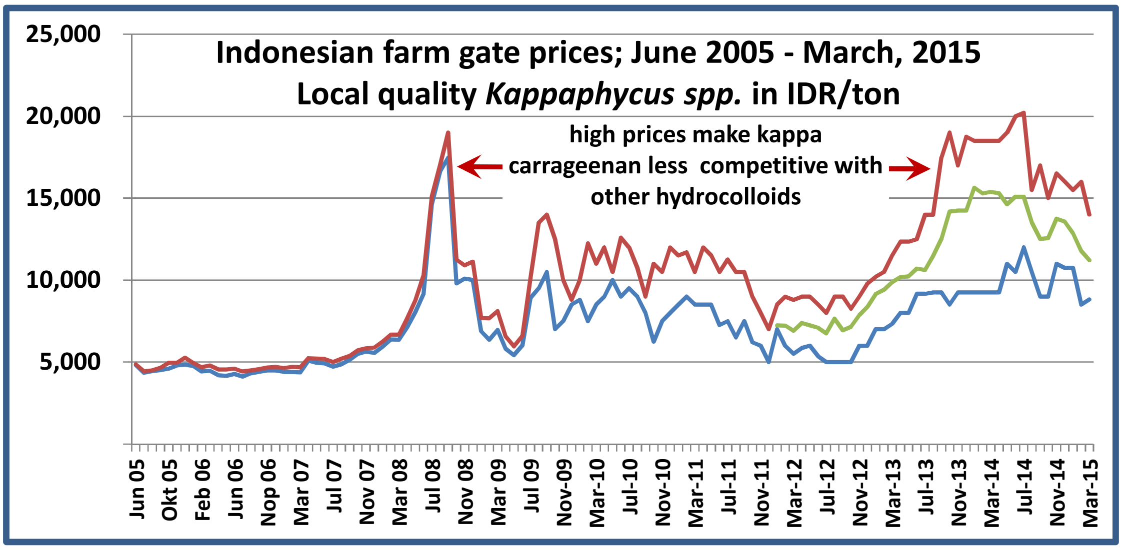
The negative side to MUZE development is that as of 2015 it was still in the research and development phase by innovative private sector companies so it was not yet ready for implementation in Sumenep. If Sumenep stakeholders engage in the process of innovation, however, they can benefits as early adopters of MUZE technology.

5. Markets and trade

5.1. Seaweed farm gate price patterns

Figure 5.1 shows Indonesian price movements for farm gate prices of raw, dried 'local quality' *Kappaphycus* seaweeds from 2005 until early 2015. Typically 'local quality' meant a moisture-content of about 42 ± 4 percent. Prices tended to be lowest at farm areas far from the hub port of Surabaya. Sumenep benefited by its close proximity to that port.

Figure 5.1. Maximum, minimum and average farm gate prices in IDR/kg for local quality *Kappaphycus spp.* in Indonesia from June, 2005 until March, 2015. (Data from Jasuda).



The price swings shown in Figure 5.1 were a constant source of concern for stakeholders at all value chain levels. Accurate real-time data pertaining to seaweed crop production were not available so factors impacting production were opaque. Processors executed inventory strategies and farmers executed planting strategies without clear market signals so value chain disconnects were frequent. The first major disconnect was during the 'cottonii crisis of 2008' when prices that had been stable at about 4-5,000 IDR/kg for more than a decade suddenly increased almost four-fold within five months. Reasons for the crisis were never made clear but panic buying by China processors in the face of false perceptions of crop failures appeared to be a major factor.

Until 2008 carrageenan prices had been stable for most of the history of the industry. Contracts from users of carrageenan blends tended to be annual in duration. The 2008 price spike shocked the industry and led to *force majeure* disruptions to many contracts. The market image of kappa carrageenan price stability was shattered and farm gate prices never fell to pre-crisis levels. This situation has arguably inhibited growth of carrageenan markets especially as RDS costs have driven kappa carrageenan prices to levels that are high relative to prices for competing hydrocolloids. Despite inhibited market growth *Kappaphycus* supplies tended to be tight relative to demand so RDS prices remained on the high side.

5.2. Collection and trading operations

Section 2.3.3 listed several risks and burdens borne by traders/exporters as RDS passes through value chain functions. For traders shrinkage control (mainly from moisture removed to achieve buyers' specifications) is a crucial requirement for preventing financial losses. Shrinkage losses are commonly in the range of 15-20%. Exporters also bear foreign exchange risk; carry costs of financing seaweed as it moves from sources to processors; bear the risk of uncertain payment balances from quality control holdbacks; and absorb processing and transportation costs. Table 5.1 shows an example of actions that would have been undertaken and costs/revenues that could have been generated by an integrated Sumenep seaweed exporter using values typical of 2014.

Table 5.1. An example of costs and income for raw, dried seaweed (RDS) purchased by a trader in Sumenep and transported to Surabaya for sale at an exporter's warehouse. Internal costs are from traders' in-house operations. External costs are disbursements by traders to third parties such as suppliers and tolling providers (e.g. transport costs). FCL means a 'Full Container Load' comprising 20 tons of baled RDS in a 20-foot shipping container.

SHRINKAGE ASSUMPTIONS				
Transport shrinkage %	2			
Process shrinkage % to 35% MC	15			
CALCULATIONS IDR PER KG RDS ITEM	INTERNAL COSTS	EXTERNAL COSTS	IDR TOTAL PER KG	M IDR PER TEN FCL*
Cost of RDS at point of origin		10,000		2,000.0
Procurement tolling cost	300			60.0
Land freight to warehouse		300		60.0
Transport shrinkage		212		42.4
Cost of process shrinkage		1,622		324.4
Process tolling costs	300			60.0
Process tolling fees	1,066			213.2
Land freight to SUB		100		20.0
Funding fee (cost of finance)		100		20.0
INTERNAL COST TOTAL	1,666			333.2
EXTERNAL COST TOTAL		12,334		2,466.8
Cost as shipped			10,600	2,120.0
Cost landed at warehouse			10,812	2,162.4
All-in cost at SUB			12,934	2,586.8
Sale price			14,000	2,800.0
Gross profit margin (IDR)			**1,066**	
Gross profit margin %			**7.6**	
(Note: Yellow boxes are filled in parameters; other fields are calculated)				
* FCL = Full Container Load = 20 tons of baled seaweed in a twenty-foot container				

5.3. Product and trade regulations

As seaweeds and carrageenan enter international trade compliance with several guidelines and regulations may be advisable or required. The quality infrastructure for carrageenan seaweed value chains involves two categories of regulations and standards. They pertain to aquaculture and to carrageenan, respectively. What follows is an adaptation of material in Neish, 2013a to the Sumenep context.

5.3.1. Aquaculture standards applied to seaweeds

Carrageenan is a segment of the food ingredient business but the cultivation of seaweeds is part of the aquaculture business. Although standard aquaculture protocols are at their formative stages throughout most of the world, there are already some initiatives for carrageenan value chain stakeholders, which include the following:

A. EUREPGAP - Euro Retailer Produce Working Group (EUREP) on standards and procedures for the development of Good Aquaculture Practices (GAP) in conventional agriculture (general regulations for integrated aquaculture assurance; control points and compliance criteria for integrated aquaculture assurance).
B. FAO Guidelines for Aquaculture Certification (under development).
C. Quarantine protocols for tropical seaweeds such as those proposed by Sulu et al. (2004).

5.3.2. Regulations and guidelines for carrageenan products

Legally defined product standards set boundaries for carrageenan products that must be met. Failure to comply means that products cannot be sold to customers or jurisdictions where the standards apply. Important regulatory documents include:

A. EU: European Union standards for E407a (Processed Eucheuma Seaweed) and E407 (Carrageenan).
B. JECFA - FAO/WHO: standards for Processed Eucheuma Seaweed and Carrageenan.
C. Codex FAO.
D. USFDA (United States Food and Drug Administration).
E. HACCP (Hazard Analytical Control Points) requirements.
F. ISO 9001: 2000, Quality Management System.
G. ISO 14001: 2004, Environmental Management System.
H. ISO 22000: 2005, Food Safety Management.
I. OHSAS 18001.

It must be noted that many carrageenan standards are 'commercial standards' that are defined between buyers and sellers. In such cases standards could not be imposed but guidelines are of use. Examples include:

A. Philippine and Indonesian National Carrageenan Standards (under development). Also proposed as bases for a BIMP-EAGA harmonized standard.
B. CAC/GL 60-2006: Codex Alimentarius Principle for Traceability/ Product Tracing as a Tool within a Food Inspection and Certification System.
C. CAC/GL 38-2001 Rev.1-2005: Codex Alimentarius Guidelines for Generic Official Certificates Formats and the Production and Issuance of Certificates.

5.4. Commercial arrangements

In the past letters of credit were the common form of commercial arrangement for seaweed purchases but current practice is generally for a buyer to issue purchases orders for a given number of container loads. Purchase orders typically specify the following:

1. Product defined as dried seaweed with genus, and sometimes species defined (e.g. *Kappaphycus alvarezii* [cottonii]; *Kappaphycus striatus* [sacol]; *Eucheuma* [spinosum] seaweed of the trade);

2. Price per ton denominated in United States dollars;
3. Price based on 35 percent average moisture content (MC) and maximum two percent contaminants;
4. Excess or low MC offset by negotiated adjustment of future volume shipped (usually "free" tonnage shipped to offset excess MC in previous shipments);
5. Seaweed packed in wrapped bales of 100 kg weight (20 tons per 20 foot container);
6. Payment on FOB basis within about two seeks from presentation of shipping documents.

5.5. Global seaweed and carrageenan markets

5.5.1. Markets for cultivated tropical seaweeds

Essentially all Sumenep seaweed production is raw, dried *Kappaphycus* used as raw material for the carrageenan market. Indonesia is the world's major source of carrageenan seaweeds and Sumenep is a major source within the country. Indonesia and the Philippines produced over 80% of cottonii and spinosum. (Figs. 5.2 & 5.3)

Figure 5.2. Cultivated tropical seaweeds are the dominant carrageenan raw material. Cottonii (including sacol) comprised about 80 percent of the total. (after Bixler & Porse, 2010)

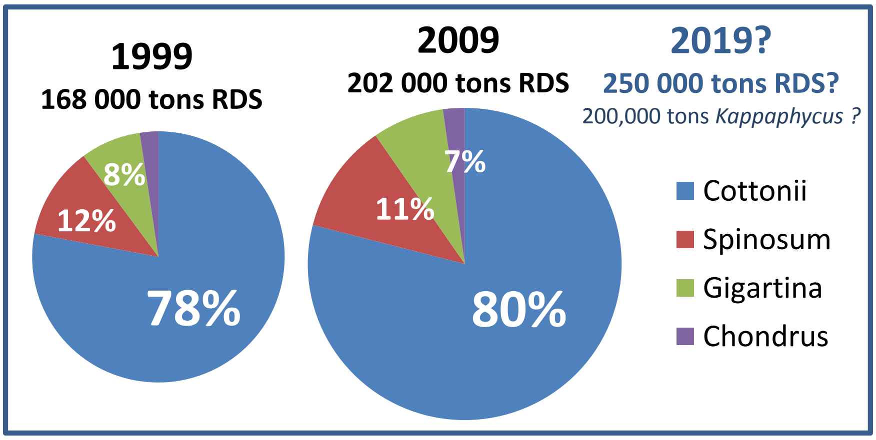
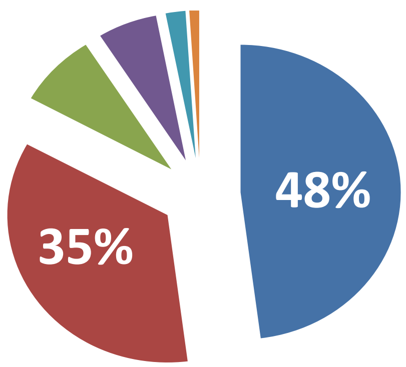


Figure 5.3. Indonesia is the world's major source of carrageenan seaweeds. Indonesia and the Philippines produced over 80% of cottonii and spinosum. Tanzania was the third largest producer but produced mostly spinosum with little cottonii. (after FAO, 2012).



	Percent
Indonesia	48
Philippines	35
Other	8
Tanzania	6
Vietnam	2
Malaysia	1

5.5.2. Markets for carrageenan

Based on the latest available data, from 2010, Bixler and Porse reported global production of carrageenan was on the order of 50,000 metric tons and markets were partitioned approximately as shown in Figure 5.4. The same carrageenan applications have dominated markets for more than three decades, although proportions have shifted with petfood declining and meat applications increasing. The proliferation of process plants has been driven by 'copycat' technology – not by innovative technology. Markets were moving toward the most cost-effective products, especially toward SRC (Fig. 5.5).

Figure 5.4. Estimated partitioning of carrageenan markets (after Bixler and Porse, 2010).

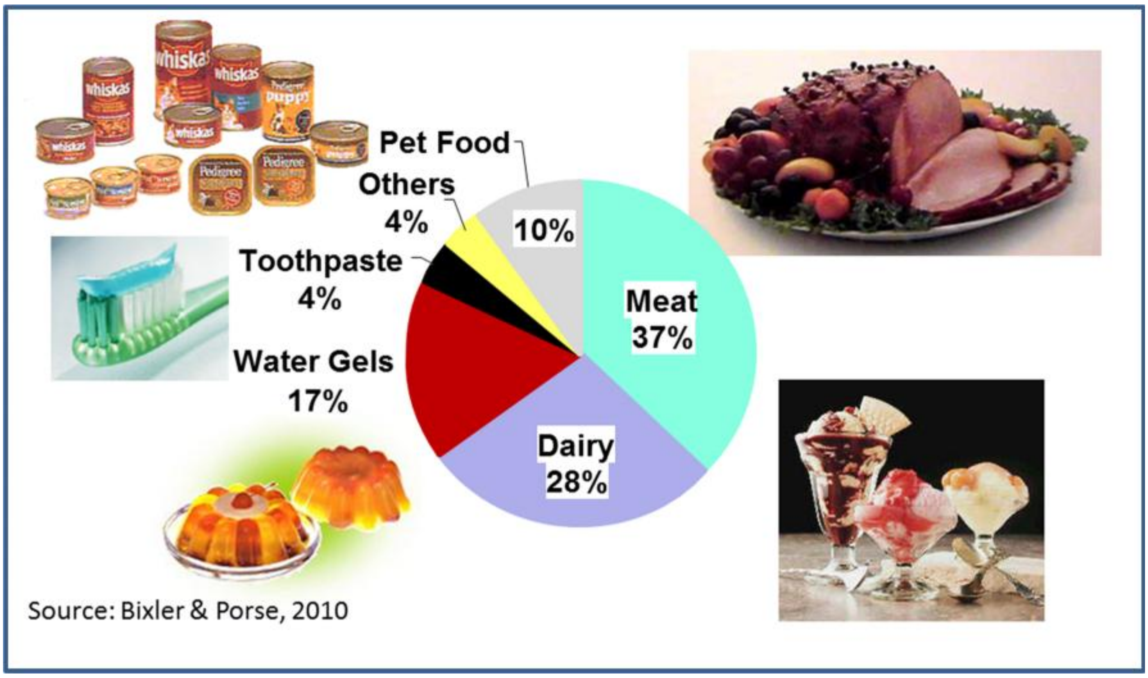


Figure 5.5. Markets were moving toward the most cost-effective products. Essentially all Sumenep seaweed production was raw, dried *Kappaphycus* used as raw material for the carrageenan market. (Source: Bixler & Porse, 2010).

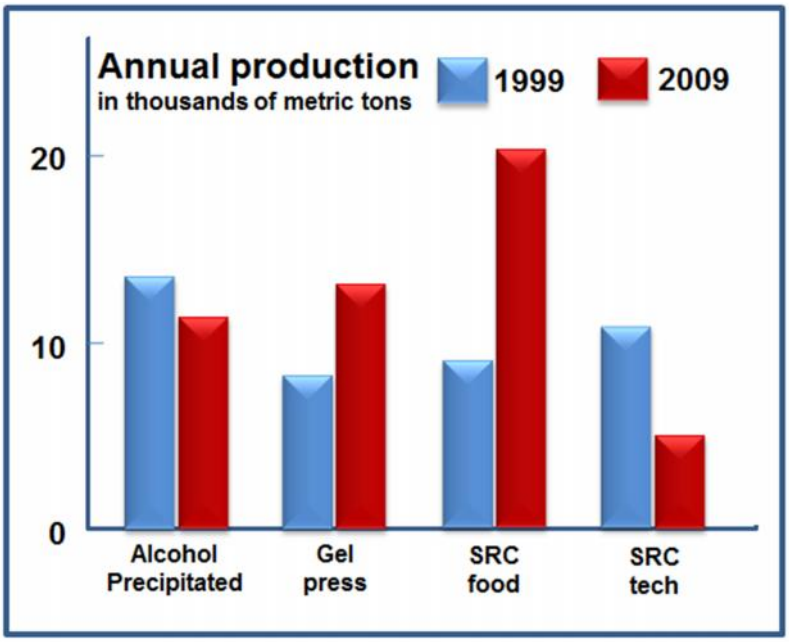


Figure 5.6. Robust revenue growth due to price increases but weak profit growth 1999 to 2009. (Bixler & Porse, 2010). Amounts are shown as billions of USD.

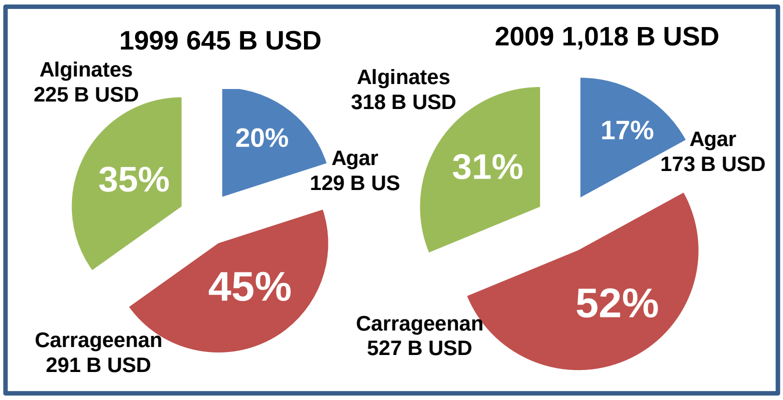
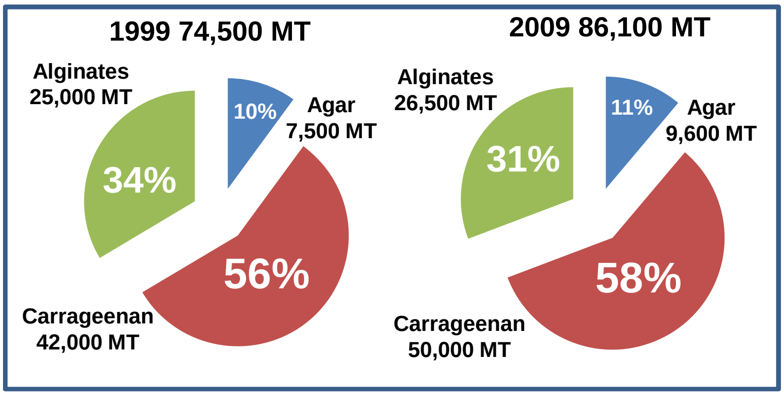


Figure 5.7. Market volume growth in hydrocolloid markets from 1999-2009. Market growth was sluggish and no new major carrageenan applications were developed. (Bixler & Porse, 2010).



5.6. Market challenges

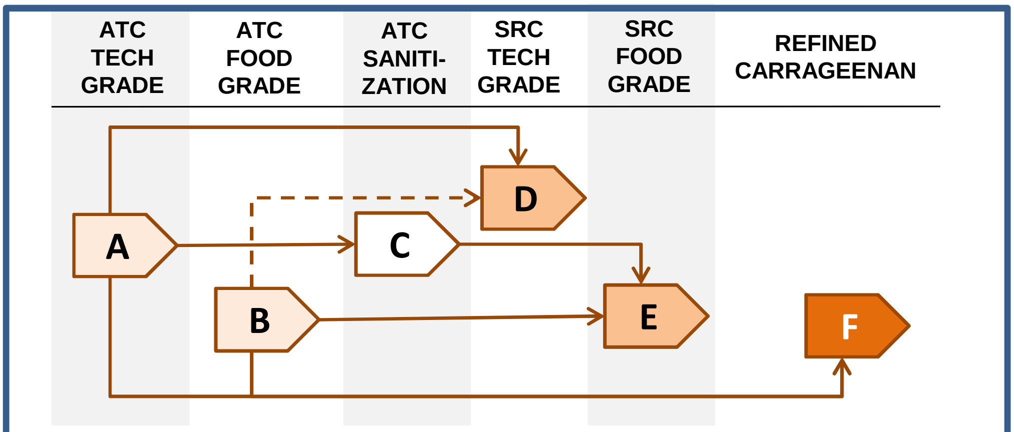
5.6.1. Marketing of ATC

Alkali-treated cottonii chips (ATC) is an intermediate process stage during the manufacture of SRC (Figs. 4.2-4.4). ATC can also be used for manufacture of refined carrageenan. Figure 5.8 shows process paths followed by technical grade and food grade ATC leading to SRC and RC production. Features of these paths that impact on marketability of ATC are:

1. Most ATC factories utilize sun-drying of 'chips' and are not capable of making food grade ATC.
2. The major market for technical grade SRC made from ATC was historically the petfood stabilizer market. That is a shrinking 'sunset market' because gelled petfoods are being displaced by dry formulations that do not use carrageenan.
3. In order to make food grade SRC from technical grade ATC it is necessary to undertake expensive sanitization and re-drying operations.
4. In order for ATC to be of value to further-processors it must be made to strict specifications that are specific to individual buyers.
5. Most processors have experimented with buying ATC and found that it was more economical for them to make their ATC from RDS using their own process lines.
6. Sanitization is not necessarily an issue for RC makers using ATC as raw material so there could be a market selling to them so long as carrageenan modification is done to specification. If tariff barriers are not an issue China could be a market for technical grade ATC.

Caveat: Before building an ATC factory it is wise to form contractual relationships with anchor buyers. ATC is best sold as a 'bespoke' product that becomes a performance chemical. There is little or no market for 'commodity' ATC.

Figure 5.8. Schematic depiction of process paths followed by technical grade and food grade ATC leading to SRC and RC production.

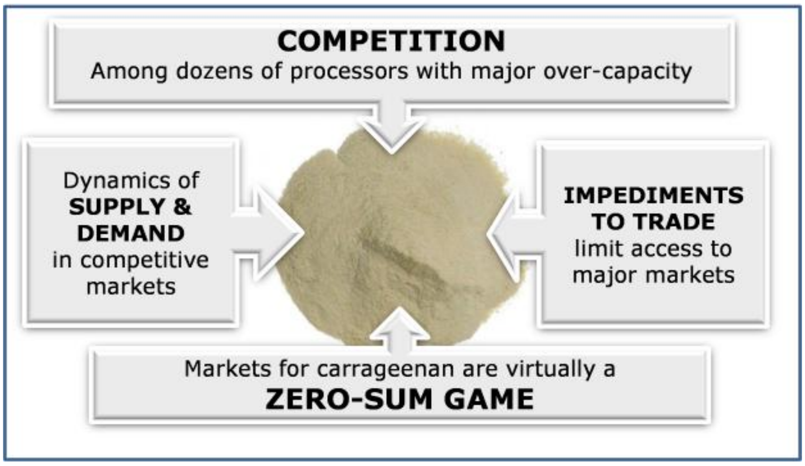


#	SYSTEMS	ACTIONS	PRODUCTS
A	Tech ATC	ATC made using drying systems such as open concrete slabs that are not sanitary	Technical (petfood) grade SRC
B	Food grade SRC	ATC made using drying systems such as mechanical dryers that are sanitary	Food grade ATC
C	Sanitization & re-drying facility	Tech ATC sanitized by washing in antimicrobial solutions, then re-dried in mechanical dryers	Food grade ATC
D	Technical grade SRC factory	Technical grade ATC is milled and blended	Technical (petfood) grade semi-refined carrageenan (SRC)
E	Food grade SRC factory	Food grade ATC is milled and blended	Food grade semi-refined carrageenan SRC
F	RC factory	ATC is pasted, then runs through RC process. Sanitization occurs during process.	Refined carrageenan (RC)

5.6.2. Four realities of carrageenan seaweed, SRC and RC markets.

Hurdles for entry of Sumenep-based enterprises into value-adding activities find their roots in the four carrageenan market realities indicated in Figure 5.9.

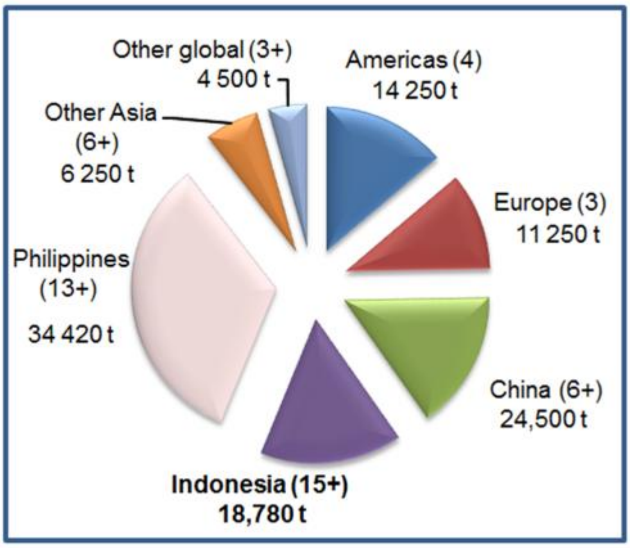
Figure 5.9. Four realities of carrageenan markets that impact on all value chain levels.



5.6.3. Global competition in carrageenan markets

Carrageenan processing plants come and go and merge and split and combine processes for various products so it is difficult to keep an up-to-date database of processors. Table 2.2 listed the major producers known as of 2015 and it was evident that plant capacity was at least double the size of carrageenan markets (Fig. 5.10). Interviews and experience gained working with Indonesian processors provided ample indication that it is extremely difficult for new entrants to gain market share in carrageenan markets.

Figure 5.10. This schematic pie chart shows region; number of carrageenan factories; and tons annual capacity for carrageenan as of 2014. More than 47 factories with over 114 000 tons of capacity were chasing about 50 000 tons of market. See Table 2.2 for more details.



The fact of global overcapacity in carrageenan production does not necessarily comprise a barrier to installation of additional capacity under conditions where substantial competitive advantage can be achieved. For example, process capacity close to exceptionally cost effective seaweed sources based on Sumenep comparative advantage could lead to competitive advantage especially if live seaweed was feeding into MUZE processes where the carrageenan component is ‘subsidized’ by sale of non-carrageenan components.

5.6.4. Impediments to trade

Sumenep is a supplier of raw, dried seaweed (RDS); it is not a supplier of value-added seaweed products. Trade constraints of carrageenan markets are a root cause of that situation. Although Indonesian RDS and carrageenan are sold to global markets, the Philippines and China have by far the most impact (Fig. 5.10). China is the biggest customer for Indonesian raw, dried seaweed (RDS) but low prices charged by Chinese manufacturers and high Chinese value-added tax (VAT) on the order of 17 percent inhibit (but do not prevent) entry of foreign carrageenan and agar into China. Meanwhile cheap Chinese RC in international markets inhibits RC production elsewhere, including from Indonesia.

PT Algalindo Perdana is an example of an Indonesian processor that has become a successful ingredient solutions provider within China. They export carrageenan in blends to China and find that even after paying VAT there is room for profit if effective marketing and sales strategies are applied.

The major carrageenan producer in the world as of 2015 was Shanghai Brilliant Gum Co. Ltd. (BLG) with Chinese factories in Shanghai and Zhejiang. On their website index page BLG has identified themselves as the world's biggest carrageenan manufacturer with global market share of nearly 30 percent. BLG claimed consumption of 'Eucheuma Seaweed' volume equal more than 40 percent of Indonesian production. (http://www.sh-blg.com/en/ [5 April, 2015]).

Interviewed Indonesian exporters estimated that as many as 4,000 tons of cottonii RDS per month were being exported from Indonesia to BLG as of 2015. BLG has penetrated world markets with RC at prices that competing processors (e.g. from the Philippines) claim are at or below their production cost. FMC Biopolymer closed its European kappa carrageenan factories (previously the largest in the world) by 2004 and commenced buying their kappa RC building blocks from BLG, among others.

An interesting factor of the China trade is that, after seaweed and fresh water, the main chemical used in producing ATC/SRC is potassium hydroxide (KOH) and Indonesia imports most KOH from China. About ten percent of variable production cost is from KOH purchases (Table 4.2).

The status of ATC entering China is a grey area that is worth examining and there are industry rumors that some processors are considering this option. Chinese producers of refined carrageenan can use technical-grade ATC because it is sanitized during the RC process. If it makes sense to make ATC in Indonesia using Chinese KOH; if buyers' quality standards can be met; and if ATC is treated as seaweed rather than as carrageenan under tariff regulations; then using ATC as feedstock could be a cost-effective proposition.

As of early 2015 it was announced that BLG will build a major ATC/SRC process plant in South Sulawesi on a twenty hectare site north of Pare-Pare. That factory is apparently aimed at non-Chinese SRC markets but it could also supply large quantities of ATC and SRC as raw material feed-stocks to BLG factories in China.

After China, the Republic of Philippines (RP) is the major market for Indonesian RDS. The Philippines is a major RDS producer but production has declined in recent years. Several large carrageenan manufacturers have based process plants there starting in1979 when FMC built the first SRC factory there (the author was project manager). By 2006 RP had become a net importer of cottonii RDS and now imports about 50,000 tons per annum according to letters sent to Asosiasi Rumput Laut Indonesia (ARLI) by the Seaweed Industry Association of the Philippines (SIAP) (Azis; *pers. Comm.*). RP and RI processors are rivals for buyer trust and market share. For buyers switching hydrocolloid suppliers is risky, expensive and time consuming. Major buyers are generally happy with their long-term, trusted Philippines carrageenan suppliers (Bixler; *pers. comm.*). They have been reluctant to develop supply relationships with later-coming Indonesian manufacturers. However this situation may be changing because with primacy in seaweed Indonesia is looking better and better as a carrageenan and agar source. Declining RP seaweed production related to typhoons and terror incidents was causing buyers to look for positions in Indonesia by 2015.

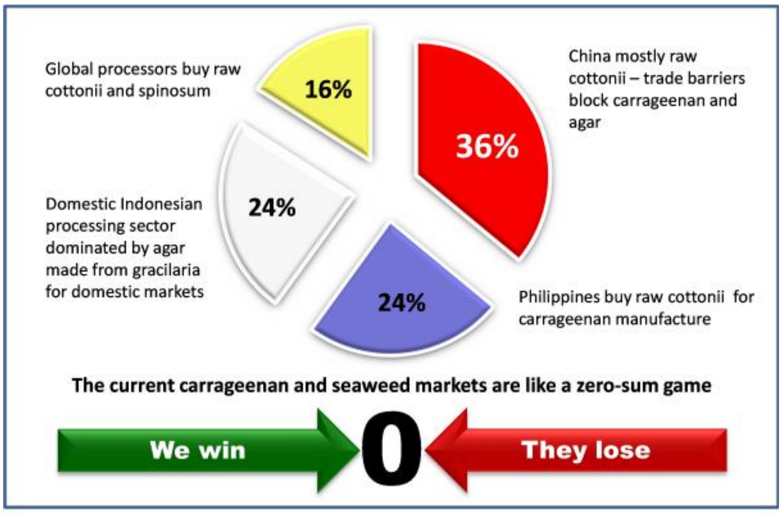
5.6.4. A zero-sum game

A 'zero-sum game' is a situation in which one person's gain is equivalent to another's loss, so the net change in wealth or benefit is zero. Present markets for Sumenep RDS are almost entirely as raw material for making kappa carrageenan. This market is mature and slow growing. The current RDS market is like a zero-sum game. For Sumenep to gain market share the Philippines and other Indonesian seaweed production areas must lose market share and they are sure to defend their positions.

5.6.5. Supply and Demand

The 'law of supply and demand' defines the effect that the availability of a particular product and the demand for that product has on price. Generally, if there is a low supply and a high demand, the price will be high. In contrast, the greater the supply and the lower the demand, the lower the price will be. The impact of supply-and-demand dynamics is amply illustrated in historical farm-gate prices for *Kappaphycus* RDS (Fig. 5.1).

Figure 5.11. Estimated proportions for RDS sales to major markets. (Source: Neish estimates based on trade data analysis). The current carrageenan and seaweed markets are like a zero-sum game. For Sumenep to gain market share others must lose market share.



Modest growth has been the rule in carrageenan markets during recent decades (Fig. 5.12) and seaweed production capacity is greater than demand from such markets can absorb. Seaweed farmers long ago learned that falling prices mean an excess of supply over demand so they have tended to adjust planting levels to anticipate market movements. In the opaque seaweed value chains of recent decades market signals have been poor for both buyers and sellers so despite the relative stability of kappa carrageenan prices the farm-gate price of Indonesian *Kappaphycus* has shown a pattern of significant market swings (Fig. 5.1).

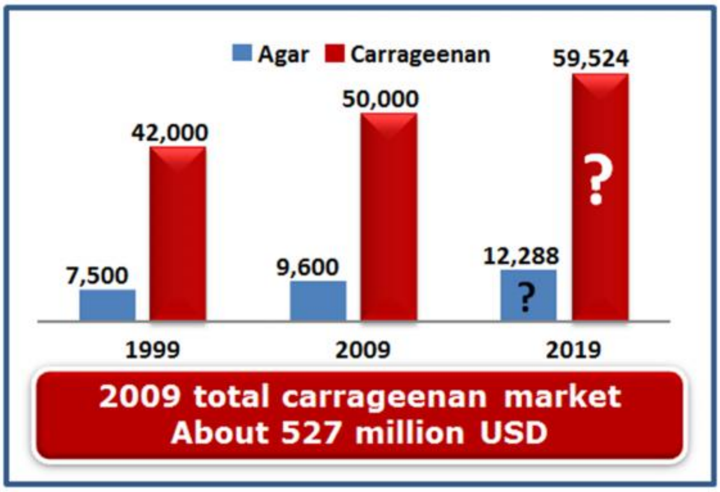


Figure 5.12. There has been weak carrageenan and agar demand growth for decades. Extrapolated figures assume continued growth at the 1000-2009 rate.(After Bixler & Porse, 2010)

5.6. Market opportunities

If carrageenan processors remain as the only buyers of Sumenep RDS and if the well-being of farmers is the goal of Sumenep industry stakeholders, then there is merit to focusing on building market share as an RDS producer rather than being concerned with adding to excess industry plant capacity by building carrageenan process facilities in Sumenep.

Shifting around the geographical locations of process capacity does not necessarily improve the market for RDS from farmers. In fact there are concerns that farmers will lose free market access to best-price markets if local processors must be supplied preferentially or if seaweed levies and other financial measures are introduced to favor seaweed processors with particular geographic locations.

The development of new products from MUZE technology requires that processing should commence with live seaweeds so value addition will necessarily commence at farm areas. Furthermore, a proliferation of agricultural nutrient products and other products from seaweeds will get the Sumenep seaweed industry out of the 'zero-sum carrageenan game' and into a 'development-for-growth' game as new, large markets develop both domestically and internationally. Innovation is the key to future Sumenep seaweed market opportunities.

5.7. Ultimate limits to market growth

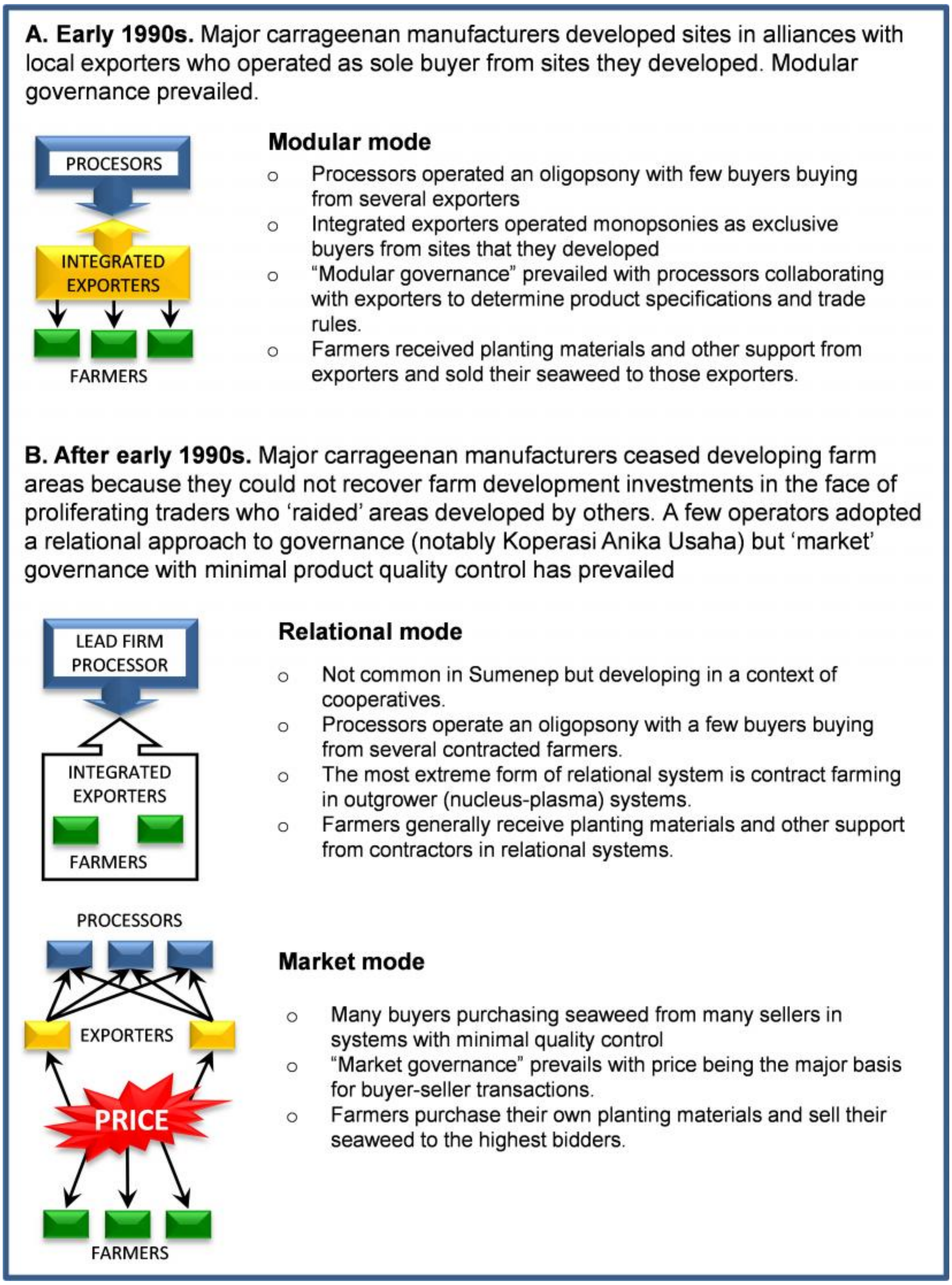
In the near-term Sumenep seaweed farm development is limited by a lack of accessible markets. This will change as innovation leads to a proliferation of marketable products that can be made from seaweeds. In the long-term Sumenep seaweed farm development will be limited by the space available along multi-use coastal zones. As of 2015 Sumenep had large under-utilized areas where seaweeds could be planted with only about 400 hectares of planted area in almost 250,000 hectares of territorial seas.

6. VC governance and competitiveness

6.1 Market structure and governance

The history of Sumenep market structure and governance in Sumenep falls into two development periods. (Fig. 6.1).

Figure 6.1. Market structure and governance in Sumenep fitted into two development periods. (adapted after Gereffi et al 2005, Panlibuton et al 2007 and Neish, 2008a).



6.2 Strategic alliances, trust and commitment

During early days of seaweed farm development in Sumenep a strategic alliance was formed between major carrageenan processing companies such as FMC Biopolymer and aspiring seaweed exporters such as PT Sumba Subur who utilized the talents of BDS provider CV Duta Teknik (now CV Multiagar Kembang). This alliance undertook initial farm development around Gili Genteng and Bluto. The first commercial shipments started in the early 1990s and similar efforts were funded by other carrageenan processors. Until the mid-1990s, companies that developed specific areas retained substantial monopsonies that enabled them to recoup development investments. With the proliferation of ASEAN-based processing plants of speculating seaweed traders from nearby Surabaya processing and exporting companies had difficulty protecting farm development investments. Development of new farm areas diminished and alliance relationships weakened as processors 'played the field' by buying from two or more competing exporters. As of 2015 there were no known strong strategic alliances of processors with farmer groups in Sumenep and 'market governance' tended to predominate (Fig. 6.1).

At the farm level almost all seaweed farmers belong to more or less formal groups (Kelompok). This is the norm for many economic activities in Indonesia, with most farmers and fishermen belonging to kelompok. Benefits and costs from farmers aggregating into groups are summarized in Table 6.1.

Table 6.1. Some benefits and costs of aggregating farmer enterprises

BENEFITS	COSTS
Size confers bargaining power	Strong, effective management is essential
Safety in numbers … shared risks	Individual farmers lose some of their independence
Financial strength enhanced	Needs effective financial management
Pooled resources for R&D	Must find support for R&D
Economies of scale	Substantial capital needs
Enhanced access to market system support	Discipline & commitment required from owners

In Sumenep kelompok were aggregated at a higher level by a larger 'cooperative of kelompok' known as Koperasi Anika Usaha (KAU). KAU included about 25 kelompok distributed throughout five municipalities in Sumenep and included more than 1,000 farm households (about fifteen percent of the Sumenep total). KAU was reported to be the only formal cooperative in Sumenep and as of early 2014 only about 240 tons of RDS was marketed through it (Masruri *pers. comm.*) but the co-op was active in brokering sales of live biomass for replanting among member kelompok. KAU was planning to develop brand identity and get into producing premium quality RDS as an avenue to encouraging member kelompok to market more of their production through the co-op.

6.3 Seaweed market power and distribution of value addition

As of 2015 Sumenep RDS entered a totally free market that was not dominated by any value chain actor at any level. The law of supply and demand reigned supreme. Prices are fairly transparent as they can easily be discovered with a few calls or text messages from a mobile phone and price trend can be seen at the website www.Jasuda.net.

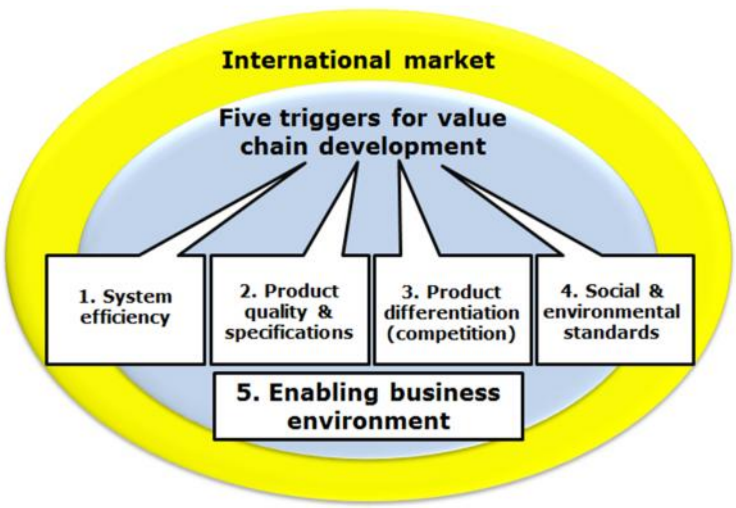
Buyers seek bargaining leverage by sourcing from two or more exporters within Indonesia. Long-term letters of credit between processors and exporters were the rule until about the mid-1990s but most purchases since then have used short-term purchase orders as the medium of transaction (Section 5.4).

Opaque value chains and poorly understood price swings were experienced by all value chain actors (Fig. 5.1). Table 5.1 provides an example showing the partitioning of costs as RDS moves from farm to export venue. Typically about 70 ± 5 percent of the export price goes to farmers and exporter gross profits are about 10 ± 5 percent.

6.5 Value chain competitiveness (5 triggers SWOT analysis)

Value chain development comprises an improvement of cooperation between stakeholders of a particular sector and the coordination of their activities along different levels of a value chain with regard to the ‘five triggers’ shown in Fig. 6.2 and with regard to strengths, weaknesses, opportunities and threats (SWOT).

Figure 6.2. Five triggers for value chain development. The ultimate goal is to increase the competitiveness of a sector in the international market.



To reach consumers seaweed enterprises must go through other market system stakeholders. Using the five triggers as a framework helps to identify opportunities and constraints to making the local target sector more competitive and integrate it more effectively into value chains and markets. A five triggers analysis is combined with a SWOT analysis for the Sumenep situation in Table 6.3.

Table 6.3. Preliminary 5-triggers/SWOT analysis of the Sumenep seaweed value chain situation based on findings of the present study and previous studies by Neish.

<table>
<tr><th colspan="2">1. SWOT Analysis</th><th>2. Value Chain Triggers</th></tr>
<tr><td rowspan="2">1.1 Strengths
• Seaweed grows well during most seasons in many areas
• Stable and favorable “peace and order” situation
• Large human resources base
• Proximity to Surabaya hub port
• Seaweed industry has high priority with government</td><td rowspan="2">1.2 Weaknesses
• Kappaphycus cultivars seasonal in most regions; cottonii supply cannot meet demand
• Agronomy systems and value chains have low productivity
• Piecework mode of operation encourages low productivity
• High waste because all biomass components are not made into products</td><td>2.1 System:
Indonesia has robust developing systems for producing and processing seaweed. Major players are financially strong and eager to expand value addition. Government is supportive and has seaweed as a high priority..</td></tr>
<tr><td>2.2 Product quality/specification:
Indonesia produces good SRC but has trouble breaking into markets already dominated by established processors from other countries, especially RP. There is under-capacity for RC and little or no capacity for nutrient products.</td></tr>
<tr><td rowspan="2">1.3 Opportunities
• Large areas available for farm expansion
• Close to potential agricultural nutrient markets
• Political and business environment favorable for joint venture development with global technology and market players</td><td rowspan="2">1.4 Threats
• Possible weather-related crop failures
• Natural disasters (e.g. tsunamis)
• Displacement of seaweed farming and competition for human resources by other industries
• Failure to develop new products and markets</td><td>2.3 Product differentiation (competition):
Current production is not differentiated from competitors in RP, China and elsewhere. For differentiation to occur there must be innovative value addition that aims new products at new markets.</td></tr>
<tr><td>2.4 Social and environmental standards:
Seaweed farming has developed as an important source of cash for people living in poverty – especially for women. Environmentally, seaweed farming is sustainable.</td></tr>
<tr><td colspan="2">3. Market requirements.
Indonesian seaweed meets market requirements for quality but sometimes falls short of market demand for volume. Still supplies mostly undifferentiated RDS; not premium quality RDS or finished product. Value chain development requires innovative value addition that aims new products at new markets.</td><td>2.5 Business environment:
Farmers still lack organization that enables farmer groups to operate as enterprise units. Overall, though, there is an excellent business environment for development of value adding capacity.</td></tr>
<tr><td colspan="3">4. Other observations (e.g. surprises) – or main findings:
The Indonesian seaweed industry is well established but is still mainly a provider of raw material; not finished product. Private and public elements necessary for the development of value adding facilities are in place. People at the highest levels of business and government are accessible and appear to be willing to work together and also to work with farmers. The key need for development is to innovate rather than copying old-school technology.</td></tr>
</table>

7. Value chain finance

7.1 Financial needs for production, trading and processing

Most funding for seaweed farm development in Sumenep was originally provided by exporting companies; in some cases with support through strategic alliances with major processors. The strongest exporters appear to be well funded with their own capital and they also appear to have strong relationships with banks. It is lack of technology and new products to market - not lack of finance - that seems to be limiting development at upper levels of the value chain.

7.2 Sources of funding for farmers

Aside from some cash advances by traders, collectors and exporters seaweed farmers get support from Government sources; sometimes with support by development organizations.

The norm for seaweed farm financing in Sumenep was clear. All farmers utilized self-financing. Some borrowed funds, biomass or assets from relatives or fellow kelompok members or received supplementary financing from their credit union.

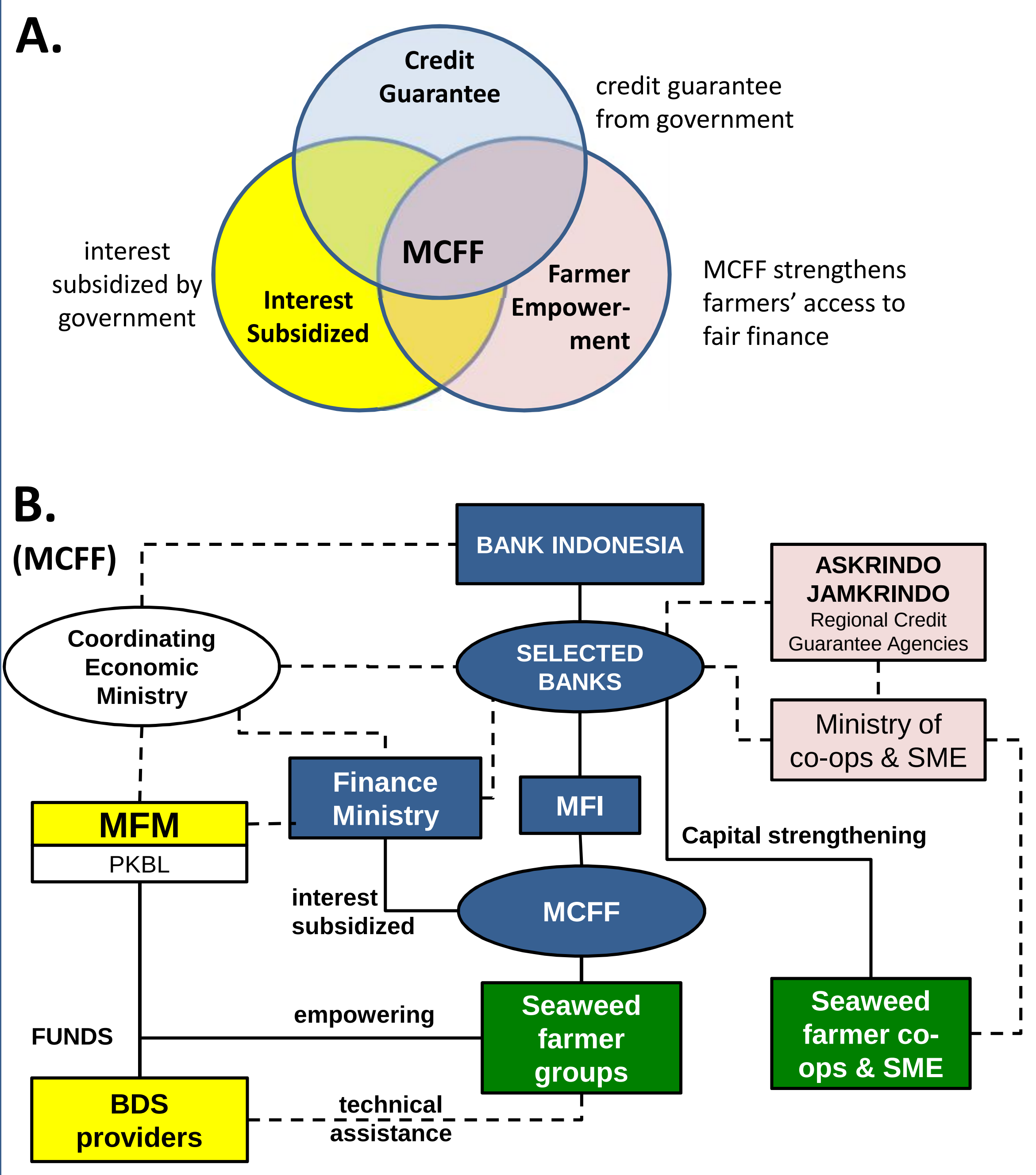
Government subsidized bank financing is also available under the National Credit Program (Kredit Usaha Rakyat or KUR). This program is limited to Rp 20,000,000.00 (twenty million rupiah) per person / organization / group / cooperative. The interest rate at the time of writing was 22% per annum.

In order to encourage national banks to increase lending to low-income groups such as farmers and fishermen, the Government has given incentives in the form of:

- Micro-KUR (Peoples Business Credit) style loan guarantees, with at least 70% -90% subsidy.
- Food and Energy Resilience Loans (KKPE) interest subsidized, around 8%-12% per annum depending on the commodity.
- Funds to conduct capacity building for the farmer & fishermen.

The credit model for seaweed farmers in Indonesia is illustrated in Fig. 9.1. and the Micro-credit scheme for farmers and fishermen (MCFF) is outlined in Fig. 7.1.

Figure 7.1. A. Credit Model for Farmers & Fisherman. B. MCFF : Micro-credit scheme for farmers and fishermen. (after Kusmuljono, 2012)



MCFF : Micro-credit scheme for farmers and fishermen
MFM : Ministry of Fisheries and Maritime Affairs
MFI : Microfinance Institution
PKBL : Program Kemitraan & Bina Lingkungan (State-Owned Enterprise Assistance Program)

8. Environmental issues & energy use

8.1.1. Environmental issues

Five categories of environmental impact relevant to cottonii and spinosum plantations are:

1. Primary impacts caused by effects of seaplant metabolism and demography;
2. Secondary impacts caused by wastes or other impacts from post-harvest treatment and handling of crops;
3. Collateral impacts caused by activities that are directly related to plantation operation including installation of habitat systems; trampling the sea floor; damage caused by the use of boats and vehicles; processing activities; and effluents;
4. Indirect impacts caused by domiciles, work places and process facilities placed near plantations;
5. Direct processing impacts caused by effluents, solid wastes and other aspects of processing activities.

Negative plantation impacts are most strongly associated with crop production on or very near the sea floor, namely:

1. Disruption of benthic community structure by removal of organisms and cutting of sea grasses.
2. Substrate abrasion and disruption caused by crops coming into contact with the sea floor.
3. Skewing of species composition caused by the introduction of new sets of ecological niches due to the physical presence of seaplants and plantation habitats.

Positive impacts include increases in fish numbers; replacement of destructive activities by farming; and farmers gaining a sense of "stewardship" over coastal areas.

Impacts with either positive or negative effects include changes in primary production; and farms changing the nitrogen regime of the reef community.

At the time of writing seaweed farming in Sumenep was mostly done using floating systems of types that predominate in Southeast Asian seaweed farming. Four ways of minimizing cottonii and spinosum plantation impacts by using floating systems include:

1. New habitat is created rather than existing benthic habitat being interfered with.
2. Substrate is placed into the water column where nutrients are most available.
3. Benthic communities are left intact. Planting seaweeds on or near the sea floor disrupts natural benthic communities and effects species diversity.
4. Crops can be tended using minimally destructive methods. The use of vessels, rafts and dive gear minimizes trampling of benthic habitats and organisms.

8.1.2. Energy and water use

The energy sector in Sumenep consists of unreliable electric power, petroleum and petroleum products; it is also supplemented by firewood and its related products. Energy consumption by the present Sumenep seaweed industry is minimal. Seaweeds are sun dried and many water craft are propelled by wind, poles or paddles. Boats with petrol or diesel engines are also used.

The major energy use is for road and sea transport. If processing plants are built in Sumenep they will require three phase power on the order of 300-500 KVA each in order to operate cookers, dryers and mills. This is available as demonstrated by the ATC factory shown in Plate 4.1.

The present Sumenep seaweed industry does not use fresh water except for human consumption. If processing plants are built in Sumenep they will require fresh water on the order of thirty cubic meters per factory per day (assuming production of 100 tons of SRC per factory per month). This water requirement would be greatly reduced if MUZE technology is used and water is recycled using waste water evaporation systems. Such systems could be solar assisted to minimize electricity consumption.

8.1.3. Processing impacts minimized by MUZE processing

As explained in Section 4.3 and 4.4 predominant current carrageenan process technology wastes much, if not most of biomass value. Such processes require large amount of fresh water and can generate high-chloride effluents in amounts of tens of cubic meters per ton of carrageenan produced.

On the other hand, if emerging multi-stream, zero-effluent biotechnologies are employed fresh seaweed biomass is fully utilized and fresh water is recovered so there is little or no waste. (See Fig. 4.4).

9. Business and socio-political contexts

9.1 Product and trade regulations

Seaweed as a product undergoes stages of quality control before it can be exported. Farmers need to dry the seaweed to the required moisture content for local quality (generally about 42 ± 5percent) and make sure that the seaweed is clean. Exporters do re-checking to make sure that the quality is reached before exporting and they absorb any shrinkage due to cleaning or further-drying of seaweed (Table 5.1). To market/export seaweed or seaweed products one has to get approvals and export permits/licenses from the port of export. This function is normally performed by shipping agents.

9.2 Governance and support from government and academia

Indonesian Government agencies exert legal governance over value chain functions and also provide support to the industry in terms of information, knowledge, training and trade facilitation. Some academic institutions, NGO and development organizations also provide extension support. Examples are show in Table 2.3. The Government of is a link between farmers and exporters. It plays roles such as looking for markets, negotiating prices, settling issues related to taxes or revenue, and importation of seaweed strains for cultivation. Sometimes Government organizations such as KKP or DKP also provide farming materials to farmers. The Government encourages farmers to form groups and associations and also start small credit systems such as cooperatives and credit unions.

9.3. Public service provision

Some seaweed-related businesses in Sumenep provide for a percentage of profit to enhance community development or support community activities including constructing mosques or musholla. However, some of these provisions may stop when the business is bad. There is a corporate social responsibility (CSR) component to seaweed industry development that should play an increasing role as innovations such as MUZE process technology become commercial realities.

9.4. Tradeoff between high productivity and high labor

Piecework systems are effective at distributing farm revenues through the community but this can come at great cost in productivity if use of small ‘bibit’ is encouraged. Farm productivity is ten times greater where the larger bibit are planted (see Section 3.6).

At Sumenep farm areas on the main island of Madura a ‘lead-farmer’ farm model predominated. Module owners/farmers contracted people to attach cuttings (*bibit*) to lines (*ris*) on a piecework basis. Rates related during farmer interviews varied from as low as 250 IDR/line to as much as 1,500-2,000 IDR/line. It was observed that very small bibit of about 20-40 grams were being planted. Contracted laborers tended to be organized in groups and were mostly female family members or neighbors of farmer households. Several of the ladies interviewed while attaching bibit to lines stated that their family owned raft modules.

By contrast, in nuclear family farms or outgrower systems there is a tendency to conserve labor and boost productivity by planting large bibit of about 100-200 grams (Fig. 3.6). Thus the plants being harvested on lead farmer systems may be smaller than the size of bibit typically planted in nuclear family or outgrower systems.

The lead-farmer approach of piecework bibit attachment systems in Madura is similar to systems common in South Sulawesi. During the IFC-PENSA program of 2004-2008 the 'big bibit' system was introduced to South Sulawesi from East Flores using farmer-trainers. SulSel farmers readily acknowledged productivity increases but after several months 'small bibit' practices returned. The reason given was that using small bibit led to more piecework and that, in turn, led to more domestic harmony due to distribution of farm revenues. In effect the piecework system was institutionalizing a low productivity approach to seaweed farming. By contrast farm productivity in the Kangean and Sapeken Islands appeared to be much higher than in visited main island areas. This was associated with the use of larger bibit on longline systems operated more using nuclear family systems or on lead farmer systems of independent family units not associated with kelompok.

9.5. Social and cultural context

Since 1990 seaweed farming has been generally expanding in Sumenep. The most diligent farmers were able to make earnings well above the poverty level. Interviewed farmers generally asserted that seaweed farming was their most lucrative economic activity. Seaweed farming was also complementary and compatible with other village economic activities such as fishing and farming land crops. Ready cash from seaweed farming had a noticeable multiplier effect. Shops, support services for seaweed farming and village infrastructure all benefited visibly from seaweed cash flowing through local village economies.

Links between the supply and the demand ends of seaweed-to-hydrocolloid value chains are being developed to build competitive advantage from Sumenep comparative advantage. The present UNIDO study is an example.

Sumenep has considerable potential for expansion of seaweed farming and processing and substantial additional potential exists for broadening the scope of such activities. Seaweeds can be developed for nutrient applications, including a key role as the basis for integrated aquaculture using the ecosystem approach to aquaculture (EAA) of FAO. According to FAO, animal aquaculture is projected to rise from about 50 to 83 million metric tons per annum by 2030. This increment would be worth at least USD 46 billion. With almost 250,000 hectares of farmable inshore waters Sumenep should get a share of this opportunity.

10. Conclusions and recommendations

1. **Farm production opportunities:**
    a. Sumenep produces about 5 percent of Indonesian seaweed raw material and has the capacity to produce much more.
    b. Sumenep has comparative advantage as a seaweed raw material source due to a combination of generally favorable weather; fertile sea water; abundant human resources; and close proximity to the major hub region of Surabaya.
2. **Farm productivity issues:**
    a. The lead-farmer approach of piecework bibit attachment on raft systems used in much of Sumenep encourages use small bibit (cuttings) in order to create piecework opportunities that, in turn, lead to domestic harmony due to distribution of farm revenues among village populations. In effect the piecework system institutionalizes a low productivity approach to seaweed farming.
    b. By contrast, in the nuclear family farms or larger lead-farmer longline systems used in the Kangean and Sapeken Islands there is a tendency to conserve labor and boost productivity by planting large bibit of about 80-100 grams.
    c. It takes the same amount of labor and the same size of ocean systems to handle 20 gram bibit as it does to handle 200 gram bibit but in good seasons when fivefold growth is common during six week growing cycles a 20 gram bibit grows to become 100 grams and a 200 gram bibit grows to become 1,000 grams. Farm productivity is ten times greater where the larger bibit are planted.
    d. Means should be sought to increase farm productivity and market competitiveness in ways that still realize income distribution objectives.
3. **Value adding opportunities**
    a. Despite prior failures, there may be an opportunity to operate ATC capacity in Sumenep provided that contractual relationships are formed with anchor buyers. ATC is best sold as a ‘bespoke’ product that becomes a performance chemical. There is little or no market for ‘commodity’ ATC.
    b. The status of ATC entering China is a grey area that is worth examining and there are industry rumors that some processors are considering this option. Chinese producers of refined carrageenan can use technical-grade ATC because it is sanitized during the RC process. If it makes sense to make ATC in Indonesia using Chinese KOH; if buyers’ quality standards can be met; and if ATC is treated as seaweed rather than as carrageenan under tariff

regulations; then using ATC as feedstock could be a cost-effective proposition.

c. The development of new products from MUZE technology requires that processing should commence with live seaweeds so value addition will necessarily commence at farm areas. This is an attractive long-term opportunity for Sumenep.

d. A first step toward MUZE processing can be production of cottonii/sacol white RDS that is being sought by SRC processors. This can be done using simple solar technologies near to farm locations.

4. **Market opportunities:**

   a. If carrageenan processors remain as the only buyers of Sumenep RDS and if the well-being of farmers is the goal of Sumenep industry stakeholders, then there is merit to focusing on building market share as an RDS producer rather than being concerned with adding to excess industry plant capacity by building carrageenan process facilities in Sumenep.

   b. The development of new products from MUZE technology will enable proliferation of agricultural nutrient products and other products from seaweeds that can get the Sumenep seaweed industry out of the 'zero-sum carrageenan game' and into a 'development for growth' game as new, large markets develop both domestically and internationally.

   c. Innovation is the key to development of future Sumenep seaweed market opportunities. The Sumenep seaweed industry occurs within a compact geographical area where there is adequate transport, logistics and communication and developing infrastructure.

5. **Farmer aggregation issues:**

   a. At the farm level almost all seaweed farmers belong to more or less formal groups (Kelompok). Benefits and costs from farmers aggregating into groups lean toward benefits outweighing costs.

   b. In Sumenep kelompok were aggregated at a higher level by a larger 'cooperative of kelompok' known as Koperasi Anika Usaha (KAU). About 15 percent of Sumenep farmers were associated with KAU, which marketed RDS for member kelompok and was active in brokering sales of live biomass for replanting among member kelompok.

   c. KAU was planning to develop brand identity and get into producing premium quality RDS as an avenue to encouraging member kelompok to market more of their production through the co-op.

   d. The KAU model seemed to be an attractive approach to aggregating farmers in a beneficial way. Development of KAU and additional similar co-ops should be examined as a feasible way for farmers to maximize the benefits of aggregation.

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