Title
A Look Into the Carrageenan Industry: How Tourism, Markets and Demand Affect the Seaweed Farmers of Bali Indonesia

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Publication Date
2016-04-01
This research clarifies what the current economic state of affairs is for the carrageenan industry with an emphasis on Indonesia. And in doing so, determine whether seaweed farming is, in fact, as lucrative as they say. The literature review will focus on the market of raw dried seaweeds within Indonesia, ultimately leading to how demand influences the market price. This paper attempts to uncover the reason for why the current market price is at an all time low for seaweed farmers. In addition, informal interviews with seaweed farmers will be analyzed to assess how market pressures, tourism and the marine protected area are affecting their present day livelihoods in Bali, Indonesia.

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Table of Contents

Introduction .................................................................................................................. 3

Background .................................................................................................................. 4
  Scientific Classifications .......................................................................................... 4
  Physical Characteristics ......................................................................................... 5
  Habitat ..................................................................................................................... 6
  History ...................................................................................................................... 7
  Nusa Penida Marine Protected Area ...................................................................... 8
  Seaweed Cultivation Technique ........................................................................... 10
  Seaweed Processing ............................................................................................... 11

Methods ..................................................................................................................... 12

Economic Literature Review ......................................................................................... 14
  Introduction ........................................................................................................... 14
  Supply and Demand of Raw Dried Seaweeds ..................................................... 15
  Supply and Demand of Carrageenan ................................................................ 16
  Supply Chain ......................................................................................................... 17
  Conclusion ............................................................................................................ 19

Discussion .................................................................................................................. 19
  The Market ............................................................................................................ 19
  Tourism .................................................................................................................. 23
  The Marine Protected Area .................................................................................. 25

Conclusion .................................................................................................................. 27

References .................................................................................................................. 28

Appendix A ................................................................................................................. 31

Appendix B .................................................................................................................. 32
Introduction

Seaweed cultivation is quickly becoming more prevalent among nations in the Indo-Pacific as demand for seaweed increases (Neish 2013). The global production of seaweed has increased from 4 million wet tons in 1980 to about 20 million wet tons in 2010, according to the Food and Agriculture Organization of the United Nations (FAO) statistics (Neish 2013). The main contributor for this expansion is the farming of red seaweeds (Rhodophyceae) (Neish 2013). Red seaweed is important for the processed food industry in that the extracts, hydrocolloids, are used as thickening, stabilizing, emulsifying and gelling agents in many dairy and alternative dairy products like yogurts and almond milk (Bixler & Porse 2011). After the seaweed is processed, these extracts are called carrageenan and it has become quite standard as an ingredient in popular organic dairy companies such as Stonyfield and Organic Valley.

The carrageenan industry was valued at $762 million in 2013, an increase from $640 million in 2011 (Global Carrageenan Market 2016; Mulyati 2015). This rate has been estimated to be about a 5% increase per year for the global market of carrageenan (Hayashi et al. 2007). With this growing demand, seaweed farming has the potential to be a very valuable commodity in areas where it is grown. Many of these coastal areas are currently in a state of being overfished and seaweed farming is becoming a praised alternative to make a living (Neish 2013). Seaweed farming is being sold and introduced as a climate safe, sustainable, and lucrative alternative to overexploiting reef communities with destructive fishing habits (Hill et al. 2012). Whether this proves to be true has yet to be analyzed on many fronts.
This research clarifies what the current economic state of affairs is for the carrageenan industry with an emphasis on Indonesia. And in doing so, determine whether seaweed farming is, in fact, as lucrative as they say. The literature review will focus on the market of raw dried seaweeds within Indonesia, ultimately leading to how demand influences the market price. This paper attempts to uncover the reason why the current market price is at an all time low for seaweed farmers. In addition, informal interviews with seaweed farmers will be analyzed to assess how market pressures, tourism and the marine protected area are affecting their present day livelihoods in Bali, Indonesia.

**Background**

**Scientific Classifications**

Carrageenophytes are a number of species of the red algal family *Solieriaaceae* in which such hydrocolloids can be extracted for use in food based industrial applications (Hurtado-Ponce et al. 2013). *Kappaphycus spp.* were once classified into the genus *Eucheuma* since they are members of the economic group called commercial *eucheumatoids* which is made up of all the members of the carrageenophytes (Ask & Azanza 2002). However, eventually the genus *Kappaphycus* was formed by Doty (1985) to discern some of the species in *Eucheuma*. This came with many name changes that often cause confusion when scientific names and trade names are used interchangeably (Table 1). One species of particular economic importance, *alverezii* was changed from *Eucheuma alverezii* to *Kappaphycus alverezii*; its trade name being cottonii despite that *K. cottonii* can be considered a separate species (Zuccarello 2007). Fortunately to avoid
commercial confusion, their trade names are often used in the industry for clarification: 

*K. alverezii* is known as cottonii and *E. denticulatum* is known as spinosum (Table 1).

<table>
<thead>
<tr>
<th>Previous Name</th>
<th>Present Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. denticulatum</em></td>
<td><em>E. denticulatum</em> (trade name = spinosum)</td>
</tr>
<tr>
<td><em>E. alvarezii</em></td>
<td><em>K. alvarezii</em> (trade name = cottonii)</td>
</tr>
<tr>
<td><em>E. striatum</em></td>
<td><em>K. striatum</em> (trade name = cottonii)</td>
</tr>
<tr>
<td><em>E. cottonii</em></td>
<td><em>K. cottonii</em></td>
</tr>
</tbody>
</table>

**Table 1. Previous and current names of the commercial eucheumatoids (Ask & Azanza 2002)**

**Physical Characteristics**

In general, to identify cottonii, it is best to look for a typically yellow-orange to a shiny green firm, tough, fleshy alga with a course, cartilaginous thallus (plant body) that can lie along the substrata or be erect with coarse determinate branchlets arranged in irregular spines (Fig. 1). Cottonii can grow up to 2 meters tall and branchlets can be 1-2 cm in diameter with inflated branches at their bases, tapering towards their apices (Trono 1992; Univ. of Hawaii undated). These characteristics should indicate either of the two economically important species of *K. alvarezii* or *K. striatum* (cottonii) (Trono 1992).

**Figure 1. Kappaphycus alvarezii or cottonii (left - green) and Eucheuma denticulatum or spinosum (right - red)**
While similar, spinosum can usually be distinguished by its color, which is often a darker red, however, it could also be brown or green (Fig. 1). The thallus consists of densely covered cylindrical branches, tapering to acute tips. The branches can be 1-8 mm long with spinose determinate branchlets arranged in simple whorls away from the center of the body. These branchlets or stubby spines are numerous, giving the alga a rough warty appearance (Trono 1992).

**Habitat**

Cottonii can be quite successful in a variety of substrates including the upper subtidal of reef flats, a sandy-coral bottom where other species of algae are not immediately present, and a rocky substrate where the water current ranges from slow to moderate (Univ. of Hawaii, undated). In contrast, spinosum thrives on sandy or corally to rocky substrates in areas that are constantly exposed to moderate to strong water currents (Trono 1992). Seagrass beds tend to grow in similar areas in which these algal species would thrive. Both cottonii and spinosum species are native to the Philippines and Indonesia and the immediate area, whereas in other areas of the Indo-Pacific they are introduced as invasive species. Spinosum is an especially dominant component in many algal communities where it could prove problematic in areas like the United Republic of Tanzania where spinosum prevails in cultivation (Trono 1992, Neish 2013).

Seaweed farming is a practice predominantly occurring in Indonesia, the Philippines, and the United Republic of Tanzania. This environmental range is optimal for cultivating red seaweed because it has a tropical marine climate with average sea temperatures of about 25°C to 30°C. The largest seaweed farming areas in Indonesia
include Sulawesi, Moluccas, Nusa Tenggara Island and Bali (Mulyati 2015)

**History**

The islands of Nusa Penida (Lembongan, Ceningan, and Penida) in Bali, Indonesia are situated in a unique area in which farming has been going on since its inception into the country. Historically, carrageenan was first extracted from wild seaweeds like that of the species, *Chondrus crispus*, found in more moderate tempered waters such as the coast of England, Maine or Ireland. The name carrageenan was derived from this cold-water carrageenophyte, its common name being Irish Moss or Carrageen Moss which was used as a traditional healing gelatin for thousands of years (Necas & Bartosikova 2013). Eventually, as demand started to pique, the supply from wild seaweed became inadequate and in some countries, wild seaweed became depleted, driving the advent of seaweed aquaculture (Neish 2013).

After the successful introduction of seaweed farming in the Philippines by Maxwell Doty in 1971, many multinational carrageenan companies took notice with hopes of expansion outside of the Phillipines (Mulyati 2015). Bali, Indonesia, specifically, the Nusa Penida islands were at the forefront of seaweed cultivation in Indonesia as the Copenhagen Pectin Factory Ltd. supported the development of seaweed aquaculture in 1978 (Mulyati 2015). The other multinational carrageenan businesses included Marine Colloids, Cargill, and CP Kelco (Neish 2013). Unfortunately, the yield of the species brought to these islands was too low, so seedlings were instead imported from the Philippines in 1984 where seaweed farming took off among the local Balinese as a lucrative means of income (Adnan & Porse 1987).
The Nusa Penida Marine Protected Area

The community of the Nusa Penida islands had free reign to pursue seaweed farming in any location they believed would provide a successful crop yield. In many cases, the presence of seagrass beds are prime indicators as perfect habitat for seaweed farms (Lyimo et al. 2006). As such, seaweed farms are densely aggregated in a calm bay between Nusa Ceningan and Nusa Lembongan with the more economically important species of cottonii dominating cultivation (Mulyati 2015; refer to Fig. 2). Spinosum is also grown, but generally on the northern side of Nusa Penida.

Figure 2. A map of Bali, Indonesia, the colored boxes surrounding each map indicates where that magnification is on the corresponding map. The yellow-boxed map shows the three islands of Nusa Penida. The orange-boxed map shows the bay where many seaweed farms are situated. Each dark rectangular patch illustrates a group of farms.

After many decades of unregulated growth, a Balinese Non-Governmental Organization (NGO) called the Coral Triangle Center (CTC) felt that the Nusa Penida
islands needed to be preserved for longevity in an area with such high livelihood
dependence on marine resources. In addition, after a Rapid Ecological Assessment was
conducted in 2008, the site was recognized as a critical area of marine biodiversity. The
CTC immediately began planning to regulate these three small islands by engaging with
the many stakeholders of the islands including seaweed farmers, recreational dive
companies, and fishermen to create a system that would work best for all participants
(Welly 2014). The zoning system as, as shown in Figure 3, includes a number of
activities by providing specific designations for each to occur within such boundaries.
The designation for seaweed farms makes up an area of 464.25 hectares (Fig. 3).

**Figure 3. Nusa Penida Marine Protected Area.** Different colors represent different
designations for each activity. Refer to Appendix for more detailed information about
the zoning regulations. For further information regarding the MPA refer to Appendix A.
The Nusa Penida Marine Protected Area was established in 2010, covering an area of 20,057 hectares, under the management of the Klunkung District (Balinese Government). The CTC is a key factor in compliance as they are apart of a joint patrol system also made up of representatives from the village police (Pecalang), District Government, Indonesian Police, Indonesian Navy and fishermen groups. Under standard operation procedure, this enforcement unit will patrol the Nusa Penida MPA once a month (Welly 2014). So, if a farmer were to cross the strict GPA coordinates set up through the zoning system designations, a joint patrol officer would keep them in line for fear of further damage to the reef flat and surrounding environment, and they would have to remove their farm.

**Seaweed Cultivation Technique**

As cultivation continues to spread throughout the Indo-Pacific, reaching as far west as the eastern shores of Africa to the eastern boundary of Guam, farmers in Indonesia have adopted an “off-bottom” method of farming (Conklin & Smith 2005). Cottonii and spinosum can be so easily farmed due to their unusually high regenerative capacity; a fragment can double in biomass in 15-30 days (Univ. of Hawaii, undated). Clonal propagation or fragmentation is their primary mode of reproduction and pieces as small as .5 cm can be used as seedlings for a farm (Smith et al. 2002; Bast 2014).

The seedlings, which are just small fragments from an adult alga from a previous harvest, are inserted into a nylon rope. The rope lines are attached between two bamboo or wooden stakes, which are generally sanctioned in 10 x 10 meter square plots (Neish 2013). After around 32 days or when they reach about 1 kg in weight, the algae can be harvested by hand (Bast 2014). The crop will be tended to depending on the low tide so
this can happen at all hours of the day or night. A quarter of the harvest is spared for seedlings for the next month. The harvested seaweed is then dried on tarps placed on the ground. In order to fetch a fair market price from the collectors, the seaweed should be sand and stone free with a moisture content no greater the 40-50% (Neish 2013, Mulyati 2015).

**Seaweed Processing**

After the seaweed is collected and exported out of the country, it must be processed in order to extract the hydrocolloids from the alga to produce carrageenan (McHugh 2003). Carrageenan has a wide variety of applications beyond its use as an ingredient in food including in many consumer and industrial goods. In terms of human food consumption, it can be used in dairy products like ice cream, evaporated milk, milk puddings, chocolate milk, processed cheese, Jell-O, jellies, and baby food. In addition to pet food, other consumer good uses include in toothpaste, shampoos and cleaners, skin creams, lotions, and air fresheners. Industrial products like abrasives, pigments, textiles, and pharmaceutical products may also contain carrageenan (Mulyati 2015). There are three different types of carrageenan, kappa, iota, and lambda, each coming from separate species of red algae and each having their own individual applications in the industry. Kappa carrageenan is obtained primarily from cottonii, iota carrageenan is derived from spinosum, while lambda is from *Chondrus crispus* (Imeson 2009). Kappa carrageenan tends to have much more lucrative uses in application and therefore is always more economically valuable than iota carrageenan, making cottonii worth more than spinosum as raw dried seaweeds (RDS) (Mulyati 2015).

Different methods and treatments are used to produce different types of
carrageenan ranging from refined carrageenan (RC) to semi-refined carrageenan (SRC). (Verhoeven 2012). Refined carrageenan, with an increased carrageenan content, is fit for human consumption but requires more intensive techniques and is often more expensive to produce. Semi-refined carrageenan, with a decreased carrageenan content, was initially unfit for human consumption and used for pet food, however, food grade SRC was developed and eventually became a popular substitute for RC in the 1990’s. The use of food grade SRC is much cheaper and can mimic many of the applications to that of RC. Even so, RC, produced through a more demanding alcohol-precipitation method, has a market in the higher end applications like toothpaste, dairy products and pharmaceuticals. Whereas food-grade SRC and the less intensive processing method of gel-pressed RC tend to be used in lower end applications like suspending the chocolate in milk (Mchugh 2003; Neish 2013). Refined carrageenan is primarily processed in China, Europe, the US, and the Philippines in processing companies with more capacity. Smaller processing companies found in the Philippines, Indonesia, and China tend to process the semi-refined carrageenan (Neish 2013).

**Methods**

In order to first understand what the current economic state of affairs is for the carrageenan industry, a full economic literature review was conducted. There is not much available for a full synopsis of the industry so it was vital to collate information from each piece of literature discussing individual dynamics of the industry to get an idea of the industry as a whole. The focus was on the development of sustainable seaweed farmer
livelhoods in the context of regional and global value chains, paying particular close attention to the earlier steps in the supply chain from farmer to exporter within Indonesia. The steps beyond exporting are more vague and difficult to analyze so the value of the seaweed was only described up to that of the processing companies.

In order to conduct interviews, working with the Coral Triangle Center was vital. In short, they help preserve and ensure the longevity of natural marine resources within the Coral Triangle of the Indo-Pacific. They were an invaluable resource because of their close relations with many of the farmers and farmer’s associations on the Nusa Penida islands due to their involvement with the creation of the MPA. They also helped to provide a translator, who was stationed on Nusa Penida.

The interviews were conducted to get an idea of how the industry is being perceived by the seaweed farmers during a time when tourism is vastly dominating the economy of Bali. The focus of the interviews were on how the market influences their continued reliance on seaweed farming as a lucrative means of income, how much they are currently selling their RDS for and whether supplemental occupations are necessary in order to make a living. In addition, tourism was brought up to get an idea for how it is affecting their way of life currently and in the future. The Nusa Penida MPS was not a focus with the interview, however it is still a factor affecting their livelihood. In addition to the farmers, the head of one of the farmers association was interviewed.

The general questionnaires in which the interviews are based upon can be found in Appendix B. In some cases, the format for asking questions was not so rigidly followed to get more in depth answers of a particular topic that was thought to be of interest during an interview. Both the farmer interview questions and the farmer’s
association interview questions are included in the appendix. All of the interviews were recorded by electronic recording device as well as by hand at the time of interview.

The last step in this research is to analyze all of the results from both the literature review and the interviews. The results were integrated together to get an idea of how the seaweed farmers are being affected. The market prices were of particular importance as they were related in conjunction with the current market prices determined through the interviews with the farmers. These prices were analyzed to look for trends. The interview responses were also analyzed in order to make inferences as to how tourism, markets and the MPA are affecting the farmers in the big scheme of things. The potential future of the industry is then construed based on personal accounts and experiences with the seaweed farmers all while incorporating the newly found knowledge of the global carrageenan market into the discussion section.

**Economic Literature Review**

**Introduction**

Seaweed farming did not begin until 1984; however, today it resembles that of a traditional economic activity falling within the context of village social norms and etiquette integrated into the fabric of many traditional communities (Neish 2013). This still stands true for the communities of the Nusa Penida islands due to its simplistic and practical nature. Unfortunately for the community of Nusa Penida, the future of seaweed farming looks bleak with many market pressures affecting this seemingly unsustainable livelihood. While it may not be a traditional way of life to be preserved, the onset of
seaweed farming has allowed many third world countries to slowly step out of poverty (Neish 2013).

**Supply and Demand of Raw Dried Seaweeds**

Indonesia dominates the global production of raw dried seaweeds. Producing an estimated 198,359 tons in 2011, it has exceeded that of the Philippines, which had previously been the leading producer of RDS. Production of both cottonii and spinosum during 2011 had reached 4.6 million tons (wet weight), roughly equivalent to $1.5 billion, an increase by almost a half billion from the prior year (Mulyati 2015, Neish 2013). Seaweed production in Indonesia in 2000 was worth a mere $21.7 million (Neish 2013). Indonesia currently accounts for about three-fourths of the world tonnage and value of seaweed production (Harrison-Dunn 2015).

The past decade has resulted in a steadily growing market for raw dried seaweeds, particularly in China, accounting for about 55% of Indonesian exports. China makes use of carrageenan in products like pharmaceuticals, meat, jelly, and soft candy applications (Mulyati 2015). The market in China was expected to grow at about 10% per year, unfortunately, in the past year; that market has all but disappeared (Mulyati 2015; Hajramurni 2015). Even with relatively high demand from other markets like Vietnam, the US, and the European Union, seaweed farmers have been struggling to market their product (Verhoeven 2012; Hajramurni 2015; refer to Fig. 4). The cause for this unexpected decline in overseas demand can be attributed to Chinas absence in the market after having stockpiled excess amounts of seaweed in storage facilities (Hajramurni 2015).
Supply and Demand of Carrageenan

The global carrageenan industry was most recently valued at $762 million in 2013 (Global Carrageenan Market 2016). It seems that predictions for an increase in global demand for carrageenan rising by about 4-6% per year are correct (Hayashi et al. 2007, Mulyati 2015). Currently, the sales value of carrageenan is the highest in the world among other hydrocolloids with an increase in average price of carrageenan rising by 50% within the decade of 1999-2009. Desserts and ice cream tend to dominate the end-use product market for application of carrageenan creating the majority of the demand. The total export value of carrageenan was $968 million in 2013 (Mulyati 2015).

Most Indonesian seaweeds are currently exported internationally as raw dried seaweeds in order to be processed into carrageenan, so this means that the country has yet to capture most of the value added to the seaweed (Neish 2013 refer to Fig. 5). And because of this, the Indonesia government has made attempts to limit the exporting of
raw seaweed in order to process it domestically. This resulted in industrialization policies with hopes that new processing facilities are constructed within the country to retain the value of the seaweed that is being lost by exporting the carrageenan rather than the raw dried seaweeds (Verhoeven 2012). While some believe that Indonesian processed seaweed is the future, carrageenan can be bought for much cheaper from China or even Europe (Harrison-Dunn 2015). Nonetheless, the growth of processing facilities has allowed Indonesia export volume of carrageenan to increase by nearly 300% from 2011 to 2012 (Mulyati 2015; refer to Fig. 8).

### Supply Chain

Economics normally tends to favor the processing of raw materials close to their source. Under normal circumstances, shortening the supply chain like processing RDS near the seaweed farms can save several hundred USD per ton of carrageenan (SRC chips or powder costs) (Neish 2013). Unfortunately, Indonesia is made up of several hundred islands and transitioning from an international market to a domestic market does not shorten the supply chain as it would in most cases. Unless there is a processing facility on the same island in which the seaweed was farmed, then traders must expend more time

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**Figure 5.** A comparison of the value after the raw dried seaweed has been processed for the years of 1999 and 2009 (Bixler & Porse 2011)
and money into transporting the seaweed on small boats throughout Indonesia. In addition to the high cost of inter-island logistics, the product delivery will be small and infrequent (Verhoeven 2012). On the other hand, when exporting to China, shipping is conducted regularly with large containers with the capacity to hold more seaweed out of simply one port in Indonesia, Sulawesi (Mulyati 2015).

The extra cost of seaweed transportation is generally absorbed by an increase in value as you move up the supply chain (refer to Fig. 6). The current carrageenan industry is dominated by the prices that carrageenan processors make when they don’t have the necessary supply of RDS (Gayathri 2015). Unfortunately, very little economic data is accessible to analyze the market beyond carrageenan exporters.

**Figure 6.** A simplified supply chain of the carrageenan industry from raw dried seaweed producer to end product blended producer. The early market value increase (12.5%) from farmer to trader is highlighted (Mulyati 2015).
Conclusion

With many farmers feeling that seaweed farming was their most lucrative economy activity, it is easy to see how important such a practice can be in many Indonesian communities (Neish 2013). Seaweed farming has the potential to push families over the national poverty line with farm gate prices of around $.80 per kilogram, and a minimum of 2000 meter of production lines (Valderrama et al. 2015). Neish (2013) also claimed that in 2008, many farm families were earning an estimated income of around $5,000 per year. Even with diligence, by today’s standards, market prices of seaweeds are too low to rely on farming as a sole source of income.

Discussion

After analyzing the informal interviews among all the farmers and the results of the economic analysis, more insight was gained on the three factors that affect the farmers on Nusa Penida. These three factors can be summed up in the following discussion by tying in the current economic state of affairs with that of the conclusions found from the literature review. On top of the market pressures, tourism continues to be a major threat for the future of seaweed farming while the marine protected area limits the extent to which one can farm.

The Market

The market price for seaweed farmers is currently at an all time low, such prices were not described by the economic literature review because they are a recent development within the carrageenan market. The current price per kilogram of seaweed
was calculated using the results of the interviews collected, so these prices are inferred. The data from the cottonii farmers had been skewed by the fact that they were farming both species of algae; the price per kilogram could not be calculated, considering how different the prices are between cottonii and spinosum. The farmers that were solely farming spinosum on the North side of Nusa Penida proved to give me accurate data as they both checked out. The current prices per kilogram for 2016 were $0.16 for spinosum and an inferred $0.39 for cottonii (refer to Fig. 7). According to Fig. 7, the prices have not been this low in nearly two decades. This is often a point of contention with the seaweed farmers of Nusa Penida considering how in 2009 they were making more than twice the amount they are right now (refer to Fig. 7). One cottonii farmer even said that he is currently not farming any seaweed because the market price is so low. This farmer had to rely on fishing, instead, like many others who needed to supplement with an additional source of income such as cow farming, coconut farming or working in tourism.

![Figure 7. Average farm gate prices or how much the farmer can sell the seaweed for to the collectors. Most recent data (2016) based on interviews of farmers in Nusa Penida (Bixler & Porse 2011; Mulyati 2015).](image)
It can only be speculated that this all time low in market prices is most likely related to the industrialization policies put forth by the Indonesian government. While the restriction of raw dried seaweed exports would have been a factor in the prior years, the government had canceled its plan to restrict exports (Verhoeven 2012). As such, the only reasonable explanation is that since around 2011, the growth of processing facilities has allowed for a huge increase (300%) in carrageenan export volume (Mulyati 2015; Figure 8). There is almost an indirect correlation with increase in export volume leading to a decrease in seaweed market price (refer to Fig. 7 & Fig. 8). An interesting trend to notice in Figure 5 is that the value of carrageenan seems to be proportional with that of the value of the RDS. This could suggest that the farm gate prices may be directly related to how much the carrageenan is being sold for. Unfortunately, this stands true only for an international supply chain.

**Figure 8.** Indonesia export and import volume of carrageenan from 2010 to 2013 (Mulyati 2015).
The industrialization policy seems to be having adverse effects on those at the beginning of the supply chain including both traders and farmers. Foreign processing companies like Shemberg, the largest carrageenan processor in the Philippines, has decided to invade the Indonesian market hoping to get a cut of the domestic seaweed supply (Verhoeven 2012).

The monthly minimum wage chart illustrates how much an average spinosum farmer of today can earn in a month in comparison to that of the standards of Indonesia and that of California (see Table 2). These same farmers would have exceeded minimum wage in 2009, however the price they can sell their seaweed for is drastically lower putting them close to the poverty line by Indonesian standards. If such a pattern continues into the future, many seaweed farmers will have to explore alternate means to make a living, proving those who believe seaweed farming a means for a more lucrative income wrong. Especially considering $52 per month is a long way off from $5,000 per year, which would equate to about $415 per month (Neish 2013). To help alleviate this situation in Nusa Penida, there were a few advocates for the construction of a processing facility right on Nusa Penida. This would greatly shorten the supply chain, eliminate the need for many traders, and allow for a higher farm gate price for the farmers. In the past seaweed farming did have the potential to improve the economies of many third world countries, however now with such an unpredictable

<table>
<thead>
<tr>
<th>AVG. SPINOSUM FARMER</th>
<th>INDIAN MINIMUM WAGE</th>
<th>CALIFORNIA MINIMUM WAGE</th>
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</thead>
<tbody>
<tr>
<td>$52</td>
<td>$96</td>
<td>$1,600</td>
</tr>
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</table>

Table 2. The spinosum farmer’s monthly wage is calculated based on current market price and the amount of kilos an average farmer can produce in a one-month period. Monthly earnings in Indonesia and California based on corresponding minimum wages (International Labour Organization 2015).
global carrageenan market, it seems the best route to alleviate poverty in Indonesia is through tourism (Valderrama et al. 2015).

Tourism

While the Nusa Penida Area is a 30-minute boat ride away from Mainland Bali, it is quickly becoming a hotspot destination for Bali tourists because of all the amazing things these three small islands have to offer. Depending on the season, dedicated surfer and divers will make way to Lembongan Island to catch the legendary surf or dive the crystal clear water in hopes of getting a glimpse of the mysterious mola mola at certain times of the year or witness the magnificent manta rays all year round. This rapid development of tourism is starting to take its toll on the locals and the environment of Nusa Penida, as it is not the same island as it was ten years ago.

All of the farmers said that as tourism expands, there is less space to dry their seaweed because the construction of villas, homestays and hotels infringes on their land. One farmer believed that if the seaweed price continues to stay low then many farmers would go into tourism since it is more stable. While others believed, contradictorily, that even with the price varying subtly from year to year, it is a much more stable way of living since tourism depends on the season and the tourist. Most farmers would consider going into tourism if the tourism industry were booming. One farmer even wished to own a villa/homestay.

Transitioning from seaweed farming to the tourism industry does have great allures of wealth and this was witnessed while visiting the islands. Many of the employees of local dive shops used to be seaweed farmers. Even village leaders are starting to recognize the opportunities tourism could allow a small village. The local chief
of Jungut Batu had recently ruled that all seaweed farm contracts be declared null within the year in favor of more recreational tourism space on the beaches. The allure and power of tourism was demonstrated 10 years ago on Nusa Dua (mainland Bali) that had previously been crowded with seaweed farms all along the southeast shore. Today, all that remains are private beaches owned by luxurious hotels.

In an effort to manage this power, the Coral Triangle Center is working with a few farmers in order to combine tourism and seaweed farming. They are working with a number of farmers associations like that of Segara Kaksu in order to kick-start a trial period in which extra seaweed could be used directly (without processing) to sell products made from seaweed like soap, chips, and ice cream. The farmers can make these products themselves in their own kitchens with only a few locally sourced ingredients like rice flour for the seaweed crackers. This could very well be a plausible idea as local and organic seaweed ice cream would sound enticing in the middle of a sweltering hot and humid day in Bali.

Tourists are rather common on Nusa Lembongan, however, it was an unusual site to see a busload of Chinese tourists walking through the village and taking pictures of the farmers and their farms. The head of the local farmers association responded to this by saying that this has been going on for awhile and there are a select few tourist groups that come to the same spot every day. If such were the case, this steady flow of tourists could be a profitable target for their seaweed products. In addition, the farmers could also start charging the tourist companies a small fee for using that spot as a destination everyday. Some of the local farmers tried to adapt to this by building small merchandise stands.
where the tourists take pictures. The wife of one of the farmers that was interviewed happened to own the largest merchandise tent in the area.

There are plenty of opportunities to enlist in the tourism industry for those farmers who aren’t willing to bear the brunt of the market forces. This is especially enticing since a Marine Protected Area protects the surrounding marine resources, ensuring that tourist will continue to come by the boatload to experience the charm of the Nusa Penida islands.

**The Marine Protected Area**

Seaweed farming is only allowed within the specific parameters that the MPA designates. The seaweed farm designations were created with the coral reef flat in mind. Because seaweed grows so much more quickly than coral, it can easily outcompete coral reefs, which could potentially be a huge ecological issue for seaweed farming in other areas of Indonesia. Since the seaweed farming had been going on for a number of years before the MPA was sanctioned, it is important that the seaweed farms are kept in check with the hopes of restoring the habitat that was lost prior to the MPA. Even so, the potential of surrounding habitat and environments being fragmented by the onset of rogue algae is still there. If any stray pieces happen to be spotted, farmers and/or the joint patrol team will pick them up.

Seaweed farming may not cause complete ecosystem degradation in all situations. In one instance it was found that, despite significant levels of habitat fragmentation, the farms could benefit fishermen in that the seaweed provides a food source for certain herbivorous fish species like the rabbitfish (Hehre and Meeuwig 2016). This is interesting to hear because it could be possible for farms to be strategically situated in areas where
reef degradation has already occurred. This would allow the seaweed farms to provide not only for the farmer, but a fellow fisherman as well. Unfortunately, this would require a plan and most farmers do not have the ability to farm seaweeds in locations outside their immediate place of residence.

As mentioned before, seagrass beds are prime indicators as ideal habitat for seaweed farms (Lyim et al. 2006). Seagrasses are submerged marine flowering plants found primarily in temperate and tropical coastlines (Short et al. 2007). Not surprisingly, the majority of seaweed cultivation takes place exactly where the greatest biodiversity of seagrass is located, especially Indonesia (Short et al. 2007). While coexisting habitat is possible, farmers prefer the substrate to be clear before cultivating because sea urchins generally found within seagrasses would destroy their crop (Lyimo et al. 2006).

Regardless, Eklöf et al. (2005) found that seagrass beds underneath seaweed farms were disadvantaged anyway. Essentially, coexistence is unlikely and the removal of seagrass beds in areas where farming is occurring could pose a serious threat for the environment and the inhabitants considering the ecosystem services seagrass beds provide.

Seagrass beds have competent carbon sequestration potential in comparison to many other carbon capturing plant species (Duarte et al. 2010), they have demonstrated the ability to capture almost triple the amount of carbon that terrestrial forests can uptake (Fourquean et al. 2012). Some of the goods and services seagrass beds provide include food, raw materials, coastal protection, erosion control, water purification, and providing coastal breeding and nursery habitat, carbon sequestration, tourism, recreation, and research (Barbier et al. 2011). While the elimination of seagrass beds is a huge environmental loss, seaweed farming has contributed to the improvement of the socio-
economic status of many coastal communities especially those in the Nusa Penida islands.

The socio-economic improvement seaweed farming brings to the communities has been instrumental in forming positive changes for the Nusa Penida islands. The willingness to collaborate with environmentalist in order to plan for a marine protected area shows how local communities have strengthened their coastal stewardship of the marine environment and its resources. Seaweed farming has helped provide for a sustainable subsistence livelihood allowing many to stray away from the national poverty line. In addition, it has enhanced community accord and cooperation through creation of the farmers associations. Regardless of the sober future of seaweed farming, it helped to greatly improve upon the socio-economic status of a third world community.

Conclusion

As Indonesia is the top producer of raw dried seaweeds in the world (Mulyati 2015), its economies current industrialization seems to have caused a global shift in carrageenan supply chains. A reduce in the availability of Indonesian raw dried seaweed exports is inevitable with increased domestic processing. This reduction means international seaweed processors (carrageenan manufacturers) must look elsewhere for seaweed raw material. While great for the Indonesian economy as a whole, the seaweed farmers will take the hit. Without government interference to provide for the increased costs traders must face with inter-island logistics, the market price for seaweed will remain low. Besides the pressures of an uncertain market, seaweed farmers in Nusa Penida must face tourism expansion and MPA constraints, which threaten their livelihood and ability to make seaweed farming a sustainable source of income for the future.
References


<table>
<thead>
<tr>
<th>ACTIVITIES</th>
<th>CORE ZONE</th>
<th>SUSTAINABLE FISHERIES ZONE</th>
<th>UTILIZATION ZONE</th>
<th>OTHER ZONE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CORE ZONE</td>
<td>TRADITIONAL FISHERIES SUB-ZONE</td>
<td>SPECIAL ARRANGEMENT TOUSSIM SUB-ZONE</td>
<td>SEA-WEED FARMING SUB-ZONE</td>
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<tr>
<td>Bottom Line Fishing</td>
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<td>Trawling Line Fishing</td>
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<td>Gill Fishing</td>
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<td>Gill Drifted Long-Line Fishing</td>
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<td>Set Net Fishing</td>
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<td>Drifted Net Fishing</td>
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<td>Gill Floating Long-Line Fishing</td>
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<td>Muumuu Fishing</td>
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<td>Fence Bamboo Trap Fishing</td>
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<td>Free Diving with Spear Fishing</td>
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<td>Collecting Crab</td>
<td>X</td>
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<td>Reef Cleaning/ Core Mining</td>
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Notes:
- X: Not Allowed
- ✓: Allowed activities.
- ✓1: Allowed activities with permit.
- ✓2: Allowed only for Boundary Marker.
- ✓3: Allowed under the provision that any fauna such as sharks, ocean sun-fish, manta ray and endanger species must be released.
- ✓4: Allowed under the provision that each dive location can only be visited by a maximum of 10 boats at a time.
Appendix B

Farmer Interview Questions
Focus → Does the market determine how much crop is being produced?

1) How/when did you get involved with farming?
   ~Did someone approach you with the means to start a farm or was it passed down to you?
   ~How did you gain access to the water resources, --> through MPA?

2) What species are you growing?

3) How many ara do you own (ara – 10m x 10m)?

4) How much crop can you harvest in a year?
   ~Are there seasons and how do they effect harvests?
   ~Are you able to harvest by yourself or do you have family members/others help?

5) Are you a member of the Farmer Association?

6) How much can you sell your seaweed for?
   ~Do you feel that you are making enough to sustain your livelihood?

7) Can you make money in other ways?

8) Do you think tourism could effect the future of farming here?

Farmers Association Questions
Focus → Where is the seaweed being exported and is this effected by demand?

1) Are you involved with the process of collecting directly/ can you give me a little bit more information on how this process works?
   a. ~Who does the collecting and who do they work for?
   b. ~Is there a limit for the amount of crop a buyer/collector can take?

2) Where does the seaweed go after it has been collected/where is it exported?
   a. ~And for what purpose/what is the extract carrageenan used for?
   b. ~Do you have any ideas as to the cost of exporting?

3) Do the farmers work together?
   a. ~Is there an advantage to working together?

4) How is the pricing determined?

5) Is it being exported as whole pieces of dried seaweed?

6) Where does the processing take place?

7) How large is the average farm? How many square meters can one farmer own?