The seaweed industry in the Pacific islands

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A joint study undertaken by ACIAR and the Secretariat
of the Pacific Community (SPC)

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Foreword

Pacific island governments and communities are constantly seeking to tap new and established international markets for their farm produce. There is a well-established market for the variety of farmed seaweed from which carrageenan, a high-value colloid used in the food and pharmaceutical industries, is extracted.

Several Pacific island countries have attempted seaweed farming. While the results have been variable, they indicate that there is some potential for a viable industry in the region that would contribute to farm incomes and island economies.

Experience so far suggests that the main impediments to a successful industry in the region are distances from markets and low outputs of individual countries. The total contribution of the region to world seaweed production is currently very small and variable, and the transport costs to markets very high. There are also problems in the production process that need to be solved.

This paper gives the results of a study, jointly undertaken by ACIAR and the Secretariat of the Pacific Community (SPC), that paints a clearer picture of the constraints on seaweed production and marketing by Pacific island countries and the options available for overcoming them. It draws on first-hand information from seaweed farming in Fiji, Kiribati, Solomon Islands and Vanuatu.

It concludes that the primary challenge at present is for Pacific island countries culturing seaweed to increase their production to a consistent level. This will require, among other things, provision of good technical support to farmers.

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Summary

The seaweed *Kappaphycus alvarezii* (formerly *Eucheuma cottonii*), used as a source of the hydrocolloid carrageenan, has been farmed in the Pacific for more than 20 years, but the yields have fluctuated for a variety of reasons. Kiribati has had the most consistent results with production at times exceeding 1000 tonnes per year dry commodity, but has also at times suffered losses due to high winds and rises in sea temperature. Production in Fiji has been affected by cyclones, political changes and competition for labour from other crops such as copra and bêche-de-mer, so that yields have varied from zero up to about 500 tonnes (dry) per year. Solomon Islands is developing its industry, assisted by a European Union funded seaweed commercialisation project. Vanuatu has run farming trials but has been hindered by fish grazing on the young seaweed plants.

This variation in the scale and continuity of supply has placed serious constraints on marketing, and Pacific island nations have been disadvantaged in price negotiations with the limited number of international buyers, effectively being forced to become 'price takers'. Marketing – more specifically options for regional cooperation in seaweed marketing and processing – was identified as a priority research area during the December 2003 ACIAR–Pacific island consultations in Suva.

This project reported here was initiated with the aim of more clearly identifying marketing constraints and opportunities for seaweed in selected Pacific island countries, including consideration of options for regional cooperation in marketing and processing. The countries originally selected were Fiji, Kiribati, Papua New Guinea, Solomon Islands and Vanuatu, but Papua New Guinea did not participate and may become involved in seaweed farming at a later date.

The objectives of the project were as follows:

- to more clearly identify and evaluate marketing constraints and opportunities for seaweed in selected Pacific island countries, including consideration of options for regional cooperation in marketing and processing
- to examine the production, processing, transportation and marketing options for the cultivated *Kappaphycus* industry in selected countries of the Pacific Community region, with a view to improving profitability and sustainability.

This report gives details of the current supply of and demand for *Kappaphycus* and the reasons for its positive future potential. It then summarises, for each of the seaweed-producing countries, the subjects listed in the second objective of the project: current production and prospects for expansion of seaweed farming, internal and export shipping costs and availability, current marketing arrangements, prospects for seaweed processing in the region. Full details are given in Appendixes 2–5.

As regards the first objective, as a result of information gathered from country representatives and the visits that followed to the three seaweed-producing countries (Fiji, Kiribati, Solomon Islands) it became apparent that the quantities of seaweed being produced were too small to consider any regional cooperation in marketing and processing.

The priority for all countries must be to increase production. Total annual world production of dried *Kappaphycus* is about 220,000 tonnes. Production for the Pacific islands for 2005 is expected to be about 1150 tonnes dry product (0.5% of world production). This would need to increase to at least 5000 tonnes (preferably 10,000 tonnes or approaching 5% of world production) before regional cooperation in marketing could be considered. Because of shipping costs between the islands, it would be uneconomic to ship dried seaweed from

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individual countries to a single, central island hub for export to buyers. Regional cooperation might be possible by establishing a regional marketing authority that dealt with all buyers and that directed shipments to be sent as required from individual countries direct to buyers.

However, even when regional annual production reaches 5000 tonnes, regional cooperation in marketing may not be agreeable to all producing countries. In Kiribati, the industry is government controlled; in Fiji the government plans to pass control to the private sector once production is firmly established; in Solomon Islands all marketing is by the private sector. Private-sector companies that spend time and money developing markets and clients may see little advantage in surrendering their autonomy to a regional organisation. It may depend on market conditions when regional production reaches the suggested 3–5% of world production.

Processing of seaweed within the region was the subject of a study sponsored by Kiribati. The conclusion reached was that a regional annual production of 10,000 tonnes of dry *Kappaphycus* would be necessary to support a plant for the production of semi-refined carrageenan (SRC) and that such a plant must be located in an area where sufficient quantities of water were available (which excluded Kiribati). However, since then, trials have been commenced by the SEAPlantNet project into small-scale production of SRC chips using minimal quantities of water, at sites near the seaweed-farming areas. [SEAPlantNet, is an initiative of the International Finance Corporation's Program for Eastern Indonesia SME Assistance (IFC–PENSA)]. Development of such a process would allow individual Pacific island countries to do their own part-processing and export value-added chips, with 25% of the weight and a smaller volume compared to dried seaweed.

When the country reports and country visits showed that regional cooperation in marketing was not feasible at present, the proposed sub-regional workshop on marketing was replaced by one that would promote cooperation in production. This workshop resulted in useful discussions between farming representatives from four countries who resolved to continue communication and cooperation on all matters relating to seaweed farming. Several recommendations were made and responsibilities for follow-up assigned. They are listed in Appendix 1.

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Objectives

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- to examine the production, processing, transportation and marketing options for the cultivated *Kappaphycus* industry in selected countries of the Pacific Community region, with a view to improving profitability and sustainability.

The countries originally selected were Fiji, Kiribati, Papua New Guinea, Solomon Islands and Vanuatu. Papua New Guinea decided to give seaweed farming a lower priority for the immediate future and did not participate in the project.

The project examines the industry that has developed around the farming of *Kappaphycus alvarezii*. This seaweed is the raw material for the production of carrageenan, a hydrocolloid used as a thickening, gelling and stabilising agent in a variety of industries but especially in food and pharmaceutical products.

Current world supply and demand for *Kappaphycus*

At present the demand for *Kappaphycus alvarezii* (Doty) Doty ex Silva (known in the industry as 'cottonii' [*K. alvarezii,* formerly *Eucheuma cottonii*]) is strong, supplies are short and the price is high. The shortage began in late 2002, when Chinese buyers entered the market in the southern Philippines offering above-normal prices, then the El Niño in December 2002 caused a warming of the sea in the southern Philippines resulting in a 55% fall in production. Some farmers tried to recover lost income by harvesting seaweed after only 3–4 weeks (instead of 6 weeks) but the quality was so poor that processors ceased buying from some areas. Then, in 2003, some of the usual buyers increased their demand; the Seaweed Industry Association of the Philippines reported in October 2003 that the supply to France had increased from the normal 4000 tonnes[1] per year to 6000 tonnes, China had moved from zero to a rate of 12,000 tonnes per year and South Korea doubled its annual imports from 1500 to 3000 tonnes.

In the Philippines, demand for cottonii has been strong for the past 2 years, raising the farm-gate price per kg from 29 pesos (P29) in 2002 to P34 in 2003 and P42–45 in early 2005. Buyers from Degussa (France) had to pay US$900 per tonne in December 2004, despite having a contract in early 2004 for US$800 per tonne. On the other hand, the price for *Eucheuma denticulatum* (formerly *E. spinosum* and known in the industry as 'spinosum') is P11 per kg. In 2003, Philippine processors required 155,000 tonnes of seaweed but only 128,000 tonnes were produced. The strong buying by China increased the shortfall for local processors and they suffered a similar shortage in 2004. Under the national seaweed development program, signed by the Philippines Government and the private sector, production is targeted to increase to 166,000 tonnes in 2005 and 280,000 tonnes by the end of 2006. The actual production for 2005 will probably be about 110,000 tonnes. Indonesia has increased its production from about 25,000 tonnes in 2001 to 55,000 tonnes in 2004, while it is likely that about 80,000 tonnes will be produced in 2005. Large quantities are used within the country to produce low-cost, pet-food-grade, semi-refined carrageenan, but increasing quantities are

[1] Unless otherwise indicated, the seaweed production weights given in this report are of the dried commodity.

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being exported to the Philippines and China. The export price of seaweed rose from US$600 (2002) to US$800–850 (2004) but in mid 2005 had returned to US$600.

Production in Tanzania (Zanzibar) has fluctuated over the past few years; spinosum was popular originally, but its low price has caused some farmers to change to cottonii, even though they find this is more difficult to grow. Current production is about 1000 tonnes per year of cottonii and 5000–6000 tonnes of spinosum.

In Cambodia, the Ministry of Agriculture recently reported that seaweed production grew from 6000 tonnes in 2003 to 16,000 tonnes in 2004 and was expected to reach 20,000 tonnes in 2005. Based in Kampot, three companies are reported to employ about 1500 families (Xinhua News Agency). In all other countries, farming is done by individuals or families who provide their own materials and sell their crop; previous efforts to employ people to farm seaweed have not been profitable. A South Korean company introduced farming in 1999 and now employs about 700 farmers. The price of dry seaweed has increased by 50% since 2003.

Vietnam is also producing cottonii but the quantity is uncertain. F. Baricuatro, a spokesperson for Indo-Pacific, a major seaweed trading company, said in September 2004 that Indochina (comprising Vietnam and Cambodia) was expected to produce 3400 tonnes of seaweed by the end of 2004, but this is in sharp contrast to the above official Cambodian figures that were announced in February 2005. A Vietnam News Agency Bulletin (27 August 2005) reported that the central and southern provinces exported 1000 tonnes in the second half of 2003 and all of 2004, but that this had increased to 2000 tonnes for the first 6 months of 2005.

Figure 1. Fresh *Kappaphycus alvarezii* (cottonii)

China is said to have more than 150 small and medium processing plants that require at least 50,000 tonnes per year of raw material to produce pet-food-grade, semi-refined carrageenan, according to the Seaweed Industry Association of the Philippines (SIAP). In 2002, they purchased 15,000 tonnes from the Philippines, which had increased to 20,000 tonnes in 2003 and, by September 2004, to an estimated annual rate of 50,000 tonnes. In January 2005, Chinese traders active in the southern Philippines were buying at US$950 tonne, 19% higher than the November price of US$800 tonne. More recently, they are reported (SIAP, May 2005) to be buying from Indonesia at US$600 per tonne.

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Figure 2. Dried *Kappaphycus alvarezii* (cottonii)

In Sabah, East Malaysia, farming is well established with a production of 5000–6000 tonnes per year. In West Malaysia, construction of a seaweed farm on a 15-hectare site in Merlimau, Malaka State, began in September 2004 and was expected to produce its first harvest of cottonii in mid 2005, but it failed to achieve this target. The project involves the construction of 150 ponds and is being undertaken by Melaka Cell Farming Sdn Bhd, a joint venture between Melaka Biotech Holdings (a subsidiary of the Melaka State Government) and Cell Farming Systems (a subsidiary of Cell Farming Ventures (CFV)). CFV intends to form joint ventures with other producing partners at several locations in Peninsular Malaysia. In the longer term, the company intends to provide extraction facilities.

PepsiCo India Holdings Pty Ltd, the soft drink and snack food company, is obliged to invest in food processing and farming, conditions stipulated for allowing its entry into India. In cooperation with the Central Salt and Marine Chemical Research Institute, Bhavnagar (a CSIR organisation), it has established seaweed cultivation in Rameswaram, Tamil Nadu State. In early 2004, PepsiCo reached an agreement with the Andhra Pradesh government to promote the cultivation of cottonii by members of women self-help groups in coastal areas of the state. At that time, the company stated that it had exported 200 tonnes of cottonii from Tamil Nadu and would establish a processing unit when production reached 10,000 tonnes. Indian production may be limited by the availability of sufficient suitable coastal areas.

In the Pacific, three countries are farming cottonii: Kiribati, Fiji and Solomon Islands. At present, Kiribati is producing 600–800 tonnes per year and Fiji less than 100 tonnes, while Solomon Islands is currently expanding from a pilot program that produced 256 tonnes in 2004 and which at commercial scale should provide at least 1000 tonnes within 3 years. More details about activity in the Pacific are given below and in the accompanying country reports.

Information about recent production is summarised in Table 1.

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Table 1. Annual production of *Kappaphycus alvarezii* (tonnes of dry product)

Country	2003	2004	2005[a]
Philippines	128,000	–	110,000
Indonesia	–	55,000	80,000
Tanzania (Zanzibar)	–	1,000	1,000
Cambodia	6,000	16,000	20,000
Vietnam	–	1,000[b]	2,000[c]
Malaysia (Sabah)	–	6,000	6,000
India	–	200	–
Kiribati	–	650	800
Fiji	–	48	50
Solomon Islands	–	256	300

[a] Estimates
[b] From mid 2003 to end of 2004
[c] Actual production in first half of 2005

Future potential of *Kappaphycus* production

The future market for cottonii is tied to the future prospects for the carrageenan that is extracted from it. Industrial Market Research International, an independent agency that monitors the global hydrocolloid industry, predicts global demand for carrageenan to grow at an annual rate of 4–6%. The Seaweed Industry Association of the Philippines expects world demand for carrageenan to increase by an annual average of 5–6% for the next 10 years. Others in the industry suggest similar figures, averaging around 5%.

This expansion should come from extending current uses in meat, poultry and dairy products to areas such as India and other Asian countries, and Central and South America. Other potential markets for refined carrageenan are in oral care strips and capsules for the pharmaceutical industry. The use of gelatin for capsules is losing favour due to the incidence of mad cow disease and its human variant, Creutzfeldt-Jakob disease. Hard capsules use the carrageenan from cottonii, soft capsules from spinosum. Carrageenan is cost effective: 1 kg of carrageenan (US$16) produces as many capsules as do 4 kg of gelatin (US$24). Another carrageenan product, Carraguard, is undergoing clinical trials by the Population Council (www.popcouncil.org) to prevent the transmission of the AIDS virus and may later be commercialised. Carraguard is a formulation based on *lambda–kappa* carrageenan derived from certain species of seaweed, but all details are regarded as proprietary and are held by the Population Council and its supplier of Carraguard, FMC Biopolymer.

This steady increase in the use of carrageenan means that, even when the current shortage in supply of cottonii is overcome, there will be a continuing rise in demand for it. The current high demand–short supply situation has continued for over 2 years and shows no sign of changing. As noted previously, it began around the last quarter of 2002, when Chinese buyers entered the market offering higher prices than usual. The shortage has continued since then, with occasional relief when the Chinese have stopped buying. However, previously there have been several boom and bust cycles in which prices have fallen from highs of US$850–900 to lows of US$300–350 per tonne.

The farm-gate price versus future production of *Kappaphycus*

The farm-gate price is the price paid to the farmer by whoever is the first buyer in the seaweed marketing chain.

Over the past 20 years there have been several cycles of boom and bust in the international price for cottonii and this has always affected the farm-gate price. Typically, a shortage occurs for some reason (such as a fall in the number of farmers, an unusual rise in water

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temperature or other adverse weather changes, destruction by epiphytes, a surge in buying by speculators) and this shortage pushes up the farm-gate price. These high prices attract more people into farming seaweed, their increased production eventually leads to an oversupply and the prices fall, farmers become discouraged and return to their previous activities, the supply falls and eventually another shortage occurs.

A stable farm-gate price is essential for stability in the industry, for both farmers and carrageenan producers. In an effort to stabilise the market, some of the processing companies have negotiated with sellers to enter into fixed-term contracts at a set price. Such arrangements can provide certainty of income for the farmers, so they are more likely to continue farming, assuring the processors of a stable supply of raw material. If new buyers cause a sudden surge in demand and spot prices rise above the agreed contract price, then the farmers may feel they are not being paid enough. However, they benefit when the surge subsides and spot prices fall, often below the contract price, since the contract protects them from the potential loss. So there are long-term benefits for both buyers and farmers in having fixed-term contracts at fair prices.

It is unlikely that the current high farm-gate price of P40–45 per kg in the Philippines can be sustained for long periods. In some of its applications, carrageenan competes with other hydrocolloids so its cost must be competitive with them. If the price of seaweed pushes up the cost of carrageenan too much, carrageenan may lose market share and both processors and farmers will suffer. One example can be found in toothpaste: Colgate has changed to using cellulose gum in its standard lines and now uses carrageenan in only its higher-priced products. Cellulose gum is produced by the chemical modification of cellulose, has many producers and is never in short supply, so prices remain very competitive and stable.

Buyer requirements

The carrageenan processors are the final buyers in the seaweed marketing chain. Failure to meet their quality requirements will result in lower prices for the seaweed; consistent low quality may force them to move to other sources. Their basic requirements are dry, clean and high-carrageenan-yield seaweed. Consistent delivery of such material by Pacific island countries would ensure them a good position in the market.

Moisture content is important because high moisture leads to deterioration of the seaweed during storage and transport, and a consequent loss in carrageenan content and quality. Moisture content must be 40% or less, preferably 35%.

Processors prefer suppliers who can provide a consistent turnover of seaweed. In tropical environments, storage conditions of the dried seaweed are important since lengthy periods at high temperatures will cause deterioration of the carrageenan, even when dried to 35% moisture content. Processors prefer to see short-term storage and regular shipments, even if the shipments are not large.

Foreign matter such as sand, plastic tie-ties, pieces of coral etc. must be less than 3%. The adulteration of seaweed with common salt (sodium chloride) is not acceptable.

Processors sometimes pay on the basis of samples provided by the supplier. Sampling must be carried out in the manner specified by the processor to ensure the samples represent a fair assessment of the actual shipment.

Some processors would prefer to pay for seaweed on the basis of the amount and quality of carrageenan per tonne of seaweed and are working towards a means of rapidly assessing these. This would be a fairer basis of payment since the processor is really buying

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carrageenan and it would reward farmers who harvest after a reasonable growth period and penalise those who look for a faster turnover by harvesting early. Early harvesting results in low carrageenan content and low gel strength. This basis of payment would also encourage farmers to seek out varieties that give higher yields of carrageenan. An alternative being developed in Indonesia is to track seaweed from point of origin, through the marketing chain, to the final buyer (carrageenan processor). With such a system the processor would know exactly the source of higher quantities of better-quality carrageenan and would be willing to pay a higher price for higher quality. European processors were very enthusiastic about the possibilities of such a system during recent discussions with representatives of IFC–PENSA.

In the Pacific islands, regular shipments are important since this assures the buyers that the seaweed is not being stored for too long.

Production in the Pacific

Kiribati, Fiji and Solomon Islands are the only current producers of *Kappaphycus*. Vanuatu has conducted some small-scale trials, but had problems with fish grazing in several locations. Papua New Guinea has expressed interest in establishing seaweed farming but has given it a lower priority for the time being.

Kiribati has the longest history of seaweed farming, starting in the 1980s in the Gilbert Islands. Production fell in the Gilbert Islands, but was replaced by seaweed farmed by new settlers on Fanning Island (Line Islands group), reaching a peak of nearly 1400 tonnes in 2000. Production began to fall in 2002, however, when a cruise ship began regular visits to Fanning Island and some islanders moved from seaweed farming to making articles to sell to the visiting tourists. It began to recover in late 2004 and is forecast to reach 700–800 tonnes in 2005. A new strain is being introduced and production in the Gilbert Islands is expected to expand in 2006; more details can be found in the accompanying country report (Appendix 3).

In Fiji, production has fallen from a high of 520 tonnes in 2000 to less than 100 tonnes in each of the past 3 years; reasons for this are described in the accompanying country report (Appendix 2). The government's Fisheries Department has recently taken over the redevelopment of the industry and has a plan to restore production to more than 1000 tonnes in the next 2–3 years. Details of the 10-year development plan for the seaweed industry in Fiji are in the accompanying country report.

Solomon Islands ran a pilot farming program in 2003–2004 and this proved so successful that the European Union recently provided a grant of Solomon Islands dollars (SI$) 15 million over 3 years for expansion of the industry to a commercial scale. A well-planned program commenced in July 2005 and production is expected to reach 1000 tonnes per year by the end of the 3-year project. More information is available in the accompanying country report (Appendix 4).

A useful summary of the development of cottonii farming in the Pacific islands can be found in a paper by Luxton (2003).

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Figure 3. Submerged raft for seaweed cultivation, floating about 0.5 m below the surface, Maiana, Kiribati

Shipping seaweed in the Pacific

Internal shipping

Fanning Island, the main production centre in Kiribati, is about 2300 km from the export port of Betio on Tarawa, so internal shipping costs (about US$120 per tonne) are a significant factor in the total production cost. The seaweed is packed into sacks on Fanning Island and compressed into bales after arrival on Tarawa. Shipping schedules from Fanning Island are usually about every 2–3 months, but operate on demand rather than to a regular schedule. Five ships operate between Fanning Island and Tarawa, three are government-owned and two are privately owned. Within the Gilbert group of islands, shipping is cheaper (average about US$57 per tonne, less for some of the islands close to Tarawa), and more regular. Islands near Tarawa can be visited up to three times a week while for those more distant, every 2 weeks is usual but sometimes this might stretch to 4 weeks, depending on requirements and available cargo.

In Fiji, when output was at its peak in 2000, the production was spread over a wide area of the country making regular shipping difficult to arrange and coordinate. It is now planned to concentrate on reviving production in the Southern Lau group of islands, beginning with Ono-i-Lau, where some farmers are still active. This island is the most remote island in Fiji, about 440 km from Suva. It has been the main production area over the past 2–3 years but, because of the low production and its remoteness, shipping costs have been high (US$115 per tonne, packed in sacks). The Fisheries Department plans to run a regular service to the region, assisted by a government shipping subsidy scheme and probably using a vessel to be donated by China. The Fisheries Department is also investigating the possibility of compressing and baling seaweed on Ono-i-Lau, which could reduce the shipping volume to one quarter of the original.

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In Solomon Islands, the pilot farming project (2003–2004) was mostly in the Western and Choiseul provinces and the new commercialisation project (2005–2008) will at first concentrate on developing these areas and later Malaita. Private shipping companies take the seaweed to Honiara; scheduled shipping is fairly regular but charters are possible if justified by the quantity of seaweed available. Freight rates can be negotiated, depending on competition at the time, but on average the cost is US$55 per tonne in sacks.

Figure 4. Unloading bags of dried *Kappaphycus alvarezii*, shipped from Tabuaeran (Fanning Island), at the jetty in Betio on Tarawa, Kiribati

Export shipping

Shipping between Pacific countries and from Pacific countries to the rest of the world is both complex and expensive. Some Pacific countries are linked to each other by direct routes, others connect by transhipment, mainly in Fiji, Australia or New Zealand. Engaging the services of a competent freight forwarder or shipping agent is the most efficient way of obtaining the best rates and routes.

Kiribati exports seaweed to Cebu, Philippines, using Chief Container Services (CSS). After leaving Tarawa, the ship visits the Marshall Islands, Vanuatu, New Caledonia and Australia, where the cargo is transhipped to Cebu. The journey can take up to 30 days and costs US$2850 per 20-foot (6-m) container. The Atoll Seaweed Company is investigating the possibility of chartering a vessel to bring goods into Tarawa from the Philippines, then taking supplies to Fanning Island and afterwards backload it with seaweed, sailing directly to Cebu from Fanning Island.

Any proposal to accumulate seaweed from various Pacific island countries at one hub, such as Fiji, before exporting to international buyers is unlikely to be economic because of the high costs of inter-island shipping and the extra port charges required. The rate from Kiribati to Fiji, for example, is US$2070 per 20-foot container (using KSSL, the shipping line owned by the Kiribati Government). If this container is then transhipped to Cebu, the additional cost would be US$2340 (P&O Line) plus port and origin charges (US$400); so the total cost by this route is US$4810, compared with the direct route cost of US$2850 using CSS. A similar result is obtained if Solomon Islands' seaweed is first shipped to Fiji (see below).

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Figure 5. Bales of seaweed at Tarawa, Kiribati, ready for export

At present, the seaweed produced in Solomon Islands is exported to a processor in Normandy, France, with the nearest main port being Le Havre. Other processors are located in Denmark, the Philippines and on the east coast of the United States. The following rates were provided by Tradco Shipping Ltd, the main export shipping company in Honiara:

- Honiara to Cebu, Philippines via Singapore, approx. US$2500 per 20-foot container
- Honiara to Le Havre, France, approx. US$3800
- Honiara to Copenhagen via Hamburg, approx. US$4000.

If the seaweed is sent first to a shipping hub such as Fiji and from there to Le Havre, the total cost would be at least US$4750 per container; so, as with Kiribati, there would be no saving by trying to centralise shipping from one hub in the western Pacific.

From Fiji, seaweed has been exported to Denmark, the Philippines and the east coast of the USA. A new buyer is currently being sought by Fiji, but the following are typical rates for a 20-foot container to each of these destinations, and to France. The rates include currency adjustment and bunker adjustment fees, security fee, local port and origin charges. Each destination has at least two sailings per month from Suva:

- Suva to Denmark (Copenhagen), US$3760, 5–6 weeks transit
- Suva to France (Le Havre), US$3360, 5–6 weeks
- Suva to Philippines (Cebu), US$2740, 5–6 weeks
- Suva to USA (east coast, Philadelphia), US$3850, 4–5 weeks.

Marketing in the Pacific

Kiribati and Fiji each sell through a single, government-authorised domestic buyer/exporter, while Solomon Islands has opted to market through multiple government-licensed domestic buyers/exporters.

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Farm-gate prices

In theory, the farm-gate price in Kiribati and Fiji should be stable; set at a level by the sole buyer that is reasonable for the farmers, yet commercially viable. In Solomon Islands, it should depend on the ability of the internal buyers to take into account the likely highs and lows of international prices so they can offer prices that they can realistically sustain under all conditions. In practice, Kiribati and Fiji have failed, and Solomon Islands is about to be tested.

In Kiribati, the farm-gate price is set by the government-owned Atoll Seaweed Company, which is the sole buyer and exporter. All farmers receive the same price whether they farm on Fanning Island, 2300 km from the export port of Betio, or on one of the islands less than 100 km from Betio. This fits the i-Kiribati culture, where such equality is expected and the norm. In 2002, the farm-gate price was set at A$0.45 (US$0.23) per kg. In 2004, the government raised the farm-gate price to A$0.60 (now US$0.46, due to a stronger Australian dollar), agreeing to subsidise the Atoll Seaweed Company for the increase. Given the high internal and export freight costs for Kiribati, this farm-gate price is too high and the company would become insolvent without the government subsidy.

In Fiji, the farm-gate price was set by the Fisheries Department at 0.50 Fiji dollars (FJ$) per kg in 1998 and has remained at that price. Farmers have complained about the price in recent years, although it compares favourably with copra, another source of income available to them. Copra requires harder work but payment is received quickly and regularly. Seaweed farmers must work for 6 weeks to have a crop to sell and, in the past, this time factor, plus a lack of immediate payment at the end of the 6 weeks, have together probably been more important as a cause of declining farmer interest than the price per kg. The few remaining farmers are asking for FJ$1.00 (US$0.58). This is not sustainable, particularly when the international price falls, so some compromise must be found by the Fisheries Department as it works to rebuild the industry in Fiji; currently it is proposing a price of FJ$0.70 per kg.

Solomon Islands has issued four buyer–export licences to date and hopes to increase competition among buyers, thereby benefiting farmers. With the current high international prices, these buyers may be tempted to push the farm-gate price up to levels that will be unsustainable when the international price falls from US$800–900 to, say, US$400–500 per tonne. Those who are responsible for implementing this European Union-sponsored farming project are well aware of this problem and will try to convince the buyers that it is in their own interests to exercise restraint with farm-gate prices.

International sales

The marketing chain is short for all three current producers: the farmer sells to a buyer who sells and exports to the end user.

In Kiribati, the Atoll Seaweed Company has been selling to CP Kelco, a carrageenan producer with processing factories in Denmark and the Philippines. The company has entered into 5-year contracts at a cost and freight (c. & f.) price that can be reviewed on request at 3-monthly intervals. The contracted price has been in US dollars, whereas Kiribati uses Australian dollars as currency and this has created problems in recent years. As the Australian dollar rose in value versus the US dollar (from A$1.90 to A$1.30 per US$1) the company's income in Australian dollars has fallen by about 30%. The most recent contract has expired and the Atoll Seaweed Company would prefer to have any new contract in euros since the euro–Australian dollar exchange rate has been more stable.

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In Fiji, FMC Biopolymer was granted exclusive rights for 5 years to purchase seaweed through a Fijian supplier appointed by FMC. FMC Biopolymer has carrageenan-processing factories in the USA (Maine), Denmark and the Philippines (Cebu). During the contract period, seaweed was shipped to all three destinations, but mainly to Denmark. FMC negotiated a free on board (FOB) price with the Fijian supplier and this was revised at times. However, the output and quality of the seaweed declined to such an extent that FMC recently withdrew from the market and the Fijian supplier also withdrew from buying seaweed (for more detailed reasons for the decline see the accompanying Fiji Country Report in Appendix 2). The Fijian Government, through its Ministry of Fisheries and Forests, is now undertaking the redevelopment of the industry and will market the product through a long-term contract with a suitable buyer. The Ministry plans to offer the industry to the private sector once it has reached a viable and stable output.

In Solomon Islands, only one buyer/exporter has been active until recently and that company has sold its product to Degussa Texturant Systems, which has a carrageenan extraction plant in Baupte, Normandy, France. No details of the company's arrangements with Degussa have been made available. There is no indication of where the other licensed buyers/exporters will sell their product when they become active.

Cooperation in marketing

Consideration has been given to the proposition that Pacific island countries might cooperate in marketing their seaweed, on the basis that their combined output would give them leverage for better international prices and improved freight costs. There is, however, insufficient production in the region at present to give this serious consideration; in 2005 the combined production might have reached 1200 tonnes. In a world market of about 200,000–220,000 tonnes, a combined output of at least 5000 tonnes would seem to be a minimum quantity needed to have any impact on price but it could take 3 years to reach this target.

If and when the target is reached, would countries cooperate? Those that have only one internal buyer/exporter might consider it, but in countries like Solomon Islands with, say, 3–4 competing exporters it seems much less likely, unless they were all losing money. Any advantage in freight costs by exporting the combined products from one port is likely to be lost because of the cost of shipping to that port from cooperating countries. If countries were willing to have centralised marketing it might be feasible to set up a single marketing body/office but still ship from each participating country, as directed by the marketing office.

Seaweed processing in the Pacific

Refined carrageenan is used mainly as an additive to human foods and in pharmaceuticals. The production of the refined grade of carrageenan from cottonii is undertaken by so few processors because it is a difficult process with few details publicly available; it also requires a considerable capital investment. Any investor wishing to set up such a facility without the assistance of an established processor would have to be willing to be patient for a return on the investment. It is unlikely that any of the major producers would wish to duplicate their facilities in the Pacific; there could be other, more profitable ways of investing the required capital and there would be the risk that, if regional production fell, the factory would need to import seaweed to an area where freight rates are quite high. Some have built facilities in the Philippines, where over 120,000 tonnes per year of raw material is available, but even with a production of 10,000 tonnes in the Pacific, it would be better economics and less risky to ship the seaweed to Europe or the Philippines.

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Less difficult to produce is *semi-refined* carrageenan, which itself can be divided into three broad grades: one that is acceptable for human consumption; another that is useful for pet food and other commercial uses where bacterial counts are less important; and the third, called alkali-treated cottonii chips (ATC chips), that is sold as a raw material for producing the grades that are suitable for human consumption. There is little direct extra profit in producing ATC chips, but the advantage for Pacific countries could be that the volume of product to be shipped is reduced to one-quarter of that of the original seaweed.

Figure 6. Sun-drying alkali-treated cottonii (ATC) chips

A consultancy report prepared for Kiribati suggests that a minimum annual input for an ATC production unit would be 10,000 tonnes of cottonii. This annual output is unlikely to be achieved by any single Pacific island country in the next 5 years and the cost of inter-island shipping would preclude aggregating production from different countries in the one production centre. However, the SEAPlantNet organisation is experimenting with the design of a mini-factory for the production of ATC chips, requiring an input of only 100 tonnes per month of dry cottonii. If successful, this could be useful for Fiji and Solomon Islands, but the quantities of water required for production might be a problem for Kiribati.

SEAPlantNet commenced in 2004 as an initiative of the International Finance Corporation (IFC) Program for Eastern Indonesia SME Assistance (IFC–PENSA). It is funded by IFC, the Asian Development Bank, and the governments of Australia, Canada, Japan, The Netherlands and Switzerland. It has a farmer cooperation program (providing technical assistance), a value-adding program and a value-chain facilitation program (facilitating information exchange between farmers and between farmers and the world).

SEAPlantNet is also developing a new technology in which solid and liquid products are separated from fresh seaweed at the source. Fresh (undried) seaweed is pressed or squeezed to produce as much liquid as possible from the seaweed. This results in two products: the liquid and the solid cake that remains. The liquid contains minerals and plant-growth stimulants such as auxins and cytokinins; tests have shown it improves yields of some crops by 20–30% when used in conjunction with NPK fertilisers. It is usually applied as a foliar spray containing 2–10% of the liquid. However, the solid cake that remains is of particular

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interest as a potential source of carrageenan, since most of the carrageenan in the harvested seaweed would remain in this cake. SEAPlantNet is developing a small-scale treatment process for this cake to produce alkali-treated cottonii using minimal quantities of water. This could result in a significant amount of processing of the wet seaweed being done at or near the sites of the seaweed farming rather than the current situation where the seaweed is simply dried and exported. The process has been proven on a pilot scale, but substantial research and development and marketing are required for full market development.

Sub-regional workshop on seaweed farming

Since this study had shown that cooperation in marketing and processing of seaweed was not feasible until production was significantly increased, the emphasis of the project was shifted and directed to finding ways of improving and expanding seaweed farming in the region. To that end, a meeting to discuss seaweed farming was held in Nadi, Fiji. The principal participants were technical personnel involved in seaweed farming in Fiji, Kiribati, Solomon Islands and Vanuatu. In an advisory role were representatives of SEAPlantNet, the University of the South Pacific, the Secretariat of the Pacific Community and the Australian Centre for International Agricultural Research.

The principal participants presented country reports on seaweed farming and all participants joined in a round-table discussion of farming methods and various problems that had been encountered. This exchange of information and ideas at a personal level gave the principal participants a widened appreciation of the issues involved in farming and has provided a firm basis for future cooperation and sharing of expertise between countries. Cooperation in the immediate future will occur in such areas as the sharing of new cottonii strains, exchange of information on epiphyte/disease outbreaks and discussion of ideas/methods that are found to motivate farmers to be more productive.

The development of communication between farmers, and between farmers and buyers, was seen as a key factor in improving productivity. The PFnet system being implemented in Solomon Islands is giving positive results. Farmers often find their own best methods for their particular environment and can help each other when good communications are available, especially between remote communities. Farm production is more stable when farmers are satisfied that the price they receive is fair, so the communication system should allow them to access prices in other countries and other areas within their own country. SEAPlantNet is developing such a system of communication in Indonesia and offered to assist Pacific island countries to develop their own.

In marketing their seaweed, Pacific island countries are at a disadvantage when compared with major producers such as the Philippines and Indonesia, because of the higher cost of shipping to seaweed processors. They therefore need to have some advantage, even more so because their production is small and will probably remain relatively low, compared with these countries, in the next few years. SEAPlantNet described recent meetings with international seaweed processors who were very enthusiastic about the idea of the introduction of a 'tolling' system. In this system, the source of any seaweed is recorded all the way through the chain, from initial drying on the beach to the point where it is shipped to the processor. With such a system the final buyers (processors) can know exactly where better quality seaweed originates and pay a premium for it, or vice versa. SEAPlantNet plans gradually to introduce such a system in Indonesia. The principal participants at the workshop realised that adoption of such a 'tolling' system would give them an advantage in marketing, but the idea failed to appear in the final list of recommendations from the meeting, probably because the emphasis of the workshop was on farming rather than

marketing. Nevertheless, those responsible for overseeing the industry in each country should encourage its introduction.

The final list of recommendations, drawn up jointly by all the workshop participants, is given in Appendix 1.

Conclusion

At present the total regional production of *Kappaphycus* is too low to consider regional cooperation in marketing or processing. Annual regional production in 2005 is estimated to have been 1500 tonnes, only 0.5% of the total world production. Output would need to reach at least 5000 tonnes, preferably 10,000 (5% of world production), to obtain any price leverage or to justify the capital cost of the current type of processing plant. Even at an output of 10,000 tonnes, the present cost of shipping between Pacific island countries is too high for the economic aggregation of regional production at a single port for export, or a single centre for processing.

For marketing, it might be possible to establish a central marketing organisation for the region that then arranges exports from individual countries direct to a processor. This would be more likely if only one government-controlled exporter existed in each country. However, by the time production has reached 5000–10,000 tonnes there are likely to be several companies involved in marketing and exporting seaweed in the region and they may see little commercial advantage in relinquishing their autonomy to a centralised marketing organisation.

For processing of seaweed within the region, the best prospect lies in the current development projects of SEAPlantNet. If successful, they would provide a small-scale processing plant that could be established near farming areas, requiring a minimal quantity of water and producing very little effluent.

The primary challenge at present is for each country to increase production to a consistent level. Farmers are most productive when they have good technical support, receive fair and regular payments, and have good communication between themselves and with the world markets. As production levels rise, the marketing of even small quantities of seaweed will be assisted by providing regular shipments of a product with consistent, high quality. The introduction of a 'tolling' system that records the origin of the seaweed all the way through the marketing chain would be a further incentive for processors to buy from Pacific island countries.

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APPENDIXES

Appendix 1

Recommendations from the ACIAR–SPC sub-regional meeting on seaweed farming, Capricorn Hotel, Nadi, Fiji, 25–27 October 2005

All participants were involved in this discussion on future action, resulting in a comprehensive list of recommendations together with suggestions on how they could be implemented and who would be responsible. The recommendations are as follows and suggestions for implementation etc. are in italics.

1. Using a good communication network is an essential first step to enable countries to collaborate on any aspect of the seaweed industry, especially at this time in regard to farming and improving production.
    - *Staff of farming organisations in all countries to utilise email, fax and phone to maintain consultation and cooperation on any aspect of farming*

Farming

2. Countries within the Pacific can learn from each other and share with each other about the mechanisms that will motivate farmers to produce, e.g. cash payments, bonus system.
    - *All countries involved; connect with SE Asia (Indonesia is a logical and geographical connection to the Pacific through PNG)*
3. Initially concentrate farming on a small number of sites, rather than spreading efforts more thinly over a large number of sites. This has been a successful strategy in Solomon Islands.
4. There is a need to encourage collaboration on the sharing of cultivars (subject to quarantine protocol) and for research on new *Kappaphycus* strains.
    - *Fisheries departments undertake research; regional agencies to assist with technical supervision and quarantine*
5. It is essential that there be some regional collaboration on quarantine procedures.
    - *SPC, USP to continue efforts; invasive issue explored further (e.g. with Secretariat of the Pacific Regional Environment Programme (SPREP), Hawaii)*
6. Develop a better understanding of buyer specifications (e.g. 30% water content) and eliminate 'trading games'.
    - *Learn from SEAPlantNet*
7. Communication between farmers and from farmer to buyer can significantly boost the production within countries. Possibility of learning from SEAPlantNet in Indonesia, PFnet model in Solomon Islands for communication with remote communities.
    - *Countries to study communication methods with remote communities in Indonesia and Solomon Islands*
8. Explore lessons learned and trends for development of farming and marketing in major producing countries.
    - *SEAPlantNet to share the lessons from Indonesia and Philippines*

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9. Applied research. Some topics are of global importance and efforts could be collaborative at an international level. Priority topics include:
   - ice-ice outbreaks
   - epiphytes
   - grazers
   - processing technology
   - alternative seaweed products
   - local applications (e.g. fertilisers, animal nutrition).

   • *Utilise the USP (use USP extension centres); involve ACIAR as a donor and technical agency; producing countries to be involved in refining and implementation*

10. Identify the opportunities and constraints for equal gender participation in seaweed farming (traditional and innovative).

    • *Possibly supervised through the USP*

Training

11. Countries in the region should combine their efforts in delivering technical assistance (e.g. training materials, training workshops) to farmers. Encourage the type of agency collaboration already in place (e.g. between SPC and USP).

    • *All countries involved*

12. Encourage between-country placements within the Pacific community to support emerging countries to learn from more advanced countries.

    • *SPC and governments of producing countries to facilitate*

13. There is a need to maintain a program of 'training-the-trainer' type courses.

    • *USP, SPC, Fiji to explore a training module in 2006; all producing countries to assist in identifying a 'model' farmer who can also be a teaching resource*

14. Regional efforts could be coordinated through a regional posting (organise training, share country experiences, technology).

    • *Position could be located within SPC but would be working closely with USP*

Promotion of farming

15. Identify a few successful seaweed farmers to showcase the viability of seaweed farming as Micro, Small and Medium Business Enterprises and to be a catalyst for production.

    • *Countries to identify*

16. Countries should make a concerted effort to find and empower their entrepreneurs in the seaweed farming industry.

    • *Producing countries to find entrepreneurs*

17. Encourage countries to raise the profile of seaweed farming in regional forums as a viable alternative livelihood for coastal peoples – build on comparative advantages (cf. tuna). Regional organisations should also maintain communication with non-producing countries that may wish to farm seaweed in the future.

    • *SPC through regional forums, communications*

18. Regional organisations and countries should work together to lobby donors (EU, World Bank, ADB) to support where necessary the development of seaweed farming.

    • *SPC to coordinate*

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Processing

19. Explore the benefits of in-country processing versus exporting raw product with transparent value-added chains in place.

    - *Focus on the current three producing countries (Kiribati, Solomon Islands, Fiji); Kiribati to share its processing consultancy report; SEAPlantNet to advise on progress of small-scale processing project*

Marketing

20. There is an opportunity for regional collaboration in marketing; countries could share marketing intelligence, prices paid, exporting strategies.

    - *All involved, SPC take a lead, learn from SEAPlantNet*

21. Consider establishing a third-party testing facility in the region to act as an honest broker between buyers and sellers in verifying export quality.

    - *USP a potential host for the facility*

22. Consider the need to develop regional product standards and certification schemes (linked to third-party testing) to conform with global standards. Pacific islands should target a high-quality product and consistent quantity in order to secure a stable market demand. The Pacific region needs to build a positive image. Consider developing a single Pacific-wide brand (contribute to broader discussion on other products such as ornamentals).

    - *SPC to work with ForumSec; marine ornamentals standards; other aquaculture standards*

General

23. Countries should develop national development plans for the seaweed industry and share this plan with other producing countries as a means to communicate their future intentions and targets (production levels etc.).

    - *Countries to develop plans, SPC to help disseminate information*

24. Continue efforts to hold regional forums regularly.

    - *SPC to help organise and seek funding; consider an internet-based forum etc.*

25. Use the above recommendations as a framework for a regional inter-governmental agreement that countries will cooperate in boosting seaweed production within the region. Submit this framework to the SPC Heads of Fisheries meeting for endorsement.

    - *SPC to work through the current ACIAR consultancy and with all workshop participants to formulate final framework*

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Appendix 2

Fiji – country report

Aminio Raimuria, Ledua Ovasisi and Dennis J. McHugh

Summary

There have been three cycles of seaweed farming in Fiji: 1985–87, 1989–92 and 1998–2002. Small quantities are still being farmed – 48 tonnes of dried seaweed in 2004, down from a peak of 520 tonnes in 2000. Reasons for the decline since 2000 include slow payment to farmers, movement by many farmers back to copra or to fishing bêche-de mer, a reduction in the frequency of internal shipping as production fell, and political upheaval. FMC Biopolymer, the international buyer, withdrew from the market in 2005, because of low production, poor quality due to prolonged storage and high international freight costs. The local buyer, REL Fisheries, also withdrew at the same time.

Having reviewed the previous history of the industry, the Fisheries Department has identified the following past problems and proposes the potential solutions discussed below.

(a) Farming has been spread over too many areas in Fiji so that service and support to farmers could not be maintained at a satisfactory level. Future development will concentrate on the Southern Lau islands, starting with Ono-i-Lau, where previous farming has been successful because of very favourable water flow and nutrient conditions, decreased likelihood of elevation of sea temperature and the ability to recover from cyclones.

(b) Previously there were too few extension officers to cover the wide area over which seaweed farming was spread, and their training and knowledge were inadequate. A revised training program will be initiated to provide the smaller number of professional extension officers that will be required to service the Southern Lau area.

(c) Choice of farming sites has usually considered only physical factors such as current flow, nutrient availability, water temperature and clarity etc. In future, socioeconomic factors relating to the proposed farming community will also receive serious consideration.

(d) The off-bottom method of farming is the only one to have been used. However, as farming develops in the Southern Lau group, floating rafts may be introduced if expansion of farming is limited by the availability of shallow-water sites.

(e) The cost of internal shipping from Southern Lau was high and, as production fell, its frequency became inadequate. Baling equipment will be installed on Ono-i-Lau so the volume of product to be shipped can be reduced and the Fisheries Department will resume a regular, subsidised shipping service.

(f) The farm-gate price has been fixed since 1998. Farmers say it is too low and payment has been too slow. The Fisheries Department will review the farm-gate price and control payments to farmers.

(g) The Fisheries Department will supervise quality control, baling, internal shipping and international sales until the industry has stabilised at an acceptable level of production at which time it will be offered to the private sector.

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Past experience

The first attempt to farm a carrageenan-containing seaweed was in 1976, off the island of Bau on the east coast of Vitu Levu. Growth rates were good, but all stocks were lost in a cyclone in 1980.

In 1984 thalli of *Kappaphycus alvarezii* were taken from Tonga and planted on the barrier reef north of Rakiraki, using the off-bottom method. These initial plantings were used as a source of seed material for a pilot farm that was then used as a training place for new *Kappaphycus* farmers. Farms were organised off the northernmost part of Vitu Levu and in mid 1985 in other areas outside Rakiraki [Tavua, Kiuva (Tailevu) and the island of Moturiki off the east coast]. A joint venture company between Coast Biologicals Ltd (a New Zealand company) and the Fiji Development Bank was established to manage and promote the expansion of farming. A benefit of this was a secure market for the dried seaweed, which was exported to New Zealand for processing (Luxton et al. 1987).

Early results were promising and the highest production achieved was about 280 dry tonnes by 240 farmers in the 12 months to September 1987. However, in 1988 only 60 dry tonnes were produced by 30 farmers. This decline was the result of several factors: the Fiji political situation, a fall in business confidence, and a strengthening of the New Zealand dollar. All of these were such that the economic viability of the project appeared to be poor, so Coast Biologicals withdrew from Fiji in September 1988.

A new company, Seaweed (South Pacific) Ltd, was formed in 1989, based on capital from Australia, Fiji and New Zealand. It invested in off-bottom company farming at Nanuca (Savusavu, Vanua Levu) and raft farming at Kiuva (Robertson 1990).

The Marine Colloids Division of FMC Corporation indicated its willingness to buy the dried seaweed; it had demonstrated the practical features of farming and postharvest treatment during a workshop in Fiji in late 1989, sponsored by the FAO South Pacific Aquaculture Development Project in Suva. This was probably the first time farming had been organised by a company with employees doing the farming. Previous farming in Fiji and the Philippines had been done by self-employed farmers who sold their harvests to traders, so their earnings depended on their output. This latter incentive was lacking in the company model, production was lower than expected and after a cyclone destroyed much of the infrastructure and crop, the company became insolvent in 1991. Luxton (2003) commented that this illustrates that economic viability is dependent on paying people for their production, not paying people to produce.

The Fisheries Department and the National Marketing Authority then supported another company, Oceanic Trading Ltd, but seaweed farming ceased in early 1993. Several reasons have been put forward for this. The marketing agent was unable to ship enough volume to cover costs, followed by a reduction of the farm gate price from FJ$500 to FJ$350 per tonne. The Fisheries Department was faced with inadequate funds to provide further technical support. However, there were also quality-control problems (high moisture content) with a shipment from Oceanic Trading, which led to its rejection by the overseas processor. Cyclone Kina in January 1993 was the final straw for any farmers still remaining after the beach price had been lowered.

In early 1997, the Commodity Development Framework identified seaweed farming as an alternative income-generating venture for the grassroots people living in the rural coastal and maritime zones.

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Seaweed farming was revitalised in the same year using cuttings from wild seaweed growing in the Southern Lau group. A tonne of this was transferred to Kiuva, Tailevu for the establishment of the Fisheries Department seaweed nursery farms for the areas identified for development. These areas included provinces of Serua, Cakaudrove, Tailevu, Lomativiti, Ra and the Yasawas. Following the success of the nursery farms, seed cuttings amounting to over 40 tonnes (wet weight) were transferred to the identified areas to fast-track farm expansion activities for 1998 and 1999. The seaweed farms of the provinces of Lau and Macuata were re-established using wild stocks that were growing abundantly in those areas. The latter provided the necessary seed requirements for the establishment of the second Fisheries Department seed-stock nursery located at Dreketi.

In May 1998, the FAO South Pacific Aquaculture Development Project in Suva sponsored another regional training course on *Kappaphycus* farming. The Government of Fiji, in November 1998, allocated approximately FJ$2 million towards the establishment of seaweed farms. It was used in the procurement of materials and equipment for 658 farmers; this included about FJ$1,120,000 for 320 outboard motors, about FJ$540,000 for 451 punts and about FJ$260,000 for farming and postharvest materials such as rope, raffia, netting and clear plastic. The outboard motors and punts were supplied to farmers under an agreement with the Fisheries Department. This stipulated that the farmer must have previously planted at least 400 lines of seaweed, must use the equipment only for seaweed farming and subsistence fishing, must sell all dried seaweed to the Fisheries Department or a company approved by the Fisheries Department, and that ownership of the equipment would be transferred to the farmer once he/she had produced 20 tonnes of dried seaweed.

By December 2001 many farmers had lost interest in seaweed because other activities became available that either paid cash (copra) or more money (bêche-de-mer). However, shipping problems to Ono-i-Lau also contributed to this fall in interest. In 2000 the Fisheries Department had provided a ship every fortnight, but towards the end of the year an overseas company took over and the service deteriorated. This was because of the distances involved, the small loads and the low shipping subsidy under the Government Shipping Franchise Scheme. The Minister for Fisheries and Forests said the government was aware of the transportation problem and had allocated $150,000 for subsidies to seaweed commercial development (source: British Broadcasting Corporation/Fiji Daily Post – 10.12.2001). An improved, subsidised service was provided but was no longer viable by the end of 2002 when the annual production had fallen to only 80 tonnes. Production in 2004 was 48 tonnes.

Farm sites

Description of sites

Surveys carried out to determine the viability of the sites included the following factors:

- water depth, preferred 0.8–1 m at mean low tides
- far from coral heads and coral reefs
- sandy substrates with slight growth of local seaweed
- good distances from freshwater outlets
- water temperature ranging from 25–30° C
- moderate water exchange
- absence of pollution – clear water with good light penetration
- close to land with abundance of bush timber.

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Sites such as those on Ono-i-Lau, the southernmost island in the Southern Lau group, also have advantages such as:

- ability to survive El Niño events (such as the one in 1997) because they are so far south, had little rise in water temperature and the lagoon is flushed every day
- ability to survive cyclones reasonably well – the lines are cut before the cyclone arrives and any seaweed that breaks up is held in the lagoon.

However, experience in recent years has shown that the suitability of sites cannot be determined by physical factors alone; economic and social aspects of the potential farming community must be considered. Sometimes other forms of income may be available, or become available, that are more attractive than seaweed farming. Examples can be found in Fiji, where catches of bêche-de-mer became available in some seaweed-farming areas so farming was abandoned in favour of the more lucrative bêche-de-mer market. On Fanning Island, Kiribati, seaweed farming suddenly declined when cruise ships began regular visits; the local people found it was easier and more profitable to make and sell handicrafts for tourists rather than farm seaweed.

Tuvuca Island, in the middle of the Lau group, on the other hand, is an interesting example for potential farming. Its present source of copra (and income) is in a valley in the middle of the island and people have a long and arduous climb to get the copra out. The island has a suitable lagoon and seaweed farming would be easier.

A village needs to have enough interested people for the total output to be commercially viable, villagers need the ability to organise their time between farming and community commitments, traditional leaders must be supportive and there needs to be a motivation to earn cash. These and other socioeconomic factors are discussed in a paper by M. Namudu and T. Pickering presented at the 18th International Seaweed Symposium and which will be published in a special issue of the journal Hydrobiologia.

Ownership of sites

Ownership of land and farming sites follows traditional custom. Once a potential site is found, the local chief is consulted for agreement on the general principle of seaweed farming. If he agrees, then he allocates the land and water areas to individuals. However, as the seaweed industry expands, it may be necessary to make these agreements legally binding.

Farming methods

Commercial seaweed cultivation in Fiji has used only the off-bottom method, although the floating-raft method has been used to develop seed stocks. Both methods are described in Attachment 1.

Finance sources

Potential seaweed farmers with no experience or knowledge of seaweed farming were assisted with basic training skills such as site selection, farming methods, seed-stock selection and postharvest handling. This training was usually carried out to help farmers in establishing their own seed-stock nurseries from which cuttings could be taken for planting out after 6 weeks.

Basic start-up seaweed farming materials (with a value of FJ$490) to maintain a minimum 400-line farm were provided at no cost to the farmers. These materials were nylon ropes, raffia, netting, clear plastic and galvanised nails. Further assistance was provided to individual farmers attaining and consistently maintaining the minimum requirement of a

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400-line farm. This assistance was in the form of a marine-ply vessel (6 m) and a 15-HP outboard motor, valued at FJ$4700. A total of FJ$5190 was provided to an individual/family-based farm that met the criteria for the assistance package. This assistance was given under the terms of agreement previously described.

Figure A2.1 *Kappaphycus alvarezii* (cottonii) farmed by the off-bottom method on the inner side of the reef, Kiuva, Fiji

Production

Total annual production in tonnes of dried seaweed since 1998 is shown in Table A2.1.

Table A2.1 Production of *Kappaphycus alvarezii* in Fiji, 1998–2005. Tonnages are of dried commodity.

Year	1998	1999	2000	2001	2002	2003	2004	2005[a]
Tonnage	21.5	302	520	280	80	20	48	(40)

[a] To end of September

Past production, variability and losses and causes were described earlier. The following causes of losses were noted in the study by M. Namudu[1]:

- herbivorous fish
- placement of farms in swift currents or rough seas
- filamentous epiphytes and ice-ice (white or pink discolouration caused by fungal infection)
- lack of seedlings.

1 'Some socio-economic findings about seaweed farming in Fiji'. Presentation made by M. Namudu at the sub-regional meeting of Pacific islands seaweed farming organisations, November 2003, Nadi, Suva.

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Namudu noted that some farmers lacked technical knowledge and/or lost motivation due to lack of visits by extension officers.

Plans for future expansion of production are covered later.

Prices

The farm-gate price for all farmers, no matter where they farmed in the country, was set in 1998 by the Fisheries Department at FJ$0.50 per kg (dry). The price has remained unchanged. Farmers would now like to receive FJ$1.00 per kg. However, with the cost of internal freight from places such as Ono-i-Lau it is unlikely that this is economic even with the current high international prices for *Kappaphycus*. Some compromise between 50 cents and one dollar is more likely to be viable.

FMC Biopolymer, USA, was exclusively responsible for buying locally grown seaweeds for its extraction plant based in Copenhagen, Denmark. Before the privatisation of the local marketing, the Fisheries Department was responsible for purchasing, transporting, quality control, baling and containerisation of seaweed, and exporting. FMC offered to buy Fiji seaweed in its first year of full production at US$430 (FOB) per tonne and this was later increased to US$480 until the transfer of the local marketing to REL Fisheries.

A memorandum of understanding (MOU) was endorsed and signed by FMC and the Ministry of Agriculture, Fisheries, Forests, and the Agricultural Landlord and Tenant Act (ALTA), in March 2001, in which FMC was given exclusive buying rights of seaweed in Fiji, up to the first 3000 tonnes per year. The company agreed to:

- provide, as appropriate, technical support in the form of technical brochures, handbooks, baler plans, and training to farmers
- cooperate with the Ministry to help develop seaweed cultivation in other South Pacific countries, through the support of government agencies in those countries and appropriate development agencies
- select and enter into a contract with the seaweed supplier to ensure that the seaweed supplier fulfilled its responsibilities as defined in the MOU.

FMC in turn appointed a local company, REL Fisheries, to act as its local marketing agent (the seaweed supplier in the MOU). FMC offered an increase in price to its local agent to US$550 (FOB) per tonne in mid 2001 and this was later increased to US$650. However, for its last shipment this was reduced to US$350 because of the poor quality of its carrageenan content, probably due to prolonged storage before shipment.

The agreement with FMC has ended and FMC has withdrawn from the market. REL Fisheries has also withdrawn from the purchasing and shipping of seaweed within Fiji.

FMC lost interest because of irregular shipments (due to the fall in production), low quality of the carrageenan in the seaweed (due to prolonged storage on the production sites and/or Suva) and high international freight costs from Fiji.

REL Fisheries found that the business was viable when production was at the rate of about 50-tonnes per month; shipping collections were economic at 2–4-weekly intervals and on receipt in Suva there was sufficient product to immediately bale and pack into containers so storage costs were minimal. With falling production, the frequency of shipping from Ono-i-Lau had to decrease (the journey from Suva is 240 nautical miles, takes 36 hours for a 70-tonne vessel at a cost of FJ$13,000), leading to longer storage times both in Ono-i-Lau and Suva (product was stored in Suva until sufficient was accumulated to fill a 20-foot shipping container).

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Marketing

From 1998–2001, Fisheries Department officials and project staff purchased seaweed from farmers for cash, with buying trips scheduled every fortnight. Movement of purchased seaweeds from the farm gate to the nearest port was also the responsibility of the officials by means of government-contracted vehicles, and deck-loaded on local vessels bound for Suva or Lautoka. The journey, depending on the location of the port, usually takes 12–36 hours. All seaweed was received at the Fisheries Department headquarters based in Lami for final quality assessment and baling, and was exported in containers, usually holding up to 20 tonnes per container. Transportation costs from the producing sites to the main centre averaged FJ$150 per tonne, and export freight costs were US$2000–2600 per container.

In 2001, REL Fisheries took over all these functions under the terms of the MOU between the Ministry of Agriculture, Fisheries, Forests and ALTA, and FMC. In the following year, production began to fall and became concentrated on Ono-i-Lau; other producing areas had found other activities that were more profitable, especially bêche-de-mer. Lower seaweed production meant shipping from Ono-i-Lau became less frequent, REL was unable to ship overseas until sufficient seaweed was accumulated so payments to REL were delayed and REL in turn delayed payment to farmers. Farmers are paid on delivery for products such as copra and bêche-de-mer, so for 1–2 weeks work they receive cash at the end of it. On the other hand, seaweed farming goes on for 4–6 weeks and if payment is further delayed, farmers become dissatisfied with the speed of cash flow for their work and sometimes give up seaweed farming. So farming on Ono-i-Lau continued to fall and seaweed farming became unpopular because of slow payment.

The internal shipping cost for REL from Ono-i-Lau was FJ$180 per tonne; the seaweed was packed (with force) into flour sacks, freight costs were FJ$2.00 per bag and about 90 bags contained 1 tonne of seaweed. The shipping space for 1 tonne of seaweed is about four times the space required for a tonne of copra. Because Ono-i-Lau was often the last port of call for a ship before returning to Suva, loading of seaweed was sometimes not possible because of lack of space.

The costs of baling, loading containers, transfer of containers to ship, and associated documentation, cost about FJ$170 per tonne. Storage costs had to be added to this when production was low or slow and long-term storage in Suva was required.

A new vessel, purchased for the fisheries sector under the People's Republic of China's bilateral assistance program to Fiji, will be used by the Fisheries Department, so the present government subsidy (to Kahn Shipping) will be paid to the department and regular services to Ono-i-Lau will be possible.

Current status of marketing

A MOU of 6 months duration has been signed with PHY Enterprise Marketing, a local agent for the Japanese market. With the aim of strengthening competition to ensure maximum benefit to farmers, the services of the Agriculture Marketing Authority have also been engaged; this is an agency, initially funded by government, for specifically marketing agricultural products.

Export shipping

Table A2.2 gives current freight rates, supplied by Williams and Gosling, Suva. They are purely freight rates, payable to the shipping line ex Suva port to arrival at the specified destination. Freight rates can change, so these should be considered as estimates; they are useful for making comparisons of costs for different routes. There may be other local costs;

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the costs below are based on picking up a full container within Suva and delivering it to the wharf. If Suva were to be used as a hub for supplies out of Honiara and/or Tarawa there would be transhipment costs; for example, if a container is shipped to Suva by one company and is then to be forwarded to Europe by a different company, the first container might have to be emptied and the contents repacked into one belonging to the company shipping to Europe.

Table A2.2 Freight rates for shipping seaweed from Fiji. All rates are for 20-foot containers.

	Exports	
1.[a]	Suva to Denmark (Copenhagen) Line: P&O Frequency: two sailings/month Transit: 5–6 weeks	US$3363.80
	Suva to France (Le Havre) Line: P&O Frequency: two sailings/month Transit: 5–6 weeks	US$2963.80
	Suva to Philippines (Cebu) Line: P&O Frequency: two sailings/month Transit: 5–6 weeks	US$2338.80
	Suva to USA (east coast, Philadelphia) Line: P&O Frequency: two sailings/month Transit: 4–5 wks	US$3452.80
2.	Local port service charge, levied by the carriers to help compensate for high port costs	FJ$250.00
3.	Origin charges, including documentation, attendance and customs, but not insurance and packing of containers. Any overtime or standby is at cost.	FJ$400.00
	Imports	
4.	Solomon Islands (Honiara)–Suva Line: Indotrans Asia Frequency: two sailings/month Transit: 6 days to Lautoka	US$1925.00
5.	Tarawa–Suva Line: KSSL Frequency: one sailing/month Transit: 6 days to Suva	A$2722.50
6.	Local port service charge	FJ$250.00
7.	Origin charges and transhipment	Not included

[a] All rates are ocean freight rates (P&O company) for 20-foot containers and inclusive of a currency adjustment factor, a bunker adjustment factor (an allowance for changing fuel costs) and a security fee.

Note. The above rates are in contrast to export rates from Indonesia (Surabaya) to Europe, which are about US$1200 per container.

Future plans

A new team in the Fisheries Department plans to concentrate on increasing seaweed production. A refocus program for 2006–2015 has been prepared; this 10-year development plan has set a production goal of 10,000 tonnes per year by 2015. The target for 2005 is 100 tonnes. Production was previously spread too widely around Fiji, making it difficult to provide support and services to farmers, and not enough of the available funds was used for extension purposes. An inventory will be conducted of the areas that were involved in seaweed production. The farm-gate price for dried seaweed, which had been fixed at FJ$0.50 per kg for several years, has been increased to FJ$0.70 with the possibility of later increases depending on the outcome of negotiations for FOB prices.

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The plan for future production includes:

- refocusing the program on productive areas – the Southern Lau group within the first year, with farming expanded to other areas in 2007
- an aim to have each farmer produce 4 tonnes dried seaweed in their first year – a bonus scheme may be implemented that would provide an outboard motor and boat to any farmer who achieved 4 tonnes per year
- use of the off-bottom method but also floating rafts where appropriate, particularly when expanding farming in southern Lau
- work to improve on the output of 4 tonnes per farmer per year
- improving the quality and amount of advice/support to farmers
- providing better qualified people on the ground; for example, people who are capable of recording water temperature, current speed and salinity, and are able to draw conclusions from the data
- according a high priority to rapid training of more trainers, which is seen as being essential
- reviewing/revising farming methods
- raising the farm-gate price, but cautiously, after careful consideration of all costs
- Ministry funding and controlling all aspects of the seaweed sector until production reaches a stable output of 3000 tonnes per year, at which point it can be handed over to the private sector.

Attachment 1 – Seaweed cultivation methods

Off-bottom method

Wooden stakes are driven into the substratum at 30-cm intervals, in two straight rows oriented so that the seaweed lines strung between them will be parallel with the prevailing current. The stakes are 5–10 cm in diameter and up to 1.5 m long. A propylene line (3 mm diameter and typically 10 m long) is suspended between two stakes and short pieces of raffia ('tie-ties') are attached at 20-cm intervals for tying of plants. In recent years, farms have also been built with stakes spaced 1 m apart and end lines are employed for attachment of seaweed lines at 20-cm spacing, thus requiring fewer stakes. The line preparation (attachment of seaweed pieces 100–150 g in size) is usually done on-shore in the cool of the evening and the lines are left damp and covered up overnight for planting out the next morning. The lines are suspended at least 20–30 cm from the sea bottom and 20–30 cm from below the level of the water surface at low tide, so that the seaweed is never exposed directly to the air or sunlight. These farm dimensions, particularly line length, are not hard and fast rules and they can require adaptation for particular sites; for example, lines may be 5 m or 20 m long, depending upon prevailing sea conditions.

Before large-scale farm development commences, a crop-logging approach is recommended whereby small plots of two or three lines are tried at various locations and using various dimensions, until the farmer has built up a picture of what works best. An ideal farm size that can be operated by a single person is in the range of 320–480 lines, although much larger farms can be managed providing there is sufficient labour available and the farm is properly managed. Better plant growth is obtained if farms are maintained at least twice weekly (shake line to remove sediment from plants, remove entangled drift seaweeds, tighten sagging lines) but in practice this chore is often neglected.

Figure A2.2 Attaching short pieces of raffia (tie-ties) to the main polypropylene line [above left]

Figure A2.3 Tying small pieces (about 100 g) of *Kappaphycus alvarezii* (cottonii) to the polypropylene line using the tie-ties previously attached [above right]

Figure A2.4 The line containing the *Kappaphycus* propagules ('seedlings'), ready for attachment to stakes (off-bottom method) or rafts (floating-raft method) [right]

These images are from Solomon Islands.

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Floating-raft method

Although farmers are aware that an alternative seaweed farming method is available, it is not practised, simply because there is more than sufficient shallow-water space available for the off-bottom method. However, the project staff have on some occasions used the floating-raft method to improve seed-stock quality. This method allows the seaweed to rise and fall with the tide, keeping it in more or less constant environmental conditions. The seaweed is suspended at a depth of around 40 cm below the water surface at all times. Frames of various sizes are constructed from bamboo, mangrove or other buoyant and seawater-resistant materials. Monofilament lines (3 mm diameter) are stretched across the frame 10–15 cm apart; 15 pieces of seaweed can then be attached to each line. The frame is attached with seedlings on shore and then taken to the growing site, usually at a depth above 2 m at spring low tide. The rafts are secured to coral heads or anchored and, as the seaweed grows and becomes heavier, more bamboo floaters are required to maintain buoyancy.

Figure A2.5 Attaching lines with attached seaweed to a floating raft in Solomon Islands

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Appendix 3

Kiribati – country report

Kevin Rouatu and Dennis J. McHugh

Summary

Seaweed farming was introduced into the Gilbert Islands in the 1980s. Production reached a peak of 1020 tonnes of dry seaweed in 1991, but has since fallen for reasons that include strong westerly winds destroying many farms, rising seawater temperatures causing losses, and late cash payments and insufficient support to farmers. Now Fanning Island in the Line Islands is the main producer, reaching a peak of almost 1400 tonnes in 2000 with only 55 tonnes from the Gilbert Islands in the same year. The introduction of a regular cruise ship from Hawaii to Fanning Island in 2002 has resulted in a 50% reduction in output as islanders have shifted to producing souvenirs for the visitors.

The Atoll Seaweed Company Ltd (formed in 1991; 100% government-owned) buys all seaweed from the farmers and transports it to Tarawa where it is baled and sold to the carrageenan producer, CP Kelco, under a long-term contract with a pricing that can be reviewed quarterly. The contract is in US dollars, whereas the Kiribati currency is Australian dollars. Since the exchange rate over the past 3 years has changed from A$1.99 (for each US$) to A$1.24, the company has suffered a fall of about 30% in its income.

Farming has usually been by the off-bottom method in shallow lagoons, although floating rafts have proven useful when fish grazing is a problem; the rafts are more easily moved to a new location. Also, if seawater becomes too warm near the surface, rafts can be lowered into deeper, cooler water. Growth conditions on Fanning Island are very good; harvesting is done every 4 weeks rather than the 6 weeks needed in most other locations. Social/cultural attitudes have slowed the increase of production in the Gilbert Islands. The attitude of the people there is that if they have enough of what they need today, why worry about tomorrow, so they farm only when the cash is needed. On the other hand, those who migrated to the Line Islands are more interested in generating cash so they can pay for their land and relocation costs.

Farm-gate prices were raised last year (by the government) from A$0.45 to A$0.60 per kg, a price that is not affordable. When the costs of internal shipping, baling and handling in Tarawa and international freight are added to the farm-gate price, the company finds it is losing money, even with the government subsidising the recent rise in farm-gate price. Efforts are being made to reduce the costs of international freight to the Philippines.

The company has plans to increase production. A new strain of *Kappaphycus* has recently been made available and seedling material is being grown in nurseries. It is a compact plant, less likely to break up in poor weather and believed to have better chances of thriving when conditions are not ideal. In the Line Islands it will be tested in areas where the original strain failed to grow. In the Gilbert Islands the new strain will be tested on five islands in an effort to revive the interest of former seaweed farmers and taken to other islands where positive growth has been recorded and islanders have fewer sources of income.

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Past experience

Seaweed farming was introduced into Kiribati in the early 1980s with assistance from the British Overseas Development Agency and the Fisheries Department of the Kiribati Government. In 1991, the Atoll Seaweed Company Ltd was incorporated to take responsibility for the production, collection and export of the dried *Kappaphycus alvarezii* (also known in the trade as *Eucheuma cottonii* or simply 'cottonii'). The company is also charged with the introduction and commercialisation of farming of edible seaweed.

The company was incorporated with the financial assistance of the New Zealand Overseas Development Agency and, in 1996, the European Union added its support to the seaweed development project. The Kiribati Government has a 100% share of the company, which has a share capital of A$500 (500 ordinary A$1 shares). These shares are held by the Minister of Fisheries and Marine Resources Development (60%) and the Minister of Internal and Social Affairs (40%). The company has worked with the Fisheries Department and has received technical assistance, particularly from the European Union and New Zealand to fulfil its responsibilities.

The government has assisted the company by funding some of its projects, particularly in the initial stages, by providing technical assistance and physical support through its Ministry of Fisheries, and by subsidising the company during downturns in the seaweed market. The government gives the company exclusive authority to export any seaweed or seaweed product.

Various problems have been encountered in seaweed farming in Kiribati. They can be categorised as environmental and geographical, managerial and social problems. Some could be tackled, while others, such as social and cultural norms, are more difficult to resolve.

The environmental and geographical problems are as follows:

- unpredictable weather patterns, especially strong westerly winds destroying farms – these are still a problem
- in the Gilbert Islands, seasonal warming of the sea making some sites unsuitable for planting, with the only solution being selection of new sites
- non-lagoon islands – no material or technique is compatible with open-sea growing, which is still being researched
- grazing on seaweed by fishes – both territorial and the more serious shoaling fishes, which come in millions and are unpredictable – the problem is still under research
- the remoteness of some producing islands means that support is not efficient.

Managerial and some other problems are:

- lack of coordination of assistance to farmers
- occasional lack of materials
- erratic shipping services
- poor communication with the outer islands, particularly the Line Islands
- expensive import and export shipping freight costs
- delayed seaweed payments to farmers
- the company's revenue is directly affected by the US–Australian dollar exchange rate. Payments for seaweed are received in US dollars and the conversion has fallen from A$1.99 to A$1.24 in the past two and a half years, resulting in a fall of 31% in the company's income.

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The social and cultural problems are as follows:

- People are relaxed. They do not worry about tomorrow, so farming is not in their line of duty unless it is an instant beneficial activity. Contracting farmers with immediate payment for daily or weekly work is one of the solutions. The company had a trial of employing people (all women), and paying them weekly (payment could be made daily if necessary). The wage was calculated on the basis of costs and expected yield. However, the trial failed because the seaweed died; this is the risk in contract farming, with the contractor standing to lose both the wages paid and the value of the harvest. Another trial is planned that, if successful, will encourage entrepreneurs to take over, pay wages, harvest the seaweed and sell it to the Atoll Seaweed Company.
- In the Kiribati community, people rely heavily on other relatives, with even a third or fourth cousin being considered a very close relative.
- Unlike in other countries, where the farming of crops is part of daily life, the Kiribati people do not depend on short-rotation crops grown and harvested in weeks or months, but on perennial tree and root crops such as breadfruit, coconut, and babai (taro), and on imported foodstuffs.

Farm sites

The farm sites are in lagoons with sandy bottoms or mud flats but always intertidal. The common method used is with off-bottom lines submerged at least 20 cm below the surface at low tide, to avoid sunburn and the trapping of surface rubbish. However, when fish grazing is a problem, floating rafts, submerged about 30 cm below the surface, have been found to reduce the amount of grazing. The loop method of attaching propagules has been introduced but many still prefer tie-ties since pieces that break off can more easily be re-attached to the lines using tie-ties. Normally *Kappaphycus* is grown for 6 weeks before harvesting, but on Fanning Island conditions are such that harvests can be collected every 4 weeks; if left for 6 weeks the plants become too large and are more likely to shed pieces.

Figure A3.1 A raft for use in the floating-raft method of farming

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On Fanning Island, farmers planted directly off-shore from their land and so established informal rights, recognised by others, even though the government legally has rights over the water areas. Latecomers planted in areas between the villages. There can be conflicts of interest with others, such as fishermen, shell collectors etc. but these are resolved through the traditional chiefs.

Farm equipment such as stakes, lines, crowbars, tie-tie string etc. were originally supplied by a credit system from the company, payment being deducted from the money later paid for the crop. However, as farmers became established they acquired enough cash to pay at the time of purchase, so the credit system has been abolished.

Production

Over the past 5 years more than 95% of the total national production has come from Fanning Island in the Line Islands. Production (in tonnes, dried seaweed) from 2000 to the end of September 2005 is shown in Table A3.1. Total production for 2005 was likely to have been about 800 tonnes.

Table A3.1 Production of *Kappaphycus alvarezii* in Kiribati, 2000–2005. Tonnages are of dried commodity.

Location	Year					
	2000	2001	2002	2003	2004	2005[a]
Gilbert Islands	55.20	10.04	2.73	21.91	1.53	4
Line Islands	1383	1148	528	468	635	550

[a] To end of September

The fall in production in 2002 on Fanning Island coincided with the regular visits of a cruise ship from Hawaii, owned by Norwegian Cruise Lines. Some farmers found it more profitable to make handicrafts for sale to tourists rather than farm seaweed. However, an upturn in production started in 2004 when sources of raw materials (shells, weaving materials etc.) needed for souvenirs started to decline.

Also, many islanders, especially on islands where growth is good, are not active in seaweed farming because of some of the constraints listed previously. A social household survey was conducted to determine what other factors have led to lowering of production. One factor appears to be the government's commitments to paying school fees so parents no longer need to earn this money by growing seaweed.

As noted earlier, in the Gilbert Islands losses have occurred through warming of waters, fish grazing and strong westerly winds (many of the farms are on the western side of the islands). Water measurements are now being made so that warning can be given to move lines to new locations when necessary. Floating rafts can be dropped to cooler water at lower levels as long as sufficient light is available. Floating rafts are also more easily moved than fixed lines if fish grazing becomes too destructive. When farming is carried out near the shore, heavy rain can cause losses as run-off reduces salinity. Lines or floating rafts must be moved farther offshore if this occurs. An alternative is to direct run-off away from the lagoon. Salinity measurements need to be taken regularly during wet seasons.

Prospects for expansion of production

A new strain of *Kappaphycus* has recently become available from the Philippines. It is a much more compact plant, probably less prone to breakage and believed to grow and survive better when exposed to less than ideal conditions.

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Figure A3.2 Plants of the new strain of *Kappaphycus alvarezii* (cottonii)

Plans for the future – Line Islands

In the Line Islands it is planned to farm areas where the original strain has failed to thrive, using the new strain. Productivity will also be improved by ensuring that prompt payment is made to farmers and by increasing the availability of advisory services by the company. The new strain will not be introduced into the Line Islands until early 2006. The forecast dry tonnage of the original strain for the Line Islands for May–December 2005 is shown in Table A3.2.

Table A3.2 Estimated production of *Kappaphycus alvarezii* (original strain) in the Line Islands, May–December 2005. Tonnages are of dried commodity.

Month	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Estimated production (tonnes)	32	40	60	80	85	85	100	100

Plans for the future – Gilbert Islands

In the Gilbert Islands, SSIP (EU) funds will be used to target five islands with the new strain. Test plots will be tried first. Each test plot will consist of the following:

- 1 × 5-metre line; propagules, 100 g, 20 cm apart; plot is left for 1–2 weeks; if plants thrive, expand the number of lines; if not, abandon the area.

The forecast production (tonnes of dry seaweed) for May–December 2005 is shown Table A3.3. It is based on introduction of the new strain in May, using 120 kg for five islands, relative growth rate 4%.

Table A3.3 Forecast production of *Kappaphycus alvarezii* (original and new strains) in the Gilbert Islands, May–December 2005. Tonnages are of dried commodity.

Production (tonnes)	Month							
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Original strain	0.7	0.7	0.75	0.8	0.85	1.00	1.30	1.50
New strain	–	–	–	–	2.35	4.70	9.30	18.5
Total	0.7	0.7	0.75	0.8	3.20	5.70	10.60	20.0

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Plans for the future – general

Other steps being taken to expand production are:

- another trial of contract farming is planned
- transfer of seaweed seedlings to other islands where growth has been confirmed as positive and where islanders have fewer sources of income.

The aim is to increase production to 3000 tonnes per year by the end of 3 years.

Prices

The farm-gate price is determined by the Atoll Seaweed Company (100% government-owned). It was A$0.40 per kg in 2000, A$0.45 in 2002 and was increased by government to A$0.60 in 2004, with a guarantee that the government would subsidise the company for the additional 15 cents. All farmers, whether in the Line or Gilbert islands, receive the same price. This is government policy and a reflection of an egalitarian society. The company sells seaweed at a price that has fluctuated within the range stated in the contract agreement with CP Kelco, a Danish company with a subsidiary in the Philippines. All production is sold to CP Kelco and, with this exclusive agreement, the price has been in the range US$550–730 per tonne (c. & f. Cebu) in the past 11 years. The price can be reviewed at quarterly intervals.

The current contract has expired and a new contract is being negotiated.

Marketing

There are company-paid buying agents at islands where seaweed is grown. Agents are paid a low salary but, as an incentive for them to encourage seaweed farming, they receive a A$20 bonus for every tonne of dried seaweed shipped from the island. People grow, harvest, dry, clean, sort and pack their own seaweed into sacks before selling to the agent. The agent is expected to check the quality of the seaweed before it leaves the island. All dried seaweed is shipped to Betio on Tarawa where it is pressed into 45-kg bales and then packed into shipping containers. In this way, 19–20 tonnes of baled seaweed can fitted into a 20-foot container, compared with 11–12 tonnes of unpressed seaweed.

Figure A3.3 Unloaded bags on the jetty at Betio on Tarawa, Kiribati. They are taken to the headquarters of the Atoll Seaweed Company, where the seaweed is compressed in a baling machine and bagged before international export.

Figure A3.4 Baling machine of the Atoll Seaweed Company at Betio on Tarawa, Kiribati

Internal shipping between Fanning Island and Tarawa (a distance of 2300 km) is irregular, because shipping companies wait until they are assured of an economic load. The Fanning

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route includes three islands and runs 4–6 times a year. Eleven ships operate within Kiribati; three are privately owned, seven belong to KSSL (the government-owned shipping line) and one is owned by CPP (government fishing cooperative). Five ships operate between Fanning Island and Tarawa; three government and two privately owned.

In the Gilbert Islands, those close to Tarawa can sometimes be visited up to three times a week, while shipments to/from other islands are generally every two weeks but the interval can be up to one month. Freight costs from Fanning Island are about A$160 per tonne and average costs from the Gilbert Islands to Tarawa are about half that (A$75 per tonne).

For product from Fanning Island, the internal costs amount to approximately A$210 per tonne and cover internal freight and cartage, stevedoring, agents' commission, baling and handling in Tarawa.

Export shipping

Containers (20-foot) are exported from Tarawa to Cebu, Philippines, via several ports by one foreign shipping company, Chief Container Services (CCS). The charge for one container is A$3750. Based on a capacity of 19 tonnes of dried seaweed, this is a cost of A$197 per tonne. The goods may take up to a month to reach Cebu.

The KSSL vessel, MV *Matangare*, can carry 42 containers and previously sailed to Fiji monthly but recently it has sailed only on demand. The rate per 20-foot container is A$2722 plus port charges of FJ$250 in Suva; this container rate is negotiable. The freight rate from Suva to Cebu is approximately US$2340 per container plus transhipment costs, so this route from Tarawa to Cebu is too expensive. In an attempt to reduce freight costs, Atoll Seaweed Company is exploring the possibility of combining with other traders in Tarawa to charter a vessel so that seaweed can be taken direct from the Fanning island to Cebu. Goods for Tarawa businesses would be carried on the first leg of the inward journey from Cebu, and supplies for Fanning Island would be taken on the second leg. Seaweed (bagged but not baled) would be carried on the outward journey from Fanning Island to Cebu.

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Appendix 4

Solomon Islands – country report

Gideon Tiroba and Dennis J. McHugh

Summary

After earlier trials of seaweed farming in Solomon Islands, the European Union (EU), through the Rural Fishing Enterprise Project (RFEP), provided funds in 2003 for a 1-year project to develop seaweed farms. Following the success of that project, in July 2005 a further 15 million Solomon Islands dollars (SI$) has been provided by the EU, over a 3-year period, for the Commercialisation of Seaweed Production in Solomon Islands (CoSPSI) Project. To date, most farming has been in the Western and Choiseul provinces, where both off-bottom and floating-raft methods have been used. Farm materials have been provided using EU funds, but when the project is finished farmers will need to pay for their own materials.

Production has risen from 4 tonnes of dry seaweed in 2002 to 256 tonnes in 2004; targets are 400 tonnes for 2005 and 1000 tonnes per year by the end of the project. Harvests are collected every 5–6 weeks; regularity of planting is variable depending on the cash needs of the farmer. Fish grazing and epiphytes (filamentous *Polysiphonia*) have been problems, the latter having been found to be due to stressed plants, weakened by poor water movement and rising water temperature. All farming is by individuals or families.

Farm-gate prices have been set in line with those in other countries but need to be carefully managed by buyers to avoid boom and bust cycles that usually discourage farmers and can result in collapse of farming. Buyers/exporters are licensed by the central government. Only one has been active to date, but two more licences were issued very recently. Internal freight costs are relatively high but can be absorbed by the current high international price for *Kappaphycus*. Shipping is usually by scheduled vessels, but chartered ones can be used if stocks accumulate on outer islands. Buyers/exporters should be encouraged to invest in the industry to increase production, especially in good times when international prices and margins are high. The frequency of international shipping is reasonable and while the costs are high, they are comparable with those of other Pacific island countries.

Past experience

Growth trials were started in 1988 by the UK Overseas Development Agency (ODA) at VonaVona Lagoon and Rarumana village in the Western Province of Solomon Islands. This project was designed for 1 year and its results clearly showed that growth was good (more than 5 tonnes were produced), but most sites were affected by fish grazing. *Kappaphycus alvarezii* (previously known as *Eucheuma cottonii*) was imported from Fiji. The Government of Solomon Islands did not continue the project.

In 2000, the Aquaculture Section of the Ministry of Fisheries and Marine Resources decided to organise growth trials and these were carried out in Rarumana in 2001. Seed stocks were selected and gathered from the remains of the 1988 growth trials, which were scattered on the reefs in Vona Vona. An assistant fisheries officer was stationed in Rarumana to coordinate growth trials. In September 2002, more than 600 kg of dried seaweed was produced. By this time the Rural Fishing Enterprise Project (RFEP), funded by the European Union (EU), had become involved in the seaweed farming and it, together with the Secretariat of the Pacific

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Community and the Fisheries Department of Solomon Islands, funded and organised a national seaweed training workshop in late November 2002. The core trainees were about 30 fisheries officers from the Solomon Islands national fisheries department and the provincial fisheries departments; the fieldwork took place at Rarumana.

Because of the successful growth trials in Rarumana, in April 2003 the EU provided SI$1.5 million for seaweed farm development in conjunction with RFEP for one year. This provided farm materials, outboard motors, a warehouse in Rarumana and the first PF-net (broadband, email) was set up. Now the PF-net is used by the communities, and makes for smooth communication with the seaweed buyer and the Department of Fisheries and Marine Resources. In July 2004, a warehouse was built in Waghena and the second PF-net was set up. By early 2005, there were about 130 farmers in Rarumana and the Shortland Islands (Western Province) plus 300 in Waghena, Choiseul Province, and seaweed farming had also expanded to Malaita and Makira-Ulawa.

After accepting a feasibility study, the EU recently granted a further SI$15 million for a 3-year seaweed commercialisation project, commencing in July 2005.

Previously, the main problem encountered in establishing seaweed cultivation has been fish grazing; this is seasonal and often a problem in seaweed farming. First growth trials carried out in VonaVona were certainly affected by fish grazing. Stocks have to be removed and planted on nearby sites where fish grazing is minimal.

However, farmers at Rarumana and the Shortlands recently suffered severe losses because of the filamentous epiphyte *Polysiphonia*. It has been found that these epiphytes bloom when the seaweed is stressed or weakened by poor growth conditions, especially increases in water temperature and reductions in water movement/flow (and the related nutrient supply). If the seaweed is moved to better conditions of water temperature and flow, it recovers and the epiphytes disappear. In Rarumana, water movement is dependent on the wind and, with the recent return of the winds, the seaweed is recovering. Most of the seaweed stocks in Rarumana were dried and new healthy stocks were brought from Waghena.

Farm sites

Waghena

Farms in Waghena are located in shallow waters behind coral reefs. Most farms are built on sandy areas. Depths of about 0.5–3 m during low tides are suitable for planting seaweed.

Rarumana

Farms are located in shallow waters behind coral reefs. This area has a sandy bottom with a depth of about 0.5–3 m.

Manoaba (North Malaita)

The off-bottom method of cultivation is used in North Malaita, in shallow, sandy bottoms behind coral reefs.

Shortlands

Ghaomai farms are located in front of the village on a sandy area and the off-bottom method is used. At Laumuna village, the water depth is about 6–20 m so farmers use floating rafts. In the Komaliai village, rafts have also been used in open waters, and when the weather becomes too rough the rafts are taken on shore to avoid breakage; they can be left on shore for up to 2 days if shaded and kept wet.

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Figure A4.1 Illustrating an early stage of growth and how the lines can be laid out using the off-bottom method. The stakes for one end of each line can be seen, just protruding from the water, behind the men.

Ownership of sites

In Solomon Islands, tribal land ownership extends to the seafront and water. Each landowning group has its own committee that makes decisions, but such decisions can also be influenced by who first lays a claim, by starting to farm.

Finance for farm equipment (such as stakes, lines, equipment for collection of seaweed, drying racks/mats) was provided from the EU grant, at no cost to farmers, until April 2004. Since then there has been a problem in supplying materials because of the lack of funds for freight costs. When the Commercialisation of Seaweed Production in Solomon Islands (CoSPSI) Project is implemented, a steering committee will decide on future policy, but it may involve providing some materials to farmers using a revolving fund, with payment to be made when they become established so that the funds can be used again to assist more new farmers.

Production

The total quarterly exported production for Solomon Islands from 2002 to 2005 is shown in Table A4.1. Total production has increased from 4 tonnes in 2002 to 256 tonnes in 2004. The highest producing area in 2004 was Waghena (158 tonnes) followed by Rarumana (94 tonnes), Shortlands (2.4 tonnes) and Malaita (1.6 tonnes).

The total production for the first three quarters of 2005 was 225 tonnes, lower than expected because of the losses from epiphyte infestation in Rarumana.

Table A4.1 Quarterly Solomon Islands seaweed export production (kg dry) by year, 2002–2005

	2002	2003	2004	2005
Quarter 1	–	3,443	22,144	95,000
Quarter 2	–	10,015	48,210	55,000
Quarter 3	632	6,808	71,862	75,000
Quarter 4	3,379	24,605	114,119	–
TOTAL	4,011	44,871	256,335	(225,000)

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Harvesting is carried out every 5–6 weeks. If the growth period is any longer, material breaks off because the plant becomes too large. The carrageenan quality is good but there are ongoing disputes with the international buyer about moisture content and impurities. Planting and harvesting are not always done regularly; they are often larger around December when people need more cash for Christmas and school fees.

Losses have occurred in Waghena because of weather conditions and rain in particular. Rain can lead to a fall in salinity in near-shore waters and drying also becomes a problem. In May 2005, there was a 50% fall in production because of rain and in Waghena rain can be an ongoing problem through the whole year. Grazing by fish (as well as by dugongs and turtles) can occur in all areas. The solution is to move production to another site. Wind damage can also be a problem, but can be minimised by harvesting when the plants are smaller.

Farming is done by families but occasionally they may pay for additional labour if there is more work than they can cope with; sometimes people work as a community, with families helping each other when necessary.

Plans for expansion of production are described later.

Prices

The farm-gate price in villages is SI$2 per (dry) kg (approx. US$270 per tonne). This price was suggested to the exporter by RFEP after comparison with other countries. It was reported that seaweed farmers in Waghena claimed this price was very low compared with the price offered in other Pacific countries (Pacific Islands Report, 1 November 2004). Many of the people in Waghena are of Kiribati descent and probably know that the farm-gate price in Kiribati is higher but perhaps do not know that the government-owned company is running at a loss. Approximate freight costs to Honiara are SI$0.40 per kg (approx US$55 per tonne).

Until recently, two local exporters were licensed by the government to buy and export seaweed. However, only one, Solomon Seaweed, has been active. Seaweed is exported to France, where Degussa Texturant Systems in Baupte, Normandy, is the buyer. No information about price or conditions of sale is available from the present exporter. However, the average price around the world in late 2004 was US$700–800 per tonne and it was reported that the Philippine buyer for Degussa had to pay US$900 per tonne in December 2004, although a contract for US$800 had been signed in early 2004 (Business World, 13 January 2005).

Those who buy from the farmers have the power to destroy the industry by offering farm-gate prices that are unsustainable in the long term. The *Kappaphycus* industry has a sad history of several boom and bust cycles over the last 25 years. The cycle starts with a shortage of seaweed, demand forces a rise in the international price (as is occurring at present); if the farm-gate price also rises, more people start to farm, gradually the demand is met and the international price falls; if the farm-gate price also falls then farmers are discouraged and go back to other activities, production falls, a shortage develops and the cycle starts again. In an effort to overcome this instability, several international buyers have sought to enter into long-term price contracts with producers, usually with provision for periodic reviews. This allows in-country buyers/exporters to offer stable farm-gate prices that keep the farmers satisfied and producing.

Solomon Islands is starting to expand its production at a time when international prices are at a peak and there is a danger that if the farm-gate prices match this peak then they will have to fall later when the international price returns to a lower level. If Solomon Islands is to develop a stable seaweed industry, licensed exporters need to be conscious of these facts, be

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restrained in their offers of farm-gate payments and not be influenced by any unrealistic and unsustainable prices offered in other countries.

Since the industry is in its infancy, exporters need to look at relationships with farmers; the current high international prices and good margins provide an opportunity for them to invest in the industry and encourage production.

Marketing

Four exporters are now licensed to export seaweed. One has been the only buyer/exporter to date (Solomon Seaweed), the second has not been active (Western Seaweed) and the remaining two licences were issued in June 2005. Solomon Seaweed has placed buying agents at the farming sites and they are provided with an imprest for the cash purchase of seaweed. There are no other parties in the marketing chain.

While competition among buyers can be beneficial for the farmers, there needs to be a careful control of the number of licences issued, related to the amount of production. There is only a certain amount of profit to be made from any given quantity of seaweed; if this margin is spread among too many licencees, no-one will make a profit. One suggestion that has been made is that another two licences be issued when production rises to 350 tonnes and a further two at 500 tonnes; experience will be the best way to monitor the issue of licences.

Figure A4.2 Bales of seaweed ready for export from Solomon Islands

The dried seaweed is transported by scheduled ships (private shipping companies) to Honiara, the export port, or a different boat is arranged or chartered by the exporter to collect seaweed, especially when the stocks are high. Freight rates are negotiated, usually charged by volume (number of cubic metres occupied) but are dependent on the level of competition between shippers at the time. Sometimes charges vary by species; for example, a higher rate may be charged for bêche-de-mer. Shipping to the western part of Solomon Islands is regular. Waghena is usually serviced weekly but seaweed is not necessarily shipped every time – only if space is available. Shipping intervals for other places may vary, up to every 2 months.

Internal shipping can be expensive: fuel costs are high and costs can be higher in outlying areas if production is low. It is important to concentrate production in targeted areas so that shipments are large and economical. Normally the cost of transporting seaweed is about SI$0.40 per kg.

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The seaweed project is responsible for detecting the quality of seaweed that is exported overseas. Samples are randomly collected and analysed. Recently, the seaweed project has sent samples to CP Kelco in the Philippines and the results are used for comparison. Baling is done in Honiara at a density that allows 21–22 tonnes to be packed in a 20-foot container.

Regional marketing opportunities are being studied by the Solomon Islands' government. A study is still in progress to explore trade links with Kiribati; at present it appears that freight links will be a problem. There is interest to open links with Micronesia; trading with neighbouring Melanesian countries would involve the same products/crops and offers less advantage compared to Micronesia. For seaweed, there has been informal networking between Solomon Islands and Kiribati to compare prices and, if Fiji and others become involved, a formalised arrangement for cooperation would be welcomed by the Solomon Islands.

Export shipping

The overseas shipping port is Honiara. The shipping route to France is Honiara–Singapore–Le Havre. No other details are available from the present exporter. Tradco Shipping Ltd, Honiara, is the Solomon Islands' agent for some of the major container shipping lines including the following:

- Bank Line (Europe–South Pacific–Solomon Islands)
- Chief Container Service (New Zealand–Australia/Papua New Guinea–Solomon Islands)
- Greater Bali Hai (Korea–Japan–Pacific Island Service)
- Indotrans Asia (Pacific Islands–USA–Canada)
- New Guinea Pacific Line (Asia/Papua New Guinea/Solomon Islands)
- Sofrana Lines (New Zealand–New Caledonia–Australia–Papua New Guinea–Solomon Islands.

The following are some approximate cost estimates for shipping 20-foot containers.

- Honiara–Suva US$2000 + 16.5% fuel surcharge (bunker adjustment factor), 35 days transit time, monthly frequency
- Suva–Honiara US$1200 + 16.5% bunker adjustment factor, 20 days, monthly
- Honiara–Singapore–Cebu US$2500 total cost
- Honiara–Le Havre US$3800 total cost (US$3200 + bunker adjustment factor), 60 days, monthly
- Honiara–Hamburg US$3800 total cost, 50 days, monthly, then add approx. US$200 for Hamburg–Copenhagen.

Future plans

The CoSPSI Project funded by the European Union began in mid July 2005. The project will be supervised by a steering committee composed of representatives from the donors, government, farmers and others, a total of about eight people who will meet every 3 months. A project manager and two technical officers have been appointed, all of whom have wide experience in the practical aspects of seaweed farming.

Initial efforts will be concentrated on established sites where farming can be made more efficient. The aim is to concentrate on a few areas at first and gradually expand to new sites

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so that sufficient support can be available to farmers. Training will receive a high priority; CoSPSI will employ five people over the next 3 years to do training. If farmers can be trained as trainers, the current problem of needing extension officers to travel long distances could be solved. The importance of having a well-trained group of people by the time outside technical assistance ends, is recognised.

Targets have been set of 400 tonnes for 2005 and 1000 tonnes per year by the end of the 3-year project. Unfortunately, the target of 400 tonnes for 2005 could not be reached as Rarumana production was reduced due to the occurrence of epiphytes. Rarumana should recover by mid 2005 and normal production of 10–20 tonnes per month is expected in 2006.

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Appendix 5

Vanuatu – country report

Sompert Rena and Dennis J. McHugh

Past experience

Seaweed culture in Vanuatu began in 1998 and trials were conducted up to 2005, but none of the trial farms succeeded. Farming trials started on the main island, Efate, at five different sites. Results show that growth rates are suitable but expansion of the farms was problematic due to fish grazing and natural disasters such as cyclones. Trials were extended to two other islands, Santo and Malekula, but fish grazing was again a problem. In 2004, new seaweed seedlings were imported from Solomon Islands and retrials were conducted on Malekula but failed because of fish grazing.

The trials, although unsuccessful, raised awareness about seaweed farming, and coastal communities were very interested in growing seaweed but awaiting successful results from the Fisheries Department. Trials were conducted only in some of the major islands but there are many sites on the outer, smaller islands that could be tested for seaweed farming. The Vanuatu Fisheries Department has a limited budget for travelling so that trials on very remote islands are not possible. Additionally, a shortage of well-trained personnel is a major problem.

Fish grazing has been the main problem. Trials were first conducted using the off-bottom method but the seaweed was invaded by grazing fish. Floating bamboo rafts initially solved the problem but it returned with expansion of the farms, because once the population of grazing species is well-established around the floating rafts, newly transplanted seaweed seedlings will not grow well. Gill nets were used on Malekula Island to protect from grazers and this worked well, but again it is not something that farmers would be very willing to use, because it is expensive.

The Seaweed Project in Vanuatu did not lead to any large-scale farms but some seaweed was produced and drying was also conducted. Sun drying is not a problem if there is no rain. Because of very little experience of seaweed drying, sometimes the seaweed was dried until more than 60% of the moisture was removed. Sun drying could give good results if the method for determining the moisture content of the dried seaweed were improved.

Since this was a new initiative in Vanuatu, interest was generally high, especially among bêche-de-mer buyers. One company offered to do a free test-drying in its bêche-de-mer dryer but found the heat was too strong and almost 95% of the moisture was removed.

Farm sites for trials

Seaweed-farming sites in Vanuatu included:

- shallow water behind coral reefs – Paunagisu (Efate)
- deep water in bays – Uri Island (Malekula), Eratap, Lelepa Island and Pango (all on or near Efate)
- lagoon – Erakor (Efate).

A trial in Paunagisu Lagoon gave daily growth rates up to 8.9% but as the farm expanded herbivorous fish caused severe problems. The effects of pest weeds, high sea-surface

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temperature and social factors were only minor. Any future trials in other areas will need to measure seasonal variation in growth rates.

The only seaweed project in Vanuatu was funded through the Project Development Fund (PDF). This is a fund for the Vanuatu Government, administered by the Forum Fisheries Agency.

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