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Advances in seaweed aquaculture among Pacific Island countries

Timothy Pickering
Marine Studies Programme, The University of the South Pacific, Private Bag, Suva, Republic of Fiji

*Author for correspondence: e-mail: pickering_t@usp.ac.fj

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Abstract

Recent developments in the seaweed aquaculture industries of Pacific islands are reviewed from the perspective of technical, production, geographic, marketing, species-diversification, socio-economic and institutional-support advances. Successful commercial aquaculture of seaweeds in the Pacific island region is presently based on two species, *Kappaphycus alvarezii* in Kiribati, Fiji and Solomon Islands, and *Cladosiphon* sp. in Tonga. It is possible that other candidate species could be considered for aquaculture for food (e.g. *Caulerpa racemosa* or *Meristotheca procumbens*) or extraction of agar (*Gracilaria*), although further research on the technical feasibility of aquaculture methods to produce sufficient tonnage, and particularly on their marketing, is needed. While the Pacific island region may be environmentally ideal for seaweed aquaculture, the limitations of distance from main centres and distance from markets, vulnerability to world price fluctuations, and socio-economic issues, make it unlikely that the Pacific Island region will ever rival the scale of Asian seaweed production. Regional seaweed farming can nevertheless make a useful contribution to supplement other sources of income, and can be an important economic boost for isolated outer islands where few alternative income-generating opportunities exist.

Introduction

The "Pacific Islands region" for the purposes of this paper comprises those countries and territories that are members of the Secretariat for the Pacific Community (SPC) and include the Federated States of Micronesia (Yap, Chuuk, Pohnpei and Kosrae), the Northern Mariana Islands, Marshall Islands, Nauru, Palau, Kiribati, Papua New Guinea (PNG), Solomon Islands, Vanuatu, New Caledonia, Fiji, American Samoa, Samoa, the Cook Islands, French Polynesia, Niue, Pitcairn, Tokelau, Tonga, Tuvalu, and Wallis and Futuna. Uwate et al. (1984) and Adams et al. (2001) have published reviews of aquaculture activities in the Pacific Islands region, and South and Pickering (2006) includes mention of the main seaweed aquaculture activities. Currently there are two species which provide a basis for commercial aquaculture; the red seaweed *Kappaphycus* Doty, and the brown seaweed *Cladosiphon* sp. The latter is known to occur naturally in Tonga and in New Caledonia; all cultured stocks of *Kappaphycus*, however, originated from outside the region.

Kappaphycus farming has been strongly promoted in the Pacific region because it requires a low level of technology and investment, can be operated at the family level, has relatively little environmental impact, does not require refrigeration or high-tech post-harvest processing within the country, and is normally compatible with traditional fishing and other subsistence uses of the inshore environment. It is a potential source of income and employment in rural areas with few other income-generating opportunities, and in particular is an activity that can provide income for women.

South (1993) reviewed the farming of *Kappaphycus* in the Pacific Islands up until the early 1990's, and reviews since then include Ask (2003), Ask et al. (2003c), Luxton and Luxton (1999), Luxton (2003), Pickering (2003) and South and Pickering (2006).

Various difficulties affecting the initial attempts to cultivate *Kappaphycus* in the 1980's (e.g. Tonga, Solomon Islands, Federated States of Micronesia and Tuvalu) led to the activity being abandoned in most of these countries (South, 1993).

Early results in Fiji proved encouraging, and this led to the establishment of an industry with total production of 684.4 t between 1985 and 1990 and highest yearly production of 277 t in 1987, however for a range of reasons reviewed by Ask et al., (2003c), Luxton (2003) and South and Pickering (2006) production ceased in 1993. A re-vitalization of the Fiji industry from 1997 onwards is also reviewed by Ask et al. (2003c). Annual seaweed production under this new initiative rose to 419 t by 2000, but levels have not reached the projections forecast by Ask et al. (2003c) and production is now declining. Feedback from farmers during 2003 indicated a loss of enthusiasm due to long delays in payments for seaweed produced; in some cases as long as 6 months (Pickering et al., 2003).

Seaweed production in the region has been both greatest and most consistent in Kiribati (Why, 1987; Uan, 1990; South, 1993; JICA, 1996). Commercial *Kappaphycus* cultivation commenced in the mid 1980's initially in the Gilbert Group, and later returned to the Line and Phoenix Groups where the early trials had taken place (JICA, 1996). In 1991 the commercial farming and marketing activities were handed over to the 100% government-owned Atoll Seaweed Co. Ltd. Production in recent years has been greatly dominated by a single atoll, Tabuaeran (Fanning Island) in the Line Islands, which has oceanographic conditions suited to rapid plant growth, and no copra industry owing to aged palms.

This paper reviews recent developments that might be considered "advances" in seaweed aquaculture among the countries and territories of the Pacific Islands region, including not only "technical advances" but also "production", geographic", "marketing", "species-diversification", "socio-economic" and "institutional support" advances.

Technical advances

The Pacific Islands' *Kappaphycus* industry has its origins in the Philippines and uses similar methods (McHugh & Philipson, 1989; Adams & Foscarini, 1990), so there is little to report from the Pacific region that could be considered as substantive "advances" in cultivation technology compared with Asian practices. Three principal farming methods have been tried in the South Pacific: off-bottom (fixed monofilament lines between posts driven into the substratum); floating rafts; and floating long-lines (Prakash & Foscarini, 1990; Ask 1999). Commercial cultivation in Fiji, Kiribati and Solomon Island is nowadays almost entirely by the off-bottom method. Kiribati also uses net cages for seed-stock farms, to protect plants from fish grazing.

Recently there has been a resurgence of interest in the raft method of cultivation in Solomon Islands, to reduce grazing by fish. Rafts are relatively easy to move around, to find locations where fish grazers are less abundant; placing rafts in depths of at least 5–10 m often gives good results (Alex Meloty pers. comm.). Another theoretical advantage of rafts is that a wider choice of farm sites becomes possible, because seabed type and water depth are no longer site-selection issues. In Kiribati trials of PVC-pipe rafts are now being carried out in the Gilbert Group on Abaiang and Nuotaea atolls, especially in areas where water flow is lacking (Ienimoa Kiatoa, pers. comm.). The disadvantage of rafts is that they require more labour and materials to set up (in Kiribati, even bamboo would need to be imported). In terms of their advantages, grazing by fishes on Pacific Island farms occurs at levels that can be tolerated for the most part, and there is currently no shortage of suitable reef space for off-bottom culture. The ultimate test of whether or not rafts are an improvement over off-bottom cultivation will lie in the proportion of farmers that willingly adopt this method of cultivation.

A recent advance in Asian cultivation technology is the Made Loop, described by Ask et al. (2003a) as a simple, low-tech and rapid way of attaching and harvesting seaweed plants on lines. These lines take longer to make than raffia tie-ties but are said to last longer. Furthermore, harvest is quicker, material cost is no higher, and seaweed quality is higher since less stray tie-tie material tangles in extraction machinery. Information about the Made Loop was incorporated into Pacific Island regional training materials, and most seaweed project officers in Fiji and Solomon Islands now know about it. Farmers in Fiji, however, are almost entirely using the raffia tie-tie method because Government provides farm materials to farmers and has made a multi-thousand-dollar investment in a special imported UV-resistant raffia tie-tie material which is still available in bulk quantities. Solomon Islands farmers tried out the Made Loop method after demonstration at SPC-funded training workshops held in November 2002, and many in Rarumana and Waghena are now using this method. It has not yet been tried in Kiribati as they only recently heard about it.

The main technical advance current in the Pacific Islands region is policy and research to develop better methods for translocation and quarantine of *Kappaphycus* between countries. There are intentions to introduce present varieties in the region to new locations, and to introduce new varieties from outside the region, but few guidelines are in place to manage and reduce environmental risks. SPC's Regional Aquaculture Programme, which advocates that member countries adopt responsible aquaculture practices in line with FAO guidelines, is working to conduct Import Risk Assessments (IRA's) and develop regional templates about translocation procedures for a range of aquacultured commodities including *Kappaphycus*. This has raised some research requirements, for example on the efficacy of treatments to remove other "hitch-hiker" species from translocated *Kappaphycus*, which are presently being fulfilled by the Institute of Marine Resources at the University of the South Pacific (Sulu & Pickering, Pers. comm.).

Production advances

Only in the Solomon Islands is production of *Kappaphycus* presently "advancing" (Table 1). A Fisheries Department/European Union Rural Fisheries Enterprise Project (RFEP), initially aimed at commercialization of rural artisanal fisheries, changed its focus in 2001 from finfish to seaweed in order to better meet the project's aims of "poverty alleviation through income generation, and empowerment of women through fisheries" (Rory Stewart, pers. comm.). By the first half of 2004 there were 250 seaweed farmers (Alex Meloti, pers. comm.), mainly at Rarumana in the New Georgia Group (80 farmers) and Waghena in Choiseul (170 farmers), who in the first 5 months of 2004 alone produced 51 t of dried *Kappapycus* (Table 1). Grazing by fishes has been a persistent but tolerable problem, while more serious have been difficulties in inter-island shipping, and unrealistic expectations in price created by statements of some politicians. These difficulties aside, the combination of a tightly-run seaweed project able to resist political pressures in the allocation of its resources, careful selection of appropriate private-sector partners for buying, and selection of communities who see seaweed farming as a worthwhile livelihood, appear important factors contributing toward this good start in Solomon Islands seaweed production.

In Fiji and in Kiribati, *Kappaphycus* production has recently been declining (Table 1). In Fiji, momentum was lost owing to lack of clarity and disagreement between the Department of Fisheries and the company nominated as sole exporter of Fiji seaweed, REL Ltd, over the extent of each other's responsibilities to support the fledgling industry. REL Ltd has adopted the practice of regarding the prevailing FJ$ 0.50 (US$ 0.27) beach price as a "landed in Port of Suva" price, leaving either farmers or tax-payers to cover the freight charges from outer islands to the baling point in Suva. Payment to farmers for seaweed delivered has also been very late at times, sometimes by up to 6 months (Pickering et al., 2003), which makes farmers lose heart and cease production. Government support for seaweed has been spread very widely and at times diverted to communities or projects (such as road-building to Kiuva Village) selected more for political and electioneering reasons rather than focussed upon a select few communities where seaweed is most likely to succeed. Mainly for these reasons, only 20 t was produced in 2003. Indications are that seaweed buying and marketing for the current project in Fiji may have been privatised at too early a stage and to a company too lightly capitalised, before sufficient volume had been built up to make the industry viable. Government needs to again review the current industry, learn from mistakes, and decide if it is still worth using tax-payers money to build up production to a level where there can be a smoother transition to a stand-alone industry run by the private sector.

Production in Kiribati has fluctuated widely but has always remained in the hundreds of tonnes. The centre of production moved away from the Gilberts Group to the Line and Phoenix Groups, with Tabueran providing the bulk of national output. The seaweed industry thus

Table 1. Commercial production (t) of *Eucheuma*/*Kappaphycus* from four Pacific Island countries between January 1983 and June 2004 (adapted from South 1993c, JICA 1996, Derrick Pendle pers. comm., Ienimoa Kiatoa pers. comm., Sam Mario pers. comm., Rory Stewart pers. comm., Alex Meloty pers. comm.).

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mid-2004
Fiji	–	–	30.0	173.4	277.0	60.3	80.3	87.4	55.0	60.0	–	–	–	–	–	19.8	300.0	418.6	240.0	80.0	20	13.7
Kiribati	–	–	24.9	66.0	30.0	45.1	149.2	637.0	1019.7	434.0	205.0	396.0	654.9	1249.2	924.4	742.2	1170.3	1437.8	1158.2	530.8	488.0	500
Tonga	3.0	11.0	5.0	2.0	1.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Solomon Islands	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.6	2.8	16.9	51

keenly felt the effects of alternative tourism-related economic benefits (described in Low, 2004) since Norwegian Cruise Lines (NCL) vessels began weekly calls to Tabuaeran in 2001. To counter this, Atoll Seaweed Company Ltd has embarked on socio-economic study of farmer motivations at Tabuaeran (Antoine Teitelbaum, pers. comm.) and on a strategy to re-vitalize former farming locations in the Gilberts Group closer to the main port at Tarawa (Derek Pendle, pers. comm.). There are also signs that, through reflagging of its Hawaii-based vessels to exempt them from the US Jones Act (Magin, 2003), during 2004 NLC ship visits to Tabuaeran will decline or even cease. Kiribati production is recovering and is likely to continue to fluctuate around 1000±500 t for the foreseeable future.

Production of *Cladosiphon* Kützing in Tonga, largely from a highly seasonal fishery on the island of Tongatapu, is said to be around 400 t (wet) per year (Anon, 2004). This is salted and sent by shipping container to Japan where it is sold as the edible seaweed known to Japanese as *mozuku*. The fishery now appears fully developed, with three companies involved in export, each trading about 100–200 t annually. Aquaculture trials were conducted in Tonga in order to increase production from the resource, and to try and extend the growing season. The farming method involves placing nets similar to *Porphyra* (*nori*) nets on the seabed, which become seeded by natural spore-fall. Aquaculture of *Cladosiphon* sp. in Tonga is now said to be at an advanced trial stage (Silika Ngahe, pers. comm.).

Geographic advances

There are on-going efforts to extend the geographical range of active seaweed farming, plus a gradual shift in the locations where most farming occurs. The first phase of Fiji's industry in the mid-1980's focused on the north coast of the main island of Viti Levu (Ra province), an area offering alternative livelihoods like sugar cane, tourism and commercial fishing. By the early 1990's most production was from the isolated village of Kiuva in Tailevu province, or from Cakaudrove in Vanua Levu, where the main alternatives are copra, fishing or subsistence agriculture. From 1997 onwards the islands of the southern Lau group have featured strongly, in particular the isolated island of Ono-I-Lau (the "Tabuaeran" of Fiji). It is thus clear that communities may be ripe for the introduction of seaweed farming activity if alternative livelihoods are limited to copra or subsistence agriculture and fishing.

Similarly, in Kiribati the industry began in the Gilbert Group of islands but in recent years 90–99% of national production has come from Tabuaeran in the Line Islands (Atoll Seaweed Company, pers. comm.). Efforts are now underway to re-establish farming in the Gilberts Group. In the Solomon islands production is presently centred on two places in Western Province (Rarumana, and Waghena), but cultivation in northern Malaita Island is well underway and the RFEP has mapped out a strategy for progressive introduction of farming to communities in Central District (Guadalcanal, Gela, Savo and Russell Islands) and Makira Island. Other countries like Vanuatu, Republic of Marshall Islands and PNG now have seaweed projects in their planning stages.

Species-diversification advances

The mainstay of Pacific Island seaweed production has been the *tambalang* variety of *Kappaphycus alvarezii* (Doty) Doty ex P.C. Silva. However, its thick thalli mean that it can take 3–5 days to sun-dry and this can be problematic in districts with higher average rainfall. To counter this, a variety of *K. striatum* (Schmitz) Doty ex. P. Silva *(sacol)* was introduced to Fiji during its second phase of industry development because the thalli are thinner and dry faster (in as little as 24 h). In 2002 some of this Fiji *sacol* material was taken to Solomon Islands and tested there. The *sacol* variety is more popular with buyers because of its lower moisture content and less probability of spoilage from rain while drying. The *tambalang* variety is much preferred by farmers, however, because plants are thicker and heavier, thus yielding more weight of seaweed per line (a unit of effort) than *sacol*.

As part of efforts to re-vitalize seaweed farming in the Gilberts Group of Kiribati, Atoll Seaweed Company has been looking for a seaweed variety better suited to environmental conditions there. With assistance from their overseas buyer CP Kelco, they have plans to introduce a new variety of *K. alvarezii* during 2004 (Antoine Teitelbaum, pers. comm.).

The development of a *Cladosiphon* sp. export industry in Tonga now brings the total number of commercially-aquacultured seaweeds in Pacific Island countries to two. Other edible species, such as species of *Caulerpa*, *Codium* (Chlorophyceae), and *Gracilaria*, *Hypnea* and *Halymenia* (Rhodophyceae), are already commercialized as artisanal fisheries in various places (South and Pickering, 2006). One edible

species found in Rotuma Island (Fiji) is the red seaweed *Meristotheca procumbens* P. Gabrielson et Kraft (N'Yeurt, 1996: 416). These currently have draw-backs either for aquaculture (difficult to culture) or as exports (either too perishable, or little market demand).

Marketing advances

A feature of external marketing arrangements in the Pacific region to date has been for a seaweed-producing country to secure a long-term contract with an overseas buyer. This provides producers with some degree of certainty about the range of export prices they can expect over the medium-term, and helps smooth any fluctuations in world prices for dried *Kappaphycus*. In Fiji the buyer is FMC Corporation, who set a price by Memorandum of Understanding (MOU) with the Fiji Government at US$ 0.55 per kg FOB. The local company nominated by FMC under the MOU to have exclusive right to export dried seaweed from Fiji is a private company, REL Ltd (newly set up for this purpose), who now pay USD 0.27 for seaweed once it has been brought to the main island of Viti Levu (it is no longer a "beach price"). In Kiribati the company that exports seaweed is the Government-owned Atoll Seaweed Company Ltd, which pays farmers a beach price of AU$ 0.60 (USD 0.42) per kg (of which AU$ 0.15 is a government subsidy), and is contracted to sell to CP Kelco.

A new development, then, is the situation in Solomon Islands where presently there are two local private companies (long-established in other local enterprises) gearing up to purchase dried seaweed from farmers (beach price is currently US$ 0.26 per kg) and export it. These companies have not been placed under any obligation to sell to any particular international buyer so are free to strike their own deals. Currently, both are choosing to sell to Degussa. Under a seaweed marketing plan set up by the RFEP, there will be two export licences granted until production reaches 300 t per annum, when a further licence will be granted. The situation will be further reviewed if production exceeds 500 t (Rory Stewart, pers. comm.).

Both Kiribati and Solomon Islands have succeeded in negotiating export prices superior to that enjoyed by Fiji. Though these are contract prices which are commercially sensitive and not readily available, it is believed that both countries now receive prices in the range of US$ 0.68–0.73 per kg. In addition, they are selling the dried seaweed with its salt and at 35% water content, compared with the Fiji exporter REL Ltd who must remove loose salt and achieve 30% water content.

In contrast to the sometimes volatile nature of Asian marketing arrangements, Pacific Island producers have tended to prefer stable, long-term and trusting relationships with a particular buyer. There have been and always will be maverick marketeers who urge that spot-market prices be taken, but cooler heads see the benefits of price stability and value an on-going buyer-supplier relationship. Trust is seen as important, given the general difficulty in obtaining accurate market intelligence upon which any price adjustments might be negotiated.

Export of *Cladosiphon* sp. from Tonga is now well-established as a profitable but highly seasonal fishery employing several hundred people, with three private companies involved (Silika Ngahe, pers. comm.). The main product is salted plants bound for the edible-seaweed market in Japan. *Cladosiphon* sp. has also been used as an ingredient in very expensive cosmetics and face creams (Hideyuki Tanaka, pers. comm.). *Cladosiphon* sp. is also found in New Caledonia where a local businessman, inspired by Tonga's example, has been experimenting with aquaculture techniques.

The potential of other edible seaweeds as commercial products merits further study. The possible cultivation of *Meristotheca procumbens*, a highly desirable food item in Japan (H. Tanaka, FAO/UNDP Suva; pers. comm.) falls into this category. Another candidate is *Caulerpa racemosa* (Forsskål) J. Agardh, a favourite food item in most Pacific Island countries and a high-value edible species in Japan. There is a potential to develop the fishery for the export market, although supply and post-harvest problems (e.g. spoilage during transport) need to be overcome. Niche markets also exist for seaweed products like soaps, cosmetics and medicines. Commercial soap manufacturers in Fiji like Sandollars Ltd and Mokosoi Ltd now offer a range of seaweed/coconut soaps which use farmed *Kappaphycus* as an ingredient, and these are sold in tourist hotels, airport duty-free stores and gift shops. Opportunities for seaweeds to provide the basis for household-level small businesses in the Pacific region making soaps, cosmetics and medicines are being explored (Novaczek, 2001a,b; Novaczek & Athy, 2001; Novaczek, 2003).

Socio-economic advances

The main advances in socio-economic aspects of seaweed aquaculture in Pacific Island countries have been

firstly an increased appreciation of the importance of socio-economic research in addition to technical research, and secondly better understanding of the socio-economic conditions associated with successful seaweed farming projects. Initially, during the 1980's, communities were chosen for seaweed projects purely for biological/environmental reasons. For example in Fiji the areas chosen were in Ra Province where there are strongly competing livelihoods, and project managers expected farmers to spend several days away from home and far out at sea on platforms erected near favourable growing sites (Sam Mario, pers. comm.). Later, a wide range of communities was chosen for seaweed projects and supported through provision of fibreglass punts and 40 hp outboard motors. As soon as possible, many farmers abandoned seaweed farming and used the boats for other pursuits like fishing for beche-de-mer.

Such experiences across the Pacific, in Asia and in Africa, led FMC Corporation to support post-graduate research on seaweed socio-economics at the University of the South Pacific, to identify the critical factors (alternative livelihoods, population demographics, geography, local traditions, etc.) which would enable better success in allocating available project resources for seaweed farming development. The results of this research will be reported separately (Namudu & Pickering, in press). In the Solomon Islands RFEP funded a social and economic impact assessment of seaweed development on the Rarumana community to determine the scope for future expansion and review the needs for further donor support (Wale, 2003). The Atoll Seaweed Company in Kiribati has commissioned two recent studies, one for Tabuaeran to clarify the reasons for the decline in production and develop strategies to overcome threats to seaweed production from alternative livelihoods, the other to identify socio-economic factors limiting seaweed production in the Gilberts Group (Antoine Teitelbaum, pers. comm.).

Through such research, and by trial and error, a better picture is emerging of the requirements for successful seaweed aquaculture projects in the Pacific region. Selection criteria being applied by RFEP in Solomon Islands to identify further areas for farm development have three main steps: (1) to be selected, a community should firstly be near farm sites where environmental conditions are conducive to good seaweed growth, (2) demographically, the community should be large, and (3) the availability of alternative livelihoods should be considered, for example in rural Solomon Islands seaweed farming can easily compete with copra, fishing and agriculture but not with logging (Rory Stewart,pers. comm.).

Similarly, of the business models possible for seaweed farming ventures, one has emerged a clear winner. Three main possibilities exist; (1) community (e.g. church) or tribe/clan groups farming cooperatively, (2) company farms, or "contract farming" (COFA), owned by buyers and operated by labour hired on a daily wage basis, and (3) individual or household (nuclear family) operated farms. Compared with the first two, the third (household farms) has been by far the most successful and dominates the industries in all three countries that have industries. Efforts have been made to establish COFA farms in the Gilbert Islands of Kiribati to revive production there and counter the downturn at Tabuaeran. However, the success of the COFA model in achieving this goal has not yet been demonstrated (Antoine Teitelbaum, pers. comm.).

Institutional support advances

Over the last four years, the region has advanced in terms of institutional support for aquaculture at the regional level. SPC obtained Australian AUSAid funding to set up a Regional Aquaculture Programme, which coordinates the provision of technical support and training to member countries, acts as a clearing house for information on aquaculture, and coordinates regional mechanisms for priority-setting in terms of the types of aquaculture to be supported. A regional aquaculture strategy links SPC with long-term applied research on commercial feasibility by Worldfish Centre's regional office based in Noumea, New Caledonia, and with short-term applied research and post-graduate student research at the Marine Studies Programme and Institute of Marine Resources of the University of the South Pacific (USP). *Kappaphycus* has been identified as a priority commodity for regional institutional support under these arrangements. Additionally, USP has enjoyed support for aquaculture training activities under the Canada-South Pacific Ocean Development Program Phase II (C-SPODP-II).

The Food and Agricultural Organisation's (FAO) Technical Co-operation Programme (TCP) based in Apia, Samoa, responded to increasing interest in seaweed farming by funding a consultancy to assess the feasibility of seaweed farming in selected other Pacific Island countries (Luxton, 2002). This led to an FAO TCP project to establish *Kappaphycus* farming in Marshall Islands, and to prioritization of Milne

Bay Province (MBP) in Papua New Guinea for a seaweed project (Kinch et al., 2003). The United Nations Development Programme (UNDP) has, separately, contracted non-governmental organisation Conservation International (CI) to execute a Milne Bay Community-based Coastal and Marine Conservation Programme (CMCP) and this has an alternative income generation component, under which seaweed farming is now being considered .

Support, under the regional aquaculture strategy for seaweed farming, has come in the form of training workshops and production of training materials. A training video on the seaweed farming techniques typically used in Fiji was produced by the Marine Studies Programme at USP in 2003 with funding from C-SPODP-II, and is available in English, Fijian and Solomon Island Pidgin languages, and the much-in-demand FMC Cottonii and Spinosum Cultivation Handbook (Ask, 1999) has been reprinted. SPC produced its own video to complement the USP one, through its focus on raising awareness in communities about the potential socio-economic benefits of seaweed farming, and produced a farming manual in a comic-book format. A spreadsheet-based interactive economic model has been developed jointly by USP, SPC and Queensland Department of Primary Industry to predict the viability of different seaweed farming scenarios according to user data inputs, or to compare the benefits of seaweed farming with alternative livelihoods like copra, artisanal fishing or agriculture (Johnstone & Pickering, 2003).

Donor interest in seaweed farming projects under bi-lateral arrangements in the region is also increasing. Currently, the most active in their support are the European Union in both Kiribati and Solomon Islands, and AUSAid in Solomon Islands (Rory Stewart, pers. comm.).

Conclusion

Successful commercial aquaculture of seaweeds in the region is presently based on two species, *Kappaphycus alvarezii* in Kiribati, Fiji and Solomon Islands, and *Cladosiphon* sp. in Tonga. It is possible that other candidate species could be considered for aquaculture for food (e.g. *Caulerpa racemosa* or *Meristotheca procumbens*) or extraction of agar (*Gracilaria*), although further research on the technical feasibility of aquaculture methods to produce sufficient tonnage, and particularly on marketing, is needed.

While the Pacific Island region may be environmentally ideal for seaweed aquaculture, the limitations of distance from main centres and markets, vulnerability to world price fluctuations, and socio-economic problems, make it unlikely that the Pacific Island region will ever rival the scale of Asian seaweed producing nations. Seaweed farming from this region can nevertheless make a useful contribution to supplement other world sources, and it can be an important economic boost for the less-developed outer islands of Pacific nations where few alternative income-generating opportunities exist.

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