

Supply chain and marketing of seagrapes, *Caulerpa racemosa* (Forsskål) J. Agardh (Chlorophyta: Caulerpaceae) in Fiji

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Introduction

The edible seaweed *Caulerpa racemosa* (Forsskål) J. Agardh (Class Bryopsidiophyceae, Order Bryopsidales, Family Caulerpaceae) is widely consumed in Fiji (South 1993a, 1993b, 1993c; South and Pickering 2006). The Fijian name most commonly used is *nama* (South *et al.* 2011). While women, men and children harvest *Caulerpa racemosa*, mainly in the Western and Northern Divisions, only women manage this fishery.

Previous research reports have indicated that *C. racemosa* is harvested mostly at subsistence level and is consumed locally, although some is sold at urban markets where the income derived supplements household income. Key fisheries areas include the Yasawa Islands, Labasa, Tavua and Rakiraki where *C. racemosa* is abundant and easily accessed by harvesters. These sites, among others, supply the municipal markets in Fiji. (Morris *et al.* 2014).

The health benefits of *Caulerpa* include the low calorie content; iodine, which keeps the thyroid gland healthy and thus reduces the chances of goitre and high fatty acids, chlorophylls *a* and *b*; and β -Carotene (Paul *et al.* 2014).

Other research includes taxonomic studies by South and N'Yeurt (1993) on the genus *Caulerpa* in Fiji, and the post-harvest and export potential of *C. racemosa* were reported by Chamberlain (1997) and Chamberlain and Pickering (1996). Further studies on *Caulerpa* as a food potential and marketable food product for export were reported in Novacek (2001) and Pickering and Mario (1999). In addition, Paul *et al.* (2013) reported on the potential of *C. racemosa* for aquaculture production, and preliminary studies have been conducted on preservation for extended shelf-life (Lako 2012). There is, however, very little information available on harvesting, marketing, value and preservation.

Methodology

Harvesting and supply chain data gathered from selected harvesting sites in Fiji were analysed using probability and trend analysis.

The supply chains and marketing surveys were carried out using semi-structured interviews based on questionnaires developed by Department of Fisheries personnel in Fiji. The questionnaires were either translated into the local



Caulerpa racemosa growing in the Yasawas

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languages or the interviews were carried out by surveyors who spoke the local languages.

The harvesting and marketing sites for *Caulerpa* (Figure 1) were identified from preliminary market surveys conducted in 2010. Site surveys were carried out during the months of July, October and November 2011. The harvesting sites for *Caulerpa* were Gunu, Namuaimada, Navolau, Vatutavui, Lomowai, Vatulele, Vusama, Sasake, Lakeba and Dromoniku. The marketing sites were Lautoka, Nadi, Suva, Nausori, Rakiraki, Mana Island, Tavua, Ba, Sigatoka, Labasa and Savusavu.

Anecdotal information from shipping personnel, fisheries officers and market vendors suggest that other areas in Lomaiviti (Nairai and Batiki Islands) and Tailevu, occasionally supply *nama* to urban markets, depending on availability of transport.

Results and discussion

Marketing, quantities and value

The harvesting and marketing information for *Caulerpa* in Fiji are presented in Figure 1 and Table 1. In the Western Division, approximately 70% of the crop is from the Yasawa Islands. While *Caulerpa* is sold in a number of markets, most of it is sold in the main municipal market in Suva. It is sold by the portion (in heaps), at prices ranging from FJD 2.00–4.00 per heap, the weight of which ranges from 250–300 g. The plants are generally offered to customers on plastic plates, but in Suva and Nausori it is accompanied by a small plastic bag or cup of fermented coconut and fresh chilli. The majority of customers are local people.

The peak marketing days of *Caulerpa* in Fiji are Fridays and Saturdays. Fresh, harvested stock arrives in the main markets (Suva and Lautoka) by Thursday afternoon. Some harvesters do their own retailing but most stock is sold direct to wholesalers and market vendors in Lautoka, Nadi, Sigatoka and Suva. In contrast, most harvesters located on Vanua Levu, Fiji's second largest island, retail their own stock directly with little wholesaling.

Harvesting, storing and conservation activities

Results of the interviews suggest that harvesting is limited by the tide, weather and stock status. According to the harvesters, *Caulerpa* is more abundant during the cooler months (June to September). The production capacity of the main harvesting beds has not been studied, and the population density and biomass at these sites is not known.

The most common method of storing harvested *Caulerpa* is to put it in potato or sugar sacks with or without leaves in a cool place. Post-harvest storage ranges from one to three days, depending on distance and method of transport to the market. Women in Dromoniku in Savusavu use the wound-healing method, which involves keeping the bag of *Caulerpa* soaking in the sea overnight. According to these women, this method keeps *Caulerpa* fresh for longer. The introduction of improved post-harvest treatment by the use of proper wound-healing technology would prolong the life of the crop from harvester to consumer.

In Labasa, upright branches are separated from the runners, from which they arise, either at home or at the market and wrapped in banana or pawpaw leaves before sale. Losses vary between sites and range from half a bag to

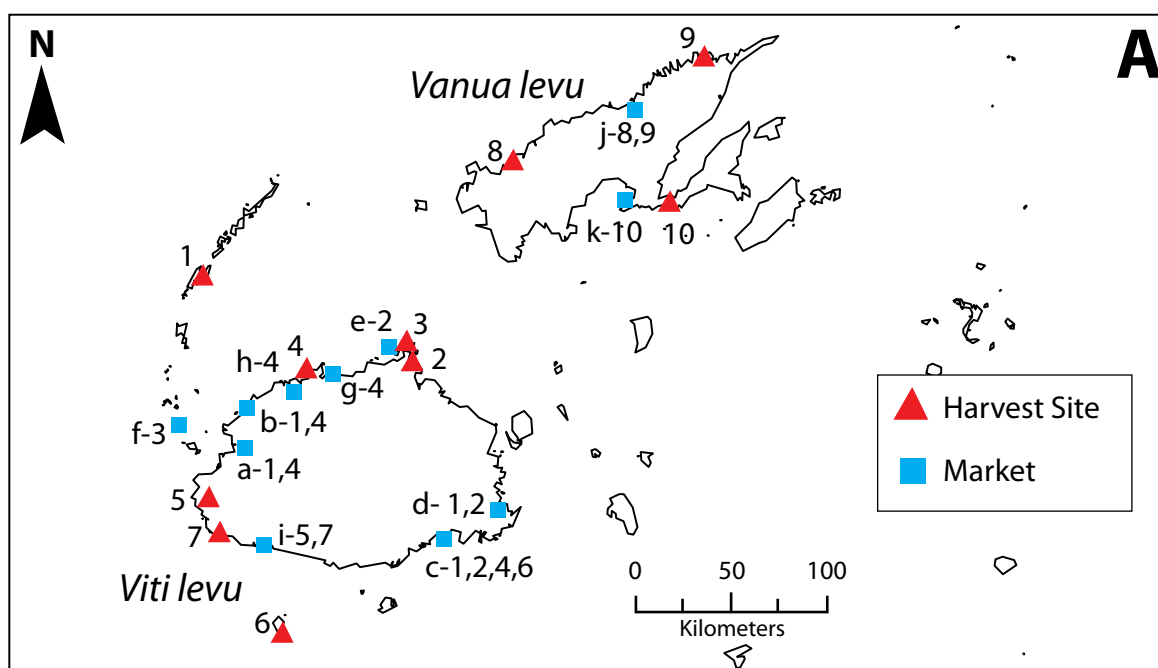


Figure 1. Harvesting and marketing sites for *Caulerpa* in Fiji
 Fiji harvesting sites/villages: 1- Gunu; 2 - Namuimada; 3 -Navolau; 4 - Vatutavui; 5 - Lomowai ;
 6 - Vatulele; 7 - Vusama; 8 - Sasake; 9-Lakeba; 10-Dromoniku
 Marketing sites: a - Lautoka; b - Nadi; c - Suva; d - Nausori; e - Rakiraki; f - Mana Island;
 g - Tavua; h-Ba, i - Sigatoka; j - Labasa; k - Savusavu.
 Note: j-8,9 indicates that the marketing site j sells marine products collected in harvesting sites 8 and 9



Market vendor selling seagrapes in Suva

one bag (approximately 18–35 kg) during each period of storage on site and at the market. This equates to approximately 35–70 kg per week.

The careful conservation of harvesting sites (as in the Yasawa Islands) over long periods of time by local villagers would be a good measure, allowing predictable harvesting. Sustainable harvesting (i.e. not removing the runners) is another important practice carried out by most harvesters, mainly in the Yasawa Islands. The women understand that harvesting of runners is unsustainable and affects the *Caulerpa* stock in their collection area.

Conservation of sites is to a certain extent in the hands of the harvesters themselves, but the sites are not formally protected. Harvesting is part of a traditional activity that includes in-shore gleaning for shells and sea cucumber, and fishing for daily meals.

Loss

The fact that harvesting of *Caulerpa* is limited to a few main sites in coastal communities means that the industry is potentially vulnerable to loss of product. Losses may be due to the combined impacts of unsustainable harvesting and natural phenomena, such as storm surges and cyclones, resulting in the sites becoming unproductive. Preliminary results from a Fiji biomass survey show that this has been the case in Rakiraki.

The future of the industry

The sustainability of the *Caulerpa* industry in Fiji depends on gathering more data on the carrying capacity of important harvesting sites such as the Yasawa Islands. The identification of new potential sites for both wild and farm harvests, such as in the Lomaiviti and Lau groups, would also be important for the sustainability of the *Caulerpa* industry. The training of harvesters and fisheries officers in creating awareness about the protection of harvest sites, the importance of the industry in sustaining livelihoods, and management issues is also vital for the growth and sustenance of the industry in the future.

The market and supply chains

The supply chains in Fiji are shown in Figure 3 and Table 1. From surveys conducted at ten sites in six areas of Fiji, a total of some 150 harvesters (part-time and full-time) were recorded. Production from these ten sites ranges from 5 kg to 2,100 kg per week, with an average of 323 kg per week. The main production areas are the Yasawa Islands, followed by Labasa, Tavua and Rakiraki.



Seagrapes being sold at Lautoka market

Caulerpa harvesting and sale provide a part-time subsistence occupation for many villagers in Fiji, with a potential maximum income of more than FJD 200 per week for harvesters. The industry provides only a small proportion (< 1.0%) of the overall national income from the inshore fishery, and *Caulerpa* sales are overshadowed by the sale of other seaweeds in some places in Fiji (South 1993b). *Caulerpa* is the main marine commodity harvested in Yasawa Islands, Rakiraki and Tavua, but in Sigatoka, Labasa and Savusavu, other marine commodities are of higher priority.

Compared with other commodities, the supply chains are simple, and in Fiji middle-men are routinely used. Road-side sales of *Caulerpa* do not routinely occur in Fiji, and the

crop goes directly to market with only a three-day shelf life because of the difficulty of being able to provide wound-healing as a post-harvest process. Shelf-life could be substantially increased if harvesters were to use an appropriate wound-healing methodology, such as holding in aerated seawater for up to 48 hours after harvesting. The lack of sustainable harvesting at some sites is a potential threat to the long-term survival of the beds.

The market supply chains show that the loss of crop occurs during handling between harvesters and consumers. This is partially a result of inadequate quality control. The port and the market serve as the consolidation point for middlemen, who then carry out the distribution to other local markets, some resorts and, occasionally, to road-side stalls.

The marketing system varies according to site. Women either sell *Caulerpa* through wholesales to middle-sellers (Yasawa Islands) or through retail sales (Sigatoka, Labasa and Savusavu) or through a combination of wholesale and

retail sales (Rakiraki and Tavua). The middle-sellers who buy *Caulerpa* from Yasawa then sell at wholesale and retail prices to other middle-sellers and consumers at municipal markets, restaurants and hotels/resorts. In some cases, harvesters take turns at retail sales in the markets.

Pricing and expenses and income

Results from this study show that *Caulerpa* production is around 115.578 tonnes per year, valued at FJD 346,734.00 (Note that the actual production figure could be higher as production from sites not visited is excluded). This figure may fluctuate depending on prices of *Caulerpa* and the amount of *Caulerpa* collected.

Overall, the price of *Caulerpa* ranges from FJD 2.00–4.00 per kilogram. Wholesale prices range from FJD 30–100 per bag, depending on the quantity of *Caulerpa* in the bag and the availability of *Caulerpa*. Retail prices range from FJD 2.00–4.00 per heap/plate, depending on the quantity.

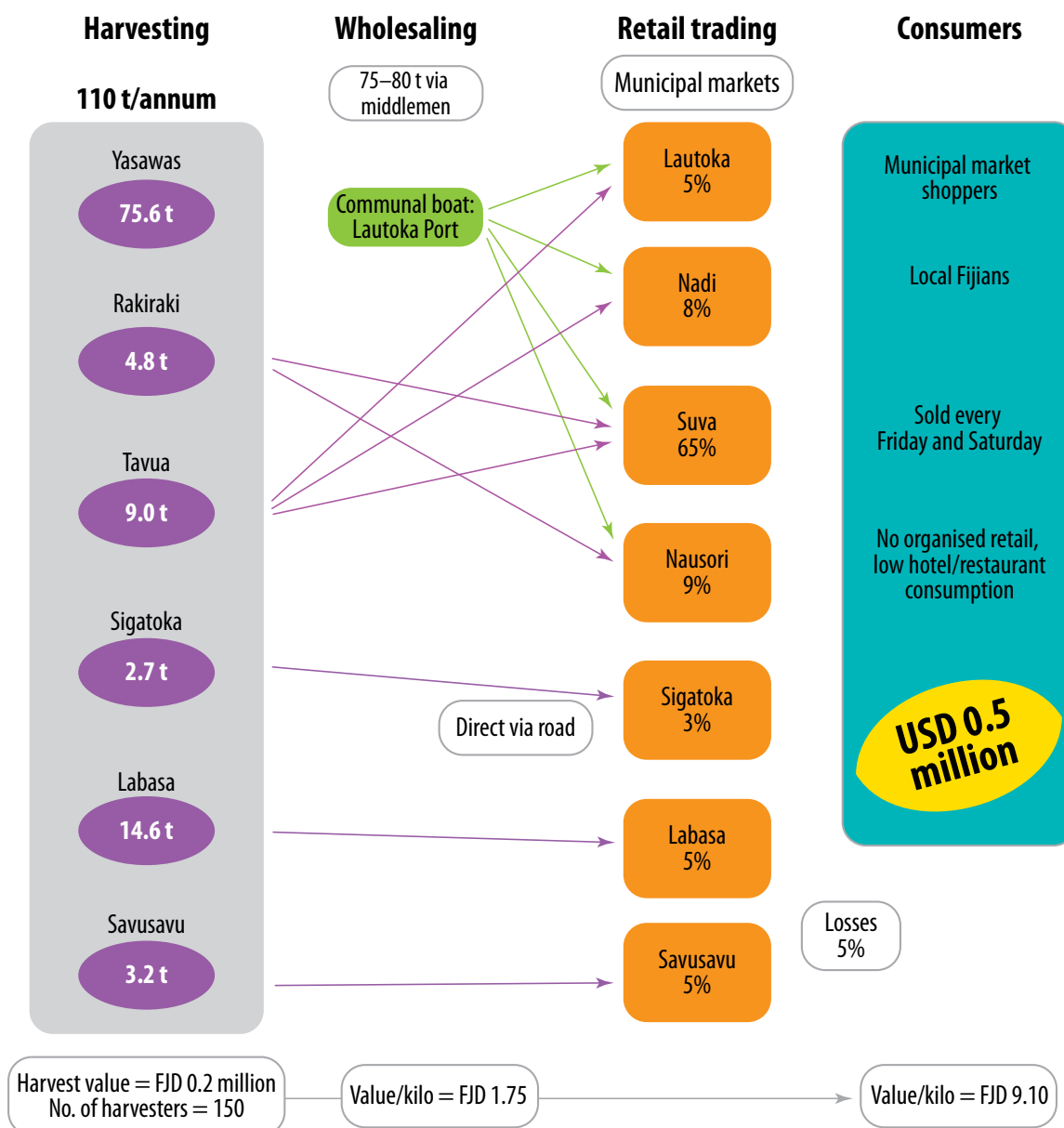


Figure 3. Industrial supply chain map for *Caulerpa* - Fiji

Table 1. Annual production and revenue from *Caulerpa* harvesting and sales in Fiji in 2012

Site	Total Production per annum (t)	Total Revenue (FJD)
Yasawa	75.6	129,600
Sigatoka	2.7	24,300
Rakiraki	4.8	24,390
Tavua	9.0	27,000
Labasa	14.6	41,040
Savusavu	3.2	9,000
Total	110	FJD 255,330 (USD 141,632)

Expenses for harvesters vary, depending on the distance from the harvest site to market, and range from FJD 21.00 to FJD 300.00 per week (average of FJD 97.00 per week).

Income ranges from FJD 30.00 to FJD 100.00 per bag, depending on the quantity of *Caulerpa* (measured by bag size) and from FJD 2.00 to FJD 4.00 per kilogram (average of FJD 3.00 per kilogram). The average income per week for one woman works out at about FJD 70.00 from wholesales and FJD 115.00 from retail sales. This equates to an average annual income per person of FJD 2,520.00 from wholesales and FJD 4,140.00 from retail sales of *Caulerpa* alone, based on the assumption that 70% of their time is spent harvesting *Caulerpa*.

Other local markets

Some resorts and restaurants have *Caulerpa* in their seafood menus. The purchasing manager at Hideaway Resort confirmed that he purchases *Caulerpa* every Wednesday and serves it to tourists on Thursday with their traditional Fijian dish cooked in a *lovo* (an earth oven).

The owner of Casablanca Restaurant on the Coral Coast also serves *Caulerpa*, but only when there is a special request from customers. He believes that in order to introduce *Caulerpa* to resorts and restaurants, there is a need for awareness and a consistent and fresh supply. Gunu village occasionally sells *Caulerpa* to tourist boat operators (Captain Cook Cruises), who serve it as a salad to the tourists. The Bounty Restaurant in Nadi is also known to serve *Caulerpa* with their seafood salad.

Suppliers

The main suppliers of *Caulerpa* on Viti Levu are concentrated in the Western Division. Major markets are supplied by two or more sources. On Viti Levu, a regular supply of *Caulerpa* from the Yasawa Islands goes to Suva, Nadi and Lautoka markets. Rakiraki *Caulerpa* is regularly supplied to the Suva market and to Mana island and occasionally to the Nausori market. A regular supply of *Caulerpa* from Tavua goes to the Lautoka, Nadi and Suva markets and occasionally to Ba and Tavua markets. Suva market also receives an occasional

supply from Vatulele. A regular supply of *Caulerpa* from two sites and an occasional supply from one site in Sigatoka are sent to the Sigatoka market. On Vanua Levu, regular supplies of *Caulerpa* from six sites are sent to the Labasa market and regular supplies from two sites plus occasional supply from one site are sent to the Savusavu market.

Shell-life of *Caulerpa*

The shelf-life of *C. racemosa* can be improved by preservation in brine, and some preliminary trials have been conducted at the University of the South Pacific's post-harvest facility. When bottled in weak (10%) brine, after treatment to reduce bacterial numbers, shoots have lasted for three to four months. Preserved shoots that have undergone heat treatment have, however, higher fibrosity than fresh-brined ones, and this could reduce their value to consumers. Given the short shelf-life and the many critical control points determined during preliminary surveys along the

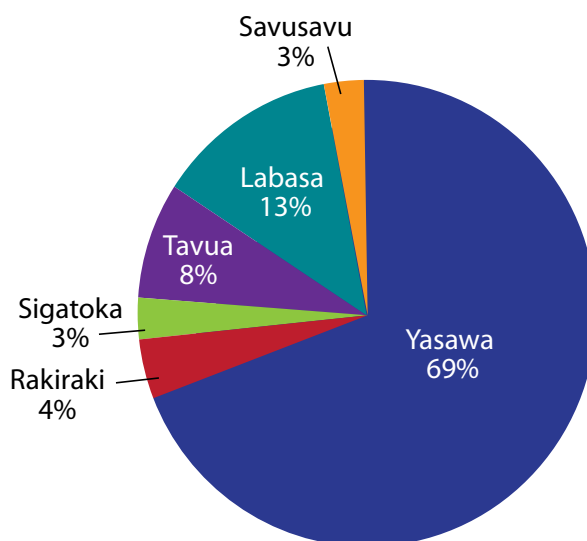


Figure 2. Production (%) of *C. racemosa* per area

chain (especially since markets are up to 100 km away), it would be worthwhile to conduct a proper Hazard Analysis and Critical Control Points (HACCP) analysis of the cold-chain in order to determine the best methods of intervention (Lako 2012).

Export markets

Export of *Caulerpa* has not yet been fully exploited due to the difficulty of keeping it fresh for a long period. Export trials done in the late 1990s were unsuccessful. In 1999, Chamberlain and Pickering conducted a HACCP-type study of the post-harvest treatment of seagrapes for the artisanal and export fisheries in Fiji. After holding the sacks in seawater for two days to allow for healing of the wounds created by harvesting, an attempt was made to ship the plants to Japan in vented, polystyrene boxes. The boxes were drained and prepared for air shipment. During this process approximately 50% of the plants were rejected. After a nine-and-a-half-hour flight to Osaka, followed by a 15-hour road journey from Osaka to Nagoya, 100% of



Market vendor in Labasa selling seagrapes

the shipment was rejected. Apart from the quality and storage issue, it was calculated that the shipment costs were prohibitive. While this attempt was unsuccessful, the study led to a number of recommendations for future ways of shipment and avoiding loss of plants (South *et al.* 2011).

In 2011, a local seaweed export company sent a trial shipment of five kilograms of pickled (brined) *Caulerpa* to New Zealand. It was reported that this shipment reached the customer in good condition (even after being in quarantine for at least two days). The preservation process was fairly simple; *Caulerpa* bought from the Lautoka market was sorted (almost 50% was rejected), washed in fresh water and packed in plastic bags containing brine. This demonstrated that export of *Caulerpa* to nearby countries is possible.

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