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Social and economic dimensions of carrageenan seaweed farming in India

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1. INTRODUCTION

India possesses 434 species of red seaweeds, 194 species of brown seaweeds and 216 species of green seaweeds. Traditionally, seaweeds have been collected from natural stocks. However, these resources have been depleted by overharvesting and hence the need for their cultivation has arisen over time. Today, seaweed cultivation techniques have been standardized, improved and made economically viable. In addition, the industry has developed a preference for greater stability through a sustained supply in terms of quantity and quality of farmed, raw materials. Nevertheless, collection of seaweed production statistics is not systematic in India; official time series of seaweed production are not readily available at the time of writing.

Despite the various native seaweed species in India, it was not until the beginning of the twenty-first century that the country made concrete progress towards organized seaweed farming. The delay in progress was caused by a number of factors including locational disadvantages, inconsistent performance of species for commercial exploitation, absence of a complete package of farming practices, and insufficient industry and policy support.

Although the commercial potential of *Kappaphycus alvarezii* had been previously recognized and its culture technology had been perfected by the Central Salt and Marine Chemicals Research Institute (CSMCRI), culture at a commercial scale only began when PepsiCo India Holdings Ltd (PepsiCo) made its entry into the venture with a pilot-scale investment in the early 2000s. The entry of PepsiCo turned out to be decisive, as it acted as a catalyst to rejuvenate the industry–institutional linkages. The concept of self-help groups (SHGs) spearheaded by the National Bank for Agricultural and Rural Development (NABARD) also led to rapid development in the Mandapam area of Ramanathapuram, which soon became the hub of seaweed farming in the country.

Self-help groups in the fishing villages of Vedalai, Thonithurai, Ariyankkundu and R. Vadakadu operate more than 1 000 rafts at the time of writing. Many of the SHGs have been able to obtain a yield of more than 50 kg per raft per cycle (dry weight). Based on the findings from this study, seaweed farming offered 161 and 144 days per farmer per year of annual employment in the Rameshwaram and Mandapam areas, respectively. With current development projections targeting 5 000 families in the near future, the seaweed sector could generate about 765 000 person-days of employment in Ramanathapuram District. It has been estimated that India can produce one million tonnes of dried seaweed and provide employment to 200 000 families with annual earnings of about INR100 000 per family.[1] The annual turnover of *Kappaphycus* seaweed farming alone is estimated to be INR2.0 billion.

Spearheaded by private investments, the institutional and financial support of the Government of India through development agencies and research institutes has been fundamental for the development of the sector. The distinct possibility of expansion of operations based on successful commercial trials in potential sites will give a significant boost to the sector. Seaweed farming has all the potential to rise from a low-income livelihood activity into a reasonably profitable commercial enterprise in coastal India.

2. CARRAGEENAN SEAWEED PRODUCTION AND VALUE CHAIN

2.1 History

The first organized attempt to culture seaweed at an industrial scale in India was initiated by PepsiCo in 2000. After experiments, substantial activities began in 2002

[1] Exchange rate as of April 2010: USD1.00 = INR44.422.

with the leasing of an area of 10 ha on the Palk Bay side towards Mandapam;[2] about 100 kg of planting material (*K. alvarezii*) received from the CSMCRI were seeded. Early challenges included heavy grazing by fish and the need for modifications in the culture technology to enable adoption by local growers. Monoline cultivation gave way to raft culture with net bottoms to prevent grazing by fish.

After having demonstrated the economic feasibility of the proposed venture, the company decided to modify its business model in 2003. Instead of hiring daily wageworkers, PepsiCo encouraged workers to engage in contract farming by making available the culture infrastructure on a staggered payment basis. Although contract farming offered a greater potential for increased income, the proposed contractual arrangement did not gain immediate acceptance among fishing villagers.

In August 2008, PepsiCo sold its eight-year-old seaweed cultivation business in India to a group of entrepreneurs led by a former PepsiCo executive. PepsiCo transferred the assets of the seaweed venture at book value to a newly formed company, Aquagri. Through Aquagri, PepsiCo continues to honour its buyback commitment made to the SHGs.

Aquagri has placed its focus on the agricultural by-produce, ensuring marketing through strategic associations with agro-based businesses. At the time of writing, the company was planning to extend operations on the Gujarat coast and set up the first seaweed processing plant in Tamil Nadu. Aquagri has also provided buyback guarantees for the new cultivation projects launched by the CSMCRI in the states of Gujarat and Andhra Pradesh; in addition, Aquagri has indicated its intent to set up manufacturing facilities at these centres once activities scale up.

Ramanathapuram District in Tamil Nadu (Figure 1) was identified as the target location for studying the structure, conduct and performance of seaweed farming in India in view of its historical background, locational advantages, industry interactions, socio-economic institutional framework and opportunities for expansion and growth. For these reasons, Ramanathapuram District has long been recognized as the centre of seaweed farming in India. Table 1 provides a timeline of the major events marking the development of seaweed farming in Tamil Nadu since 2000.

2.2 Production

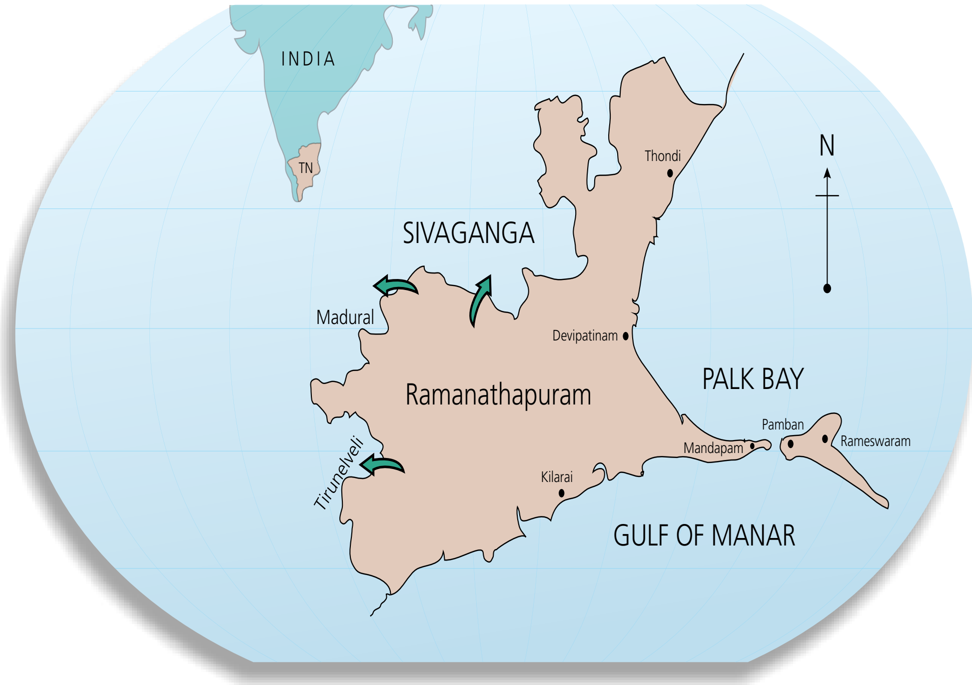
Seaweed farming production in India increased from 21 tonnes in 2001 to more than 714 tonnes (dry weight) in 2009 (Table 2).

Kappaphycus seaweeds grow profusely in areas with sandy or rocky bottoms, salinity in the range of 28–33 ppt, temperature about 30 °C ± 3 °C, depth about 1.5 m, moderate light intensity and wave action. A seed plant of 150 g grows to more than 600 g in 45 days in calm waters such as those found in the Palk Bay area. Seaweeds only require sunlight and transparent seawater with mild wave action for replenishing bottom nutrients. However, *Kappaphycus* can grow even faster in the open sea where wave action is fairly high (AFI, 2008).

Seaweed farming can be affected by many problems. Grazing fish such as siganids (rabbitfish) and puffers can damage the crops. Siganids are the most destructive, especially if the plants have not grown much. Entire crops can be devoured and even dense beds can be severely damaged. There is no simple solution except to move the farming location to another site where predators are less prevalent. Turtles pose a special problem – besides grazing, they also crawl through the farms, causing

[2] PepsiCo had initially requested permission to operate along a 35-km stretch along the Gulf of Mannar and Palk Bay, equivalent to an area of about 350 ha. The company had a preference for the Gulf of Mannar because of its calmer seas, conducive to faster growth rates (average daily growth rate [ADGR] of 6–8 percent). However, because the selected area fell within the Gulf of Mannar Marine National Park, cultivation was restricted to the Palk Bay side, where growth rates are lower (ADGR of 2.5–3.5 percent).

FIGURE 1
Map of Ramanathapuram District, Tamil Nadu, India



devastating physical damage. Long-spined sea urchins are also a pest and can cause injury to farmers who try to remove them.

The most common symptom of poor health is "ice-ice", a disease so named because of the white segments that appear on the plants, causing them to break at that point. There is disagreement about its causes. Some people argue that the segments are indicative of a bacterial or viral infection while others attribute the disease to physical stress caused by changes in the farming environment.

Storms lead to strong water movements that can cause plants to break apart and even cause physical damage to the rafts and lines. Locations that are subject to cyclical cyclones should be avoided; if this is not possible, precautions should be taken during the period of storms (McHugh, 2003). The period from October to December in Tamil Nadu is one of seasonal rains and cyclones.

In spite of these challenges, it has been estimated that seaweed can be farmed in about 200 000 ha or 0.001 percent of the exclusive economic zone (EEZ) of India (Krishnamurthy, 2005). The rocky beaches, mudflats, estuaries and lagoons on the Indian coasts offer ideal habitats for seaweed farming.

2.3 Value chain

Harvested seaweeds are sun-dried on the beach and then bundled into bales. Although the institutions and companies involved in the development of seaweed farming have constructed drying platforms, most drying is still conducted by farmers on the sandy beaches. Apparently, this problem has not yet been corrected owing to Aquagri's willingness to source the dried weed irrespective of its impurities.

The marketing channels for seaweed are illustrated in Figure 2. Basic prices are arranged to the satisfaction of farmers taking into account the effort invested. In 2009, Aquagri was offering INR16/kg of dried weed. Although it has been argued that Aquagri currently holds a monopsony advantage, competing companies have

TABLE 1
A timeline of the development of seaweed farming in Tamil Nadu

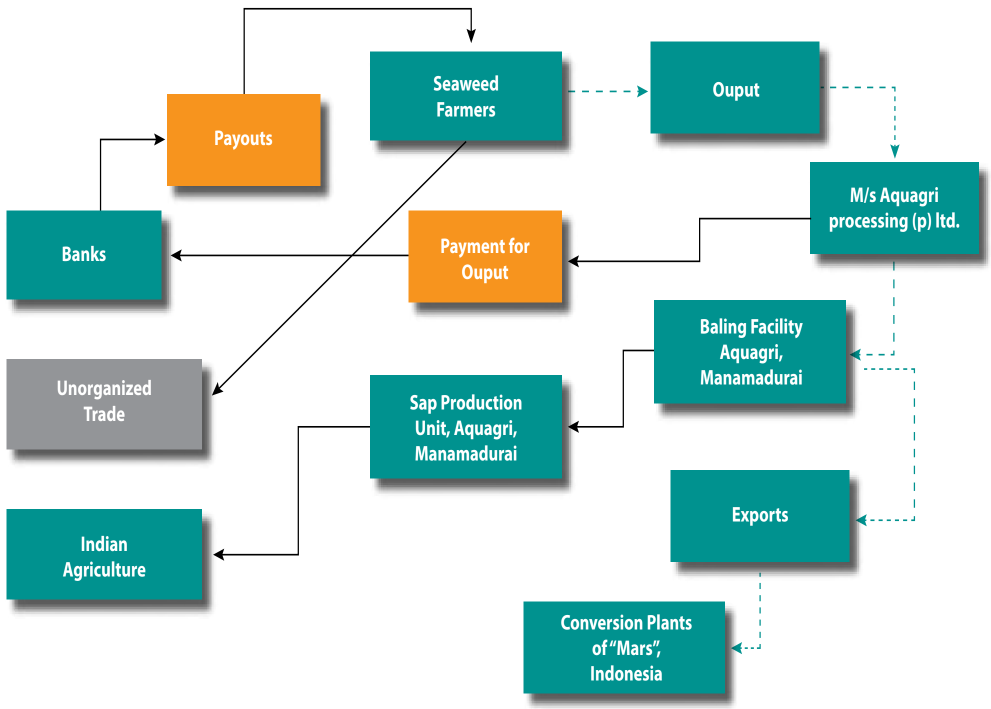
2000	Agreement with the Central Salt and Marine Chemicals Research Institute (CSMCRI) on *Kappaphycus* cultivation and genesis of the undertaking.
2001	The project seaweed cultivation was commenced in February 2001. The net-bag technique was the method formulated by the CSMCRI, but was not found suitable for commercial scale. The Tamil Nadu Government granted PepsiCo access to 1 km of waterfront (10 ha) for pilot-scale cultivation at Palk Bay. Farming began in Munaikkadu (Mandapam area) by adapting the monoline method.
2002	Coastal Regulation Zone (CRZ) officials visited the PepsiCo site to monitor the 10-ha farming area and certified the project. Monoline cultivation was in place until April 2002. Owing to severe grazing, the entire seeded area (10 ha) was lost in May. Thereafter, trials were conducted to establish a commercially viable method. The sum of INR200 000 was paid to the Tamil Nadu Maritime Board (TNMB) for the leasing of the 1-km waterfront area. A full-fledged quality control laboratory to check the quality of dry weeds was also established.
2003	Based on the results of more than 120 trials, the bamboo raft technique emerged as the most suitable, commercially viable method. The daily-wage model was withdrawn and the contract faming method was successfully implemented in March 2003.
2004	About 3 500 rafts were harvested, delivering 126 tonnes. Another 5 000 rafts were seeded for further expansion. Trial cultivation was also carried out in Prakasam District (Andhra Pradesh).
2005	PepsiCo expanded farming to Tuticorin District (southern tip of Tamil Nadu). For the first time, three self-help groups (SHGs) received subsidies from the District Rural Development Agency (DRDA) to engage in seaweed cultivation. The Department of Biotechnology (DBT) sanctioned INR9 million to rehabilitate tsunami-affected areas, which led to the floating of 5 500 rafts. The company entered into an agreement with the State Bank of India (SBI) for establishing a buyback guarantee; both infrastructure and cultivators were placed under insurance coverage.
2006	Expansion of farming to Tanjore District. A total of 8 100 rafts were harvested, delivering 244 tonnes of dry weed. The sap extracted from *Kappaphycus* was found to be an excellent biofertilizer.
2007	Expansion of farming to Pudukkottai. The DBT activated a project in Tanjore but, owing to poor growth/whitening, it was moved to Mandapam. Monoline method was restarted again in Mandapam as it was found to provide better returns. Trial cultivation was carried out in Krishna District (Andhra Pradesh); however, salinity drop in back waters and rough waves in open seas led to poor plant growth.
2008	Aquagri took over the PepsiCo project. Commercialization of AquaSAP started.
2009	Construction of a semi-refined carrageenan (SRC) unit at SIPCOT was initiated.

TABLE 2
Area production and exports of *Kappaphycus* in Tamil Nadu, India, 2001–09

Year	Cultivation method	Growth rate (%)	Business model	Procurement cost, INR/kg (dry weight)*	Number of ML/BR	Production dry weight (tonnes)	Exports (FCL of dry seaweed)
2001	ML	1.5–6.0	Company owned	Daily wage system	Test plots	21	1
2002	ML	2.2–2.4	Company owned	Daily wage system	ML: 5 275	82	4
2003	BR: 75% ML: 25%	2.0–2.5	Company owned and contract farming	Daily wage system & 4.50	ML: 3 567 BR: 1 962	147	7
2004	BR	2.6	Contract farming	4.50 & 7.50	BR: 3 469	126	6
2005	BR	3.25	Company owned	7.50 & 8.50	BR: 3 450	135	6
2006	BR	2.5–3.0	Company owned	8.50 & 10.00	BR: 8 100	244	12
2007	BR: 95% ML: 5%	2.5–3.0	Contract farming and private cultivators	10.00 & 12.00	BR: 10 464	315	15
2008	BR: 90% ML: 10%	2.5–3.0	Company owned	12.00 & 14.00	BR: 16 000+	588	28
2009	BR: 90% ML: 10%	2.5–3.0	Company owned	14.00/kg (dry) 1.75/kg (fresh)	BR: 18 000+	714**	34**
Total						2 372	113

* The column includes two values to indicate that prices offered to self-help group (SHG) members were revised in the same year.
** Data incomplete for 2009.
Note: BR = bamboo rafts; ML = monoline; FCL = full container load (1 container = 21 tonnes).

FIGURE 2
Marketing channels of seaweed farmers in Ramanathapuram District, Tamil Nadu



routinely induced the farmers to break the contracts by offering a marginally higher price. However, Aquagri has developed its own price-incentive schemes for loyal and high-volume producers. In addition, non-price arrangements such as assisting farmers to meet their family and social obligations have contributed to build bonds of mutual trust and loyalty.

SAP[3] is a major product extracted from the dried weed in India. The partnership established between PepsiCo and the CSMCRI to explore more water- and energy-efficient processing technologies led to the development of a fresh-weed processing system that yielded SAP, an organic fertilizer rich in micronutrients, aminoacids and growth hormones. Since then, SAP has been applied to a range of crops (brinjal, onion, corn, black gram, paddy, sugar cane) and has consistently increased yields by 12–40 percent. According to the CSMCRI, *Kappaphycus* SAP also contains considerable quantities of nitrogen, phosphorus, potassium, organic matter, sodium calcium, magnesium, manganese, iron, copper, zinc, cobalt, molybdenum, sulphate and chloride. Incidentally, applying SAP at the germination stage of seaweed cultivation has also shown impressive results in terms of increase in growth of roots and shoots.

At the time of writing, efforts were under way to build a plant in Manamadurai for the extraction of carrageenan; with the plant scheduled to be commissioned in January 2010. Dried seaweed is exported by PepsiCo to carrageenan conversion plants in Indonesia. International price fluctuations, which have disrupted the development of seaweed farming in other locations in the world, have had relatively little impact in India owing to the large demand from the domestic market.

Aquagri has recently completed the construction of two facilities for processing seaweeds in Tamil Nadu (Mandapam and Manamadurai). These facilities are capable

[3] In this context, SAP is not a generic term but indicates the liquid biofertilizer developed by Aquagri and branded as AQUASAP.

of handling 150 tonnes/day of fresh seaweed; most of the input material is being converted to SAP; the residual content after extraction of SAP is used for the extraction of carrageenan. These are state-of-the-art facilities using solar power and biofuels as energy sources. Aquagri has sourced the technology for extracting SAP from wet seaweeds and acquired exclusive marketing rights for three years from the CSMCRI.

Other firms such as SNAP are also developing *Sargassum*-based value-added products, including organic manure, foliar sprays, and liquid and gel fertilizers. SNAP is certified by the Agricultural and Processed Food Products Export Development Authority (APEDA) under the National Program for Organic Produce Certification. Other government departments have also certified SNAP products.

Competitive pricing arrangements were extended to farmers by PepsiCo. Price incentives were also offered to growers who produced more than the targeted quantity, so as to prevent breaching of contracts. With the opening of the new SAP plant, Aquagri would increase its purchases of wet *Kappaphycus*, enabling growers to devote a greater portion of their time to farming rather than drying. Wet seaweed was being purchased from the SHG members at the rate of INR1.50/kg at the time of writing.

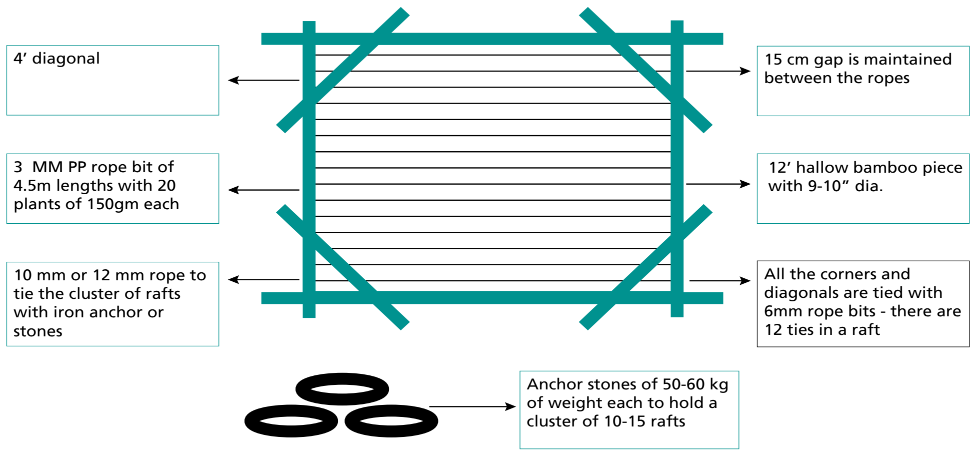
3. CARRAGEENAN SEAWEED FARMING: ECONOMIC AND SOCIAL PERFORMANCE

3.1 Techniques

Two different culture techniques are practised in Mandapam: raft culture (also called floating) and monoline culture (also called off-bottom). The raft method is suitable in areas where water currents are weak, e.g. Palk Bay. A floating frame made of bamboo (normally of dimensions 3 m × 3 m) is used to suspend the seaweed about 50 cm below the surface. Three-millimetre polypropylene ropes are stretched in parallel between the two sides of the raft, at intervals of 10–15 cm. The seedlings are tied to the ropes and the raft is anchored to the bottom. Anchor ropes may be needed to hold the raft below the surface at the beginning, but as the plants grow and add weight to the raft, extra support (such as polystyrene foam boxes tied to the corners of the raft[4]) may be required to prevent it from sinking too low in the water. Specific details of this technique are provided in Figure 3.

FIGURE 3

Top view of a 3 m × 3 m bamboo raft with 4 ft (1.22 m) diagonals



[4] In Palk Bay, both thermocol pieces and empty plastic bottles are used for flotation. Plastic bottles are now being phased out as an environmental safety measure.

With a 15 cm interval between 2 lines, 20 lines can be attached to a 3 m × 3 m raft, which would provide a total of 60 m of lines for planting seaweed.

A cluster of 10 rafts in the normal season (4–6 rafts in the monsoon season) can be anchored with a 15kg, 5-toothed iron anchor. Alternatively, holed stones can be linked with chains and then tied to the cluster. The major advantage of floating rafts is that they can be easily moved to another location if necessary, and removed from the water during bad weather. Rafts can also be used as drying racks by providing appropriate support when placed onshore.

In typical monoline culture, a seaweed farmer is given 45 ropes of 60 m. These are tied in two sections to avoid sags in the line caused by the weight. Thus, the lines are arranged in two 45 m × 30 m plots, with each line straddling the two plots. A total of 300 seaweed cuttings are inserted in each rope, leaving a spacing of 20 cm. The initial weight of seedlings is 200 g and, thus, a total of 60 kg of seed material is required per 60 m rope. Normally, the seaweed plants are simply tied up to the nylon ropes. However, in the summer months of May–June (the fish breeding season), the plants are covered with net bags to avoid grazing by fishes, which increases production costs. The seeds are always covered with net bags in Tuticorin and Kanyakumari.

3.2 Economic performance

Productivity and profitability: raft vs monoline

According to the information provided by Tamil Nadu Department of Fisheries (TNDoF, 2009), a subsidized raft aquaculture operation (*Kappaphycus*) by an SHG farmer trainee goes as follows:

- It costs about INR738 to construct and seed a 3 m × 3 m raft. Most of the investment (INR568) is needed for building the farming system; INR 130 is needed for seeding; and INR 40 is needed for miscellaneous tools (Table 3).
- Assuming that on average a farmer trainee manages 45 rafts,[5] then the operation would require an initial investment of INR 33 230. Half of the investment is subsidized by the TNDoF; the other half is financed with a commercial bank loan.
- Operation normally runs for only 270 days per year because seaweed culture is usually not practised during the northeast monsoon (about 95 days). Therefore, there are 6 operation cycles per year (45 days per cycle). Then, the amortized capital cost is INR123 per cycle (Table 3).
- With 60 kg of initial seeds planted on lines of a total of 60 m in length, a 3 m × 3 m raft would be able to generate about 280 kg of fresh seaweed in a 45-day cycle; out of which, 60 kg would be used as seed materials for the ensuing cycle; the rest processed into 20 kg of dried seaweed (10:1 ratio; 2 kg removed as impurities).
- At the price of INR16/kg, the 20 kg of dried seaweed would yield INR320 of revenue per raft per cycle.
- As part of the harvest is used as seed materials, the initial seed materials should not be counted as an expense.
- The operation is usually conducted by family labour and requires little cash expenses. However, there is on average a financial expense of INR8.2 per raft per cycle, including expenses of INR6.8 in interest and INR1.4 for insurance.

A typical 60-m monoline operation in Ramanathapuram District goes as follows:

- It costs about INR38 to set up a 60-m monoline system, which is much cheaper than a 3 m × 3 m raft system. The cost of the nylon ropes accounts for 33 percent of total investment; however, labour charges for installation account for the highest share (38.5 percent).

[5] If a farmer can seed and harvest one raft per day, then on average a farmer would be able to manage 45 rafts for a 45-day production cycle. However, many farmers are able to handle as many as three rafts a day, greatly enhancing their economic returns.

TABLE 3
Investment requirement for one raft (3 m × 3 m) in Tamil Nadu

Items	Investment (INR)	Amortized capital cost for 6 cycles/year operation (INR/cycle)
Farming system (3 m × 3 m raft; 60-m lines for growing)	**568**	**94.7**
- 1 bamboo raft (64-ft)	211	35.2
- 5 cornered anchors	63	10.5
- Floats	25	4.2
- 3-mm nylon rope (1.25 mm thickness/4.5 m length/20 lengths)	52	8.7
- 20 ropes for seeding	21	3.5
- 6-mm thickness nylon rope (for raft construction, 36 m)	75	12.5
- 3.5 m × 3.5 m nets for reducing grazing	89	14.8
- 2-mm thickness ropes for tying the nets to raft bottoms (28 m)	10	1.7
- Nylon rope for tying rafts together (5.4 m)	12	1.9
- 10-mm anchor ropes (17 m)	10	1.7
Initial seed	**130**	**21.7**
- Seed materials (*Kappaphycus*, 60 kg)	105	17.5
- Expense for transporting seed materials	25	4.2
Tools	**40**	**6.7**
- Mats, ladders, baskets, knives, etc.	40	6.7
Total	**738**	**123.1**

- Similar to the raft system, the 60 kg of initial seed materials is worth INR105, which is not counted as an expense because the materials will be replenished by part of the harvest.
- Harvest is normally conducted after 45 days in Ramanathapuram District.[6] A 60-m rope may yield 400 kg of fresh seaweed;[7] 100 kg of which is separated as planting material for the subsequent cycle; the rest become 28 kg of dried seaweed (10:1 ratio; 2 kg impurities removed).
- At the price of INR16/kg, the 28 kg of dried seaweed production generate INR448 of sales revenue per cycle per rope.
- If the wage for family labour is not included, the operating cost per rope is INR120, including INR50 for harvesting.

The operation and financial situations of the two systems highlighted above are summarized and compared in Table 4. The results indicate that:

- The monoline operation appears to have higher yield than the raft operation. For the same length of rope (60 m) and same amount of seed materials (60 kg), the production of monoline operation (400 kg of fresh seaweed) is higher than the raft operation (280 kg). Consequently, the sales revenue of the former is 40 percent higher than the latter.
- The cost of the monoline operation (INR158) is a little higher than the raft operation (INR106), which mainly reflects the operation and harvest cost under the monoline operation. As mentioned above, the amortized cost of the monoline farming system is much lower than that of the raft.
- The net profit per cycle for the monoline operation is INR290 (USD6.0), higher than the INR206 (USD4.3) for the raft system. This result implies that, on average,

[6] Because growth rates are higher, the production cycle is shortened to only 30 days in the southern districts of Tuticorin and Kanyakumari.

[7] The expected yield ranges from 350 to 400 kg of fresh seaweed.

TABLE 4
Financial analysis of raft culture vs monoline culture in India

Item no.	Item	A 3 m × 3 m raft (60 m lines for growing)[1]	Monoline (60 m lines for growing)
(1)	**Production**		
(2)	- Initial seed materials (kg)	60	60
(3)	- Fresh seaweed per 45-day cycle (kg)	280	400
(4)	- Fresh seaweed reserved as seeds (kg)	60	100
(5)	- Dried seaweed product (kg)	20	28
(6)	**Price of dried seaweed (INR/kg)**	**16**	**16**
(7)	- Price of dried seaweed (USD/tonne)	331	331
(8)	**Revenue (INR/cycle)**	**320**	**448**
(9)	**Cost (INR/cycle)**	**114**	**158**
(10)	- Operational expense (including depreciation)	106	158
(11)	Farming system	95	38
(12)	Initial seeding	4.2	–
(13)	Tools	6.7	–
(14)	Operation	–	70
(15)	Cost of harvesting	–	50
(16)	- Financial expenses	8.2	–
(17)	Interest	6.8	–
(18)	Insurance	1.4	–
(19)	**Net profit (INR/cycle)**	**206**	**290**
(20)	**Net profit (USD/cycle)**	**4.3**	**6.0**

[1] Data for the raft system adapted from Seaweed Culture, Golden Jubilee Village Self Employment Opportunities, Government of Tamil Nadu (2008-09).
Notes: USD1 = INR48.405 (2009). (8) = (5) × (6). (9) = (10) + (16). (12) Including only the cost of seed transportation. (19) = (8) – (9). Numbers may not add up due to rounding.

the raft farmer could earn about USD4.3 per day, amounting to USD1 150 per year for 270 days of production.

Although monoline culture appears to be more profitable than raft culture, the operational difficulties may be greater (there is a higher threat of grazing by fish; ropes could break, leading to crop loss; and plot maintenance is labour-intensive).

The above analysis is based on the assumption of 400 kg/cycle for monoline culture. If the yield is only 350 kg/cycle, then the net profit will be only INR210, similar to the raft culture.

The non-monetary advantages of raft culture make it a preferred system choice in Ramanathapuram District. Therefore, this study concentrates on the socio-economics of the raft culture system.

Profitability and viability of raft culture

Consider the 3-year operation of a 1-ha seaweed farm with 900 rafts with the following specifications:

- Each raft contains 60 m lines for growing. With 900 rafts, the farm has 54 km of lines for growing.
- After three years of operation, a new set of investments needs to be made.
- One production cycle lasts 45 days. There are 4 production cycles in the first year and 6 cycles in the second and third years.
- In a production cycle, each raft is planted with 60 kg of seed material and produces 20 kg of dried seaweed after part of the harvest is set aside as seed materials for the next cycle.

The initial investment requirements for the seaweed farm are summarized in Table 5.

The annual revenue, cost and net profit of the farm are summarized in Table 6. The results indicate that:

- The farm is profitable with USD9 460/ha (USD175/km of line) for the first year (4 cycles) and USD16 228/ha (USD301/km of line) for the second and third years (6 cycles per year).
- The profit margins are 40 percent for the first year (4 cycles) and 45 percent for the second and third years (6 cycles per year).
- The break-even prices (USD199/tonne for the first year and USD180/tonne for the second and third years) are much lower than the actual price (USD331/tonne).

The cash flow situation of the three-year operation is summarized in Table 7. The results indicate that:

- The farm's net cash inflow is USD190 for the first year and USD19 293 for each of the second and third years.
- The positive cash inflow in the first year implies that the farm can recover its investment within the first year. Specifically, the pay-back period for the operation is about 0.98 year.
- The internal rate of return (IRR) of the 3-year operation is 110 percent.

TABLE 5
Initial investment for a 1-ha seaweed farm with 900 rafts (54 km of growing lines)

Item no.	Item	Unit	Annual amount
(1)	**Initial investment**	**USD/ha**	**12 336**
(2)	- Seedlings (54 tonnes)	USD/ha	1 952
(3)	- Farming system (900 rafts)	USD/ha	10 383
(4)	**Initial investment per kilometre of lines**	**USD/km**	**228**

Notes: USD1 = INR48.405 (2009). (1) = (2) + (3). (4) = (1)/54. Numbers may not add up due to rounding.

TABLE 6
Annual revenue, cost and net profit of a 1-ha seaweed farm with 900 rafts

Item no.	Item	Unit	1st year (4 cycles per year)	2nd and 3rd years (6 cycles per year)
(1)	**Annual dried seaweed production (per cycle: 20 kg/raft)**	**tonnes/ha**	**72**	**108**
(2)	**Price of dried seaweed**	**USD/tonne**	**331**	**331**
(3)	**Annual revenue**	**USD/ha**	**23 799**	**35 699**
(4)	**Annual costs**	**USD/ha**	**14 339**	**19 471**
(5)	*Fixed cost*	*USD/ha*	*4 076*	*4 076*
(6)	- Depreciation	USD/ha	3 066	3 066
(7)	- Interest on investment (7%)	USD/ha	864	864
(8)	- Insurance (1.2%)	USD/ha	147	147
(9)	*Operating cost*	*USD/ha*	*10 263*	*15 395*
(10)	- Braider twining charges	USD/ha	2 231	3 347
(11)	- Transportation	USD/ha	1 934	2 901
(12)	- Raft maintenance	USD/ha	5 875	8 813
(13)	- Miscellaneous	USD/ha	223	335
(14)	**Annual net profit**	**USD/ha**	**9 460**	**16 228**
(15)	Annual net profit per kilometre of line	USD/km	175	301
(16)	**Profit margin**	**%**	**40**	**45**
(17)	**Break-even price**	**USD/tonne**	**199**	**180**

Notes: USD1 = INR48.405 (2009). (3) = (1) × (2). (4) = (5) + (9). (5) = (6) + (7) + (8). (9) = (10) + (11) + (12) + (13). (14) = (3) – (4). (15) = (14)/54. (16) = (14)/(3)*100. (17) = (4)/(1). Numbers may not add up due to rounding.

TABLE 7
Financial feasibility of a 1-ha farm over 3 years

Item no.	Items	Unit	Year 1	Year 2	Year 3
(1)	Cash outflow	USD	23 609	16 405	16 405
(2)	- Investment	USD	12 336	–	–
(3)	- Interest & insurance	USD	1 010	1 010	1 010
(4)	- Operation	USD	10 263	15 395	15 395
(5)	Cash inflow (operation)	USD	23 799	35 699	35 699
(6)	Net cash inflow	USD	190	19 293	19 293
(7)	Pay-back period	Year		0.98	
(8)	Internal rate of return	%		110	

Notes: USD1 = INR48.405. (1) = (2) + (3) + (4). (6) = (5) – (1) Numbers may not add up due to rounding.

Summary

In sum, the above analyses provide strong evidence of the economic and financial profitability and viability of seaweed farming in Tamil Nadu. The estimated high rate of return on investment is consistent with the findings of Padilla and Lampe (1989), who calculated an IRR of 78 percent for seaweed farming in the Philippines; Shang (1976), who estimated an IRR of 56 percent for Gracilaria cultivation; and Firdausy and Tisdell (1991), who reported an IRR of 123 percent in Bali. Seaweed farming has thus emerged as one of the most profitable livelihood options for coastal fishing communities in various locations of the Asian continent.

3.3 Social performance

The socio-economic status of seaweed farmers was assessed through personal interviews using a pre-tested schedule. Details on socio-economic parameters associated with seaweed farming were collected from 437 sample respondents,[8] 226 from Mandapam and 211 from Rameshwaram.[9] The two regions represent the mainland and island ecosystems, respectively (Figure 1).

The SHGs surveyed were predominantly formed by women, although a few SHGs consisted exclusively of men while some SHGs were mixed. Agencies that actively support the SHGs include the DBT, Ramanathapuram Rural Development Agency (RDDA) and TNDoF. The Aquaculture Foundation of India (AFI) has provided seedlings and other materials to farmers in the region.

At the time of writing, a number of SHGs in Vedalai, Thonithurai, Ariyankkundu and R. Vadakadu were handling more than 1 000 rafts each. These SHGs have been exposed to *Kappaphycus* culture longer than other groups; because of this experience, they are able to obtain annual yields exceeding 50 kg per raft (dry weight). The performance of the most recent SHGs is expected to improve over time. Overall, farmers report that they have been able to obtain good returns from the activity. Seaweed farming is expanding to other districts within Tamil Nadu such as Pudukottai and Thanjavur.

Family characteristics

The characteristics of seaweed farming households under survey are summarized in Table 8. The results indicate that the average family size of the surveyed seaweed

[8] The population of organized SHG seaweed farmers at the time of the survey was estimated at 1 000. The sample was drawn based on purposive sampling proportionate to size.

[9] Farmers in the Mandapam region included in the sample were specifically located in Vedalai, Umilyalpuram, Munaikadu, T. Nagar, Meenavar colony and Thonithurai. The locations covered in Rameshwaram were Pamban, Akkalmadam, Nallupanai, Ariyankudu, A. Vadakadu, Parvatham, Sambai, Mangadu and Olaikuda.

TABLE 8
Family characteristics of surveyed seaweed farmers

Indicators	Mandapam (N = 226)	Rameshwaram (N = 211)
Average family size (no.)	4.5	5.5
Share of nuclear family (%)	97	77
Share of joint family (%)	3	23
Share of family with male household head (%)	64	66
Share of family with female household head (%)	36	34

farming households was 4.5 in Mandapam and 5.5 in Rameshwaram. This is consistent with the national average of 4.5 for fisher families reported by the Marine Fishery Census (CMFRI, 2005).

Most of the sample respondents' families belong to the nuclear family type.[10] However, Rameshwaram has a relatively greater number of joint families[11] involved in seaweed farming. The social development programmes promoted by the Government of Tamil Nadu have led to a general improvement in the socio-economic conditions of the overall population. These programmes have also altered the structure of families, with joint families giving way to nuclear families. This phenomenon is also occurring in coastal villages.

As in most other states of India, household heads in Tamil Nadu are usually the most senior male in the family. Recently, widows have also represented as household heads if they are income-earners. However, the survey results indicate that a substantial proportion of seaweed farming households under survey (36 and 34 percent for Mandapam and Rameshwaram, respectively) were led by female household heads. The concept of the SHG was founded on the basic premise that women are more responsible and have a better disposition to work towards achieving social and economic independence. In the case of seaweed farming, rather than assuming a leadership role, males in fishing households have followed their women. The initial success of women in seaweed farming motivated men to enter the activity as well.

Age and education

The age and education characteristics of surveyed farmers are summarized in Table 9. The results indicate that about 60 percent of the surveyed farmers in both regions were middle-aged individuals (31–50 years old). This age bracket corresponds to a productive group of individuals that is usually receptive to new ideas and is capable of implementing them, even if doing so involves some risk.

TABLE 9
Age and education of surveyed seaweed farmers

Age & education	Share of surveyed households (%)	
	Mandapam (N = 226)	Rameshwaram (N = 211)
Age		
≤ 31	31	25
31–50	61	59
> 50	8	16
Education		
Illiterate	1	7
Elementary	43	8
Lower primary	21	18
Upper primary	22	43
Secondary	11	18
Higher secondary	2	6

[10] A nuclear family is a family group consisting of only a father and mother and their children, who share living quarters.

[11] A Hindu joint family or Hindu undivided family or a joint family is an extended family arrangement prevalent among Hindus and consisting of many generations living under the same roof. All the male members are blood relatives and all the women are either mothers, wives, unmarried daughters or widowed relatives.

The estimated 52.8 percent of average literacy rate in the district was lower than the national average (65 percent), reflecting relatively poor educational facilities in the area. However, the surveyed seaweed farmers appeared to have higher literacy rate than the national average. Indeed, about 13 and 24 percent of respondents in Mandapam and Rameshwaram, respectively, have reached a secondary level of schooling or higher.

On average, the surveyed farmers in Rameshwaram appeared to have a higher education level than those in Mandapam.

Employment

Fishing and seaweed farming are the two most important occupations in the two areas under survey. The occupation and professional experience of surveyed farmers are summarized in Table 10. The results indicate that almost half of the respondents in Mandapam practised fishing as their primary occupation, while only 13 percent chose fishing as the primary occupation in Rameshwaram. Seaweed farming has become the primary livelihood activity of fishers in Rameshwaram, which has helped reduce pressure on the fish stocks of the area. The emergence of seaweed farming has also helped reduce political tension with neighbouring Sri Lanka over access to common fishing grounds.

Most of the respondents (92 and 72 percent in Mandapam and Rameshwaram, respectively) have 11–25 years of experience in fishing. Most of these individuals belonged to the middle-aged group and could successfully adapt to innovations in seaweed farming techniques.

As the concept of seaweed farming was introduced only after 2001, most of the respondents had only up to 5 years of experience in seaweed farming. Although most farmers had fewer years of experience in seaweed farming than in fishing, many of them have chosen the latter as their primary occupation (Table 10). This indicates the level of commitment of stakeholders, as fishers perceive seaweed farming to be a less risky and more sustainable activity compared with traditional fishing practices.

The employment patterns of surveyed seaweed farming households are summarized in Table 11. The results indicate that:

- On average, one member per family is involved in active fishing in both areas.
- On average, one member per family is involved in post-harvest activities (i.e. peeling, drying, freezing, processing, value addition) in the Mandapam area, while two members are involved in the Rameshwaram area.
- For seaweed farming, on average, two members per family are involved in the activity in both Mandapam and Rameshwaram.

TABLE 10
Occupation and professional experience of surveyed seaweed farmers

Occupation & professional experience	Share of surveyed households (%)	
	Mandapam (N = 226)	Rameshwaram (N = 211)
Occupation		
- Respondents taking fishing as primary occupation	48	13
- Respondents taking seaweed farming as primary occupation	52	87
Fishing experience		
≤ 10 years	6	23
11–25 years	92	72
> 25 years	2	5
Seaweed farming experience		
≤ 5 years	87	84
6–7 years	9	13
> 7 years	4	3

TABLE 11
Employment patterns of surveyed seaweed farming households

Name of the occupation	Mandapam (N = 226)		Rameshwaram (N = 211)	
	Average no. of members per family	No. of days employed per person per year	Average no. of members per family	No. of days employed per person per year
Active fishing	1	179	1	181
Post-harvest activities	1	96	2	100
Seaweed culture/harvest	2	144	2	161

- The average annual working days per person in fishing and post-harvest activities is marginally higher in Rameshwaram (181 and 100 days) than in Mandapam (179 and 96 days). A similar trend was also observed for seaweed farming (161 days in Rameshwaram as opposed to 144 days in Mandapam).

As indicated in Table 11, on average, a seaweed farming household in Mandapam and Rameshwaram has two family members engaged in seaweed farming; the average annual total of working days is 144 days per person in Mandapam and 161 days per person in Rameshwaram. It is estimated that there were about 517 and 483 seaweed farming households in Mandapam and Rameshwaram, respectively. Therefore, seaweed farming would be able to provide 148 896 and 155 526 person-days of employment per year in the two areas, respectively. The various development programmes in the region are currently planning for a total of 5 000 families to become involved in seaweed farming, which would translate into 765 000 days of employment in the district (assuming 153 days of employment per person per year). More generally, it has been argued that seaweed farming could provide employment to 200 000 families in the country, with annual earnings of about INR100 000 per family (AFI, 2008).

Wealth and indebtedness

Housing is an important indicator of the socio-economic status of an individual, particularly in small villages. All respondents in both areas were living in their own houses. With regard to the housing type, the proportion of kutcha[12] houses was high in Mandapam (75 percent). The proportion of kutcha and pucca houses was about the same (49 percent) in Rameshwaram (Table 12). Only four respondents in Rameshwaram (two percent of the surveyed households in the regions) were found to reside in reinforced cement concrete houses.

Livestock husbandry is an important source of supplementary income for the fisher households. Maintaining livestock is often seen as a symbol of prestige among rural households. About 55 percent of respondents in Mandapam and 59 percent in Rameshwaram maintain livestock to supplement their income and domestic needs (Table 12). The most common livestock type is poultry.

Table 13 presents the average amounts of loans taken out, repaid and outstanding for Mandapam and Rameshwaram. Households take out loans for different purposes, including domestic activities and social obligations. Although the institutional loan procedures are slightly more cumbersome, respondents tend to prefer institutional loans to those provided by commercial moneylenders because the repayment process

[12] A pucca house is one that has walls made of any of the following materials: burnt bricks, stones (packed with lime or cement), cement concrete, timber, ekra, etc. In addition, the roof is made of tiles, galvanized corrugated iron sheets, asbestos cement sheets, reinforced brick concrete, reinforced cement concrete, timber, etc. In a kutcha house, the walls and/or roof are made of materials other than those mentioned above, such as un-burnt bricks, bamboo, mud, grass, reeds, thatch, loosely packed stones.

TABLE 12
Wealth status of surveyed seaweed farming households

Housing and livestock ownership	Share of surveyed household (%)	
	Mandapam (N = 226)	Rameshwaram (N = 211)
Type of house		
- Kutcha	75	49
- Pucca	25	49
- Reinforced cement concrete	0	2
Livestock owners		
- Cattle owners	18	4
- Buffalo owners	7	0
- Poultry owners	30	55

TABLE 13
Level of indebtedness in the surveyed regions

	Average loan taken out per household (INR)	Average loan repaid per household (INR)	Outstanding loan per household (INR)
Mandapam			
Institutional	4 350	3 050	1 300
Moneylenders	1 505	1 292	213
Rameshwaram			
Institutional	8 071	7 607	464
Moneylenders	5 089	4 763	324

is regarded as more transparent; this trend has accentuated since the advent of seaweed farming in the region.

Income and livelihood

The income status of surveyed seaweed farmers is summarized in Table 14. The results highlight the clear potential of seaweed farming for improving the socio-economic status of communities in both regions.

Seaweed farming appeared to provide higher income than fishing. In both regions, most respondents' income from fishing was within the range of INR10 001–20 000, while most respondents' income from seaweed farming was more than INR20 000.

In Rameshwaram, the income from seaweed farming was more than INR30 000 for almost half of the respondents, more than INR40 000 for more than 32 percent of the respondents, and more than INR50 000 for 10 percent of the respondents.

As indicated in Table 15, food items accounted for more than 60 percent of the consumption expenditure of an average household in Mandapam and Rameshwaram; medical expenses and clothing were the other two relatively large expenditure items. Such consumption patterns reflect the characteristic of households with relatively low incomes.

Seaweed farming has enabled households to raise their economic status significantly, with members of SHG families contributing substantially to total household income. In the last five years, the surveyed households have been able to acquire electronic appliances such as TVs, DVD players and mobile phones in addition to household appliances such as mixers and grinders. A total of 135 respondents (60 percent) and 141 persons (67 percent) have purchased mobile phones in Mandapam and Rameshwaran, respectively, in the last five years.

The surveyed seaweed farmers were asked how income from seaweed farming affected their livelihood; the answers are summarized in Table 16. The results indicate that:

TABLE 14
Income status of surveyed seaweed farmers (N = 437)

Income levels (INR per year)	Share of surveyed households (%)			
	Mandapam (N = 226)		Rameshwaram (N = 211)	
	Fishing	Seaweed farming	Fishing	Seaweed farming
Less than 10 000	28	9	13	2
10 001–20 000	69	33	57	25
20 001–30 000	3	57	19	24
30 001–40 000	0	1	8	17
40 001–50 000	0	0	2	22
50 001–80 000	0	0	1	8
80 001–100 000	0	0	0	1
More than 100 000	0	0	0	1

TABLE 15
Consumption expenditure patterns in Mandapam and Rameshwaram

Item	Mandapam		Rameshwaram	
	Expenditure (INR/year)	Percentage of total expenses (%)	Expenditure (INR/year)	Percentage of total expenses (%)
Food	18 525	65.19	19 819	62.79
- Fish	8 030	28.26	9 448	30.00
- Meat	2 568	9.04	2 205	6.97
- Oils	2 358	8.30	2 704	8.55
- Other food	5 569	19.60	5 462	17.27
Clothing expenses	2 027	7.13	3 407	10.77
Children education	1 210	4.26	1 749	5.53
Medical expenses	4 284	15.08	3 668	11.60
Electricity	836	2.94	851	2.69
Fuel charges	1 193	4.20	807	2.55
Recreation	0	0.00	583	1.85
Social function	342	1.20	701	2.22
Others	0	0.00	0	0.00
Total	**28 417**	**100.00**	**31 625**	**100.00**

TABLE 16
Impacts of seaweed farming on household expenditure

Expenditure supported by income from seaweed farming	Share of surveyed household (%)	
	Mandapam (N = 226)	Rameshwaram (N = 211)
Consumption expenditure		
- purchase quality clothing	99	89
- engage in social and religious travelling outside the district/state	37	25
- celebrate a marriage in the family	4	46
- transfer to a better educational institution	0	9
Capital expenditures		
- purchase cattle/poultry	74	84
- purchase consumer durables (e.g. modern electronic appliances)	69	66
- purchase or renovate current home	68	48
- purchase agricultural land	0	4

- Income from seaweed farming has helped most respondents improve their clothing and enabled many of them to engage more frequently in social functions such as social and religious travelling. Seaweed money has helped almost half of the respondents in Rameshwaram celebrate a marriage in the family.
- Income from seaweed farming has also helped most respondents purchase household assets such as livestock and consumer durables. Most respondents have used seaweed farming income for home purchase or renovation. About 4 percent of respondents in Rameshwaram have been able to purchase agricultural land with their seaweed income.

Summary

The results of the survey reveal that seaweed farming has emerged as a new, sustainable livelihood option for the fishing communities in the surveyed district. Encouragement of seaweed aquaculture with appropriate policy, financial, technical and institutional support can also serve to relieve pressure on overexploited fish stocks. Dramatic structural changes in the socio-economic status of many fishers have taken place the last ten years – a number of seaweed farmers actually started as hired labour for other farmers; however, many of them used this initial experience to become members of an SHG. After a few production cycles, SHG members can aspire to operate their own set of rafts and become a farmer capable of hiring labour to look after their own plots.

Seaweed farming has major strengths but also some weaknesses. Although Tamil Nadu is the second-most literate state in India (second only to Kerala), the expected social transformation resulting from higher levels of education (e.g. reduction in drinking and gambling) has yet to be reinforced, although the advent of seaweed farming seems to have made a positive contribution in this regard. A problematic feature of organized seaweed farming in India is that farmers are tempted to renege on their contracts if they are offered higher prices by competing agents, possibly leading to a chain reaction among neighbouring farmers. The established procurers have taken steps to address this situation by offering higher prices to farmers who attain high levels of production and ensure proper stock management.

4. GOVERNANCE AND INSTITUTIONS

4.1 Government agencies

Government agencies have actively supported seaweed cultivation through financial assistance and training. One of the agencies is the National Fisheries Development Board (NFDB). The NFDB is a government agency chartered in 2006 with the specific aim of supporting the development of the fisheries sector in India. Considering the vast potential of seaweed cultivation and processing in India, the NFDB has developed supporting schemes for the promotion of these activities. This support includes: (i) training and demonstration programmes; and (ii) the establishment of seaweed processing units. The NFDB also considers the provision of financial assistance for the construction of seaweed processing plants.

At the state level, the TNDoF supports seaweed farming as an alternative livelihood strategy for small-scale fishers (R. Dinakaran, personal communication, 2009). From 2007 to 2009, the TNDoF trained 1 300 fishers (13 batches of 100 members each) in the farming of *Kappaphycus*. This included 200 members of 40 SHGs who received a government subsidy under the Joint Liability Group scheme of the TNDoF.

4.2 Financial institutions

The State Bank of India (SBI) began to promote seaweed cultivation projects in collaboration with the Aquaculture Foundation of India (AFI) in 2006. It is estimated that each member of participating SHGs earned more than INR5 000 a month after repaying the monthly loan instalment to the SBI. This model represented a new approach for funding livelihood restoration projects following the destruction caused by the tsunami in December 2004. Almost 80 percent of those involved in these SHGs were women.

To ensure smooth implementation, farming contracts were arranged between the SBI and PepsiCo, enabling the bank to provide credit support to the SHGs interested in seaweed cultivation while PepsiCo agreed to procure the harvested seaweed.

The experience with SHGs has proved a major success in entrepreneurship development and loan recovery. By 2006, the SBI had granted a total of about INR 22.6 billion to more than 540 000 groups, 64 662 of which were located in Tamil Nadu. This approach was also implemented in the livelihood restoration project in Mandapam and extended to Tuticorin and Kanyakumari in the southern tip of Tamil Nadu. The SBI had plans to extend the project to other states and other coastal districts in Tamil Nadu. By March 2007, the SBI was planning to release more than INR1.0 billion in credit to support the livelihoods of more than 10 000 families.

Encouraged by the success of these SHGs, the District Rural Development Agency (DRDA) began providing subsidies to selected SHGs under the Swarnjayanti Gram Swarozgar Yojana programme, which covered 50 percent of the project cost, provided the subsidy did not exceed INR10 000 per person or INR125 000 per SHG, whichever was less. Under this scheme, the Bank of Baroda financed 40 SHGs (covering 200 members) in 2008–09. Sporadic financing has also been provided in Thanjavur, Tuticorin and Kanyakumari districts of Tamil Nadu by the Indian Overseas Bank and the SBI.

Another financial institution that has provided assistance to seaweed farming is the National Bank for Agriculture and Rural Development (NABARD). It is a refinancing development bank with a mandate for facilitating credit flow for promotion and development of agriculture and small-scale industries in rural areas of India. The funds available to commercial banks, including the SBI, for lending to the agriculture sector are normally routed through NABARD. Under this scheme, financing of SHGs is collateral-free. Because many SHGs in the Mandapam area already had savings accounts with their local banks, the channelling of collateral-free microcredit was facilitated. The involvement of the banks has also assisted the SHGs with mobilization, capacity building, training and extension of technology. Marketing arrangements were assured through contract-farming mechanisms wherein PepsiCo agreed to procure the harvested seaweed at a predetermined minimum price and remit the cash through the bank accounts.

An "Aquaclinic Centre" (Meenvalamaiyyam) in Mandapam has been promoted by NABARD and the M.S. Swaminathan Research Foundation, an Indian NGO that implements training programmes on various livelihood opportunities in fisheries (including seaweed culture), in association with the TNDoF. Seaweed culture has been singled out by the Government of India as one of the rural technologies deserving of promotion (Kunnumkal and Sant, 2002).

4.3 Self-help Groups (SHGs)

An SHG is an association of rural poor who have volunteered to organize themselves into a working group. The members of an SHG agree to save regularly and pool their savings into a common fund (known as the group corpus) and utilize the common fund through a common management arrangement.

At the time of writing, there were more than 110 SHGs involved in seaweed farming in Ramanathapuram District. Each group usually comprised five persons. In 2002–03, the daily-wage corporate model was the prevailing production arrangement in the region, which came to be replaced by the more successful SHG/Kudumbam (family) model of cultivation (KMC) model.

The KMC is a farming system initially introduced by PepsiCo and then widely adopted for *Kappaphycus* culture in Tamil Nadu. All seaweed farming in Ramanathapuram District is under the KMC. Cultivation is organized by members of an SHG who normally belong to the same family but may include other members from the same community. Collectively, the group prepares the rafts, seeds the lines, provides maintenance and harvests on the due date. Basic infrastructure is facilitated by the company, the harvest is purchased on a buyback basis and payments are affected by the company through the bank accounts of the SHG. A major advantage of the SHG/KMC model is that fishers are given an opportunity to become entrepreneurs in an activity with growth potential.

4.4 Research institutes and NGOs

A number of research institutes and NGOs have made substantial contributions to the seaweed farming movement in India. Some examples are:

- The Seaweed Research and Utilization Association (Mandapam), which was established in 1970, has been engaged in seaweed-related research activities such as organizing an annual symposium on algae-related topics, and it publishes a journal, *Seaweed Research and Utilization*.
- The Krishnamurthy Institute of Algology, which was established by a group of Indian researchers who felt the need for an institution devoted to research and development on algal studies, conducts studies on morphology, taxonomy, life history and basic algae chemistry. It also conducts periodical seminars and symposia on algal-related subjects and has been publishing a journal, *Indian Hydrobiology*.
- The Aquaculture Foundation of India (AFI), an NGO based in Chennai, Tamil Nadu, plays an active role in the promotion of seaweed farming in the southern districts of Tamil Nadu. The AFI identifies the most suitable SHGs for further involvement with government agencies and financial institutes. With support from Aquagri and the government departments, the AFI also imparts training and provides support to SHG participants for obtaining government subsidies and financing from financial institutes. It also works in collaboration with colleges and universities to increase the scale of seaweed farming.

5. CHALLENGES AND THE WAY FORWARD

The adoption of the SHG model introduced by PepsiCo in 2003 has allowed Indian farmers to circumvent many socio-economic problems that hinder development of the seaweed sector in other developing countries. A participatory approach to culture and management via contract farming has facilitated rapid expansion of seaweed farming in India. Seaweed farming, an activity that began as a livelihood option, has now led to an institutionalized socio-economic transformation of the farming villages. The insights gained from seaweed farming development in India can be summarized as follows.

- The adequate implementation of the SHG model of production largely explains the success of seaweed farming in Tamil Nadu.
- The commercial cultivation of *Kappaphycus* culture is perhaps the first enterprise of its type initiated by a corporate entity in Indian agriculture.
- One of the factors explaining the success of the SHG model is the consistent support provided by the banking sector led by NABARD and other commercial banks such as the SBI, Indian Overseas Bank, and Bank of Baroda.
- The clear policy and financial support provided by the Government of India through development agencies and research establishments has given a substantial fillip to the sector.
- The potential for expansion of operations in Andhra Pradesh and Gujarat will help consolidate the seaweed farming sector in India.

- The sector has been affected by poaching; however, the extent of the practice has been limited by the organizational structure of the SHGs.
- Industrial and urban runoff is reportedly having an adverse impact on the water quality of the grow-out sites. Improper garbage disposal in the region needs to be halted.
- Occurrence of seaweed diseases such as ice-ice and epiphytism – prevalent during the summer months – needs to be studied. Preventive and/or ameliorative measures need to be implemented.
- Corporate commitment has been essential to translating the concept of seaweed farming into tangible benefits to the farming community.
- The establishment of offshore seed jetties will enable farmers to increase yields by reducing the need to divert part of their output as cuttings for the next crop.
- Better coordination between the Tamil Nadu Department of Fisheries and the Department of Environment and Forests will allow stakeholders to conduct activities with a greater degree of confidence and trust.
- The seaweed sector in coastal India has all the potential to rise from the low-income conditions normally associated with basic livelihood activities to higher levels of employment, income and consumption.

Looking forward, there is an urgent need for establishing routine procedures for the collection, compilation and publication of data on standing stocks and landings from natural seaweed beds in India, by district and state. Entry into the *Kappaphycus* farming sector in India is restricted by knowledge. Corporations need to be educated on the immense scope in terms of returns to investment associated with seaweed farming, considering the low levels of initial investment and the fast turnover that can be expected given efficient human resource management. As envisaged in NAAS (2003), a mechanism (i.e. nodal cell) for rapid clearance of new projects and discussion of issues related to seaweed culture should be established to facilitate development seaweed farming in India. The nodal cell could also serve as an authoritative forum for the discussion of government orders and interdepartmental conflicts regarding seaweed farming development in India. Finally, any ambiguities arising from the tax regime on seaweed products in terms of excise and customs duties need to be clarified.

References

Aquaculture Foundation of India (AFI). 2008. *Final report of the DBT project: seaweed farming to rehabilitate tsunami affected coastal communities in Tamil Nadu*. New Delhi, Department of Bio-technology, Ministry of Science and Technology, Government of India. 41 pp.

Central Marine Fisheries Research Institute (CMFRI). 2005. *Marine Fisheries Census 2005*. Cochin, India.

Firdausy, C. & Tisdell, C. 1991. Economic returns from seaweed (*Eucheuma cottonii*) farming in Bali, Indonesia. *Asian Fisheries Science*, 4: 61-73.

Krishnamurthy, V., ed. 2005. *Seaweeds: wonder plants of the sea*. Chennai, India, Aquaculture Foundation of India.

Kunnumkal, M.C. & Sant, B.R., eds. 2002. *Directory of rural technologies: part IV*. Rajendranagar, Hyderabad, India, National Institute of Rural Development. 398 pp.

McHugh, D.J. 2003. *A guide to the seaweed industry*. FAO Fisheries Technical Paper No. 441. Rome, FAO. 105 pp. (also available at ftp://ftp.fao.org/docrep/fao/006/y4765e/y4765e00.pdf).

National Academy of Agricultural Sciences (NAAS). 2003. *Seaweed cultivation and utilization*. Policy Paper 22. New Delhi. 5 pp. (also available at www.naasindia.org/Policy%20Papers/pp22.pdf).

Padilla, J.E. & Lampe, H.C. 1989. The economics of seaweed farming in the Philippines. *Naga, The ICLARM Quarterly*, 12(3): 3-5.

Shang, Y.C. 1976. Economic aspects of *Gracilaria* culture in Taiwan. *Aquaculture,* 8: 1-7.

Tamil Nadu Department of Fisheries (TNDoF). 2009. *Swarna Grammeena Rozgar Yojana: seaweed cultivation*. Chennai, India, Department of Fisheries, Government of Tamil Nadu. 19 pp.