PROSPECTS OF SEAWEED FARMING IN INDIA

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Aerial view of the seaweed farm, Puthukudi village, Thondi

Introduction

Seaweeds are valued commercially for their cell wall polysaccharides such as agar, algin, carrageenan etc. and for the bioactive metabolites, manure and fodder. They have a variety of commercial applications in food, pharmaceutical, cosmetics and mining industry. Some seaweeds are also gaining importance as health foods for human consumption apart from its use as raw materials in extraction of bio-active compounds and marine chemicals. Edible seaweeds (macroalgae) also have the potential to provide a rich and sustainable source of macronutrients and micronutrients to the human diet. In Japan, approximately one-fifth of meals consumed, contain seaweed.

World seaweed production was 32.4 million tonnes (wet weight) with first sale value estimated at 13.3 billion USD. In India, nearly 20,040 tonnes of seaweeds are being harvested from the wild (species of *Sargassum, Turbinaria, Gracilaria* and *Gelidiella* by nearly 5,000 families in Tamil Nadu) per year. India contributes less than one per cent of global seaweed production having annual turnover of around Rs. 200 Crores. Among the global seaweed production through farming, *Kappaphycus alvarezii* and *Eucheuma denticulatum* contributes to 41 % of the total production.

In India, seaweed farming is being carried out mostly with *Kappaphycus alvarezii*. It is one among the economically important red algae, which yields carrageenan, a commercially important polysaccharide. Farming of *Kappaphycus alvarezii* by the fisher folks of Ramanathapuram District of Tamil Nadu has touched highest yield of 1,500 tonnes dry weight in 2012-13. However, the production sharply declined after 2013 due to mass mortality. Currently, around 400 tonnes dry weight is being produced. The purchase value of seaweeds which was Rs. 4.50 kg^{-1} (dry) during 2004 - 05 has steadily increased to Rs. 50 kg^{-1} (dry) in 2019 - 20.

Seaweeds also provide protection to a variety of organisms from which biodiversity is enhanced. They absorb carbon-di-oxide (CO_2) and reduce global warming. They are also efficient in controlling organic and inorganic load including heavy metals in the inshore waters and thereby ensuring ecological balances. Large scale mariculture of seaweeds is one of the climate resilient aquaculture techniques and very much essential to mitigate ocean acidification, which indeed is a green technology without the involvement of energy, fertilizers and chemical inputs. Seaweed farming is a low-cost simple technology, which is one of the effective diversified livelihood options for the marine fishers. Moreover, it is not a labour intensive activity and hence it is a women-friendly technology.

Farming Techniques - *Kappaphycus alvarezii*

Kappaphycus farming is widely carried out by floating bamboo raft, longline or monoline and tube net methods in Tamil Nadu coast.

Bamboo raft method

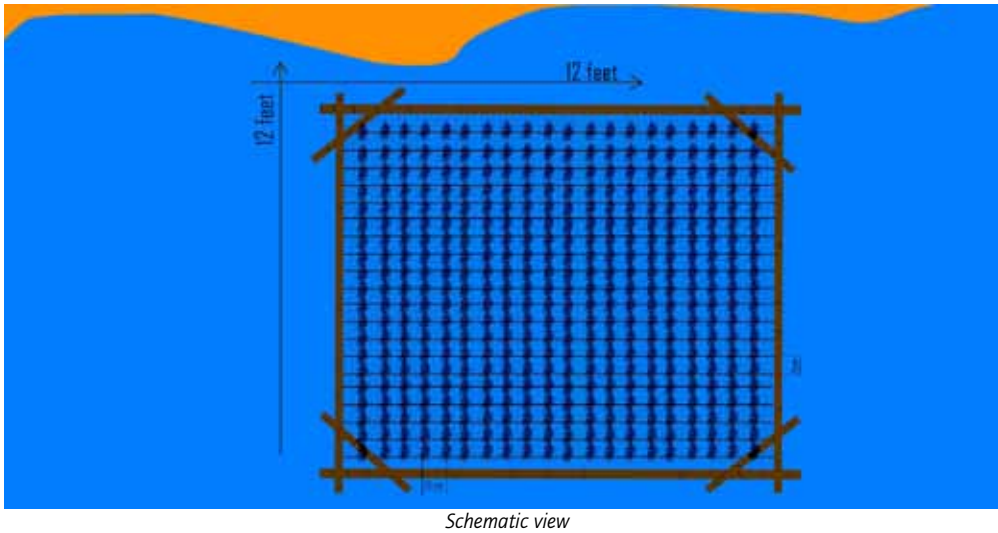
Floating **bamboo raft method** is ideal in locations which are **calm and shallow**. The floating raft is made

Tying the seeded rope on the raft

Raft ready for harvest (Crop period - 45 days)

of bamboo with dimensions of 12′ × 12′ for mainframe and 4′ x 4′ for diagonals. In each raft, around 20 polypropylene-twisted ropes are used for plantation. Around 150 – 200 grams of seaweed fragments are tied at a spacing of 15 cm along the length of the rope. A total of 20 seaweed fragments are tied in a single rope. The total seed requirement per raft is 60 – 80 kg. Fish net of 4m x 4m size is tied at the bottom of the raft to avoid grazing by herbivorous fish species. In normal season, a cluster of 10 rafts are positioned in the near shore area of 1.0 to 1.5 m depth using a 15 kg anchor. Whereas, during rough season the same cluster has to be installed using two or three anchors.

Preparing the bamboo raft



Schematic view

Floating bamboo rafts in the sea

Tying the seed

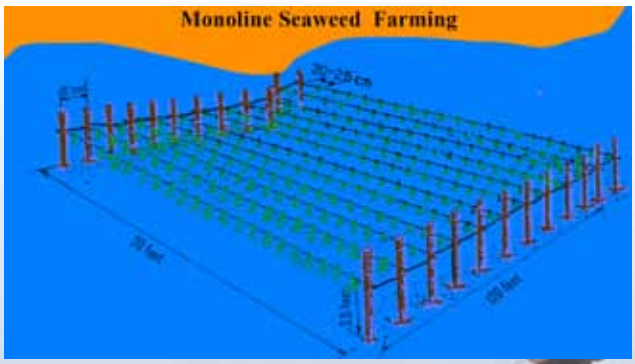
Harvested seaweed rope

Longline or monoline method

In locations characterized by **moderate wave action, shallow depth** and the **presence of less herbivorous fishes, longline or monoline method** of seaweed farming is ideal. A rectangular seaweed farming area of 120 feet length and 20 feet width is called as a segment. A total of 24 casuarina poles (10 feet length and 3-4" dia each) are required to form a segment. On one side, 12 casuarina poles are placed at 10 feet intervals (total length 120 feet). 20 feet away, a similar structure is erected parallelly as seen in the image below. The poles are interconnected using a 6mm rope and the seaweed seedling rope is fastened to this. Around 150 grams of seaweed fragments are tied at a spacing of 15 cm along the length of a rope and a single rope contains around 40 fragments. The total seed requirement per rope is 6 kg. A total of 10 ropes is equivalent to one bamboo raft in production. Hence, one segment is equivalent to 10 rafts. A fencing is made using HDPE fishing net to avoiding drifting and used PET bottles are tied on each rope for increasing the floatability.

Ropes ready for harvest after 45 days

Seeded ropes tied on the pole



Diagramatic view of a segment (10 monoline units)

Seeding the rope @ 150 grams per tie

Erecting the pole in the sea

Tube net method

Tube Net method of Seaweed cultivation

The **tube net** method can be adopted in locations with **higher wave action** in coastal states like Andhra Pradesh and Gujarat. The tube nets (10 cm diameter; mesh size of 1.5 cm) of 25 m length are held floating in the water column below the surface with an appropriate number and size of floats at regular intervals. Anchor stones (about 30 kg) are used at each end to hold the tube nets steady in the water column; if required, additional anchors of appropriate size and weight can be fixed intermediately. The seed material of 15 kg fresh weight is loaded into the tubes with the aid of a 1.0- or 1.5m long plastic pipe acting as a funnel or a hopper. The pipe diameter should be little less than that of tube net for efficient seeding. The plastic pipe is inserted into the tube net and the entire tube is pulled down, so that the mouth of plastic pipe stands out of the tube. The tube net is pulled down from the bottom of the plastic pipe carefully, in such a way that seedling material gets loaded into the tube sequentially leaving no gap between the seedlings. This process is continued till the entire tube net is seeded with algal biomass. The tube nets are closed at both ends with rope to prevent material being lost.

Economic Feasibility Analysis of Seaweed Farming
(Total 5 cycles in a year; each cycle is 45 days)

Unit cost for a floating bamboo raft

Sl. No	Particulars/Description	Quantity Required	Cost per Raft (Rs)
1.	3-4" dia hallow bamboos of 12'x 12' for main frame + 4' x 4' for diagonals (without any natural holes, crakes etc.,) @ Rs.10.00 per feet of bamboo	64'	640.00
2.	Five-toothed iron anchor of 15 kg each (@ Rs.70 per kg) – one anchor can hold a cluster of 10 rafts	1.5 kg	105.00
3.	3mm PP twisted rope for plantation – 20 bits of 4.5m each (@ Rs.230 per kg)	420 gm	97.00
4.	Cost of HDPE braider pieces (20 pcs x 20 ropes = 400 pcs of 25 cm each) (@ Rs. 330 per kg)	165 gm	55.00
5.	Raft framing rope 6m x 12 ties per raft i.e., 36mts of 4mm rope (@Rs. 230 per kg)	650 gm	150.00
6.	Used HDPE fishing net to protect the raft bottom (4m x 4m size) (@ 70 Rs/ kg)	1 kg	70.00
7.	2mm rope to tie the HDPE net (28 mts) (@ Rs. 230 per kg)	100 gm	23.00
8.	Anchoring rope of 10 mm thickness (17m per cluster of 10 rafts) (@ Rs. 220 per kg)	100 gm	22.00
9.	Raft linking ropes per cluster 10 rafts – 6mm thick – 2 ties x 3m x 9 pairs = 54m length (@ Rs. 230 per kg)	100 gm	23.00
10.	Braider twining charges		80.00
11.	Miscellaneous		35.00
	TOTAL		**1,300**

Unit cost for longline or monoline method

(equivalent to one bamboo raft in terms of production)

Sl. No	Particulars/Description	Quantity Required	Cost (Rs)
	FIXED COST		
1.	3-4" dia Casuarina pole 4nos each pole length as 10 ft (without any natural holes, crakes etc.,) @ Rs. 15.00 per feet	40	600.00
2.	3mm PP twisted rope for plantation – 20bits of 0.5 m each (@ Rs. 230 per kg)	420 gm	97.00
3.	Cost of HDPE braider pieces (40 pcs x 10 ropes = 400 pcs of 25 cm each) (@ Rs.330 per kg)	165 gm	55.00
4.	HDPE fishing net to make fencing for avoiding grazing & drifting (@ Rs. 350/kg)	1.0 kg	350.00
5.	Rope of 6mm thickness to make fencing between the poles - used to tie the plantation ropes (@ Rs. 230 per kg)	100 gm	23.00
6.	Braider twining charges		80.00
7.	Used pet bottles 40 nos. - used for floating 20 ropes (each cost @ Rs 1.50)	40	60.00
8.	Miscellaneous	100 gm	35.00
	TOTAL		**1,300**

Cost for floating 4 tube nets

(4 tube-net units is equivalent to one bamboo raft in terms of production)

Sl. No	Particulars/Description	Quantity Required	Cost per 4 tube -net units (Rs)
	FIXED COST		
1.	**Anchor stone** (@Rs. 50 /Stone)	8	400
2.	**Tubular Nets** (@Rs. 200/Tube (25m) - HDPE nets Food Grade nets used for net tube	4	800
3.	**Polypropylene ropes** (Used for tying the ends of tubes to anchor)		120
4.	**Plastic Floaters**		200
5.	**Anchor deployment**	4	280
	TOTAL		**1,800**

Operating cost for floating bamboo raft/monoline/ 4 tube- net units

Sl. No	OPERATING COST	Cost per unit (Rs)
1.	Seed material @ Rs. 8.00 per kg (bamboo raft/monoline: 150 gm x 400 ties = 60 kg; Tube nets: 15 kg x 4 = 60 kg)	480.00
2.	Labour (seeding, raft/monoline/tube nets laying & maintenance)	150.00
3.	Transportation of seed and other materials to the farming site	60.00
4.	Miscellaneous expenses	10.00
	TOTAL	**700.00**

Revenue from seaweed farming

(One bamboo raft/ monoline unit; Total 5 cycles in a year; each cycle is 45 days)

1.	Annual seaweed production (260 kg/raft/ monoline unit) (Retaining 60 kg for next crop, total fresh seaweed production from 5 cycles)	1,000 kg
2.	Total seaweed production on dry weight basis (10 %) (from 5 cycles)	100 kg
3.	Price of dried seaweed (Rs. per kg)	50
Gross Revenue in Rs.		**5,000**
Total cost of production (Rs.) (Rs.2,000 rafts/monoline units)		**2,000**
Net income (Rs.) (Gross revenue – Total cost of production)		**3,000**

Revenue from seaweed farming

(Four tube-net units equivalent to one bamboo raft; Total 5 cycles in a year; each cycle is 45 days)

1.	Annual seaweed production (260 kg/raft/4 tube net) (Retaining 60 kg for next crop, total fresh seaweed production from 5 cycles)	1,000 kg
2.	Total seaweed production on dry weight basis (10 %) (from 5 cycles)	100 kg
3.	Price of dried seaweed (Rs. per kg)	50
Gross Revenue in Rs.		**5,000**
Total cost of production (Rs.) (Rs.2,500 tube-net units)		**2,500**
Net income (Rs.) (Gross revenue – Total cost of production)		**2,500**

Unit cost for a floating bamboo raft

The crop duration for seaweed farming is 45 days and, in a year, four to six crops per cycle (6 to 9 months) are harvested depending on the climatic conditions. The 150 g seed material planted initially grows up to 500 to 1000g in 45 days. From one bamboo raft/ monoline/4 tube-nets, an average yield of 260 kg is obtained. After retaining 60 kg as seed material for the next crop, remaining 200 kg is sold either in fresh or dry weight basis. The harvested seaweeds are sun dried for two to three days and the average dry weight percentage of the harvested seaweed is 10 %. Hence, 20 kg is obtained by drying 200 kg of fresh seaweed.

The net income through seaweed farming from a tube-net (4 units) or bamboo raft method is around Rs.2,500 to Rs. 3,000/-. It is evident from the economic performance analysis that there is a substantial return/ profit from farming. If a fisherwomen family handles 30 tube-nets (one tube-net equivalent to 4 bamboo rafts) or bamboo rafts, a substantial net income of Rs. 75,000 to Rs. 90,000/- can be obtained in a year.

Farming Techniques – Native seaweed species

Gelidiella acerosa	Bottom-culture method using coral stone as a substratum
Gracilaria edulis	Longline rope method using coir rope as substrate or Single Rope Floating Raft Technique (SRFT) method
Hypnea valentiae	Monoline or Longline method using vegetative fragments
Gracilaria dura	Monoline or Longline & Floating raft method using vegetative fragments
Gracilaria debilis	Floating raft method using vegetative fragments

Issues to be addressed for expansion

The growth of seaweed farming sector is constrained primarily by lack of proper marine spatial plans, availability of start-up seed material for farming, appropriate financing and insurance. Seaweed farming in India revolves around only *Kappaphycus*. However, farming of native species like *Gracilaria edulis, Gracilaria dura, Gracilaria deblis* and *Gelidiella acerosa* is very essential to meet the demand of seaweed industries. Though farming techniques are available for the native species like *Gracilaria* spp. and *Gelidiella acerosa,* its techno-economic viability has to be studied. The prime constraint faced by the seaweed farmers are heavy loss of crop due to high temperature/disease. Other constraints were reduction in seaweed yield due to grazing and damage of bamboo rafts during natural calamities.

Currently there are around 46 seaweed-based industries – 21 agar industries (10 functional) and 25 alginate industry (12 functional) in India. In Tamil Nadu there are around 35 industries mostly located at Madurai, Ranipet, Kangeyam, Paramakudi, Kumbakonam, Nilakottai and Thirunellar. There are few industries reported at Kerala, Karnataka and Gujarat. The Indian requirement of agar and alginate is about 400 tonnes per annum and 1,000 tonnes per annum respectively, whereas only 30 % and less than 40 % respectively of it is being produced indigenously. The balance requirement is being imported. The Indian requirement of carrageenan is 1,500 – 2,000 tonnes per annum. As indigenous production is negligible, it is mostly being imported. Taking the demand on agar, alginate and carrageenan, the total annual seaweed requirement in dry weight basis is 4,000 tonnes of agar yielding algae; 5,000 tonnes of alginate yielding algae and 4,500 to 6,000 tonnes of carrageenan yielding algae. The cultivated seaweeds shall also be utilized for the production of polysaccharides, fertilizer from the sap, sludge and high-value products, such as nutraceuticals/cosmeceuticals for use against various lifestyle diseases/cosmeceutical purpose, and popularize the utilization of the seaweeds in Indian coastline as prospective functional food ingredients for improving human immunity and nutrition.

Conclusion

Expansion of seaweed farming in the country will improve the socioeconomic status of coastal fishermen/farmers and will be helpful in mitigating the negative effects of climate change while protecting the marine ecosystems from ocean acidification and ocean de-oxygenation. It is one of the important diversified livelihood options for the coastal fishers. Hence, the Government of India is planning to promote seaweed farming through Pradhan Mantri Matsya Sampada Yojana (PMMSY) by providing financial, marketing and logistical support to ensure income and welfare gains to small fisher population, especially women and fisherwomen headed households.