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GOOD MANAGEMENT PRACTICES IN SEAWEED FARMING

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भाकृअनुप
ICAR

Indian Council of Agricultural Research
Central Marine Fisheries Research Institute
Post Box No. 1603, Ernakulam North P.O., Kochi-682 018, Kerala, India

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SEAWEED FARMING

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Authors
B. Johnson, G. Tamilmani, D. Divu, Suresh Kumar Mojjada, Sekar Megarajan,
Shubhadeep Ghosh, Mohammed Koya, M. Muktha, Boby Ignatius and A. Gopalakrishnan

Design
C. Samuel@Captsee.com and K. Mugesh Manikandan

ICAR-Central Marine Fisheries Research Institute (CMFRI),
Post Box No. 1603, Ernakulam North P.O., Kochi-682 018, Kerala, India.
Phone: +91 484 2394357, 2394867 Fax: +91 484 2394909
E mail : director.cmfri@icar.gov.in
www.cmfri.org.in

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Foreword

Seaweeds (marine macroalgae) are important coastal resource valuable both for society and the environment in many countries. In India, seaweed farming is one of the effective, diversified livelihood options for marine fishers. It has high potential to supplement marine production and can provide sustainable income to the coastal fishers, especially fisherwomen. Expansion of seaweed farming in the country will improve the socio-economic status of coastal fishers and will also be helpful in mitigating the negative effects of climate change, while protecting the marine ecosystems from ocean acidification and ocean de-oxygenation. Owing to its importance, the Government of India is promoting seaweed farming through the Pradhan Mantri Matsya Sampada Yojana (PMMSY) by providing financial, marketing and logistical support.

The ICAR-Central Marine Fisheries Research Institute (CMFRI) has been working on seaweed mariculture and seaweed utilization in India since 1972. Annual seaweed harvest estimation (wild collection) from the Indian coast and production through farming in the sea along the east coast of India are being enumerated periodically by this Institute from which the potential seaweed yield has been estimated at 0.26 million tonnes/year. The institute is promoting seaweed farming activity along the coast through the Scheduled Caste Sub-Plan (SCSP) programme. The institute has developed and commercialized many nutraceutical products from seaweeds, which received appreciation from the Government of India.

The Mandapam Regional Centre of ICAR-CMFRI has developed a cottage industry model for the manufacture of agar from *Gracilaria* spp. and demonstrated agar production to many farmers and entrepreneurs. These demonstrations have paved the way for the development of many small-scale agar industries in Madurai district, Tamil Nadu. More than 60 hands-on training programmes were conducted at Mandapam RC of ICAR-CMFRI on farming of *Kappaphycus* and native seaweed species during 2011-2022 covering 1636 trainees (fishers and government officials) from Andaman & Nicobar, Andhra Pradesh, Gujarat, Maharashtra, Kerala, Tamil Nadu and West Bengal.

Currently the institute is conducting a series of awareness-cum-training programmes on Pradhan Mantri Matsya Sampada Yojana (PMMSY) and seaweed farming. This has resulted in creating interest among many farmers/entrepreneurs to adopt seaweed farming. As a part of disseminating knowledge, a document on Good Management Practices on seaweed farming has been prepared. The document has a step-by-step narration of what one should and should not do in seaweed farming. I hope this document will be very useful to all the stakeholders interested in undertaking seaweed farming activities.

A. GOPALAKRISHNAN
Director, ICAR-CMFRI

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GOOD MANAGEMENT PRACTICES IN SEAWEED FARMING

INTRODUCTION

- Seaweeds are valued commercially for their cell wall polysaccharides such as agar, algin, carrageenan etc. and for bioactive metabolites, manure and fodder.
- They have a variety of commercial applications in food, pharmaceutical, cosmetics and mining industries. Some seaweeds are also gaining importance as healthy food for human consumption apart from their use as raw materials in extraction of bio-active compounds and marine chemicals.
- World seaweed production was 35.1 million tonnes wet weight with first sale value estimated at 16.5 billion USD (FAO, 2022).
- There are 10,000 species of seaweeds globally divided across three main types; red, brown and green seaweeds.
- India is endowed with 8,118 km coastline and bestowed with 0.26 million tonnes/year wet harvestable biomass of seaweeds belonging to 700 species.
- Of these nearly 60 species are economically important for their polysaccharides.
- In India, nearly 33,345 Tonnes wet weight of seaweeds per year are being harvested from natural seaweed beds (species of *Sargassum, Turbinaria, Gracilaria and Gelidiella* by nearly 5,000 families in Tamil Nadu) (FRAD, CMFRI, 2022).
- India contributes less than one percent of global seaweed production having an annual turnover of around Rs. 200 Crores.
- Among the global seaweed production through farming, *Kappaphycus alvarezii* and *Eucheuma denticulatum* contributes to 27.8% of the total production (FAO, 2022).

SEAWEED FARMING

- In India, seaweed farming is being carried out with *Kappaphycus alvarezii.*
- It is an economically important red algae, which yields carrageenan, a commercially important polysaccharide.
- Farming of *Kappaphycus alvarezii* by the fisherfolk of Tamil Nadu coast has touched the highest yield of 1,500 tonnes dry weight in 2012-13. However, the production has shown sharp decline after 2013.
- Currently, around 400-500 tonnes dry weight per year is being produced.
- Around 1,000 families are involved in seaweed farming in Tamil Nadu coast.

Price of farmed seaweed	2010		2022	
	Dry wt. (Rs / Kg)	Wet wt. (Rs / Kg)	Dry wt. (Rs / Kg)	Wet wt. (Rs / Kg)
Kappaphycus alvarezii	16.00	2.00	70.00	16.00

FARMING TECHNIQUES FOR NATIVE SEAWEED SPECIES

Bottom - culture method using rock or any hard substratum

Raft / Monoline / Single Rope Floating Raft Technique (SRFT) method

Monoline or Longline and Floating raft method using the vegetative fragments

Tank cultivation method (Land based)

USES OF SEAWEEDS

AGAROPHYTES

- *Agarophytes* are red seaweeds used as starting raw material for agar extraction.
- As per the reports available, the requirement of agar in India is about 400 tonnes per annum, whereas only 30% of it has been produced indigenously and hence, it is being imported.
- About 4,000 tonnes of agar yielding algae such as *Gracilaria edulis, Gracilaria salicornia* and *Gelidiella acerosa* need to be collected/cultured to meet the demand. However, currently production of these seaweeds through wild collection is around 1,500-2,000 tonnes in dry weight per year.

ALGINOPHYTES

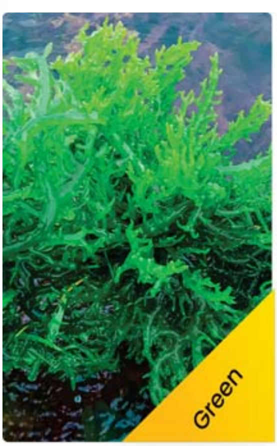
- *Alginophytes* are brown seaweeds such as *Sargassum* spp., *Turbinaria* spp., which are used as starting raw material for algin extraction.
- As per the reports available, the requirement of alginate in India is about 1,000 tonnes per annum, whereas only 40% of it has been produced indigenously and hence, it is being imported.
- About 5,000 tonnes of alginate yielding algae need to be collected/cultured to meet the demand. However, currently production of these seaweeds through wild collection is around 2,000-3,000 tonnes in dry weight per year.

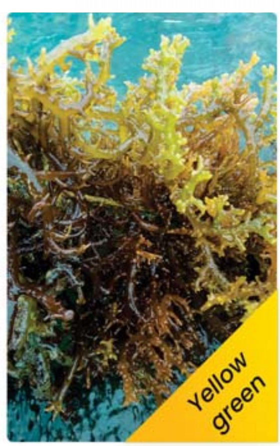
CARRAGEENOPHYTES

- The carrageenophytes are typically red seaweeds used as starting raw material for carrageenan extraction. *Kappaphycus alvarezii* is predominantly cultivated which yields kappa carrageenan.
- The Indian requirement of carrageenan is 1,500 – 2,000 tonnes per annum, whereas less than 10% of it has been produced indigenously.
- Taking the demand for carrageenan into account, the total annual seaweed requirement in dry weight basis is 4,500 to 6,000 tonnes of carrageenan yielding algae.
- The cultivated *K. alvarezii* exhibits different morphotypes and colour variants as a function of environmental parameters (Ricardo *et al.,* 2015).

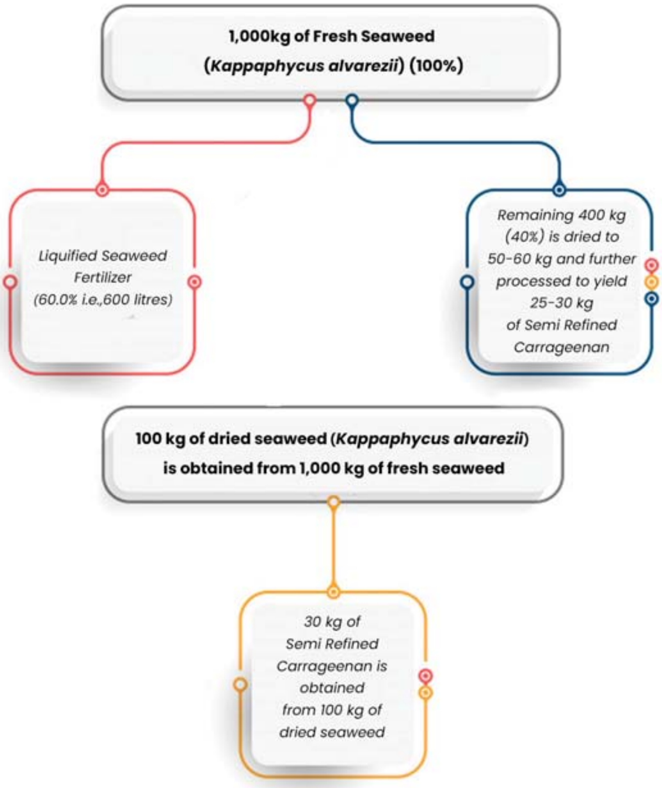
Kappaphycus alvarezii

DIFFERENT STRAINS OF *KAPPAPHYCUS*





COMMERCIAL USES OF *KAPPAPHYCUS*



EDIBLE GREEN SEAWEEDS

- Green algae like *Ulva* spp., *Caulerpa* spp., etc., can be consumed directly like vegetables for their richness in minerals, vitamins, proteins, essential amino acids and low-fat content.
- It is reported that *Ulva lactuca* consumption may help to lower cholesterol levels and it is also shown to have anti-tumour, anti-influenza and anti-coagulant activities.
- Food Safety and Standards Authority of India (FSSAI) is in the process of finalizing the safety standards for human consumption of green edible seaweed.

POTENTIAL AREAS FOR SEAWEED FARMING IN INDIA

Criteria for identifying the potential seaweed farming sites

- Nearshore areas within 1000 m distance from the lowest low tide line.
- Intertidal and sub-tidal zones with a rocky or sandy bottom.
- Previous existence of seaweed farming activity.
- Seaweed collection from natural seaweed beds.
- Sheltered areas with adequate current and tidal exchange.
- Areas with moderate wave action.
- Areas free from silt deposits.
- Optimum basic water quality parameters: Salinity (28 – 38 ppt), Sea Surface Temperature (26 – 31°C), pH (6.5 – 8.5) and Transparency (2 – 6 m).
- Areas away from fishing harbour/landing centre.
- No hindrance for existing fishing and other allied activities.
- Accessibility for inputs, transportation, marketing, watch and ward.
- Areas away from freshwater runoff and domestic or agro-industrial effluents discharge.

Potential areas for seaweed farming in India

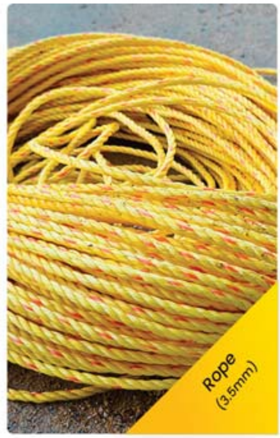
States	Approx. Area (Ha)
Gujarat *(Kutchh, Dwarka, Amreli, Gir-Somnath & Porbandar Districts)*	10,316
Tamil Nadu *(Ramanathapuram, Pudukottai, Thanjavur, Thiruvarur, Nagapattinam, Tuticorin, Tirunelveli, Kanyakumari, Cuddalore, Villupuram, Chengalpattu & Thiruvallur districts)*	5,048
Maharashtra *(Palghar, Raigad, Ratnagiri & Sindhudurg districts)*	2,724
Karnataka *(Uttara Kannada & Udupi districts)*	1,579
Odisha *(Puri, Ganjam, Baleswar & Jagatsingpur districts)*	1,525
Andhra Pradesh *(Visakhapatnam, Vizianagaram, Srikakulam, East Godavari, West Godavari, Krishna, Prakasam & SPSR Nellore districts)*	1,215
West Bengal *(South 24 Parganas & Purba Medinipur districts)*	450
Goa *(North & South Goa districts)*	120
Kerala *(Thiruvananthapuram, Kollam, Kozhikode & Kasargod districts)*	80
Diu *(Simar, Navbandar, Chakrathirth & Vanakbara coast)*	700
Lakshadweep Islands *(Agatti, Amini, Androth, Bitra, Bangaram, Chetlath, Kiltan,Kadmath, Kalpeni, Kavaratti & Minicoy Islands)*	213
Puducherry *(Puducherry, Karaikal)*	187
Total	**24,157***

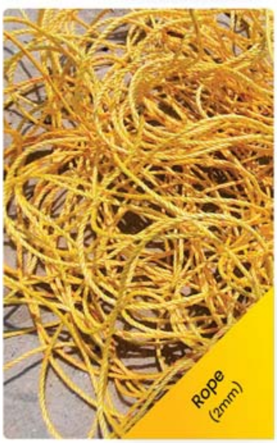
**Suitable areas along the coast of Andaman & Nicobar Islands yet to be finalized*

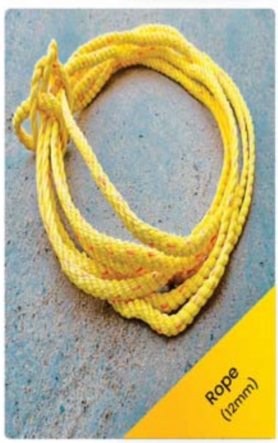
Seaweed production potential : 9.66 million tonnes wet weight / year
(400 rafts (12 X 12 feet) in 1 hectare X 1 tonnes/raft/year/24157 ha)

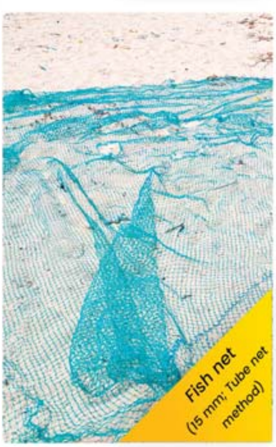
After site selection, common consensus has to be arrived with different stakeholders in the village for demarcating the area for seaweed farming. Prior intimation may be given to the fisheries and other line departments.

MATERIALS REQUIRED FOR FARMING





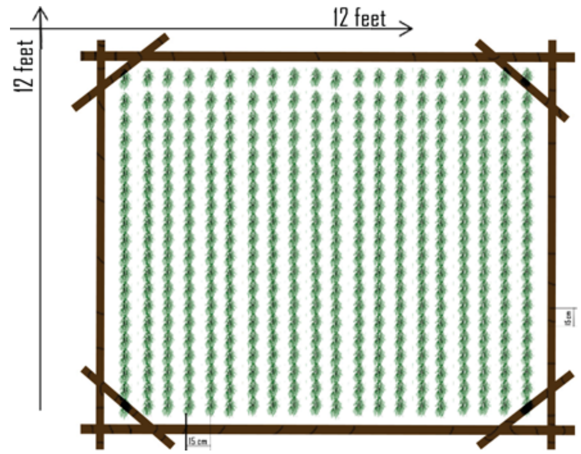




FARMING TECHNIQUES

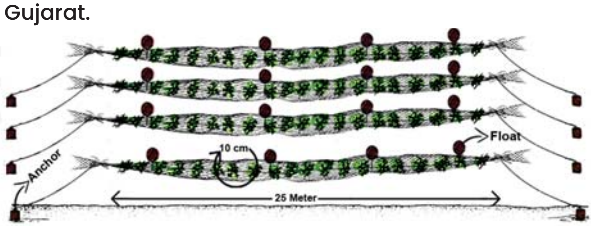
Bamboo raft method

In **places** which are **calm and shallow**, floating **bamboo raft method** is ideal.



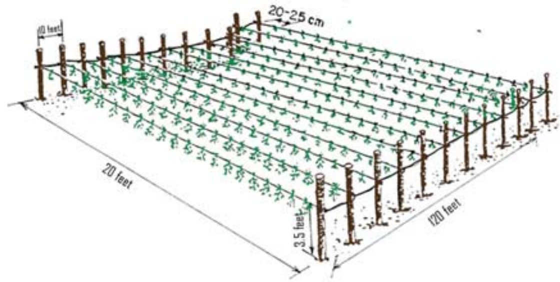
Tube net method

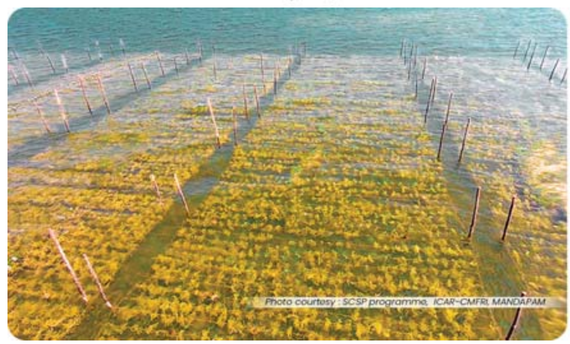
The **tube net** method is being adopted in places with **higher wave actions** in states like Andhra Pradesh and Gujarat.



Monoline method

In **places** characterized by **moderate wave action, shallow depth** and **the presence of less herbivorous fishes, longline or monoline method** of seaweed farming is ideal.





PREPARING THE FARM

- Measure and mark the area.
- Clean the site and remove unwanted materials.

PREPARING THE RAFT/MONOLINE/TUBE-NET

Bamboo raft method

Hollow **bamboo poles** of 3-4"diameter for a 12'x 12' (3.6x3.6m) main frame and 4' x 4' (1.2x1.2m) for diagonals without any natural holes, cracks etc., has to be selected and tied using 4mm rope.

Bamboos with natural holes, cracks, etc., have to be rejected.

Used **HDPE fishing net** 13' x 13' size (4x4m) has to be tied with 2mm rope on the raft bottom to protect the seaweeds from grazing.

Damaged HDPE fishing nets have to be rejected.

Plantation ropes for seeding can be made by cutting 3 mm or **3.5 mm polypropylene** twisted rope into 20 bits of 4.0 - 4.5 m length each.

Damaged ropes have to be rejected.

400 pieces of **HDPE braider** each with 25 cm length can be made by cutting the lengthy braider into 20 pieces for 20 plantation ropes.

Damaged braiders have to be rejected.

Twining of 20 braiders is to be done, each on the 4.5m length polypropylene twisted plantation rope at 15 cm intervals leaving 0.5m on either side for tying on the pole.

Seeding is to be done on the shore or in land, preferably under the shade.

Seedlings should be taken from healthy, preferably from the young portion of the plant with more apical portions.

Unhealthy seeds should be rejected.

In one hectare of area, 400 rafts of 12 x 12 feet size raft is ideal for seaweed farming. This ensures enough space between the rafts for good seawater circulation, maintenance and other farm operations.

If seedlings are taken from other districts/states, it should be placed in a clean net bag and kept at bottom (1-2m depth) of the sea for few days before planting.

Seed material should not be placed in open areas which are exposed to direct sunlight, rain, temperature and humidity changes. This would greatly affect the quality of seed material.

- 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 and 20 such ropes are tied in a raft with seed requirement of 60–80 kg.

- A cluster of five rafts linked with 6mm rope.
- A cluster of five rafts are positioned in the near shore area of 1.0 to 1.5 m depth using a 30 kg anchor tied with 12-14 mm rope.

Based on the location, the dimensions of monoline units will vary.

Method followed in Ramanathapuram district of Tamil Nadu is depicted below :

Monoline method

Required number of casuarina / eucalyptus poles 3-4" diameter of 10 feet length without any natural holes, cracks etc., are to be selected.

Casuarina/eucalyptus poles with natural holes, cracks, damages, etc., have to be rejected.

For one unit, four casuarina poles of 10 feet length and 3-4" diameter are erected at 10 × 20 feet distance, each in the corner.

On two sides, 6mm rope is tied, on which the seaweed seedling rope is tied.

Around 150 – 200 grams of seaweed fragments are tied at a spacing of 15 cm along the length of the rope (6.75m).

A total of 40 seaweed fragments are tied in a single rope.

The total seed requirement per monoline unit is 60 – 80 kg.

One segment (120 feet length and 20 feet breadth) constitutes 10 monoline units (one monoline unit is equivalent to one raft in terms of production).

Floats are tied on each rope for increasing the floatability.

Parallel orientation of monoline to water movement or shoreline will avoid damage to seaweeds, casuarina poles and minimize the attachment of floating debris.

Tube net method

Using HDPE food grade nets (1.5cm mesh size), tube nets can be made to a length of 25m with 10cm diameter.

- The tube nets 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 in between.

into the tubes with the aid of a 1.0 - 1.5 m 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.

Sea cage-based tube net method

- First activity involves, ideal site selection and installation of sea cage by stocking it up with desired marine finfish species.
- Preparation of the tube net for installing in the cage.
- Tube net fabrication should be done using fishing nets of square mesh (10 mm) net of 5 m length and 12-15 cm diameter.
- An average 1000 grams of good quality seed material can be placed in each net-tube.
- PVC pipe cut-outs are placed at regular intervals of 45 cm for maintaining the firmness of the tube net structure.
- The ends of the tube nets should be tied to the cage rings to hold the structure steady in the water column.
- A total of 5 tube nets of 5 m length for one 6 m diameter sea cage can be installed.

Selection of commercially significant seaweed species

Tube net preparation in process

Installation of prepared tube net inside the cage

Tying of the ends of tube net to the cage ring

MAINTENANCE

- Seaweeds need a gentle care.
- Daily visit to the farm is necessary.
- Broken-off, lost seedlings can be replaced periodically.
- Other seaweeds, sediments attached to the plants and ropes have to be removed regularly.
- Broken and drifted plants have to be removed periodically from the farming site.
- Damaged bamboo/casuarina poles have to be replaced periodically.

After 1 to 2 years of culture period, the unusable bamboo poles, ropes, braiders, nets have to be disposed properly instead of leaving in the sea/shore.

MANAGEMENT OF DISEASE

- "Ice-ice" is the only disease reported in seaweed farming.
- It is caused probably due to abiotic stress like low salinity, high temperature and low light intensity.
- The branches will show the symptoms of whitening and eventually disintegrate which may result in crop loss.
- If disease is observed, entire crop has to be harvested and farming has to be restarted with new seedlings.

MANAGEMENT OF EPIPHYTISM

- Attachment of undesirable seaweeds to the cultured species, which usually occur at the onset of monsoon brought by change in water temperature, trade wind and water current is epiphytism.
- Drifted seaweeds compete for space, nutrient and sunlight with the cultured species.
- Other seaweeds attached to the cultured species have to be removed periodically.

MANAGEMENT DURING NATURAL CALAMITIES

- Natural calamities like heavy storm and cyclone causes complete damage to *K. alvarezii* farms.
- Based on early weather warnings, premature harvest can be done.
- A portion of seaweed seeds can be placed in a net bag and kept in deeper waters for further use.

HARVEST

Photo courtesy: SCSP programme, ICAR-CMFRI, MANDAPAM

- Seaweeds are ready for harvest in 45 days.
- The harvested seaweed rafts/monolines must be placed over the tarpaulin sheets to avoid contamination by sand/silt.
- This method is easy and appropriate for selecting good seedling materials for subsequent cropping.

POST-HARVEST HANDLING

- Drying the harvested seaweeds on sand should be avoided to reduce contamination.
- Harvested seaweeds have to be dried on elevated drying platforms.
- While drying, impurities like stones, shells and other foreign matters can be cleaned.
- Harvested and dried seaweeds have to be covered with tarpaulin sheets during rainy seasons.
- After seaweeds are dried, they can be packed in sacks and stored in clean dry place.
- Seaweeds either in dry or wet forms are transported to the industries for commercial use.

ECONOMICS OF *KAPPAPHYCUS* FARMING

- Seaweed production: 1000 kg / raft / year-240 kg as seed material for 4 crops / year = 760 kg
- Price of seaweed: Rs. 16 /kg (wet weight) or Rs. 70 /kg/dry weight (Dry weight = 10%)
- Total revenue generated: Rs. 5320/year/raft @ Rs. 70 kg/dry weight
- Total cost of production (including capital cost): Rs. 2000/raft/year
- Net revenue: Rs. 3320/raft/year (Rs. 5320 minus Rs. 2000)
- One individual can handle average 45 rafts (12 ft x 12 ft)
- Total Net revenue (45 rafts) in dry weight = 45 x Rs 3320 = Rs. 1,49,400/year
- **In other words, production cost excluding seed cost is Rs. 26.30 / kg; Farmgate price is Rs. 70 / kg; Net gain is Rs. 43.70 / kg.**

Net revenue from one hectare (400 rafts) in dry weight = Rs. 13.28 lakhs/year.

ECONOMICS OF *GRACILARIA* FARMING

The seaweed farming trials by ICAR-CMFRI in various islands of Lakshadweep since August 2020 under the ICAR sponsored National Innovations in Climate Resilient Agriculture (NICRA project) revealed promising daily growth rate for the indigenous red algae *Gracilaria edulis* and *Acanthophora spicifera*. The experiments focused on farming using PVC net cages, PVC rafts and bamboo rafts. For scaling up the trial farming to a large-scale demonstration with people's participation, the Lakshadweep Administration has initiated a commercial scale demonstration programme with the involvement of women Self Help Groups (SHGs) and the seaweed industry with the technical support of ICAR-CMFRI.

Bamboo, being a natural material, was preferred for the scaled-up demonstration farming of *Gracilaria edulis* by the Lakshadweep Administration. However, grazing by green turtles and fouling by filamentous algae are deterrents in bamboo raft-based farming. The crop duration of *Gracilaria edulis* farming is 45 days. In a year, five to six crops or cycles (9 months) can be harvested depending on the weather condition. Seeding of 50 grams grows up to 500 to 1500 grams in 45 days. For one raft of 12 x 12 ft size, an average seed requirement is 20 kg. The average dry weight percentage of the harvested seaweed is 15 per cent (25% moisture). The farmers are set to receive Rs. 20/- per kg for dried seaweed. The economics of *Gracilaria edulis* farming in Lakshadweep is expected to be as follows:

Economics of Farming in Lakshadweep

Sl. no.	Components	Details/ Cost
1.	Seaweed production (average 20 folds growth)	2000 kg/raft/year minus 100 kg as seed material for 5 crops/year = approximately 1,900 kg (wet weight)
2.	Dry seaweed (25% moisture) (Dry weight = 15%)	285 kg
3.	Price of seaweed	Rs. 20/ kg/dry weight
4.	Total revenue generated	Rs. 5,700/year/ raft @ Rs. 20/kg/dry weight
5.	Total cost of production (including capital cost)	Rs. 2,578/raft/year
6.	Net revenue	Rs. 3,122/raft/year (Rs. 5,700 minus Rs. 2578)
7.	**Total Net revenue (25 rafts*) in dry weight**	**25 x Rs 3,122 = Rs. 78,050/year**
8.	**Net revenue from one hectare (400 rafts) in dry weight**	**Rs. 12,48,000/year**

**A person can handle an average of 25 rafts (12 ft x 12 ft)*

INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA)

- The idea of bio-mitigation along with increased biomass production can be achieved by integrating different groups of commercially important aquatic species which are having varied feeding habits. This concept is known as Integrated Multi-Trophic Aquaculture (IMTA).
- ICAR-CMFRI has been promoting cage farming of cobia, a high value marine fish since 2010. To achieve environmental sustainability and economic stability, an innovative idea of integration of seaweed with sea cage farming of cobia was demonstrated during 2014-17 at Munaikadu, Palk Bay, Tamil Nadu.
- A total of 16 bamboo rafts (12× 12 feet) with 60 kg of seaweed per raft were integrated for a span of 4 cycles (45 days/cycle) along with one of the cobia farming cages. The rafts were placed 15 feet away from the cage in a semi-circular manner, so as to enable the seaweed to absorb the dissolved inorganic and organic nutrient wastes which moves along the water current from the cage.
- Currently through IMTA, seaweed rafts integrated with cobia farming cage had a better average yield of 390 kg per raft, while in the non-integrated raft the yield was 250 kg per raft. An additional yield of 140 kg of seaweed per raft (56% additional yield) was achieved through the integration with the cage farming of cobia.
- An additional net income of Rs. 62,720/- (896 kg × Rs.70/kg of dry weight) was realized through integration of seaweed rafts with cobia cage.
- The specific rate of sequestration (per unit mass of seaweed per unit time) of CO_2 by the seaweed was estimated as 19 kg CO_2/day /tonne dry weight of *K. alvarezii* (= 760 kg CO_2 /day/tonne dry weight/ha).
- Carbon dioxide sequestration (per unit mass of seaweed/day/16 rafts/4 crops) into the cultivated seaweed in the integrated and non-integrated rafts was = 47.4 kg CO_2/day /tonne dry weight of *K. alvarezii* vs 30.4 kg CO_2/day/tonne dry weight. Hence, an additional 17.0 kg CO_2/day/tonne dry weight credit was achieved through the integration of 16 seaweed rafts (4 cycles) with one cobia farming cage (per crop).
- IMTA is an eco-friendly option ensuring sustainable income to the coastal fishers. It is also one of the significant mitigating measures for reducing the adverse impact of climate change and also earns carbon credit to our country.

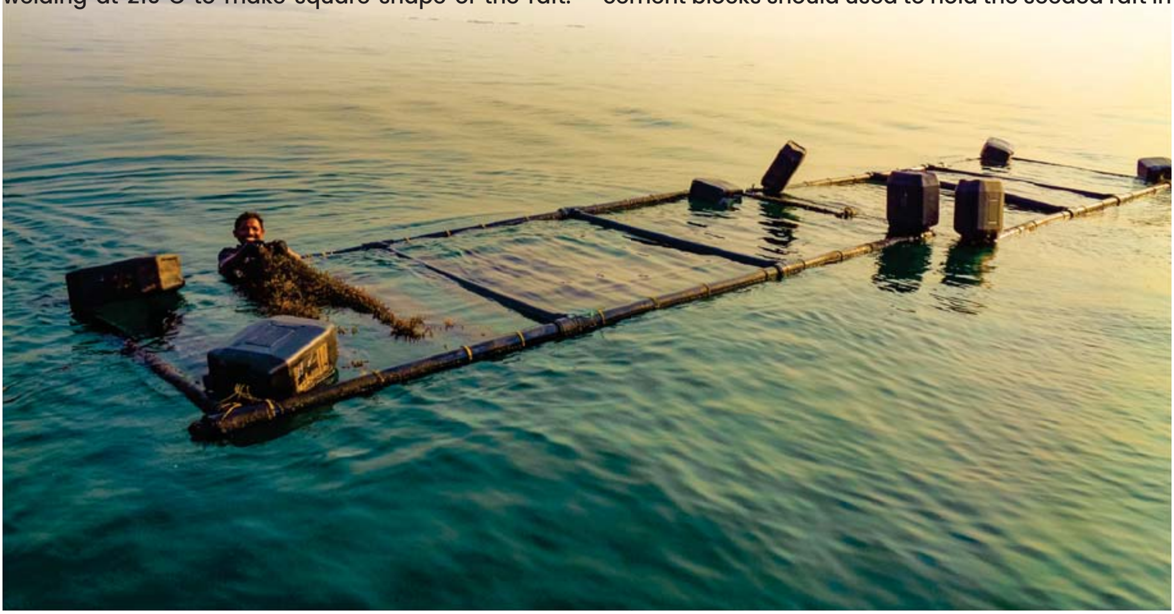
In one hectare of area, a total of 20 cages of 6 m diameter can be integrated with 320 bamboo rafts (12× 12 feet) @ 16 bamboo rafts per cage.

SEAWEED FARMING USING HIGH DENSITY POLY ETHYLENE (HDPE) RAFT BASED TUBE NET METHOD IN ROUGH SEA CONDITIONS

Seaweed culture in turbulent sea conditions is not as easy as in calm water seas. The floating bamboo raft-based monoline method commonly practiced in India is suitable for calm and shallow areas with minimum tidal influence. This bamboo raft cannot withstand high wave action. Also, seaweeds seeded in the monoline is directly exposed to the rough waters, and get easily damaged. Therfore, an innovative High Density Poly Ethylene (HDPE) raft-based tube net method supported by grid mooring is designed for culturing of *Kappaphycus alvarezii* in adverse climatic conditions prevailing mainly in North East and North West coast of India. The present method was tested along the North East coast, off Visakhapatnam and found suitable in withstanding rough weather conditions.

High Density Poly Ethylene (HDPE) pipes of 90mm outer diameter (PE 100 grade, PN 10) is used to prepare the square shaped (3x3m) floating raft. The corners of the pipe is joined by butt fusion welding at 210°C to make square shape of the raft. Tube net is prepared by using HDPE net material of 18 ply (1.25 mm twine thickness) and 25 mm mesh size (knot to knot). A mesh size of 25.0 mm (knot to knot) is recommended for tube net preparation for better growth of *K. alvarezii* through meshes of tube net. Seeds of 5.0 kg/tube net is seeded separately in the plain rectangular nets. Thereafter, both ends of the net were braced with 4.0 mm Poly Propylene (PP) rope to obtain the shape of tube net. For even distribution of *K. alvarezii* across the tube net, a few meshes were tied at an interval of 1.0 m across the length of the net; or else, *K. alvarezii* will congregate in the middle of the net tube due to growth increment after few days of culture. Seeded tube nets were tied across the length of the raft, and ten numbers of such tube nets is used for individual raft.

Raft structures should be anchored by grid mooring system preferably; however, single mooring anchoring system is also recommended. Dead-weight permanent anchors made of concrete cement blocks should used to hold the seeded raft in



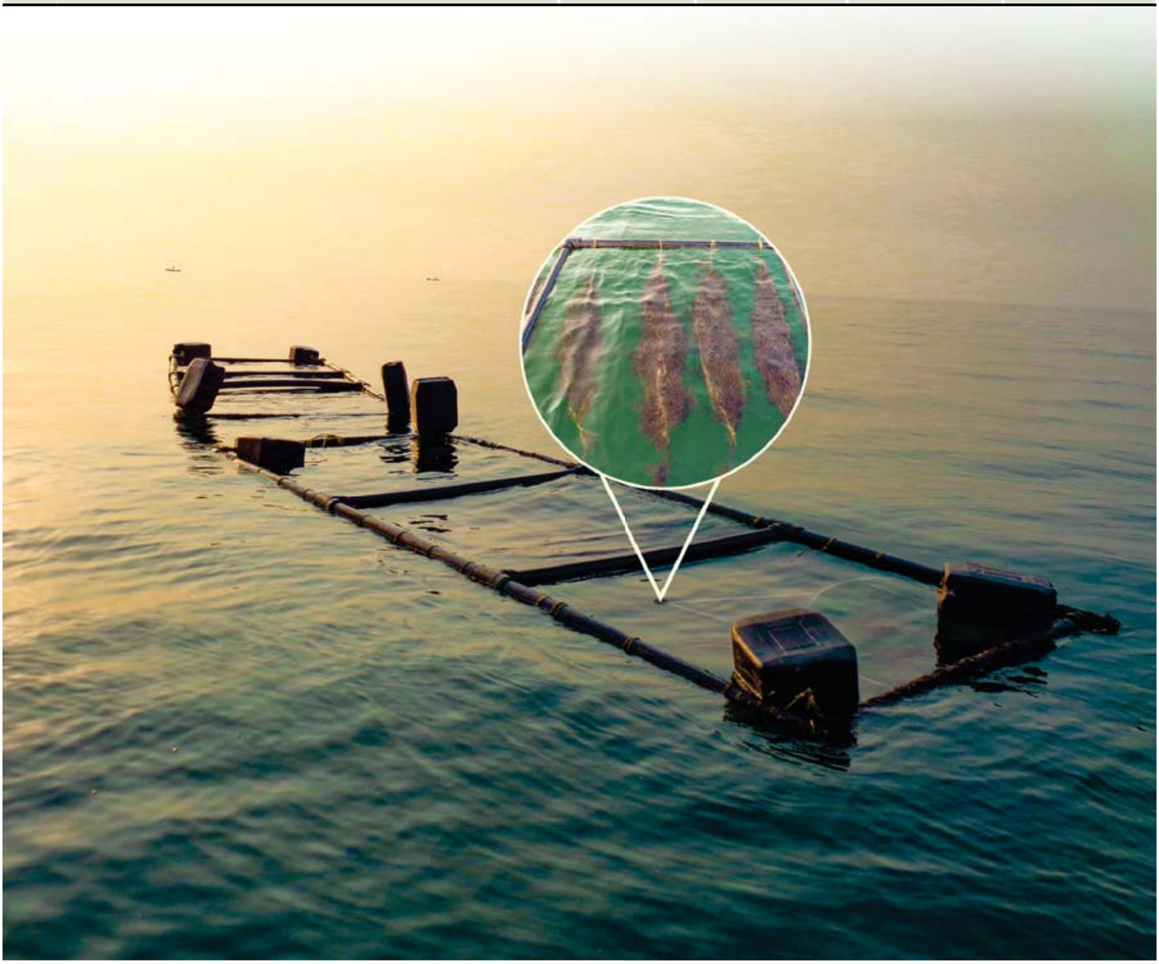
the water. The five concrete blocks in each corner of the grid is inter-connected with the help of long-link alloy steel mooring chain (13 mm diameter, 80 grade quality). This mooring chain should be connected at the top, to the floating HDPE raft with the help of D-shackles. Prior to connection with the raft, fibre reinforced plastic (FRP) cans of 200 litre capacity each, and filled with air, is attached to the mooring chain at every corner to facilitate chain floatation, thus arresting the direct downward pulling force on the raft structure. Each raft structure is tied with the 50 litre capacity cans at each corner, increasing the buoyancy of the raft. Length of mooring chain is dependent on the selected site; however, a chain length of 1.5 times higher than the water depth is advised to dissipate additional tension. The suggested mooring system helps to hold the 25 raft as a single unit.

It has been observed that the seaweed seeded with approximately 5 kg/tube net yields a production of approximately 30 kg. A total of 300 kg /raft consisting of 10 tube nets could be obtained. Therefore, *K. alvarezii* can be cultured for six cycles in a year costing 45 days of culture period/crop. Following this culture method will help to yield approximately 45000 kg of seaweed/year/cluster of 25 rafts with a net profit of 1.43 lakhs/year.

Annual costs and returns for K*appaphycus alvarezii* farming in 25 HDPE raft-based tube nets

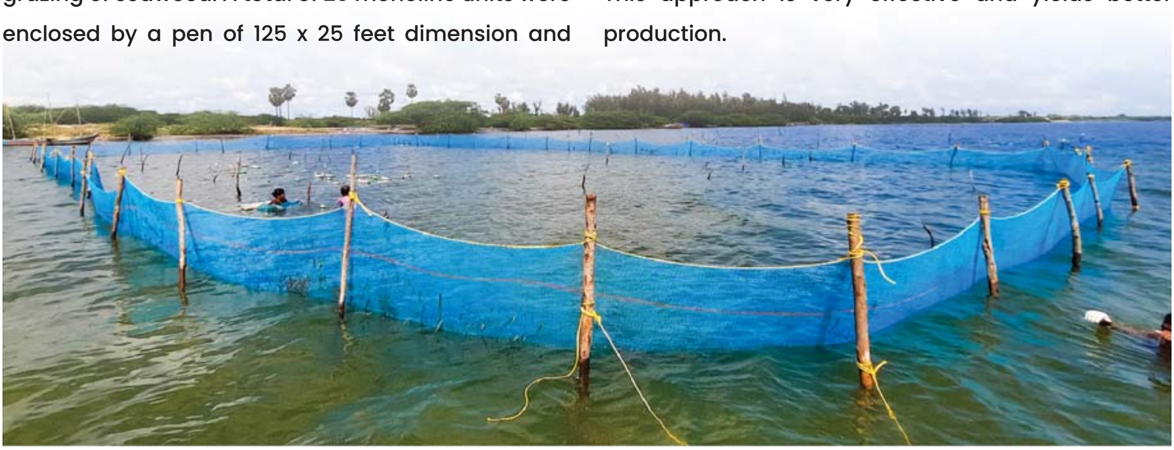
	Particulars	Quantity	Price per unit (Rs.)	Total Value (Rs.)	Economic Life (Years)
A.	**Initial Investment**				
1.	Rafts (nos.)	25	5000	125000	10
2.	HDPE Net (nos.)	25	500	12500	2
3.	Cement blocks (nos.)	20	1000	20000	10
4.	Mooring Chain (mts.)	60	600	36000	4
5.	Buoy (nos.)	100	100	10000	2
6.	Mooring buoy (nos.)	4	1000	4000	5
7.	Mooring Installation		5000	5000	
8.	**Total Initial Investment (Rs.)**			**212500**	
B.	**Fixed Costs**				
1.	Depreciation (Rs.)			35550	
2.	Interest on investment @ 7% per annum (Rs.)			14875	
3.	**Total fixed costs (Rs.)**			**50425**	
C.	**Operating Costs**				
1.	Seed material (Kg)	1250	16	20000	
2.	Labour charges for seeding and deployment (nos.)	12	600	7200	
3.	Harvesting (nos.)	24	600	14400	
4.	Maintenance and Miscellaneous Expenditure (Rs.)			15000	
5.	Interest on working capital @4% per annum (Rs.)			2264	
6.	**Total Operating Costs (Rs.)**			**58864**	
D.	**Cost of Production**				
Total Cost of Production (Rs. 50425 + Rs. 58864)				**109289**	

Particulars	Quantity	Price per unit (Rs.)	Total Value (Rs.)	Economic Life (Years)
E. Returns				
1. Total Production				
Gross Revenue (Rs.) Total production from 25 rafts is 45000 kg fresh weight (6 cycles @ 300 kg/cycle/raft)				
Excluding the seed material, the production is 37500 kg fresh weight (45000 kg – 7500kg)				
Total production in dry weight is 3750 kg (10%)				
Gross revenue @ Rs.70/kg of dry weight			262500	
2. Net Income (Rs.)			153211	



MANAGEMENT OF GRAZING – BIOLOGICAL APPROACH

Grazing by herbivorous fishes is one of the major issues in seaweed farming. To address this issue ICAR-CMFRI, Mandapam Regional Centre has initiated an innovative biological approach to prevent grazing of seaweed. A total of 20 monoline units were enclosed by a pen of 125 x 25 feet dimension and 10 nos. of Asian Seabass, a highly carnivorous fish weighing average 500 gram size were introduced inside the pen. The seabass could control the grazers like rabbitfish, small scaled terapon, etc. This approach is very effective and yields better production.



SEAWEED FARMING IN GULF OF MANNAR (GoM) CAN MITIGATE THE EFFECTS OF HARMFUL ALGAL BLOOM (HAB)

Worldwide the occurrence and intensity of HAB is increasing, which affects the fisheries and aquaculture severely. The occurrence of *Noctiluca scintillans* (Macartney) bloom in Gulf of Mannar (GoM) region of Tamil Nadu has become more frequent. In the last three years (2020, 2021 and 2022) during the months of September and October intense bloom of *Noctiluca scintillans* (Macartney) was observed in the GoM and fish kill was noticed both from the wild and cage farms. However, similar effects were not reported in Palk Bay region. Seaweed farming is predominantly adopted in Palk Bay region of Tamil Nadu, whereas such activities are not practised in GoM. Seaweed farming is capable of removing large quantities of inorganic nutrients like nitrogen, phosphorus and carbon from marine ecosystems. When seaweeds are harvested, inorganic nutrients are effectively removed from the ecosystem. Seaweed farming has a huge potential to reduce algal blooms. It reduces oceanic eutrophication, acidification, oxygenates the seawater and helps in maintaining a healthy ecosystem. Hence, seaweed farming in Gulf of Mannar (GoM) can be an option to reduce the effects of HAB.

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Good Management Practices in **Seaweed Farming**

Indian Council of Agricultural Research
Central Marine Fisheries Research Institute
Post Box No.1603, Ernakulam North P.O., Kochi-682 018, Kerala, India.
Phone: +91 484 2394357, 2394867 Fax: +91 484 2394909
E-mail: director.cmfri@icar.gov.in | **www.cmfri.org.in**