Seaweed Farming Manual

Seaweed Farming Manual is a comprehensive guide for coastal communities, entrepreneurs, and practitioners seeking to establish or improve seaweed farming operations. It provides practical, step-by-step instructions for each stage of the farming process, from planning and site selection to harvest and post-harvest management.

The manual covers:

- **Site Assessment and Farm Design:** Guidance on selecting optimal locations based on water quality, tides, and environmental conditions, as well as farm layout and structures suitable for different seaweed species.
- **Planting and Maintenance:** Techniques for seeding, growing and maintaining healthy crops, including disease and pest management, and practices for boosting yield.
- **Harvesting and Handling:** Instructions on the best time and methods for harvesting to ensure high-quality seaweed, along with proper handling and storage to reduce post-harvest losses.
- **Environmental Sustainability:** Principles of sustainable farming, including minimizing environmental impact, conserving biodiversityand supporting climate-resilient practices.
- **Economic Opportunities:** Introduction to value chains, linking farming to local and international markets, and opportunities for income diversification through seaweed products.
- **Community and Gender Inclusion:** Emphasis on involving women and youth in farming activities, building local capacity, and fostering collective action for stronger community benefits.

Packed with illustrations, practical tips, and real-world examples this manual is designed to be accessible to both new and experienced farmers. Its goal is to empower coastal communities with the knowledge and confidence to grow seaweed successfully, improve livelihoods and contribute to a sustainable blue economy.

ACTS PRESS

BE BLUE ECONOMY

Seaweed Farming Manual

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Foreword

Seaweeds are various species of marine algae and plants that grow in oceans, rivers, lakes, ranging from microscopic to large complex organisms. They are multicellular, and they lack true roots, stems or leaves, often attaching to rocks using a holdfast. Due to their multiple uses: (as food for humans, in animal feed production, manufacturing of fertilizer, medicinal use, industrial use especially in cosmetics, and as a source of biofuel, humans have been harvesting seaweed from the wild for centuries. As a result of reduced stocks in the wild due to over exploitation.

Seaweed farming originated in Japan, with documented practices dating back to as early as 1670 in Tokyo Bay (specifically Shinagawa and Omor) during EDO period. In Africa, the farming of seaweeds picked up in the 1980s, with commercial, organized cultivation establishing itself in Zanzibar and Pemba (Tanzania) around 1989. While wild, red Carrageenan-containing seaweed was collected for export in the 1930s, structured off-bottom cultivation to boost economic opportunities, particularly for women, started in Zanzibar Islands. Other countries in Africa include Kenya, Madagascar, Namibia, Senegal and Morocco. Consequently, huge potential has been discovered in seaweed farming in the Western Indian Ocean region as a key blue economy pillar. However, lack of capacity, inadequate technology, and insufficient awareness in seaweed farming has hampered the envisaged acceleration of seaweed value chains in the region. The farming in the region is presently dominated by women with relatively inadequate capacity of key actors in the value chain.

This training manual, therefore, aims to strengthen awareness on seaweed farming, build capacity of seaweed value chain actors mainly youth and women to scale up production to meet the global demand for seaweed and seaweed products. It is designed to cover basic elements of seaweed farming primarily targeted to be used in training trainers, who are based on ripple effect, are expected to train the actual coastal seaweed farmers in the region. The manual is thus designed to cover basic biology of seaweeds; seaweed farming spectra, including environmental flows; seaweed values and value addition; postharvest technology; seaweed business plans and marketing options for farmers; and challenges in seaweed farming and their suggested solutions. The training shall be best delivered both in theory, and through *in situ* practical training sessions.

Module 1

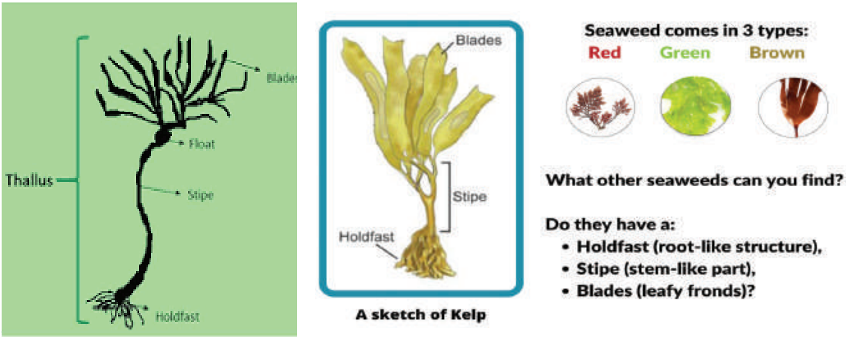
Introduction to Basic Seaweed Biology, Uses and History of Culture in the Western Indian Ocean (WIO) Region

1.1 Basic biology of seaweed

Seaweed structure

- Seaweeds are macro-algae, generally occurring in marine habitats. They are multicellular constructions but are different from higher (vascular) plants since they do not possess true roots, stems or leaves, making them thalloid in nature.
- The whole structure of seaweed (thallus) consists of a holdfast (for attachment to a substrate), a stem-like structure called stipe, and blades (branches).

(**Fig. 1)** Seaweeds are beautiful and colorful and are often called ocean ornamentals.



Basic seaweed structure (thallus)

Figure 1: Basic structure of seaweed

1.2 Types of seaweeds

- There are over 12,000 described species of seaweed (marine macroalgae) globally. These marine organisms are categorized into three main distinct groups based on their pigmentation: red algae (Rhodophyta), green algae (Chlorophyta), and brown algae (Phaeophyta) (Baweja et al. 2016) (**Fig. 2**).

- Red algae are the largest group, with over 7000 species, followed by brown algae with about 2000 species, such as kelp which can form large, productive underwater forests. Green algae include about 1500 species commonly found in shallow, warm or tropical waters (Algaebase 2000-2025).

- The brown seaweeds have the largest thalli ranging from the giant kelp that is often 20 m long to others that are 2 - 4 m long. Red seaweeds are usually smaller, generally ranging from a few centimeters to about a meter in length. Green seaweed is small, with a similar size range to red seaweed.

- In nature, most seaweed grow hard substrates like rocks attached by a holdfast.


Gracillaria spp.


Kappaphycus alvarezi


Eucheuma denticulatum

Red Seaweeds (Rodophyta)

Figure 2: Three main groups of seaweeds

1.3 Environmental requirements for seaweed growth

- Optimal seaweed growth requires specific environmental conditions, including water temperatures between 25-30^{0}C (for tropical species) or 5-20^{0}C (for temperate species), high water transparency for maximum sunlight penetration and consistent water currents (>20 cm/s) for nutrient uptake.
- The red macro-algae, such as Eucheuma, requires stable temperatures of 25-30^{0}C optimal range, while Gracilaria can withstand a wide range of temperatures, including up to 34^{0}C, though 25-28^{0}C is always cited as ideal for maximum growth.
- *Kappaphycus alvarezii (cottonni) requires warm sea water, high light levels, nutrient-enriched* water, and a high degree of water motion for successful cultivation (Glenn and Doty, 1990).
- *Eucheuma denticulatum (spinossum)* thrives in shallow clear waters. Optimal conditions include water temperatures of 25-30^{0}C, salinities of 27-35 parts per thousand, and a minimal depth of 0.5-0.6 meters at low tide, with high growth rates observed during cooler, rainy seasons (April to November).

1.4 Growth rates

- Seaweeds take up carbon dioxide dissolved in seawater. During photosynthesis, this gas reacts with water to create food for plants, and oxygen is released as a by-product.
- The seaweed then incorporates the products of photosynthesis into its tissues as it grows, locking carbon away from the surrounding water and atmosphere.
- In WIO, during the rainy season from May to August, seaweed growth rate is high because of favorable environmental parameters including; salinity, water temperature, pH and dissolved oxygen (DO).

1.5 Ecological importance of seaweed

- Biodiversity support: seaweed beds and kelp forests provide critical shelter and food for fish, invertebrates, and mammals, supporting high biodiversity.
- Carbon sequestration: Through photosynthesis, seaweed absorbs massive amounts of CO_2 helping mitigate climate change. Studies suggest seaweed beds can store as much carbon as mangroves, seagrasses and salt marshes combined.
- Water quality and filtration: Seaweed acts as a natural filter, removing excess nitrogen and phosphorus from coastal runoff, which prevents harmful eutrophication and reduces ocean acidification.

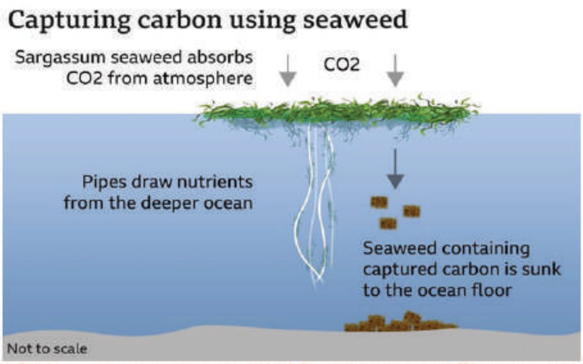


Figure 3: Carbon capture (sequestration)

1.6 Socio-economic uses of seaweed

Seaweed as human food

- Seaweed is a highly nutritious, sustainable superfood, rich in vitamins (A, B, C, and E), minerals (iodine, calcium, iron), fiber and protein, with a higher nutrient density than most land vegetables. It is linked to heart health, stable blood sugar, and thyroid regulation.

Seaweed as additive in animal feed production

- Seaweed used as a sustainable, mineral-rich (iodine, potassium, calcium) animal feed additive, improves immunity, gut health, and productivity in cattle and poultry, while specifically reducing methane emissions in ruminants by up to 90%via *Asparagopsis taxiformis* (Miles O'Brien 2025).
- It acts as a prebiotic, enhancing growth, egg production, milk and meat quality, boosting immunity and reducing the need for antibiotics, especially in poultry.

Manufacture of fertilizer

- Seaweeds' ability to sequester nitrogen and phosphorus from water has been used to produce fertilizers by communities in various regions throughout history. Traditional use was to transfer seaweed from the ocean directly to the soil, but sophisticated methods for extracting the desired components have been developed.
- Today, nutrients are sold in concentrated liquids called seaweed concentrates and are marketed as soil conditioners or fertilizers (**Fig. 5**).

Figure 5: Seaweed fertilizers

Medicinal uses

- Several compounds can be extracted from seaweed for use in medicine to treat health issues such as eczema, cancer, renal disorders, asthma, heart disease, ulcers, etc.
- The mineral content of seaweed is highly significant and probably has many health benefits, such as treating thyroid goiter.

Industrial uses of seaweed

- Some parts of seaweed from red and brown algae are used for extraction of agar, carrageenan, and alginate. These extracts are essential in pharmacology, microbiology, and tissue culture.
- Carrageenan and agar are gelling agents used to thicken foods and in the production of toothpaste, cosmetics, soaps, and medication.
- Carrageenan is widely used in the food industry, for its gelling, thickening, and stabilizing properties. Its main application is dairy and meat products, due to their strong binding to food proteins (**Fig. 6**).

Figure 6: Uses of carrageenan

1.8 History of seaweed farming in the Western Indian Ocean region

Beginning of seaweed farming in WIO region

- In the WIO region, for example Kenya and Tanzania, seaweed utilization began in the 1930s when it was collected from the wild for export to Europe.
- From 1989, seaweed cultivation in the WIO region picked up in countries like Tanzania, Kenya, Mozambique, Madagascar and a bit in South Africa.

Growth of seaweed farming in the WIO region

- Seaweed farming is practiced in several countries in the Western Indian Ocean (WIO), with most of them cultivating *Eucheuma denticulate*, *Kappaphycus alvarezii*.
- Tanzania being the largest producer of *Eucheuma* and *Kappaphycus*, with a small output in Madagascar, Mozambique and Kenya. The average annual production is 110,000-130,000 tons (FW) with Tanzania accounting for 92% and Madagascar 4.7% of the total production.
- Other countries in the region produce little or no seaweed due to environmental, diseases, economic and market challenges.

History of seaweed farming in Kenya

- Seaweed farming in Kenya began experimentally in 1989 in Gazi. Following surveys by Coppejans (1989) and Yarish & Wamukoya (1990), Kenya Marine and Fisheries Research Institute (KMFRI) found no suitable natural seaweed stocks for industrial harvest, concluding that mariculture was necessary.
- In 2001, Prof. Wakibia did Ph.D. study research on seaweed. The seaweed used for this study was *Eucheuma denticulatum* which was sourced from Zanzibar.
- In 2008, seaweed farming of *Kappaphycus alvarezii*, also sourced from Zanzibar, was introduced on an experimental basis under the RECOMAP project through KMFRI and PACT Kenya collaboration.
- KEPHIS certified the culture of *Kappaphycus alvarezii* in Kenyan waters in 2010. The certification opened the leeway for commercial seaweed farming in Kenya.
- The was formally introduced to coastal communities to provide alternative livelihoods, particularly for women, following declining agricultural yields (earth Journalism Network).
- Seaweed farming in Kenya is carried out by individuals or groups. Currently, there are about 20 groups of farming seaweed in Kwale

County and parts of Kilifi and Lamu counties.

- The groups help the farmers acquire inputs, add value to their seaweed, and sell their produce together. This helps to address common challenges and achieve socio-economic objectives.
- *Eucheuma denticulatum* comprises 98% of all farmed seaweeds in Kenya due to its resilient nature with most farmers using the off-bottom seaweed farming technique.
- The annual seaweed production in Kenya is around 100 metric tons dry weight.

Status of seaweed farming in the WIO region

- Seaweed in the WIO region is a rapidly expanding, female-dominated and sustainable livelihood, particularly in Tanzania, Madagascar and Kenya with focus on *Eucheuma denticulatum* and *Kappaphycus alvarezii*.
- While economically beneficial for coastal communities, the industry faces challenges from low market prices, climate related disease outbreaks (epiphytic invasion and ice-ice disease) and limited, shallow water cultivation techniques.
- Efforts are underway to move farms to deeper water, introduce new, more reselient species like gracilaria and develop local processing capacity to export higher value products rather than raw materials.

Module 2

Seaweed Farm Site Selection, Seeding and Production

2.1 Factors to consider during site selection for off-bottom seaweed farming

- Selecting an appropriate site for off-bottom seaweed farming is the most critical factor for operational success, impacting yield, quality, and structural integrity of the farm.
- Ideal sites are typically shallow, sheltered, and nutrient-rich, with sandy-muddy bottoms, ensuring that lines are submerged at low tide but receive ample light.
- The parameters considered for seaweed farming include:
  - ☐ **Water movement (currents):** moderate to strong water movement is necessary to ensure a steady supply of nutrients, aid in aeration, and prevent excessive temperature rises. A current speed of 20 – 40 meters per minute (approx. 10 –30 cm/sec) is generally considered ideal.
  - ☐ **Water quality and pollution:** the site must have clean, clear water, free from industrial, agricultural, or domestic pollution.
  - ☐ **Salinity:** seaweed (Eucheuma /kappaphycus) thrives in high salinity marine environments (27 –35 parts per thousand). Areas near river mouths or with heavy freshwater runoff must be avoided as they will kill the seaweed.

- ☐ **Light intensity/water depth:** clear water with good light penetration is required. The water depth shoild be enough to keep the seaweed submerged at low tide (at least 0.5 0 1 meter) to avoid sun exposure, which causes "ice-ice" disease.
- Availability of labor, acceptability by local communities, and site accessibility are additional important factors to be considered.

2.2. Factors to consider in site selection for deep-water seaweed farming

- Deep water seaweed farmers should look for good water motion that replenishes nutrients, keeps the seaweed clean and prevents extreme fluctuations in temperature, salinity, pH and dissolved gases.
- The farm should not be too exposed to strong winds, waves and currents which can destroy the floating rafts.

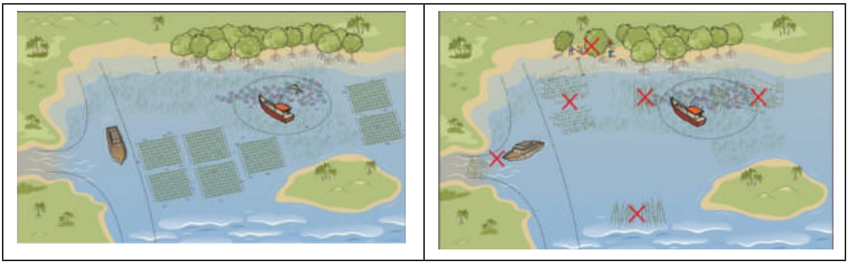


Figure 8: Good and bad sites for seaweed farm location

- Farm sites with level, sandy bottoms are better because they allow for uniform farm structures in which the lines are a standardized length and the stakes are located on the same parallel transect to the cultivation lines (TNC Manual, 2024).
- Level and sandy bottom locations also facilitate easy maneuvering by the farmer while conducting maintenance on the farm.
- Water motion is more important than light and temperature for *Eucheuma denticulatum* and *Kappaphycus alvarezii* growth because materials move in and out of these seaweeds by diffusion.

- Water movement across the farm also works to prevent the settling of fouling algae (epiphytic filamentous algae)
- Water flow rates of 20 cm/s help to provide adequate nutrients for seaweed
- Seaweed farms should not be situated in fishing areas, navigation channels and places with regular human activity.
- Areas exposed to strong wave action should be avoided to limit loss of seaweed and inputs.
- Locations with high amounts of silt, rocks, mangrove swamps, corals, turtle nests, abundant sea grasses and small pools with little water exchange should be avoided.

Table 1: Summary of site selection criteria

Parameters	Suitable	Not suitable
Depth during extreme low tide(m)	0.5-1.5	<0.1, >1.5
Dissolved oxygen (mg/l)	>6	<4
Salinity (ppt)	28-35	<12 >35
Temperature (C)	25-30	<20 >35
Turbidity (%)	>75	<25
pH	7.5-8.5	<6.5 >8.8
Water current	20-40m/m	<15 >35
Sea bottom soil	Firm, Sandy, no thick sea grass	Loam/clay
Presence of seaweeds species	Same genus	Unavailability
Marine plants/animals associated with seaweed	Present	Absent

2.3 The procedure of boundary marking of a model seaweed farm

- A model seaweed farm in Kenya consists of six equal plots, each measuring 10m × 10m (100m^2). (**Fig. 9**).

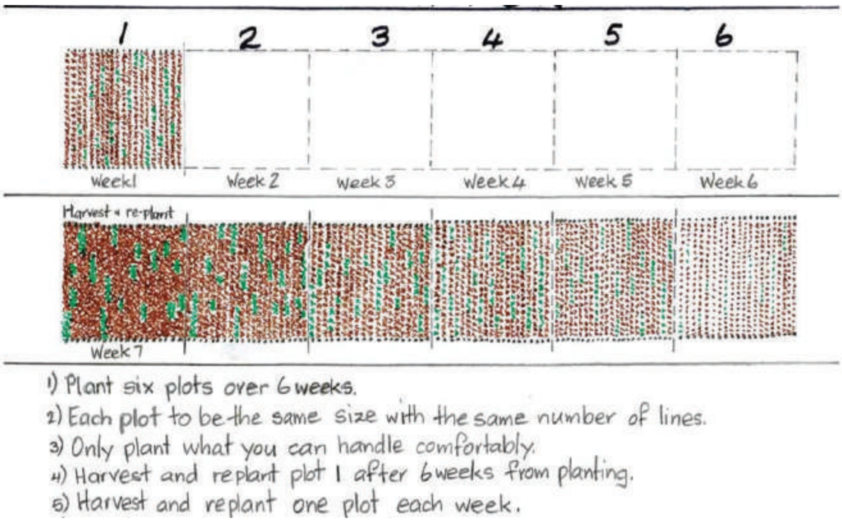


Figure 9: Model seaweed farm in Kenya

Each plot is marked out using the following steps:

- **Step 1:** Clear the targeted area of all undesirable materials and organisms including debris, slow moving organisms such as sea stars, crabs and sea urchins using a rake. These organisms compete for nutrients, light and space. They also graze on seaweed thereby hindering their growth.

- **Step 2:** Stake four wooden pegs into the sea bed using a mallet/ sledge hammer thereby marking the four corners of the first plot.

- **Step 3:** Mark out the boundaries of the remaining 5 equal plots adjacent to plot one using the same procedure used in step 2.

- **Step 4:** After marking the outward boundary of the plots, the remaining stakes are fixed at a distance of 0.5 m apart. The polypropylene lines are tied on the stakes 0.3 - 0.5 m away from the bottom depending on the water depth during low tide (**Fig. 10).** In Kenya's model seaweed farms, the length of each monoline rope is 10m.

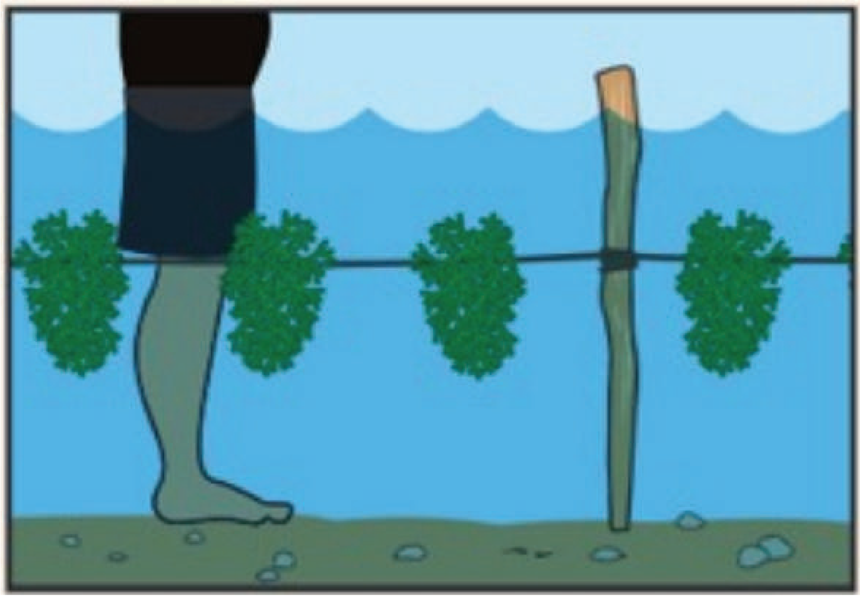


Figure 10: Monoline are tied 0.3 – 0.5m from the seabed

2.4 Positioning of the farm parallel to wind direction

- The seaweed growing lines should be oriented parallel with dominant seasonal wind direction. This is important for enhancing water movement which enhances nutrient circulation in the farm and enhanced uptake by sea weed.

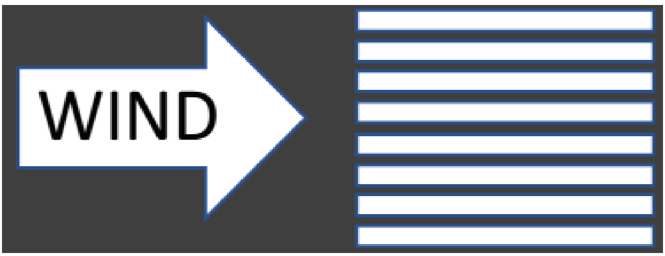


Figure 11: Wind direction is parallel to lines of seaweed

2.5 Model seaweed farm plan

2.5.1 Define model seaweed farm

- A model seaweed farm is a six-plot farm with a total of 300 monoline where propagation of the seaweed takes place. A plot consists of 50 lines of 10m long and a block consists of 300 mono line.
- The distance between adjacent lines is 50 cm. In every line, 50 seaweed seedlings are tied at 20 cm between the seedlings.

2.5.2 Size of a model seaweed farm

- A model farm covers a total area of 1500 m^2 (each plot measuring 25m × 10m = 250m^2). The six equal plots making up the model seaweed farm add up to a total area of 1500m^2.
- Each plot carries 50 lines of 10m in length, amounting to a total of 300 mono lines.

2.5.3 Installation of a model seaweed farm

- A model seaweed farm is installed step by step starting with plot 1, 2, 3, 4, 5 & 6. In each plot, the four outer boundary stakes are installed first followed by the inner ones.
- The first step is to clear the site of undesirable organisms, then stake the pegs into a strong substrate using a mallet. Tie the monofilament of nylon or polyethylene ropes on the stakes.
- The lines are installed parallel to the prevailing water current and tied at fixed intervals to allow water movement and passage. The distance of the rows of stakes is 0.5 m apart. The cultivation lines are 30-50 cm from the bottom at the lowest tide (**Fig. 12**).

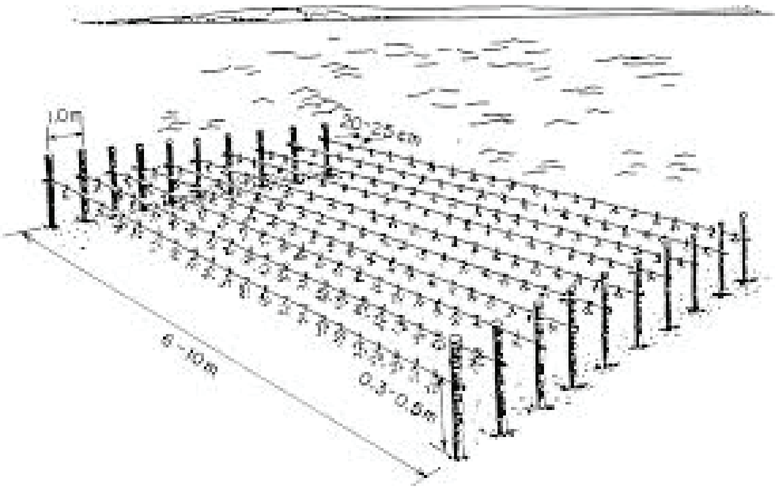


Figure 12: Installation of stakes in a model seaweed farm

2.5 Seeding of model seaweed farm

2.5.1 Monoline

- The model seaweed farm can be seeded with seedlings from outside the farm or from inside the farm. Each seedling weighs between 70-150g (average 100g) and is tied to the monoline using a plastic straw called tie-tie at a distance of 20 cm between the seedlings.
- Each monoline of 10m length therefore carries 50 seedlings, and each plot carries a total of 2500 seedlings. The whole model seaweed farm requires 15000 seedlings for the whole block consisting of 6 plots.
- Choose luxuriant and strong branches for planting. Always use a clean, sharp stainless-steel knife to cut the branches (thalli) to leave a smooth surface.
- The size of the propagules should be 100 grams. Seedlings should have no traces of grazing or early signs of ice-ice. Clean the seedlings and remove all attaching debris (**Fig. 13**).

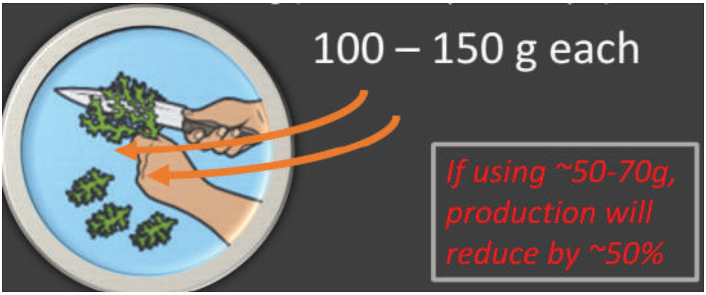


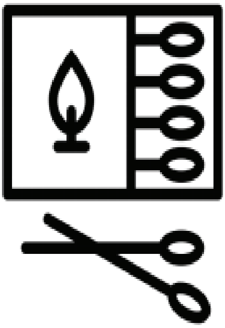
Figure 13: Preparation of seedlings for tying on monoclines

2.6 Seaweed Farming Equipment

- The essential equipment and materials for successful seaweed farming include: boat, weighing balance, multi-parameter water quality meter, thermometer, buoys, measuring tape, stakes (pegs), stainless knife, mallet/sledge hammer, polyethylene ropes, plastic straws (tie-tie), panga and manila sacks/bags among others (**Tables 2 & 3**).

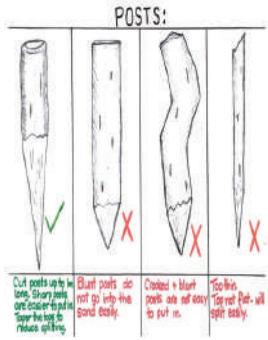
Table 2: Essential equipment used in seaweed farming

 Polyethylene rope (4'' to 6")	 A sharp knife	 A sledge hammer
 Plastic straw (tie tie)	 Tape measure	 Stakes (pegs)



Matches (Lighter)

Mining bar (Tarimbo)



Various types of pegs

Panga (machete)

Sacks (gunny bags)

Buoys

Table 3: Summary of materials required for a model farm and their estimated costs

Item / materials	Specifications	Quantity	Cost	Usage
Polyester twine (tie tie)	1.5-2 mm UV Protected	43-45 rolls of 1 kg @1000/	45000	They hold the seeds to the rope
Polyester rope	4 – 6 mm UV Protected	17 - 18 roll @2200/	39600	Holds the seeds in the water
Machete (Panga)		1@350	350	To prepare the pegs
Mallet	1-2 kgs	1@1200	1200	To drill the pegs to the ground
Mallet handle	Short handle	1@100	100	For holding the mallet

Stakes	0.5-1m length (dependent on the soil type), 2-3 cm (width in diameter)	450-600 @ 10	6000	For tying the ropes
Seaweed seedlings	Young seedling (50-100 g)	750-1500kg@	15000	For planting
Gunny bags	100kg @100	10	1000	For carrying seaweed seeds and product
PPEs • Safety shoes • Sunshades • Cap • Raincoat	: shoes : sunshades : Cap : Raincoat	1 @1200 1@300	1200	For safety
Harvesting boat			0	Transportation
Knife	Stainless	1@200	200	Cutting seaweed during planting and harvesting
Crowbar (Tarimbo)		1@1500	1500	Making holes for stakes
			111,150	

NB: these prices vary depending on the quantity

2.7 Selection, Sourcing and Planting of seed

- Seaweed cultivation involves the careful selection of high-quality thalli (seedlings), sustainable sourcing, and precise planting techniques to maximize growth and prevent disease. The process generally relies on vegetative propagation for species like *Eucheuma* and *Kappaphycus*, where fragments of mature plants are used as seeds.
- Establishing a seedling bank or nursery in deeper water allows for protection of stock during periods of warmer water, high grazer activity, or during cyclones.

2.7.1 Seed selection

- Red seaweed farmers obtain new material for planting by breaking off small pieces (70 - 150 grams) from a mature piece of seaweed and then tying these small pieces onto the polyethylene growing line using tie-tie.
- Healthy and young branches (thalli) with no signs of diseases or infection from epiphytes or thalli with discoloration should be selected as seed (**Fig. 14**). Thalli must be smooth, slippery and brittle. When cutting, use a sharp stainless-steel knife.
- Do not use small seedlings (< 100 g) or old branches. The exception is for sites with very strong currents. In this case, use smaller seedlings (50 - 70 g) to prevent the risk of breaking mature seaweeds.
- The optimal seaweed pieces to use for new propagules are mature, thick, sturdy and free from epiphytes.

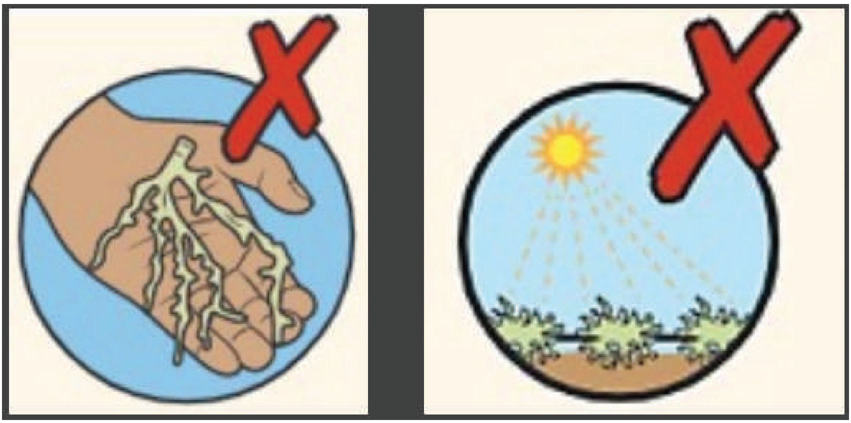


Figure 14: Avoid planting poor quality seedlings

2.7.2 Quantity of seed needed

- The total quantity of seed required to stock a model seaweed farm is calculated from the number of monoline. Each monoline of 10m length requires 50 seedlings of approximately 100g each (70-150g). Each plot contains 50 monolines.

- Therefore, each plot requires 50 seedlings multiplied by 50 monoline giving a total of 2500 seedlings. Each model farm has 6 equal plots requiring a total of 2500 seedlings multiplied by six giving a total of 15000 seedlings weighing approximately 1500 kg.

2.7.3 Transportation of seed

- When moving seed materials, keep them shaded, moist with seawater, and covered with tarpaulin or coconut leaves to prevent dehydration.
- Transport seeds in the morning or evening when the air temperature is cooler. Rice bags will work for transporting seeds if net bags are not available. While transporting big volumes of seeds (≤ 24 hrs.): avoid sunlight, rain and air. Upon arrival, put the seed immediately in the water or pour seawater on it (**Fig. 15**).

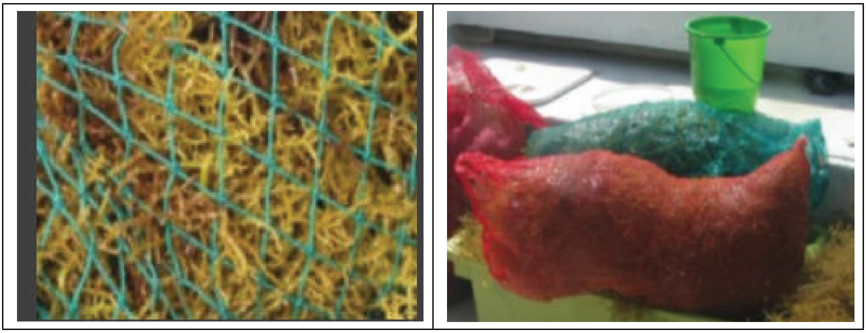


Figure 15: Transportation of seaweed seedlings using nets and bags

2.7.4 Spacing of seedlings

- The seedlings are tied on the monoline using plastic straws called tie-tie. The space between each seedling and the next on the monoline is 20 cm.

2.7.5 Seed tying

- Cut eight-inch-long soft plastic straw for tying propagules. Tie the seedling at its strongest point. The weight should be balanced on both sides of the tie-tie for free movement.

- Tie propagules/seedlings firmly to the cultivation lines at 20 cm interval.
- Tying seed on the monoline should occur in the water to avoid stress on seaweeds. Use one seedling for one loop. Pour seawater on seedlings to prevent drying.
- Avoid putting 3 – 4 small seeds (~50 g) in the same loop (too dense). Do not expose seedlings to the sun, or dry out from wind, or freshwater/rain. Tie the plant at its strongest branch using an 8-inch soft plastic twine.
- The weight should be balanced on both sides of the tie-tie. Provide a 1.0 cm space between tie-tie knot and the seaweed for growth. Immerse the seedlings in seawater to prevent drying before planting (**Fig. 16**).

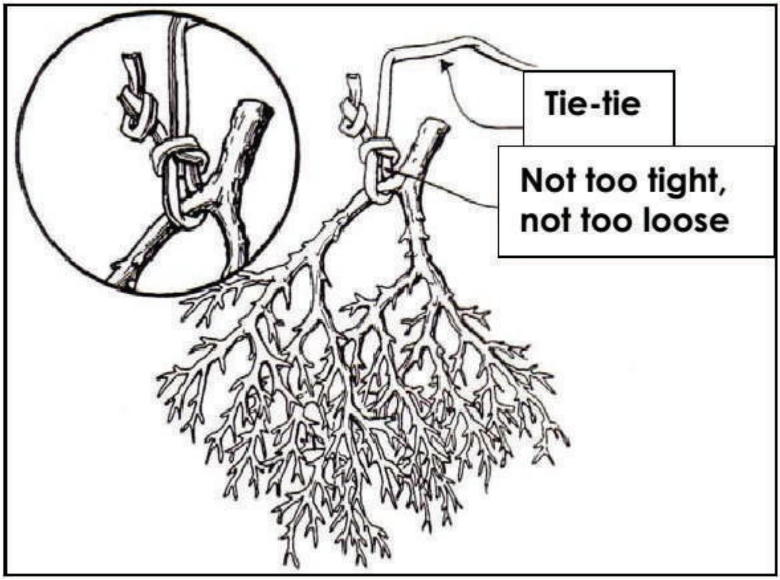


Figure 16: Tie seedlings appropriately

2.8 Seaweed farming methods

- Several methods are used in the cultivation of seaweed. Off-bottom method is popularly used in shallow areas by farmers practicing in developing countries. Floating raft and long-line methods are used in deeper waters.

2.8.1 Off-bottom method

- Off-bottom is the most popular seaweed farming technique among seaweed farmers at the Kenyan coast. In this method, seedlings weighing 70-150g are tied to 10m long polypropylene ropes of 6 mm thickness using soft plastic strings called 'tie-tie'.
- The rope with seedlings is stretched slightly above the seabed between two wooden stakes pounded to the seabed. Normally, seedlings are attached to the rope at an interval of 20 cm.
- A number of such ropes spaced at an interval of 0.5 m constitutes a plot. At the Kenyan coast, an off-bottom model-farm consists of six plots of 50 ropes each totaling 300 ropes with an estimated harvest of about 1 t dry weight per harvest after growing for 45 days.
- The technique is suitable for lagoons where water levels become shallow during low tide hence the farms can be accessed on foot. Further, the technique is practical for small-scale initiatives.
- Off-bottom method is the dominating production in Zanzibar and Kenya where the tidal range is large. Farmers are therefore only able to work during hours of low tide. This method requires low investment, easy to install and farm maintenance is cheaper (**Fig. 17**).

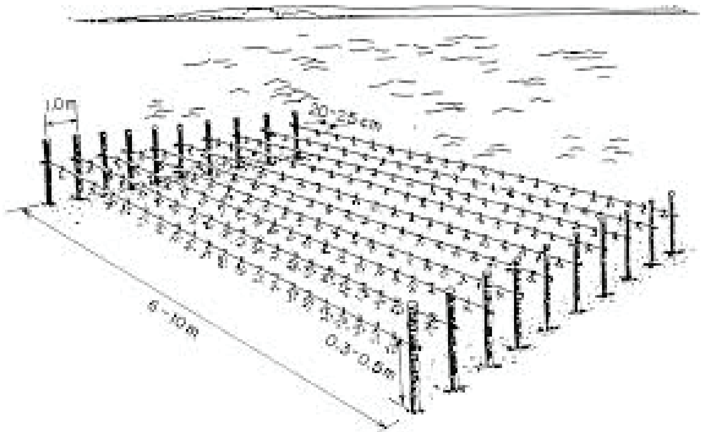


Figure 17: Off-bottom seaweed farming method

2.8.2 Floating Raft method

- This method is ideal for deeper water; the lines are attached to floating structures like bamboo or PVC pipes, anchored to the bottom. In kenya, rafts measure 3x3 meters with a diameter of 7.5-10 cm.
- This method allows for faster growth, as the seaweed remains in nutrient-rich, sunny water.
- Grazing by benthic (bottom) animals is minimized or eliminated in this method. The seaweeds are raised above, approximately 30 cm submerged in the water from the surface (**Fig. 18**).

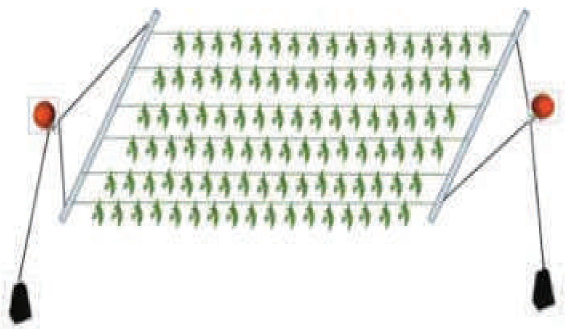


Figure 18: Floating raft seaweed farming method

2.8.3 Long-line method

- The technique requires polypropylene ropes that are 6 mm thick and about 50 m long. Seaweed seedlings weighing 70-150 g are attached to the rope as in off-bottom technique. The rope is then anchored at both ends on concrete blocks and suspended in the water column using floaters at an interval of 10 m. The technology is suitable for deeper waters of between 1-4 m during low tide (**Fig. 16**)

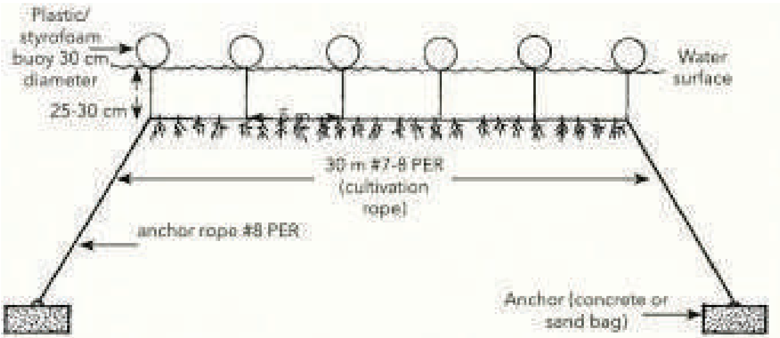


Figure 19: Long-line method of seaweed farming

2.8.4 Lag net method

- This is a broadcasting method of seaweed farming. A used 6" fishing net is laid on the substratum during low tide depending on the size of the farm one needs. A plot of the lag net method measures 10 by 5m, but an ideal farm is 600m^2 which requires 12 such plots.
- Stakes of 0.5m long are used to hold the net in position. First, four stakes are fixed into the substratum in the four corners of the net. The net is then tied firmly on them.
- Then on each side of the net, stakes of the same size are fixed using the same procedure as above. The stakes should be 1m apart and the net should be tied firmly on them.
- Beginning with the middle 1m square net, fix the right seaweed propagules weighing 70-150g unto the net (5x5 seedlings per square meter) (**Fig. 20**).

Figure 20: Seaweed farming on nets

2.8.5 Tubular net method

- The tubular net method is used in deep water areas of depth ranging from 2-6m during low tide. Farming with tubular nets requires a floating raft to suspend the nets in water.
- A tubular net can be as long as 50 m but in the WIO region, it ranges between 8-15m long. First, a fishing net of 3' mesh size is collected and the meshes of the net are aligned to be on top of each other.
- The net is then tied on one end and cut into pieces measuring 8-15 m long. Each piece is sewn into an 8m long tube using a 4mm diameter nylon rope.
- Up to 2kg of seaweed seedlings are stuffed into the net in small batches leaving spaces in between for growth. Both ends of the tubular net are tied to avoid seed loss. The tubular nets are then transferred onto a raft to grow out (**Fig. 21**).

Figure 21: Growing seaweeds in tubular nets

2.8.6 Double Made Loop attachment method

This is an improvement of the off-bottom method. It is touted as one of the best practices in seaweed farming as it has been shown to triple production on several pilot farms. It requires additional effort to prepare and seed the line, but it enables more biomass to be cultivated within the same amount of ocean area.

Just like the off-bottom method, DML uses 10m long polypropylene ropes of 4 - 6mm thickness and tie-ties.

- Instead of the pegs, ropes are tied to a thicker polypropylene rope (8 to 10mm), bound around the plot by posts.
- In this method, tie-ties are cut at a length of 0.5m each. The ends are then tied together and inserted into the middle of the rope twines.

- Tie ties are placed at intervals of 20 cm to 30cm along the rope.
- Seedlings weighing an average of 100g are tied to each end of the tie-tie. Each tie therefore carries two seedlings. A loop is formed at the end of the tie, then a seedling is inserted and fastened (not too tight and not too loose) to hold the seedling.
- The plot of 25m by 10m, is set up by placing four posts at the boundary. The 8 to 10mm rope is then bound tightly round the posts at about 0.5m from the seabed. A post should be about 1.5 to 2m long. 3 or 4 other posts should be placed along the two sides where ropes carrying seaweed will be attached to maintain the rope in place.
- The rope with seedlings is firmly tied to the thick rope on one end and stretched to the other end where it is also firmly tied.
- A number of such ropes spaced at an interval of 0.5 m constitutes a plot. A model-farm consists of six plots of 50 ropes each totaling 300 ropes.
- The technique is suitable for lagoons where water levels reach knee-high during low tide.

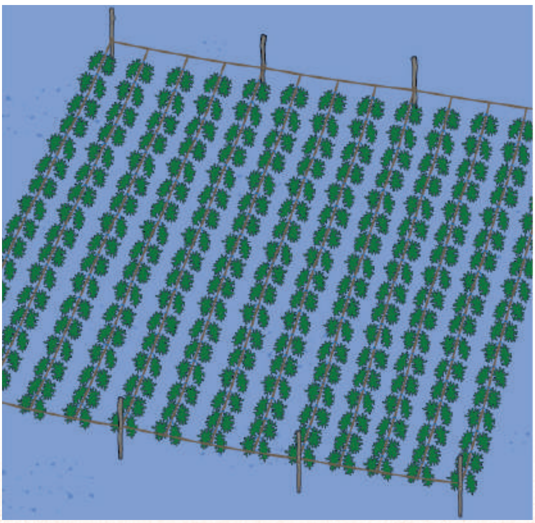


Figure 5: Standardized off-bottom seaweed farm

2.9 Practical

1. Trainees to assess a seaweed farming site for suitability
2. Mark the boundaries of the model farm
3. Prepare the farm for planting
4. Source and plant seedlings

2.10 Suggested training resources

- Resource person(s)
- Textbooks
- Flip charts
- Posters
- Pictures
- Case studies
- Video clips

2.11 Suggested assessment method

- Observation
- Written test
- Oral presentation

Module 3

Seaweed Farm Management Procedures

3.1 Introduction

- Effective seaweed farm management requires meticulous site selection, regular monitoring for pests/diseases, and proactive maintenance to prevent ice-ice disease.
- Key practices include using high quality seedlings, maintaining 6 weeks harvesting cycle, and implementing strict post-harvest cleaning and drying to ensure quality.
- The standard seaweed management practices therefore involve: replacing destroyed seedlings and stakes; removing unwanted materials in seaweed farms; removal and control of weeds and pests; disease identification and control; management of sedimentation and water quality; monitoring of seaweed growth; and seaweed harvesting, sorting, drying and storage.

3.2 Replacing destroyed seedlings, ropes and stakes

- It is important to regularly check for infected, destroyed or dead seaweeds from the strings and to replace them routinely to ensure homogenous growth in ensuring maximum yields and productivity.
- Stakes are often destroyed or lost due to physical oceanographic turbulence, or just by competitive artisanal fishermen with their fishing gears. Seaweed farms should be routinely checked and any loss of stakes detected and replaced (**Fig. 22**).

- Prior to planting, seedlings should be confirmed as healthy by a visual check to ensure non-existence of wounds, bleaching/pale color, black spots or root-like spots. Such spots on the thalli may suggest attack by epi-endophytes filamentous algae. Remove any parasitic molluscs, silt or other farm wastes forming a biofilm or mucus.

3.3 Procedures for replacement of lost seedlings, ropes and stakes

- Undertake routine inspections of the entire farms preferably fortnightly and identify lost seedlings, ropes and stakes. Frequent checking when the seedlings are still young is recommended to ensure proper shedding off, and when the seaweeds are maturing lest, they become too heavy and drop off from the line.
- Replace the lost seeding with fresh health preferably after disinfection with chlorine to prevent microbial infections.
- Replace worn out ropes and lost stakes with suitably selected and prepared (sharpened) stakes
- Tighten any loose nets and repair any broken lines and destroyed stakes (**Fig 22**).

- When a farm is a hectare or more, it is advisable to install nets in the lower position of the farm to collect seaweeds washed out by the tidal current. The mesh size of the net to be used should not be more than 4 inches made of No. 100 nylon line (**Fig. 23**).

Figure 23: Rope and stakes in off-bottom monoline seaweed farming

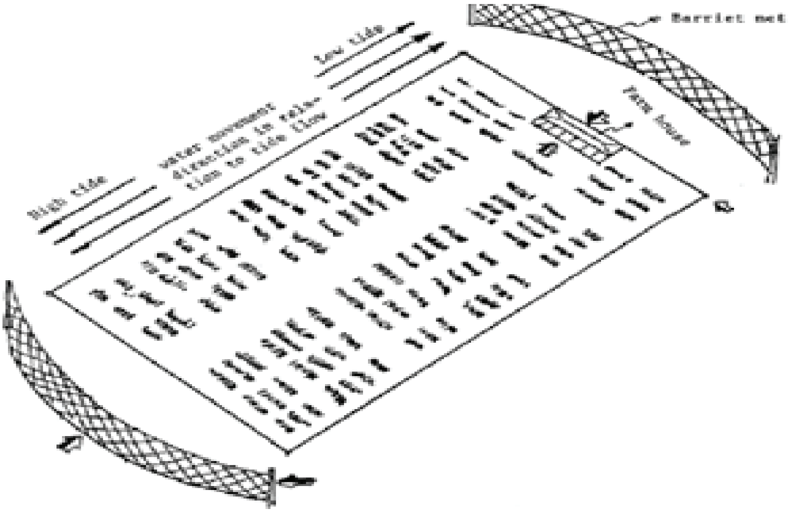


Figure 24: Barrier net to collect seaweeds washed out by tidal currents

3.4 Weeds and pests control and management

Weeds

- The wild green algae especially *Ulva* sp. commonly fouls seaweed farms (thalli, ropes and stakes) and causes damage. It hosts disease vectors and when in abundance, reduces seaweed growth rate by inhibiting photosynthesis.

Macroinvertebrates

- Epiphytic sponges, barnacles and biofilms create a conducive habitat for microorganisms for breeding, thus infecting the seaweeds (The Nature Conservancy, 2023).
- Macro-invertebrates such as echinoderms (e.g. starfish, sea urchin, and sea cucumber) commonly occur and cause damage in seaweed farms. The sea cucumber for instance, feeds on seaweed tips hindering their growth. Molluscs especially *Mytilus spp.* usually invade ropes and stakes in the farm causing nuisance

Fishes and Reptiles

- Herbivorous fishes (e.g. rabbit-fish, parrot-fish and puffer-fish) graze and cause reasonable damage in seaweed farms. Reptiles, mainly green turtles (*Chelonia mydus*) also bite seaweed thallus, causing physical damage and dislodge them from lines.
- As a farm practice, such unwanted organisms should be routinely removed from seaweed farms before they cause significant damage and losses in the farms (**Fig. 24**).

		
Mytilus spp. (Mollusc)	Crown of thorns (Starfish)	Hollothuria spp. (Sea cucumber)

		
Siganus spp. Rabbit fish	Parrotfish	Box fish

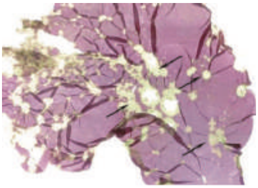
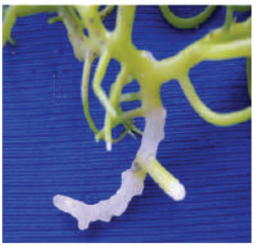
Figure 25: Common notorious pests in seaweed farming

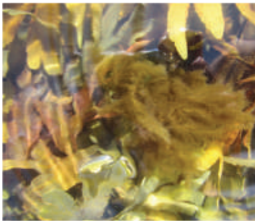
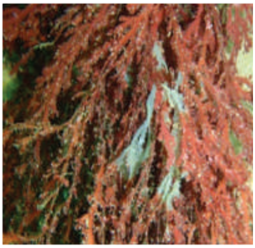
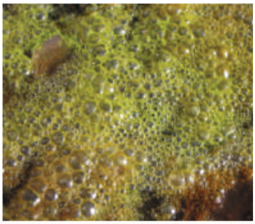
- Routine control measures of weeds and pests include daily removal of sea urchins, starfishes, rocks, dead corals and other obstacles found inside the farm daily, preferably by use of a boat (with or without engine).

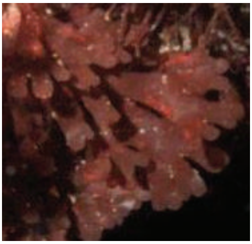
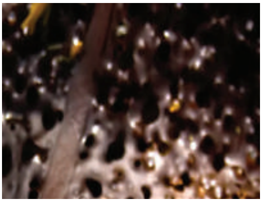
3.5 Seaweed disease identification and control

- Disease identification and control in seaweed farms is the most important management intervention in the seaweed farming as a business. Diseases usually reduce quantity, quality and commercial value of seaweeds (Ward et al. 2019).
- Most diseases are triggered by water quality and vector invasions. While inspecting health status of seaweeds, one should look for: presence of visible scarring e.g. symptoms of grazing or holes; presence of any disease symptoms e.g. signs of bleaching, attachments in the form of epiphytes and/or visible films that allow microbial activity.
- Table 4 explains some common seaweed diseases and their control/ management measures in farms (Table 4).

Table 4: Common diseases encountered in seaweed farms

Diseases	Description and symptoms	Control/Management measures
1. Green Rot 	Caused by lack of light; Green chains of fused dead cells develop on wounds of the thallus, followed by rows of pink cells and central green cells around the developing lesion.	Invert the seaweed ropes to expose the over-shaded parts to light; if thalli are still young, tip-cut to reduce overcrowding and to increase light intensity. The cut portion can be used in alginate industry
2. White Rot 	Occurs in the fronds; stimulated by strong light, high water temperature, and low nutrient levels. "Pinhole-like" white spots on the edge of shell-boring conchocelis, which gradually expand and form lesions	Reduce light by lowering the algae to deeper water column; Apply fertilizer to add nutrients
3. Ice-ice 	Bleaching of the thallus at the tips of the plant close to site of "tie tie" attachment to culture ropes Thought to be caused by environmental stress. Common in Eucheuma and Kappaphycus due to high temperature, low salinity, low light intensity; the frond loses pigments creating an 'ice'-like appearance; may be linked to stress from epiphytes; secondary infection by bacteria may occur.	Improve water quality, reduce stocking density by pruning; disinfect in chlorine. Can recover but the affected areas break out

4. Frond-twist 	Common in raft-cultivated kelp; Caused by bacteria. Fronds appear twisted, with swollen stipes and shortened holdfast	Use antibiotic like tetracycline to treat and control
5. Epiphytic filamentous algae 	Tiny black spots become visible on the cortex of the host, followed by the appearance of "goose-bumps" as the epiphyte matures. At the end of infection, dark pits are left on the cortical surface, and the host is infected by opportunistic bacteria	Wash in acid solutions; Change cultivation conditions, particularly by repositioning cultivation ropes to improve exposure to light and more favorable salinities.
6. White-blight 	Bleaching of the blade, followed by cell lysis and blade disintegration	Wash in acid solutions; Change cultivation conditions
7. Diatom blooms 	Blooms of diatoms deplete nutrients in the water column, resulting in bleaching of thallus blades	Wash in acid solutions; Change cultivation conditions

8. Red-spot disease 	Swelling of gametophyte cells, followed by filamentous fading and decaying of the thallus.	Wash thalli (blades) in acid solution
9. Hole-rotten disease 	Alginase-secreting bacteria decompose host cell walls, causing rotting and forming holes in the blade	Wash thalli (blades) in acid solution
10. Rotten thallus syndrome 	White to pinkish discoloration and gradual disintegration of thallus. Causes erosion of the pericarp	Wash thalli (blades) in acid solution

3.6 Sedimentation, bio-fouling and water quality

- Silt sediment is another management challenge in seaweed farming. Fine silt materials are irritant, as well as a potential pathway for microbes to infect thalli of seaweeds.
- It is mostly sediment (fine sand) from the ocean floor that gets trapped driven by the tidal rhythm. They settle on the seaweeds, often fatally smothering them.
- It is important to periodically and routinely inspect seaweed farms and shake off the sediments.
- Undesirable micro and macro-organisms commonly attach themselves onto seaweeds and farm structures as bio-foulers. They

smother the seaweed effectively inhibiting photosynthesis and growth.

- Bio-foulers include wild algae which intertwine with the crops occasionally leading to breaking off of the thalli.
- Fouling organisms, ranging from other seaweeds (wild) and cyanobacteria (epiphytes) to a variety of invertebrates that use the cultivated seaweeds to attach to and grow as zoophytes (**Fig. 26**).

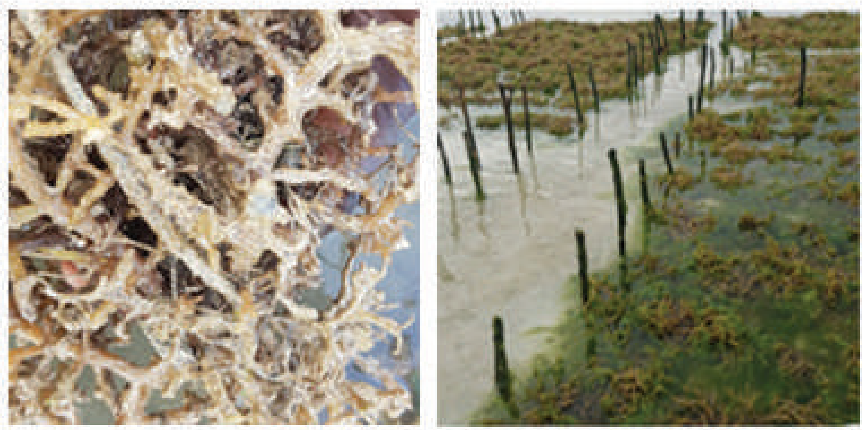


Figure 26: a) Brown seaweed smothered with fine silts b) Brown seaweed smothered by wild algae

3.7 Monitoring of seaweed growth

Introduction

- Seaweed growth monitoring is a critical activity in effective farm management.
- It generates information on rate of growth, and helps to identify elements of stunting which may lead to poor quality seaweeds, and delayed turn-around time.
- Record keeping of growth parameters is essential for analysis and to advise on necessary interventions to hasten seaweed growth (**Fig. 27**).

Figure 27: Monitoring seaweed growth in the farm

a. Procedures of monitoring seaweed growth

- Commonly used techniques are vision-based growth usually on laboratory measurements or above-ground seaweed measurements.
- The inspection and monitoring of crops and infrastructure at sea is an expensive task, requiring boats and divers when performed manually. Sea weed growth can be monitored by use of weight or lengths.
- **Step 1**: Take baseline measurement at time (t_o) either as weight (kg) or length (cm).
- **Step 2:** After some time (bi-weekly), another measurement of weight and length is performed
- **Step 3**: Growth rate is then computed as length (cm) at time t minus length (cm) at time t_o
- **Step 4**: Follow this for 1 year and for the length of the period of the farm
- **Step 5:** Any stunted growth is therefore identified, and the crop is removed and put into other uses in the value chain.

- **Step 6**: While performing this exercise, any foreign organisms especially the bio-foulers including epiphytes are checked and carefully removed from the lines and stakes to minimize chances of competition and spread of pests and diseases

b) Records of growth parameters

- Data from the growth monitoring are recorded and documented accurately, filed and stored safely for further analysis of the health condition and productivity of the seaweeds in the farm.
- It is also recommended to always keep the record of the farm such as weekly test plant records.

3.8 Seaweed harvesting, sorting, drying and storage

- Seaweeds mature for harvesting between 45-60 days after planting. At this age, they are of best quality with desirable ingredients (**Fig. 29**).
- Below 45 days, seaweeds are immature and contain little carrageenan. Harvesting of seaweeds simply involves detaching or by cutting mature stocks from the support line using a stainless-steel knife.
- The cut seaweeds are collected into a boat for onward transport to the drying platform/arena usually proximate to the beaches. Seaweed should not be left to grow more than 5 kgs for it will be destroyed by the water current or detach themselves from the line by gravity.

Figure 29: Seaweed harvesting

a) Harvesting procedure

- **Step 1:** Inspect the seaweed farm to assess maturity status and general condition and health of the stock across the farm.
- **Step 2:** Check if there are any stakes and ropes which might have fallen due to the heavy weight of mature seaweeds.
- **Step 3**: Prepare all necessary tools for seaweed harvesting to include; scissors, stainless knife, pangas, large troughs, large woven baskets, wheelbarrows or cats, waders, gumboots, boats etc.
- **Step 4:** Carefully study the tidal rhythm as seaweed harvesting is best done at lowest tide (preferably lowest spring tide) when most of the farm is exposed and easy to navigate and harvest.
- **Step 5**: Walk along the lines, row by row, or by use of a small boat, grab and pull out the lines, carefully cut off the crop from the main line using a stainless knife.
- Harvesting is completely unhealthy and loses plants. Leave about 200g on each plant for regeneration.
- **Step 6:** Ferry the harvested seaweeds to the already prepared (and sterilized) drying platform at the beach preferably when tide is just building to facilitate boat transport operations
- **Step 7:** Unload, weigh and spread seaweed on the drying platform.
- **Step 8:** Carefully keep daily harvest records of seaweeds (both wet and dry weights)
- **Note:** Remember to sterilize all the equipment and tools used (including the drying platform) to avoid unnecessary cross microbial contamination.

b) Sorting and drying of Seaweed

- At the drying platform, the harvested seaweeds are sorted by species and graded awaiting further value addition processes and marketing. For centuries, several conventional approaches have been employed for drying seaweeds at commercial level. A number of methods of drying seaweeds include (**Fig. 31**).

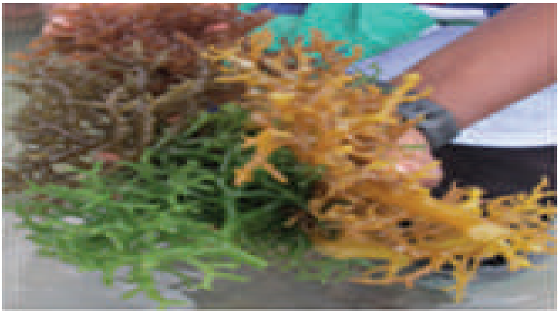


Figure 31: Sorting seaweed after harvest

Sun drying

- The simplest and oldest form of drying seaweeds is to use the power of the sun. It is the cheapest method to adopt in seaweed farming as a practice.
- Sun drying involves spreading the seaweed in a thin layer on drying racks or mats exposed to direct sunlight.
- Solar drying is particularly effective in regions with abundant sunlight like in the tropics. Sun drying can be improved to include green houses where the sun's energy is intensified, and the seaweeds are also protected from dust and other environmental challenges (**Fig. 31**).

Figure 32: Sun-drying of seaweed

Important steps in sun drying include:

- Use coconut palm or mats or polythene sheets as flooring when drying on land. Never dry the seaweed directly on soil as this may cause contamination.
- Spread the harvested seaweed thinly over the prepared drying site or platform.
- In a drying platform, the approximate amount of wet seaweed should be about 10kg/m^2.
- Turn the seaweeds at regular intervals under the sun for three days. Simultaneously, remove foreign materials from the seaweeds mats.
- Always cover the harvest to protect them from rain as this may keep them wet hence prolonged drying.
- Separate dried harvest according to species and the day it was harvested.
- Seaweeds are considered dry when there are no moist particles of sand on the surface. They are crispy and have a rubbery touch.
- Remove salt particles from the dried seaweeds by screening them with meshed screens.
- Pack clean dried seaweeds free of salt particles in large sacks and lace them up.

Advantages of sun-drying

- Sun energy is free hence making the practice affordable to local coastal communities
- The UV light from the sun kills disease causing pathogens
- It is a readily available technique, simple and doesn't involve complex machinery.
- Sun drying is cost-effective and environmentally friendly.
- Unlike high-temperature drying methods, sun drying operates at lower temperatures, which helps retain the seaweed's nutritional content.

- Sun drying reduces greenhouse gas emissions compared to conventional drying methods.

Disadvantages

- It takes longer to dry the seaweeds than other methods, especially during cloudy days.
- It is weather dependent and may become quite unreliable in bad weather conditions
- Proper hygiene and cleanliness usually becomes a challenge to prevent contamination during drying.
- Seaweed should be turned periodically to ensure even drying hence labour intensive

Oven drying

Traditional oven is used to dry seaweeds. Here, we follow the following steps:

- Lay thin seaweed sheets onto silicone mats or wax paper inside the oven on oven trays (no oil is required) and bake at 70°C to 80 °C until dried, turning blades once or twice during the process.
- Alternatively, set the oven temperature to its lowest setting at 65°C, lay seaweed pieces on a baking sheet, and keep the oven door slightly open to allow moisture to escape.
- Dry the seaweed in the oven for approximately 3 hours.
- Keep an eye on it to prevent over-drying.
- Once done, remove the seaweed and allow it to cool (Fig. 32).

Figure 33: Oven for drying seaweeds

Dehydrator

Dehydrators are one of the best in drying out seaweed (http//: Overwhelming Salted seaweed mass production factory (youtube.com) (**Fig. 33**).

Figure 34: Photo of seaweed dehydrator

Steps of dehydration

- Rinse seaweed in fresh or saltwater
- Cover it with wax paper and spread it on food dehydrator trays in a single layer and dehydrate

- Set the dehydrator to a low-temperature setting, i.e. around 35°C.
- Allow the seaweed to dehydrate for up to 8 hours.
- Check periodically to ensure even drying, and flip or rotate the seaweed if necessary.
- Once fully dried, the seaweed should be crunchy.
- Remove it from the dehydrator and let it cool to room temperature.

Air drying

- Seaweeds should be cleaned (rinsed) to remove any grit or any foreign body, and dried on the same day as harvesting, to uphold high quality (color retention). The rinsing can be done either in saltwater or freshwater (**Fig. 35**).

Figure 35: Air drying of seaweed

Steps of air drying

- **Step 1:** Wash/rinse by plunging batches of seaweeds in a pail of either saltwater or freshwater, whirl around and take them straight.
- **Step 2**: When drying seaweed, lay the pieces flat on newspaper and place them in the sun. You can also use a line to hang the seaweed.

- **Step 3**: When dry, unhand and store in a dry store ready for further value chain processes.

Packing of dried seaweeds

- **Step 1:** Choose bags made from sustainable materials. Ensure the bags are sturdy and can withstand the weight of the seaweed.
- **Step 2**: Pack, clean dried seaweeds free of salt particles in large sacks. The sacks may be of different sizes depending on the choice of the buyers, and the prevailing market.
- **Step 3:** Label each bag with essential information, such as the seaweed type, weight, and harvest date (**Fig. 35**)
- **Step 4**: store dried seaweeds in dry and cool dark environments (stores) usually in pallets free from rodents.
- **Step 5**: Avoid storing seaweed in direct sunlight or near any heat source as this can hasten its spoilage.
- **Step 6**: Make sure to keep stored seaweed away from other food items as this can lead to contamination.

Figure 36: Packing and storage of dried seaweed

Suggested training resources

- Resource person(s)
- Textbooks

- Flip charts
- Posters
- Pictures
- Case studies
- Video clips

Suggested assessment method

- Observation
- Written test
- Oral presentation

Module 4

Post-Harvest Handling, Value Addition, Food Safety and Hygiene

4.1. Post-harvest management

Washing

- After harvesting from the coastal areas or beaches, the seaweed should be washed in order to:

Figure 37: Wet and Dried seaweed

- Drying is carried out to:
- To increase the shelf-life
- For ease of handling.
- Facilitate grinding and extraction of bioactive compounds

- Drying should be carried out under moderate temperature to avoid degradation of the bioactive compounds.
- Sun-drying or controlled oven drying methods are highly recommended.
- Solar drying or drying in enclosures away from direct sunlight will have added advantage since most nutrients tend to be retained.
- For shelf- stability, the moisture content should be 12-15%.

1. Packaging and storage

- Before packaging, sorting should be done to ensure uniformity of seaweeds on the basis of maturity, color, and/or quality as dictated by the end use.
- Bulk packaging of clean dried seaweeds is recommended for ease of transportation and storage.
- Seaweeds should be packaged in clean airtight packages to prevent environmental contaminants and moisture absorption.

During storage

- Dried seaweeds must be stored in clean and dry facilities.
- Storage facilities must be fitted with pallets made of either plastic or wooden types to avoid direct placement on the floor.
- The storage facility should be easy to operate to ensure ease of movement for the personnel and seaweeds into and out of the facility.
- It is recommended to practice first in first out rotation during storage.
- Ensure regular inspection and cleaning of the storage area/structures.

1. Transportation of seaweeds

- The transportation equipment must not be sources of cross contamination.

- Ensure good handling practices during transportation:
- Transportation in designated equipment and vehicles that meet food safety standards.
- The vehicles should be covered to prevent exposure to environmental hazards e.g. dust, moisture, chemicals etc.
- The transported seaweeds should be placed on pallets to prevent cross contamination.
- Seaweeds on transit should not be transported with other food groups such as fresh produce to prevent moisture absorption and cross contamination.
- Loading and off-loading should be conducted in designated areas to prevent cross-contamination.

1. Processing and value addition of seaweeds

Why consume seaweed as Food Product

- The seaweeds are nutrient-dense macro algae with high therapeutic properties that aid in meeting daily nutrient requirements for both human and animal needs.
- The seaweeds are high in bioactive molecules and have been responsible for the health promoting properties associated with their consumption.
- Addition and integration of seaweeds in the daily household diets improves the nutritional and textural properties of food products:
- Seaweeds are a rich source of vitamins e.g. vitamin A, B_1, B_2, B_3, B_6, B_{12}, C, D, E, pantothenic and folic acids and beneficial soluble dietary fiber.
- Seaweeds are loaded with minerals e.g. calcium, magnesium, potassium, iodine, sodium, phosphorus, selenium, iron, zinc, manganese and copper etc.
- The seaweed is among the most important plant protein sources with ranging 15 - 45% of proteins.

- The seaweeds contain several phytochemical compounds including polyphenolic, polysaccharides, and sterols.
- The seaweed bioactive are loaded with antioxidant, anti-inflammatory, anti-cancer, and anti-diabetic properties.
- Seaweeds have a significantly high proportion of essential fatty acids such as eicosatetraenoic (EPA) and docosahexaenoic (DHA) fatty acids that are good for human health.

Preparation of seaweeds for processing

- Seaweeds for processing should be sorted to remove undesirable physical hazards.
- Before processing, they must be thoroughly washed and rinsed to remove remaining sand and salt particles.
- The water used for processing should be potable i.e. contain no microorganisms, low in chemicals and should have no dust and sand particles.
- The cleaned seaweeds should be immediately processed to prevent water reabsorption

Processing of Seaweeds products

- Seaweeds are diverse and can be processed into various value-added products suitable for human and animals' consumption as well as plant fertilizers.
- For food application, the general flow process is followed (Cassani et al. 2020) (Figure 38).

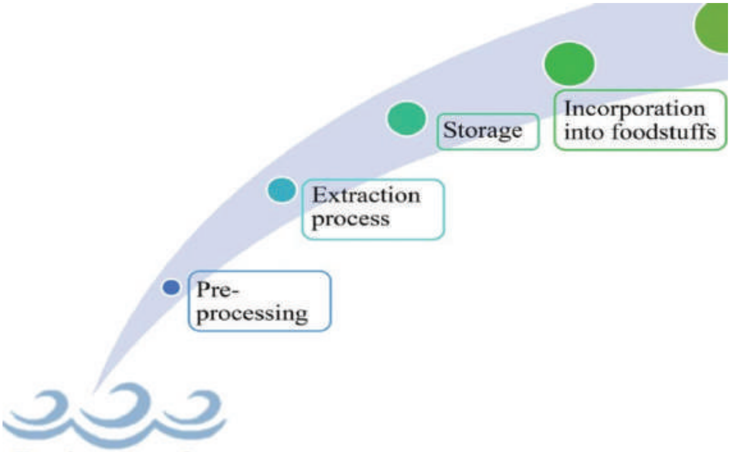


Figure 38: General process flow for seaweed uses in foods

- Processed seaweeds enhance the bioavailability of the bioactive compounds and also increase their palatability and utilization in respect to intended uses.
- Consumption of food products enriched with seaweeds have positive effects on lifestyle diseases.
- Seaweeds are suitable low calories foods that can be consumed in diverse foods.
- Applications of processed seaweeds occur at both household and industrial levels (Figure 39)

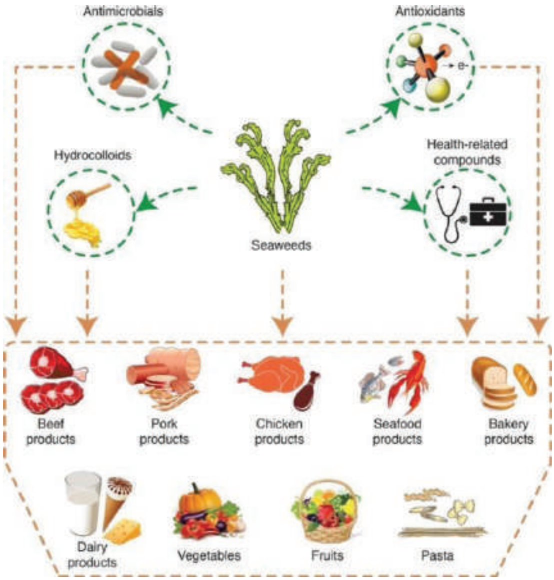


Figure 39: Some applications of seaweeds in industrial processing of seaweeds

Home-made recipes

- This involves the incorporation of seaweed gels into household diets. The gel is made by heating the seaweed in water.
- Seaweed gel is a versatile product produced from either powder or dried whole seaweeds.
- The gel can be mixed into the dough for baking chapatis, mandazi and cakes or integrated into staple foods such as ugali, cooked rice and legumes etc.
- Seaweed gels are also added to soups, vegetables and are used as thickeners in various cooked foods.
- The seaweed gel is suitable for addition into other food groups such as smoothies, dairy products e.g. mala, yoghurt and homemade juices to increase their nutritional benefits. The ratio can range 5-60%.

Industrial products

Seaweed capsules

- The general processing flow diagram for seaweed capsules is shown in **Figure 40**.

Reception of seaweeds

Washing

Drying

Milling into fine powder

placing capsules cups in the capsule maker and fill with the powder

clipping the cups together and storing them

Figure 40: A general process flow diagram for seaweed capsules

- In this whole process, proper hygiene should be considered to avoid contaminating the capsules.
- One is required to wear gloves, an apron and head gears.

Seaweed powder

- The seaweed powder is processed from sorted and cleaned sun or oven-dried seaweeds and moisture contents of <15%. General flow diagram for processing is shown in Figure **41**.

Reception of seaweeds

Washing

Drying

Size reduction

Milling and blending

Packaging

Figure 41: A general process flow diagram for seaweed powder

- When making powder, the seaweed must be washed with fresh water to remove all the salt and impurities.
- The seaweed is then dried to moisture content below 10%.
- The dried seaweed is then ground to obtain the powder.
- Seaweed powders can be sprinkled on vegetables, blended into smoothies, ugali, dough, fruit juices, or mixed into drinking water.
- Seaweed is also a thickener in soap making and works well in both vegetable and meat soups.
- Due to high concentrations of the bioactive compounds and consumption of the powder should be regulated.
- Powders can also be integrated into animal feeds and are suitable as organic fertilizers.

Organic fertilizer

Reception of seaweeds

Washing and sorting

Drying

ferment in clean water

Packaging

- Seaweeds are suitable for processing organic fertilizers to increase soil fertility and plant growth.
- Seaweed fertilizers are applicable either as liquid extracts and or in dried forms after milling the latter.
- Seaweeds can also be processed into foliar fertilizers and have high efficiency on growth, yield and quality, and pest control resistance.
- The seaweeds' bioactive molecules promote soil health, conditioning and bioremediation for crop health.
- The seaweed fertilizers improve soil texture, increase water retention and reduce disease occurrence.

Module 5

Seaweed Business Planning, Operations and Marketing

5.1. Meaning of a business plan

- The main aim of any business enterprise including seaweed farming is to make profit. Development of efficient and viable businesses requires careful evaluation and thorough planning for a new business.
- A business plan is a roadmap on how to structure, run and grow a new business. It's a way to think through the key elements of a business.
- Business plans can help in resource mobilization, or bring on new business partners. A good business plan guides through each stage of starting and managing business.
- Investors want to feel confident that they will see a return on their investment. A business plan is the tool used to convince people that working or investing in the business is a smart choice.
- <The three main components of a business plan include: production plan (production technology); marketing plan (strategy); and financial analysis (economic feasibility and viability analysis).

5.2 Seaweed production plan

- Seaweeds grow by absorbing nutrients directly from the ocean water. Consequently, seaweed farms should be sited where there is good water circulation to facilitate nutrient absorption.

- In the Western Indian Ocean region, various methods are used to produce seaweeds including off-bottom, floating raft, long-line, and tubular net methods among others.
- Seaweeds can be grown all year round with up to 8-10 harvesting cycles per year. However, changes especially based on weather conditions may not permit continuous annual production.
- It is therefore important to plan production activities ahead of time, and to have a back-up plan should the weather situation change.
- The ideal planting times vary depending on the physical condition of the seas/oceans. For instance, the monsoons in the western Indian Ocean primarily dictate suitable times for planting seaweeds in the region.

a. Annual cycles in seaweed production

- Seaweeds usually grow relatively fast, and in 45 days, the thallus is ready for harvesting. This implies that with proper planning, farmers can potentially harvest seaweeds 8-10 times per annum. The growth rate varies with different seaweed species.
- However, due to various challenges (i.e. both environmental and logistical) attaining the 8 harvests in a year occasionally becomes elusive to many farmers. In Zanzibar for instance, seaweed farmers typically harvest their crops 8 to 10 times in a good year.
- They produce around 23,000 tons of seaweed annually (Msuya, 2023). The farming cycles for seaweed are typically 4–10 weeks, depending on growth rates, and the harvested seaweed is dried on the ground before being exported and processed into carrageenan.

b. Influence of monsoons in seaweed production plan

- Working in the Western Indian Ocean during the rough southwest monsoons (i.e. May-September) is quite risky. The strong winds not only prevent farmers with smaller boats from traveling to the farms, it also makes the conditions at the farms too dangerous to work in.

- During such times, it may be best to conduct only basic maintenance of farm materials with only seed stock in the waters. The timing of seaweed planting plays a significant role in their growth and yield.

c. *Staggering production*

Seaweed production plans should be based on staggered programs to ensure there is no gap in supply. In a scheme of cyclic production of seaweeds, the actual planting should be done at staggered intervals to ensure continuous harvesting and supply to the markets. This way the farmers earn money throughout the year in a sustainable manner.

d. *Production personnel*

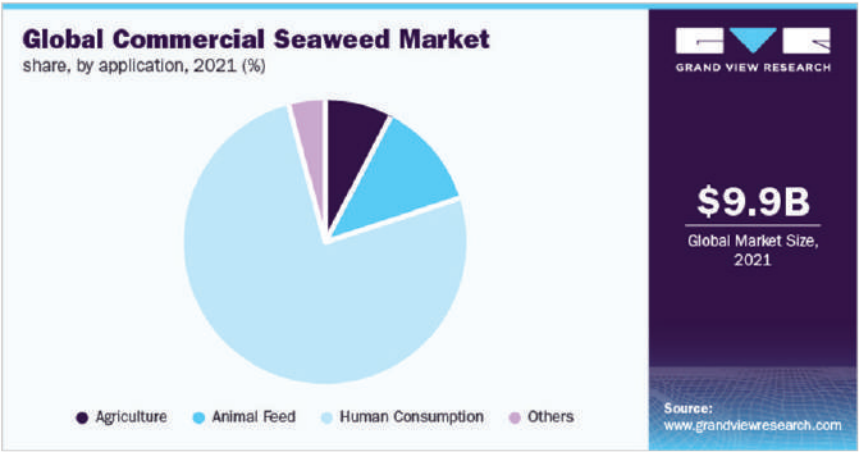
- Seaweed production is labour intensive. There should thus be a delicate balance between the number of personnel to be deployed in the production without compromising or diminishing profit margins.
- Optimal staffing of laborers particularly where physical strength is required should be promptly balanced.
- Therefore, even though seaweed production is women dominated, there should be a business room to engage a few men to perform some physically demanding operations in the farm. The size of the personnel depends on the scale of seaweed production.

5.3 Seaweed marketing plan

a. History of seaweed marketing

- The Seaweed market has seen significant growth in recent years owing to its increasing demand in various industries such as food, animal feed and pharmaceuticals (Fig. 45).

Figure 45: Global commercial seaweed market trends



- The international demand for phycocolloids (agar, alginates, carrageenan and furcellaran) has grown much more rapidly.
- The seaweed market is currently dominated by a handful of Asian countries (China, Indonesia, Japan, South Korea & Philippines), which produce 98 percent of farmed seaweed by volume globally.
- The commercial seaweed market size is estimated at USD 19.09 billion in 2024, and is expected to reach USD 28.29 billion by 2029, growing at a CAGR of 8.18% during the forecast period (2024-2029) (Mordor Intelligence, 2024).
- Seaweed marketing in East Africa (mainly Tanzania), dates back to 1970s, where marketing of seaweed products for domestic and export markets has been dominated by individual women and private foreign companies operating in the Zanzibar-Pemba Export Corridor.

b. Commercial seaweed market trends

- Asia-Pacific has the largest market for commercial seaweed. The region captures a larger market share as it has the highest population in the world.

- Moreover, due to the rising consciousness of consumers, the demand for commercial seaweed is increasing significantly.
- Due to its effectiveness in enhancing the nutritional content of food products, seaweed is in greater demand from the global food sector.
- Due to its widespread application in agriculture, animal feed, and food & beverage sectors, the brown seaweed segment is anticipated to expand quickly throughout the forecast period.
- Red seaweeds are mainly consumed as food and are a source of the hydrocolloids carrageenan and agar. The capacity of red seaweed to reduce bad cholesterol and regulate blood sugar levels is one of its primary health advantages.
- Additionally, it is thought to be a strong source of antioxidants and helps to strengthen immunity while nourishing the skin. These advantages are anticipated to fuel market expansion.

c. Importance of marketing in seaweed business

- Seaweed farmers must work hard on marketing just as they do on production. Profits are made by selling products at good prices and not by production only.
- Those who ignore marketing cannot succeed easily. Successful seaweed farming must be market-oriented (know and produce what the market requires), have diverse markets (do not rely on one market), and be committed to their customers (seek to satisfy the customer).
- Decisions on what to produce should be based on market analysis. A farmer considering seaweed production must identify appropriate market outlets, obtain information on potential price points, understand the extent of on-farm processing required, and arrange for effective transportation for product distribution, among other supply chain questions.

d. Strategy for increasing sales in seaweed business

- Market share or demand of seaweeds can be expanded or increased using the 4Ps principle of marketing:
  - **Product:** key in expanding sales is a premium product. The farmer has to ensure that the product is pleasing to the buyer before putting the product on the market;
  - **Price:** farmers must ensure competitive seaweed prices. Production costs must be kept low in order to achieve this. Price must be set to cover all production costs and profit;
  - **Promotion:** how you advertise and promote your business may make or break your business. Advertising and promotions are the lifeline of a business; and
  - **Place:** how you distribute your product to various locations where customers matter. Producers and processors may increase market shares by transporting seaweed products to locations previously inaccessible to consumers (Fig.45) .
- The key element of successful marketing is to know your customers - their likes, dislikes, expectations, taste and preferences.

e. Global seaweed markets

- Globally, the Asia-Pacific region dominates the seaweeds market. The region, particularly in China, South Korea, and Japan are key producers and consumers of seaweeds.
- China's seaweeds market is a diverse and rapidly growing industry, with a wide range of products being produced and consumed. Seaweed market in China is expected to grow and reach a projected value of US$ 4.87 billion by 2033 (World Bank, 2023).
- South Korea is one of the leading consumers of seaweed in the world, with a vibrant market for different types of seaweed products. In recent years, the demand for seaweed has grown and developed due to escalating health awareness and its various health benefits, such as high nutrient content and low-calorie content.

- Japan has a long history of seaweed consumption and cultivation. The Japan seaweed market is expected to flourish at a compound annual growth rate (CAGR) of 7.3%. They import seaweeds from other continents including Africa, Europe and America.
- The current seaweed market structure in eastern Africa involves farmers selling their seaweed to local buyers who export it raw to overseas companies (mainly China, Japan and South Korea) that process the seaweed and either sell locally or export to other countries.
- The European seaweed market is expanding, because of a growing demand for alternative and sustainable proteins along with huge demand for products with nutritional benefits. On a global scale, the commercial seaweed market in Europe was projected to grow from $15.01 billion in 2021 to $24.92 billion in 2028 at a CAGR of 7.51%, making it one of the most promising products in the seafood industry (World Bank, 2023).

5.4 Seaweed enterprise financial analysis (plan)

a. Enterprise budget

- Successful seaweed farming requires financial analysis to determine economic feasibility and profitability of the enterprise. An enterprise budget needs to be prepared.
- An enterprise budget is the estimate of annual costs & revenues for a typical year after the business is established.
- It indicates generally whether the proposed production system is profitable.
- Budgeting allows for estimates to be made on paper, prior to the commitment of funds or resources to an activity, allowing for the anticipation and avoidance of problems that will likely be encountered based on historical records.

Table 5: Enterprise Budget of 45-day production cycle in a seaweed model farm

Item	Unit cost	Quantity	Total cost
Gross Receipts			
Seaweed dried weight a(Kg)	35	1500	52,500
Variable costs			
Seaweed seedlings (kg)	10	1500	15,000
Cost of transporting seed			5,000
Cost of labor for farm management	500	15	7,500
Contingency (10%)	0.1	27500	2750
Total variable costs			30,250
Fixed Costs			
Depreciation on equipment	0.25	20000	5000
Total costs			35,250
Net income per cycle of 45 days			17,250
Net income per year – 4 crops/yr			69,000
Break-even price per kg (KES)			23.5
Break-even quantity of seaweed (Kg)			1007.1

b. *Income Statement*

- An income statement is a summary of the financial performance of a business over time (monthly, quarterly or annually is most common).
- It reflects the past performance of the business and is the report most often used by small business owners to track how their business is performing. It measures the profit or loss of a business over a specified period.
- It summarizes the income for a period and subtracts the expenses incurred for the same period to calculate the profit or loss for the business.

- It answers the question, "How much money am I making, if any?" It compares your projected performance with actual performance. It provides proof of income if you need a loan or mortgage.

Table 6: Income Statement

REVENUE	**KES**
Dried seaweed sales	210,000
Total Revenue	210,000
EXPENSES	
Labor for establishment of a model farm	18,000
Labor for routine seaweed farm management	36,000
Harvesting & marketing costs	10,000
Seedlings	36,000
Stationery	5,000
Repair and Maintenance	17,500
Cost of transportation	25,000
Annual depreciation on equipment	15,000
Total Expenses	162,200
Net Profit (Total Revenue – Total Expenses)	73,500

c. Balance Sheet

- A balance sheet is a statement of what a business owns (assets) and owes (liabilities), and the value of the owner's equity (or net worth of the business) at a specific point in time.
- The balance sheet is also known as a statement of financial position because it shows a summary of the business's financial position at a particular point in time.
- It helps a small business owner identify trends and quickly grasp the financial strength and capabilities of their business.
- The difference between the assets and liabilities is known as owner's equity. The balance sheet is so named because the equity must equal assets minus liabilities.

Table 7: Balance Sheet

BALANCE SHEET	
Current Assets	
Cash	20,000
Accounts receivable (money owed)	35,000
Inventory (seaweed in the farm)	45,000
Total Current Assets	100,000
Non-Current Assets	
Farm equipment	25,000
Total Non-Current Assets	25,000
TOTAL ASSETS	125,000
Current Liabilities	
Accounts payable (money you owe)	25,000
Bank overdraft	10,000
Total Current Liabilities	35,000
Non-Current Liabilities	
Long term business loan 1	50,000
TOTAL LIABILITIES	85,000
OWNER's EQUITY	40,000

d. Financial Ratios

- Financial ratios measure solvency and liquidity of an enterprise e.g.
- **Debt/asset ratio =** total farm liabilities divided by total assets
- **Current ratio =** current farm assets divided by current farm liabilities. The higher the current ratio, the better the capacity to meet short term financial commitments. A current ratio of 2:1 (which means the business has current assets of KES 2 for every KES 1 of current liabilities) is regarded as desirable for a healthy business.
- **Debt to Equity ratio**: gives a comparison of how much of the business was financed by owner's equity and how much was financed through debt or liabilities.
- Debt to equity ratio = Total Liabilities/Owners' Equity. It measures the ability of the business to repay long term debt.

- A debt equity ratio of 1:1 indicates that the external lenders and the owners are bearing the same degree of risk.
- A ratio of less than 1:1 means that: debt is less than owners' equity; the business is positively geared; the external lenders are bearing less risk than the owners; and the owner has a stronger financial interest in the business than external lenders

e. *Cash Flow Analysis*

- A cash flow budget is a summary of all cash inflows and outflows to the business. It provides insights into whether a business will have adequate cash available when needed to meet its financial obligations.
- It shows exactly where the cash has come from during the year and what one has done with it. Cash flow budget predicts cash shortfalls. It helps in planning for interim financing, loans and determines repayment ability of loans and their interests.
- It also provides information for timing of loan payments. A cash flow budget is not an estimate of profitability because non-cash revenue or non-cash expenses are not considered.
- For example, depreciation is not included in the cash flow budget, but payments of principal and interest on loans are. Inventory value is not included, but the proceeds from sales of capital assets are included. Only cash inflows and outflows are considered.

Table 8: Quarterly cash flow budget in a seaweed business enterprise

Item	Q1	Q2	Q3	Q4
Beginning cash	50000			
Receipts	52750	52750	52750	52750
Total Cash inflow	102750	52750	52750	52750
Operating cash expenses	25000	25000	25000	25000
Living expenses	10000	10000	10000	10000
Other expenses	5000	5000	5000	5000

Scheduled Debt payments		15000		15000
Total cash outflow	40000	55000	40000	55000
Cash available	62750	-2250	12750	-2250
New borrowing		2250		2250
Cash balance				
Debt outstanding				

Components (items) of a cash flow budget

- **Beginning Cash Balance (BCB)** – This is the amount of cash at hand at the beginning of the business period.
- **Receipts** – cash revenue generated by sales of the crop or other capital assets. Note: Cash revenue items (receipts) +BCB are summed to obtain TOTAL CASH INFLOW for the time period.
- **Operating Cash Expenses** – Expenses related directly to the quantity of seaweed produced. For example seedlings, field labour, repairs etc. Also expenses associated with the.
- **Scheduled Debt Payments** – includes principal and interest payments for each separate loan.
- **Note:** All expenses are summed to obtain TOTAL CASH OUTFLOW.
- **Cash Available** – This is the difference between TOTAL CASH INFLOW and TOTAL CASH OUTFLOW purchase of capital assets are included.
- **New Borrowing** – If the **Cash Available** is **negative**, this means that there is insufficient cash generated during the period to meet all cash obligations and additional borrowing is needed for that time period.
- **Cash Balance** – obtained by adding **Cash Available** to **New Borrowing**. It becomes the **Beginning Cash Available** at the start of next time period. Always positive

- **Debt Outstanding** – An accounting of the debt outstanding for each loan is kept at the bottom of the cash flow budget. Therefore, principal payments in a time can be subtracted out of the balance owed. New Cash flow (NCF) – the cash earning capacity of the business independent of the amount and type of financing. NCF = Total Receipts – Total operating expenses

Module 6

Challenges and Solutions in Seaweed Farming

6.1 Challenges in seaweed farming

a. Invasion by other organisms

- Seaweeds experience the challenge of invasion by other marine organisms. Epiphytes are aquatic marine plants that attach themselves to the cultured seaweeds. They are harmful to the infected plants because they penetrate to the outer layer of the host cell wall, invade it and then damage its tissue through fragmentation or disintegration. Epiphytes compete for space, sunlight, nutrients and dissolved gases that lead to stunted seaweed growth. Possible factors that trigger the occurrence of epiphytes include: state of health of the seaweed, lack of water movement, extreme water temperature, low salinity and highly turbid waters.

Figure 47: Epiphytes on seaweeds

Solution

- The mitigation measure to epiphytes is to remove all the infected seedlings, harvest seaweed and sun-dry if already bigger. Re-seedling should be done using bigger plants but make sure to tie it in new cultivation lines and also transfer locations.

b. Pests and predators (grazers)

- Seaweed is also affected by pests and predators/grazers. Grazers are categorized into invertebrate grazers and fish. Invertebrate grazers can graze heavy on new fronts and broken ends of old fronts of brown algae. Sea urchin and Sea stars may have a small-scale effect upon algal abundance in Laminaria forests. Rabbitfishes are notorious herbivores of *Eucheuma* species in the Philippines (Ohno and Critchey, 1993). Other grazers on Eucheuma are sea urchins, diadema, starfish, and synaptic (Emilio, 1988; Barter, 2008). Grazing represents a real but relatively minor loss of production to plots of mature seaweed, but nurseries can be more vulnerable and suffer greater losses. If grazing is not controlled, it can wipe out a whole farm.

Sea urchin

Puffer-fish

Rabbit-fish (Siganus sutor)

Sea turtles

Figure 48: Pests and grazers on seaweed

Solution

- The fish that graze on seaweed usually shelter around rocks and coral bommies and therefore the only mitigation available is to avoid locating seaweed plots close to such features. The long-line technique, which sets lines a few metres below the surface, is less vulnerable.

c. Diseases

- Seaweed growth is also affected by a variety of diseases such as "ice-ice" which is characterized by whitening of Eucheuma, which remains for a day or two and dissolves away separating the two adjacent parts of the thallus.
- Pitting disease is characterized by the formation of a cavity penetrating the cortex and expanding to the medullary region. Tip darkening involves tips which are darker relative to the adjacent segments below the affected branch apices, and tip discoloration disease is one where tips are discolored relative to the adjacent layers below affected apices.
- Ice-ice is a disease caused by low salinity, temperature and light intensity. Ice-ice will appear during the southeast monsoon and disappear after 2-3 months. The tell-tale signs of the disease is that the thalli degenerate, turn a pale white color similar to ice (hence the name of the disease) and eventually rot.

Figure 49: Ice-ice disease

Solution

- Practical remedy to ice-ice is to remove the affected parts, harvest, or do seedling and transfer to other locations. Health management in seaweed farms is primarily done with proper site, species selection and farm maintenance.
- The County and national governments should develop capacity-building initiatives, which are gender-responsive, including training programs in bio-security, farm management practices, and early diagnostic procedures for exotic and emerging pathogens, to enable effective pathogen management.

d. Typhoons & Cyclones

- Seaweed farms are very vulnerable to bad weather such as typhoons and storms. Many seaweed farms are destroyed by typhoons and cyclones.

Solution

- To minimize impact on seaweed farms, it is advised to choose sites that are sheltered wherever possible. Other than that, it is important to monitor weather forecasts, and if the forecast is threatening then farmers should mobilize and harvest the available seaweed to avoid any loss, and replace the stock with smaller cuttings (of 25g).

e. Marketing challenges

- Seaweed farmers along the Kenyan coast face the challenge of having one buyer which is a monopoly. The one buyer therefore dictates the price to farmers who are just price takers. The seaweed farmers therefore sell their produce at low prices since they don't have choices. The current price of KES 35 per kg of dried seaweed is too low.

Solution

- The government should support farmers to form cooperative societies, which provide platforms for public participation in decision making and bargaining power for better seaweed prices. Farmers should process some of the seaweeds to improve its value through manufacture of various products such as soap, shampoo, baking ingredients etc. This reduces dependency on the sole buyer.

f. Financial challenges

- Seaweed farmers have poor access to credit since lenders are not well sensitized on the potential of seaweed farming as a business. Farmers therefore lack the necessary finances that they need to expand and improve their enterprises.
- Consequently, they practice small-scale seaweed farming which is not very profitable. The farmers do not have the financial capability to intensively invest in seaweed farming and instead have small farms that provide them with subsistence income.

Solution

- Seaweed farmers should be empowered to prepare business plans that can help lenders better understand seaweed farming business and improve access to credit. Lenders also need to be sensitized on the business potential of seaweed farming through organized workshops and conferences.

g. Conflicts with other ocean users

- Seaweed farmers often find themselves in conflict with other ocean users such as navigators, fishers, and water recreationists among others. This is especially true if seaweed farms are located in areas with high concentrations of human activities.

Solution

- Proper site selection and zonation of the ocean for various uses are the possible solutions.

h. Lack of mechanization and technology

- Seaweed farming along the Kenyan coast is predominantly accomplished by manual labor. Staking (pegging), tying of polyethylene ropes on stakes, tying of seedlings on the ropes, routine farm maintenance, and harvesting are also accomplished without mechanization. This is labor-intensive and tedious.

Solution

- Seaweed farmers should adopt modern seaweed farming technologies and pursue mechanization of some seaweed farming activities such as harvesting

i. Lack of essential equipment such as boats

- Most seaweed farmers along the Kenyan coast use the off-bottom method which is practiced in shallow waters. Most farmers lack boats to transport seaweed during planting and harvesting due to financial constraints. Boats are needed during harvesting to carry the seaweed from the ocean to the shores. Seaweed farmers also lack safety jackets and other water protective gear to protect them from the sea.

Solution

- Seaweed farmers should mobilize funds and purchase essential equipment like boats which make their work easier. They should seek grants from local and national governments and other donors who are willing to support the development of seaweed farming.

j. High sea surface temperatures

- Seaweed growth is affected by environmental/physical factors including temperature, wind, rain pest and diseases (Emilio, 1988). Seaweed is highly affected by higher water temperature exceeding 31 °C-32°C (De San, 2012).

- Seaweed growth rate is known to be lowest during summer seasons with temperatures between 30°C-32°C (Neish & Msuya, 2013). Seaweed can sometimes experience bleaching due to high temperatures.
- Bleaching occurs when the seaweed loses its color and vitality, turning white or pale. This phenomenon is primarily caused by the stress imposed on the seaweed's photosynthetic apparatus when exposed to elevated water temperatures. The rise in sea temperature has resulted in a decrease in harvest and the destruction of some harvests.

Solution

- In order to reduce the problem of higher temperatures, seaweed farms should be located deeper inside the ocean. However, this carries higher capital and operational cost that needs to be clearly evaluated from a business perspective. It only makes sense for large volume farms with higher access to capital.

Practical

- Learners should visit a seaweed farm and check for the presence of seaweed diseases, epiphytes.
- Check the location of seaweed farms and other human activities (fishing, navigation etc.) in the areas surrounding the farm.
- Check the seaweed farm for the presence of grazers (rabbit fishes, sea urchins, sea stars, sea turtles etc.)

Module 7

Gender Equality in Seaweed Farming

Introduction

Women play a crucial role in seaweed farming worldwide. In regions like Tanzania, they make up approximately 70% of the workforce. This economic activity offers women a source of income, contributing significantly to their financial independence and social status. However, they still face challenges such as limited access to resources, education, and land rights, which can hinder their full potential. This module addresses these issues by emphasizing gender equality and empowering women in seaweed farming.

Learning Objectives:

By the end of this module, participants will:

1. Understand the role of women in seaweed farming.
2. Identify the challenges women face in this industry.
3. Explore ways to overcome these challenges through empowerment and gender equality.
4. Develop actionable steps to promote gender equality in seaweed farming.

Module Structure

This module is designed to be covered in three sessions over one week. Each session lasts for about 2 hours.

Session 1: Overview of Women in Seaweed Farming

7.1 Global Context:

- Women constitute a significant portion of the seaweed farming workforce globally. In some regions, such as Tanzania, they represent up to 70% of the workforce.

7.2 Economic Impact:

- Seaweed farming offers women from coastal communities a viable source of income, significantly contributing to their financial independence and community status.

7.3 Challenges:

- Despite their substantial involvement, women often face obstacles such as limited access to resources, education, and land rights, which limit their full potential in the industry.

Activity 1: Group Discussion

- **Objective:** Discuss the role of women in seaweed farming and identify key challenges.
- **Instructions for the Trainer:** Divide the trainees into small groups. Ask them to discuss the role of women in seaweed farming in their communities and the challenges they face. Each group should present their findings.

Session 2: Empowering Women in Seaweed Farming

7.4 Opportunities for Income:

- Women use income from seaweed farming for essential expenses, including education and healthcare, which improves their role in household decision-making.
- Discuss how women can expand beyond basic farming to involve themselves in value addition, such as processing seaweed into higher-value products like soaps and fertilizers. This diversification can lead to greater income and financial security.

7.5 Social Benefits:

- Involvement in seaweed farming has led to greater social recognition for women, providing them with both financial and social capital.

7.6 Importance of Collective Action

- Women's groups and cooperatives have been instrumental in helping women in seaweed farming overcome barriers related to market access and bargaining power. Highlight successful case studies of women forming cooperatives to pool resources, share knowledge, and increase their collective bargaining power.

Activity 2: Role-Playing

- **Objective:** Experience the benefits of women's empowerment in decision-making.
- **Instructions for the Trainer:** Ask participants to role-play scenarios where women use their income to make decisions about education, healthcare, and community involvement. Debrief with a discussion on how empowerment changes their roles within the family and community.
- **Trainer's Notes:**

- **Managing Group Dynamics:** Be mindful of group dynamics. Ensure all participants, especially women, have a voice in discussions.
- **Encouraging Participation:** Encourage shy participants to share their views and ensure dominant voices do not overpower the conversation.

Session 3: Overcoming Barriers and Achieving Gender Equality

7.7 Need for Advanced Training:

- There is a critical need for targeted education and training to help women overcome technical and market-related challenges in seaweed farming.

7.8 Access to Resources:

- Improving women's access to financial services and aquaculture resource rights can significantly boost their productivity and sustainability.

7.9 Political and Community Support:

- Policies and community actors, including men, should support gender equality to ensure women benefit equally.
- Addressing Gender-Based Violence (GBV) can be a hidden barrier that prevents women from fully engaging in economic activities like seaweed farming. Include a discussion on how GBV intersects with economic empowerment and what community strategies can help mitigate this issue.

Case Study: Amina's Story Amina is a coastal woman from Kenya who dreams of cultivating and selling seaweed—a business that promises financial independence and a sustainable interaction with her environment. However, despite her ambition, Amina faces numerous challenges that limit her ability to succeed in this endeavor. Below is her story:

1. **Education:** Amina was unable to continue her studies beyond primary school due to financial constraints and the need to help at home. Influenced by pervasive gender norms, her educational opportunities were limited, reinforcing the belief that her future should be confined to traditional roles.

2. **Resource Scarcity:** Prolonged droughts have worsened the scarcity of resources in Amina's village. Every day, she spends a significant amount of time collecting water for her family—a task that could have otherwise been dedicated to developing her seaweed farming business.

3. **Health Risks:** As a mother, Amina's responsibilities increase as the impacts of climate change affect her family. Caring for sick children and managing potential complications from pregnancy restrict her ability to engage in demanding agricultural activities.

4. **Economic Instability:** Amina's husband, Omari, has an unreliable income, which fluctuates with the seasonal catches from his fishing activities. This economic instability places additional pressure on Amina to contribute financially. However, she has little control over her own income, as Omari often appropriates the earnings she makes from her small side activities.

5. **Social Dynamics:**

   - **Limited Mobility and Information:** Amina's ability to access training on climate-resilient agricultural techniques and market information is hampered by her limited mobility and traditional restrictions that dictate women should not travel alone.

   - **Domestic Tensions:** Omari, stressed by his own economic insecurity, often opposes Amina's entrepreneurial efforts, fearing that they might challenge his authority as the household's primary decision-maker.

Activity 3: Web of Challenges Exercise

- **Objective:** Visualize and understand the interconnected challenges that women like Amina face in seaweed farming and brainstorm solutions.
- **Instructions for the Trainer:**
  1. **Setup:** Draw a large spider web on a flip chart or board. Label each part of the web with one of the challenges Amina faces (e.g., lack of resources, health risks, economic instability, domestic tensions, mobility restrictions, etc.).
  2. **Exercise:** Ask participants to identify how these challenges are connected and how they can create a web of problems that trap Amina. Then, ask participants to think of possible solutions for each challenge. Encourage them to suggest actions Amina, her family, and the community can take to help her break free from the web.
  3. **Debrief:** Discuss the importance of community support, access to resources, and gender equality in dismantling the web of challenges. Highlight how gender equality can empower women like Amina to succeed in seaweed farming.

Conclusion

Seaweed farming stands at the intersection of economic opportunities, environmental stewardship, and community empowerment. As outlined throughout this manual, it is more than agricultural activity; it is a resilient livelihood strategy capable of transforming coastal economies, strengthening food systems, and contributing to climate solutions. When farmers apply best practices in site selection, cultivation, harvesting, post-harvesting and value addition, they not only increase productivity and product quality, but also unlock access to high value markets.

However, the long-term success of the sector depends on coordinated action. Farmers, cooperatives, private sectors, researchers, and government institutions must work together to address challenges such as access to quality seedlings, financing, infrastructure, market linkages, and supportive policies. With the right partnerships and continued innovation, seaweed farming can scale sustainably while protecting marine ecosystems and ensuring equitable benefits for coastal communities.

This manual is intended to serve as a practical guide and a catalyst for progress. By applying the knowledge, techniques and strategies presented here, stakeholders can strengthen the seaweed value chain, enhance incomes, and build a thriving blue economy. The future of seaweed is promising, and with commitment, collaboration, and responsible practices, it can become a cornerstone of sustainable development for generations to come.