

Programme for the implementation of a Regional Fisheries Strategy for the  
Eastern and Southern Africa and Indian Ocean Region

Programme pour la mise en oeuvre d'une stratégie de pêche pour la région  
Afrique orientale-australe et Océan Indien



## THE FARMING OF SEaweEDS

March 2012



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The Eastern-Southern Africa  
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Implementation of a Regional Fisheries Strategy  
For The Eastern-Southern Africa and India Ocean Region

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# The Farming of Seaweeds

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Michel De San

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## Guidelines for the introduction of Seaweed Farming as an alternative livelihood opportunity in the coastal zone

The management of the coastal zones of the western Indian Ocean (WIO) is seriously compromised by the over-exploitation of coastal fisheries stocks. This overexploitation is largely due to the over-development of artisanal fisheries, which are particularly difficult to manage.

In fact, there are really only two ways to address this problem: 1) by simply legislating to reduce the fishing efforts and then enforcing that legislation, which is politically very difficult, or 2) by linking the mutually agreed introduction of less punitive management measures (for example, gear restrictions or closed areas or seasons) with the creation of alternative livelihood opportunities for fishers.

Marine aquaculture is a one such alternative that is increasingly popular following a number of successful introductions in the region. One example is the development of seaweed farming, which has been promoted over the last 20-years but other types of marine aquaculture also have potential as alternative livelihoods. These include the culture of prawns, fish, bivalves, crabs and sea cucumbers.

### Note from the Author, Michel de San, a technical advisor with 30-years experience in the WIO region

Through this booklet the author aims to build, step by step, a clear understanding of the methods and techniques for the farming of *Spinosum* and *Cottonii* seaweed. The booklet also describes the range of difficulties and challenges that are likely to be faced, such that the stakeholders (including the farmers, private sector investors, government, donors and NGOs) are able to benefit from past experience and achieve a win-win situation. With this understanding and shared experience, it will be feasible to develop, in partnership with coastal communities, an industry worth millions of dollars.

It is worth noting, however, that an investor's likelihood of reaching an annual production of 1,000mt dry-weight is only about 25%. This booklet, through the sharing of 20-years of seaweed farming experience in the region, is designed to increase this success-rate.

### Acknowledgements



Seaweed farming in the WIO region owes much to the willingness of the multinational FMC to support the development of the industry in the early days. Particularly important were the American and Filipino technicians (Erick Ingvald Ask, Jose Lagahid and Recarte Cay-am (or 'Bong')) who provided invaluable advice to farmers, technicians and the private sector in the region.

Acknowledgements are also made to the private sector who have taken risks to launch seaweed farming and to the NGOs and development agencies and donors that supported them, particularly the European Union.

Thanks also to Jim Anderson for the English translation and text review.

*Figure 2: Almost everyone involved in seaweed farming in the Western Indian Ocean knows, and has been helped by, Bong, a Filipino technician with FMC. I would like to take this opportunity to thank Bong personally, as well as on behalf of the numerous seaweed farmers and technicians, for his professionalism and dedication.*

# The Farming of Seaweeds

A guide to the farming of *Cottonii* (*Kappaphycusalvarezii*) and *Spinosum* (*Eucheumadenticulatum*) seaweeds as a livelihood and business opportunity.

## 1. Introduction to the Sector from a Global and a Western Indian Ocean Perspective

The culture of the tropical seaweed species *Kappaphycus alvarezii* and *Eucheuma denticulatum* began in the 1960s in the Philippines, with commercial-scale production reached in 1971. *Cottonii* and *Spinosum*, respectively, are the commercial names of these two species.

Since those early days, global seaweed aquaculture production was reached 180,000mt dry-weight of *Cottonii*, and 28,000mt dry-weight of *Spinosum*. Table 1 presents summary of world production.

**Table 1: World Production Figure (mt dry-weight)**

Country of Production	2001 (mt/yr)	2002 (mt/yr)	2003 (mt/yr)	2009 (mt/yr) (est'd.)	2010 (mt/yr) (est'd.)
<b>Philippines</b>	118,400	125,200	127,700		80,000
a) <i>Cottonii</i>	4,100	5,500	3,000		20,000
b) <i>Spinosum</i>					
<b>Indonesia</b>	28,800	35,600	36,800		90,000
a) <i>Cottonii</i>	3,460	3800 mt	3,100		5,000
b) <i>Spinosum</i>					
<b>Tanzania (Zanzibar)</b>	742	921	1,378		500
a) <i>Cottonii</i>	2,480	2,561	4,600		12,000
b) <i>Spinosum</i>					
<b>Malaysia</b>	3,200	3,600	4,900		3,000
a) <i>Cottonii</i>					
<b>Vietnam</b>					4,000
a) <i>Cottonii</i>					
<b>Madagascar</b>				2009 Estimated	1,000
a) <i>Cottonii</i>				1,500	1,000
b) <i>Spinosum</i>				500	
<b>Total</b>	151,142	165,321	170,778		178,500
a) <i>Cottonii</i>	10,040	11,861	10,700		38,000
b) <i>Spinosum</i>					

In the WIO-region, seaweed culture was initiated in the 1980s in Tanzania, particularly on the islands of Zanzibar and Pemba, and it was subsequently taken-up in Madagascar and Mozambique in the mid-1990s. Kenya first introduced seaweed culture, albeit in a commercially unsuccessful trial, in 2004 and then again in 2009 with the support of an EU-COI project, with the first container-load shipped in 2011. However, these are not in fact the only countries where an introduction has been attempted, but only a few countries have been able to develop an industrial-production of at least 1,000mt dry-weight, and then maintain it over more than a few years.



In general, *Spinosum* is mainly grown in Tanzania and Kenya, with *Cottoni* the dominant species in Madagascar.

## 2. The Uses of Carrageenan and Extract

The principle interest in seaweed is for the extraction of carrageenans, which are processed into gels that are subsequently used in the food industry, cosmetics, and pharmaceuticals as thickeners, stabilising agents and emulsifiers. One of the important characteristics of carrageenan-based gels is that they remain fluid under pressure and then recover their original viscosity.

The following are some examples of specific uses of carrageenan gels:

- a) Food Industry: deserts, ice-creams, concentrated milk, pasta, processed meats, sauces and Chinese soups, in beer-making processes, soy milk, animal feed, dietetic drinks, jams etc.;
- b) Cosmetics: toothpaste, shampoo, skin-care creams etc.;
- c) Pharmaceuticals: in pills, gels etc.; and,
- d) Others: for example, in fire-extinguishers and polish.

## 3. Introduction to Seaweed Farming

Seaweeds are generally cultivated in lagoons or sheltered bays. **Seaweeds obtain nutrients directly from the seawater and it is crucial to have currents that flush the site in which the seaweeds are placed.** Small cuttings are attached to a line with short lengths of string (known as 'Tie Tie') at a density of five cuttings per metre of line. In nature these seaweeds live attached to a solid substrate.

### 3.1. *Spinosum*

*Spinosum* is a robust seaweed and is relatively easy to cultivate because it is the best suited to withstanding temperature variations and infestation by algal parasites.



Figure 3: *Spinosum* on the coast of southern Kenya



### 3.2. Cottonii

Cottonii is more difficult to cultivate and requires more care and more skill. It is a seaweed that is very sensitive to infestation by algal parasites and to water temperatures above 31-32 °C. And a farm or village, even one that is technically well supported, may see much of its Cottonii seaweed disappear once or twice per year. This annual loss requires a production cycle to be established specifically to produce new cuttings.



Figure 4: A harvest of Cottonii being transported by outrigger canoe in SW Madagascar

### 3.3. Daily GrowthRate

The growth rate of seaweed located in a suitable habitat, even taking into account seasonal variations, is impressive (see table 2). A single cutting of 100g can reach a weight of 1 kg in 20-40 days, which could yield at least 8 separate harvests per year.

**Table 2: The increase in weight of a 100g cutting according to a range of daily growth rates.**

% croissancepar jour// growth rate per day	3% 100 gr	4% 100 gr	5% 100 gr	6% 100 gr	7% 100 gr	8% 100 gr
Nombre de jours// Number of days						
10 j	134 gr	148 gr	163 gr	179 gr	197 gr	216 gr
20 j	181	219	265	321	387	466
30 j	243	324	432	574	761	1006
45 j	378	584	899	1376	2100	3192

In summary, one of the keys to the culture of seaweed is to have a minimum daily growth rate of 5-8% over the majority of the year. It is advised NOT to start a seaweed farming venture if the average growth rate through the 12-months is less than 4%.

The growth rate of 4% takes account of the unavoidable negative growth rate in one or two months each year due to infestation by parasitic algae, grazing fish, the disease known as Ice-ice, high sea temperature, storms and periodic inflows of fresh water. The impact of these negative events may be further exacerbated by a farmer's lack of management of the seaweed plots.

## 4. Types of Seaweed Farming (village-based, industrial-scale or a mixture of the two), their Advantages and their Constraints

### 4.1. Techniques of Seaweed Culture

#### 4.1.1. Off-bottom (post and line)

The general approach is to suspend a series of lines of 10m in length between two posts, which are usually made of wood. This technique is best suited for lagoons, where there is relatively shallow water at low tide and for small-scale initiatives. The lines are regularly checked and the seaweed harvested during the two spring tide periods each month, at which time the farmers can work on foot, and is therefore a technique particularly suited to women farmers. Following each harvest, the seaweed is dried on land for a few days before sale.



Figure 5: Introduction of *Spinosum* farming using the off-bottom method in Kenya (EU-COI).



### 4.1.2. Longlines

This technique involves the use of line of up to 50m in length, anchored at each end and with floats attached every 10m or so to support the line. This technique is usually employed in water of between 4 and 10m and farmers therefore require access to some sort of boat to access the plots. However, as a result of the necessity of a boat the farmers can access the plots at all times, except for during bad weather.

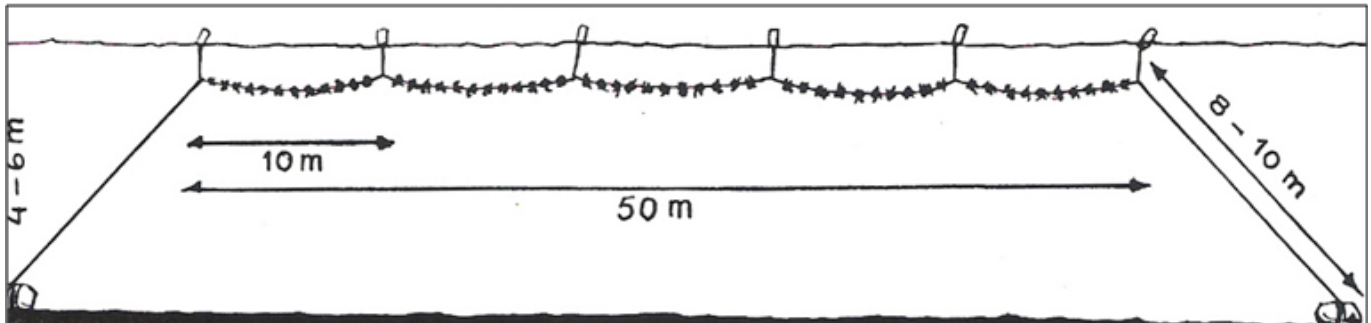


Figure 6: The Longline technique for use in deeper water

### 4.1.3. Rock-based Farming for Spinosum

Rock-based farming originated in Asia and was first introduced into the WIO region, in Zanzibar, under a EU-COI project. As the name suggests, cuttings of *Spinosum* are initially attached to a rock (roughly the size of a large fist) with an elastic band, although after a few weeks the seaweed establishes its own fixation points. The ideal density of rocks is 25 per m<sup>2</sup>.

With this technique the harvesting of seaweed is done, at low tide and on foot, by simply cutting away the new growth each cycle while leaving enough of the 'root stock' for the cycle of growth to start over again. This technique avoids the need to affix new cuttings after each harvest and represents a significant labour-saving; for example, a farmer using the line-based techniques would require up to 120,000 individual harvest manipulations per year to manage lines of just 3kms (= 15,000 separate plants). This technique has obvious attractions and an image given by farmers using this technique in Zanzibar was that it was like having an orchard of mangos, that provide their fruit all year-round.

However, there is one major constraint to the application of this technique and that is the requirement for a site well-protected from potentially rough sea conditions. In sites that are too exposed it is a certitude that the rocks will end up on the beach or at the bottom of the lagoon.



Figure 7: Rocks that are naturally seeded with *Spinosum*.



Figure 5: A *Spinosum* farm in Uzi Village, Zanzibar, using rocks with seaweed cuttings attached. At a density of 25 rocks per square-metre and 1.5 million rocks laid by 100 families, total production should reach 1,000mt per year.

#### 4.1.4 Floating Rafts

This technique is employed principally in protected bays in Asia.

### 4.2 The Village/Family Approach

There are a number of key issues that the private sector and the potential farmers should be aware of:

- Seaweed farming requires a significant amount of work;
- Experience shows that 80% of the production from a typical village is delivered by just 20% of the farmers;
- The implication of this is the need to focus on the best-performing farmers;
- 70-80% of the work (which is mainly the replacement of cuttings) is undertaken by women;
- A motivated family will be able to manage at least 3km of line and produce about 10mt dry-weight of seaweed per year;
- A production of 1,000mt dry-weight of seaweed requires 8,000-10,000mt wet-weight of seaweed. This translates to 40,000 to 50,000 m<sup>3</sup> of seaweed that must be taken from the plots and dried on land;
- The export buyer will require hundreds of metric tonnes simply to break-even financially;
- A potentially suitable village for seaweed farming will usually have only limited economic opportunities available (for example, in SW Madagascar the fisheries are overfished with an arid hinterland offering few other opportunities).

It is very much at the family and village-level where the environmental and socio-economic characteristics favour seaweed farming. After all, the work unit is usually the family and their reward is the sale of dried seaweed to the buyers.

Operating in a mutually respectful but nevertheless under a contractual arrangement, the basic nature of the relationship between these two partners can be characterised as follows:

- **Buyers → Farmers:** The buyers provide the farmers with the raw materials for production, including the lines, sometimes the posts, the boats, and the drying tables. They also link farmers with technical support and provide supervision. All this support is provided under contract with clear rules that help to weed-out the less-motivated farmers and to reallocate support to others. Payments are made in cash at least twice monthly;
- **Farmers → Buyers:** It is essential that farmers respect the exclusive nature of their contracts, which requires the sale of their seaweed to the contract partner only. It is also essential that the necessary quality of dry seaweed is produced.

#### 4.3 The 'Industrial' Approach

In the industrial approach, an investor would look for a favourable site and engage workers who would be expected to work for 22-days per month. The investor would provide close and continuous supervision and the level of wages paid are directly linked to the level of production of seaweed. This approach is predicated on the availability of individuals who are motivated by the need for a cash income; and they are often temporary economic migrants seeking to earn just enough money for their own 'projects'. It is important that any plan to use immigrant labour is carefully introduced and accepted by the local resident population. The presence of an industrial set-up does not imply that village-level seaweed farms cannot co-exist in the same area.

For private-sector investors, the advantages of an industrial/commercial operation compared to family and village-based farming are:

- A higher quality of labour, resulting in a better management of disease and fewer unforeseen problems;
- A better management of the quality of the final product with a concomitant expectation of a higher final price; and,
- Better protection against 'pirate' buyers. *For example, Tanzania has witnessed an invasion of Chinese buyers who pay a higher beach price than farmers could expect under their contracts. But the Chinese buyers have usually invested nothing in developing production capacity. And they can further improve their profit margins by saving money on transport by shipping seaweed back to China in empty containers that had previously brought merchandise from China to Tanzania. This is an unsustainable approach because it ultimately discourages the very private investment that created the seaweed farms in the first place.*

The major constraint of the medium-scale commercial approach is that one replaces a relatively simple system of farming and harvesting based on family units (even if there are, for example, 300 families operating across five villages)

with a SME of 120 employees. Furthermore, it is often necessary therefore to provide accomodation for the workers and ensure adequate provision of general supplies and foodstuffs for the site in general.

## 5. Technical, Socio-economic and Financial Challenges, and the Means to address them

Aide Memoire:Key Facts about Seaweed Farming

- Cottonii is much more vulnerable to environmental factors than is the case with Spinosum, and therefore it is harder to farm it successfully;
- From a technical perspective, seaweed that is under environmental stress may at best stop growing, and at worst, display what is in effect a negative growth rate as plant biomass is lost;
- Cottonii sells at a price at least double that of Spinosum;
- The sector of course depends on both producers and buyers, but for the latter a financial break-even production is reached at 300mt/yr for Cottonii and 500mt/year for Spinosum;
- To reach financial break-even requires three years at least;
- International buyers are not interested in exporters that cannot provide a least 1,000mt dry-weight per year;
- Evidence suggests that a private-sector investor has only about a 25% of succeeding in the seaweed farming business.

### 5.1. The Disease Ice Ice

Ice Ice develops as a result of stresses on the seaweed and these stresses are described in more detail in the following sections (5.2 to 5.7). The tell-tale signs of the disease is that the thalli (or frond) degenerate, turn a pale white colour similar to ice (hence the name of the disease) and eventually rot. It is a clear sign that seaweed is not healthy and it eventually literally falls apart with the consequential loss of a production cycle in a matter of a few days. Perhaps more serious is the loss of the supply of cuttings for the following production cycle.



Figure 6: A seaweed plant with Ice Ice

### 5.2. Water Temperature

Sea-water temperature is also a limiting factor on growth, and should ideally be between 20° et 32°C, while a sudden change in temperature (even if it remains within the ideal range) can also have a negative effect on seaweed growth.

### 5.3. Prolonged exposure of seaweed to the air (especially for Cottonii)

Exposure of seaweed to the air can have a chronic effect on growth rates, even if it doesn't necessarily result in the full-blown development of Ice Ice. This problem is associated with farmers who systematically take new cuttings only

when the harvest has been brought ashore for cleaning and drying, rather than taking cuttings in situ. A farmer can lose the equivalent weight of one or two individual harvests per year, perhaps without even realising it, because the harvest cycle can be 1-12 days longer than what it should ideally be.



Figure 7: The taking of cuttings in situ is important to avoid stressing the seaweed and reducing its growth rate

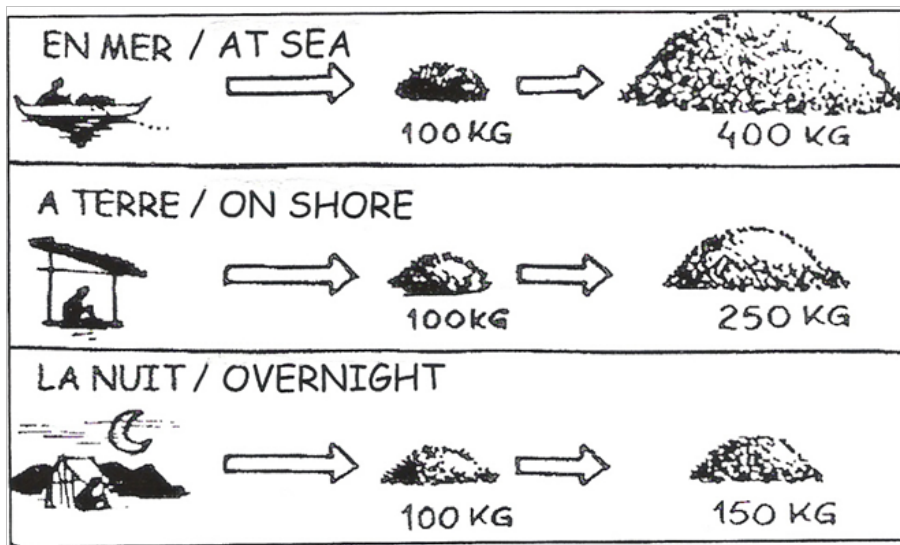


Figure 11: On the basis of a growth-rate of 4.5% per day for 30-days, this figure indicates the general difference in production as a function of exposure to the air. In fact, seaweed that under environmental stress can stop growing for between 1 and 12 days. The farmer therefore loses, without even knowing it, one or two harvests per year.

#### 5.4. Salinity

Salinity is also a limiting factor on seaweed growth, particularly if it drops rapidly. Such a rapid drop in salinity would usually occur as a result of heavy rains in adjacent river catchment areas. Overall it is necessary to avoid sites where salinity is outside of the range of 23-38 grammes/litre (ppm); the average salinity in the western Indian Ocean is 35-36ppm. Freshwater is more buoyant than seawater and one solution to the risk of freshwater influx is to set the lines at least 1-metre below the sea surface.

#### 5.5. Algal Parasites (Cottoni is more vulnerable than Spinosum)

To best understand the nature of the problem of algal parasites of seaweed the following is an example of what happened to a well-managed and productive Cottoni farm in NE Madagascar.



The company had attained a production of Cottoni of close to 2,000mt dry-weight per year. Then a massive infestation of Epiphytic Filamentous Algae (EFA) took place that caused a 50% decline in production in 2010. This, exacerbated by the presence of other parasitic algal, discouraged the farmers to the extent that production had almost ceased in 2011.

This is by far the biggest threat to seaweed culture, and also the most difficult situation to manage, and the farmers and buyers will always lose money!

The infestation of seaweed plots by EFA (or 'pest' seaweed) is recurrent but often seasonal. It can bring on a massive loss event, where some or even all of the production can be lost. And farmers may then be left without stock suitable for cuttings and are therefore obliged to spend one harvest cycle for no other reason than to replace this stock. It is likely, due to pest seaweed, that two of the normal eight harvests per year will be lost.

**How to Limit the Damage.**

- Build on past experience;
- Ensure good monitoring of the farm itself, particularly during the seasons where algal parasites are more common. In fact, the infestation by EFA develops progressively, permitting time for a response (see below);
- Mobilise the technicians to support the best farmers;
- Increase the diversity of the locations of the seaweed plots;
- Diversify the modes of production. In fact, longlines set deeper in the water column will be less frequently and less rapidly infested than seaweeds growing off-bottom in the lagoon.



Figure 12: A Kenyan technician checking the lines of a non-motivated farmer (no farmer's shadow on the seaweed). In such situations, if no improvements are seen, it is advisable to reduce the size of the individual's farm and ultimately to end the contract.

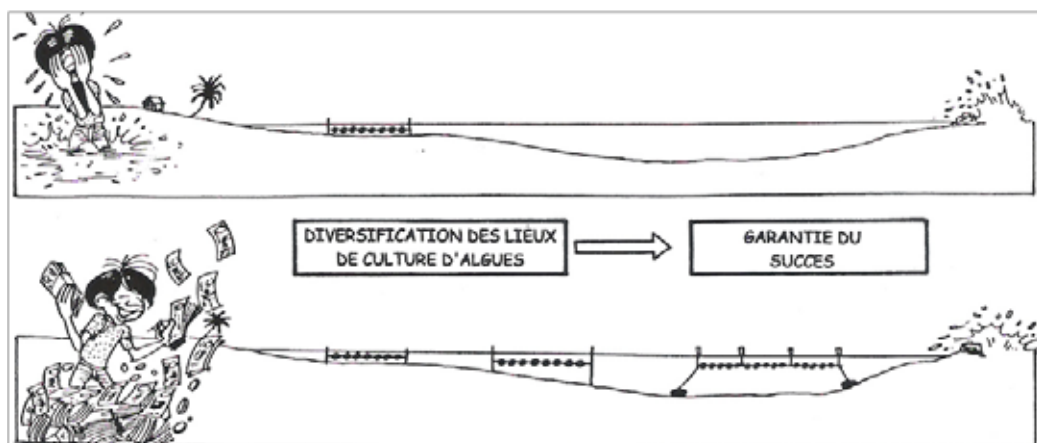


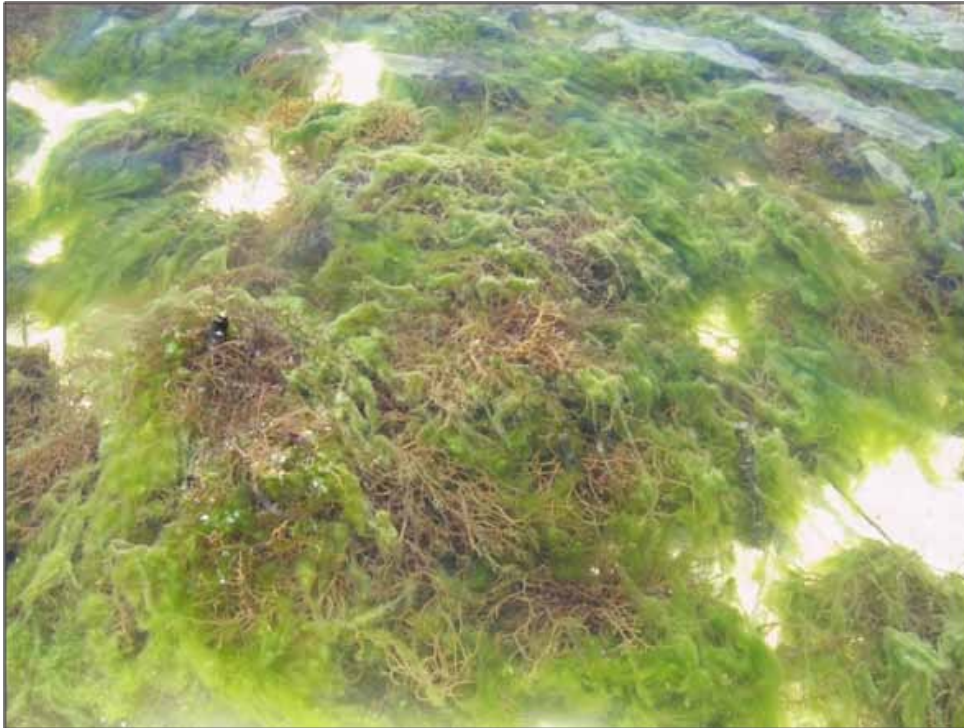
Figure 13: The diversification of sites and modes of production is essential, as shown in this figure by José Lagahad, a Filipino seaweed farming expert.



- Ensure a rapid mobilisation of the farmers to harvest the seaweed because seaweed harvested and dried is equivalent to money in the bank and prevents farmers becoming discouraged;
- Attach only small cuttings (e.g. cuttings of 25-50gr as opposed to the normal 100gr) with the remaining healthy seaweed;
- Establish a back-up nursery in a site that is not contaminated by the infestation;
- Mobilise the farmers to clean the seaweed still in situ on the re-stocked lines.

**The six most damaging parasitic algal are the following:**

- Macro-algae: Enteromorpha, Ulva, Chaetomorpha, Hypnea and Hydroclathrus.



*Figure 14: Spinosumparasitised by Enteromorpha.*

- Epiphytic Filamentous Algae (EFA).



Figure 15: Cottonii parasitised by EFA in a commercial farm in the north-east of Madagascar. This farm saw its Cottonii production decline by 50% in 2010, while in 2011 it was almost zero.

## **5.6. Turbidity**

Seaweeds can endure a certain level of turbidity. But they are vulnerable to high turbidity caused by terrigenous material, that can stick to the thalli and induce Ice Ice. Farmers need to regularly shake their lines to remove the silty deposits from the seaweed.

## **5.7. Storms and Cyclones**

It is obvious that seaweed farms are vulnerable to bad weather. To minimise its impact on the farm, 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 mobilise and harvest the available seaweed to avoid any loss, and replace the stock with smaller cuttings (of 25g).

## **5.8. Grazing of Seaweed (by herbivorous fish, sea urchins and marine turtles).**

By far the biggest losses from grazing of the seaweed crop is to herbivorous fish (often Rabbitfish (Siganidae)) although normally this is only a seasonal problem. These fish usually shelter around rocks and coral bommies and therefore the only mitigation available is to avoid locating seaweed plots close to such features. The longline technique, which sets lines a few metres below the surface, is less vulnerable. 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.

## **5.9. The best strains of Seaweed**

In the WIO, all the seaweed farming is of varieties (or strains) of just two species, *Kappaphycus alvarezii* (Cottonii) and *Euचेuma denticulatum* (Spinosum). Different strains of seaweed do not share the same biological characteristics. Some strains are better adapted to, for example, higher water temperatures but at the same time may have lower growth rates. All the strains currently cultivated in the WIO originate from The Philippines and Indonesia because their growth rates are better than the native strains.

If investors or farmers wish to introduce new strains and/or species then an Environmental Impact Assessment (EIA) will be necessary. In a recent example from Kenya, the EIA process took 18-months to complete. In general, diversifying the species/strains used for seaweed production is not straightforward and requires full participation of buyers and the relevant Government ministries, as well as a significant level of competence.

## **5.10. Socio-Economic Issues**

In making the choice of sites, as well as needing suitable environmental conditions for the growth of seaweed, the socio-economic characteristics of the local population and their ability and willingness to work on the farms are essential to consider. What are their needs? What other marketable resources are available? Are individuals and families willing to work hard? And what are the main characteristics (e.g. relating to power relations, wealth distribution, ethnic mix etc.) of the village? These are some of the many questions that are better dealt with before investment in farming begins, rather than after.

## **5.11. The Battle to Buy: Investors versus illicit buyers**

A good example of the intense competition between buyers of seaweed is found on Zanzibar. Here the investors, who have provided training, materials, drying-tables and boats, often see their contracted farmers sell the seaweed, for a better price, to Chinese buyers who themselves have invested nothing.

This behaviour can lead directly to the cessation of inputs and support from the investors and a reduction in overall production. For a government, however, it is not easy to manage a sector in which the actors have such diverse interests. However, as far as it is possible, the government should try, in partnership with the stakeholders, to support the development of coherent sector plans where the interests of all parties are taken into account, allowing the sector to flourish.

A case in point is Kenya, where a potential investor from Pemba, Zanzibar (already producing 2,000 dry mt/year) had previously suffered from the presence of Chinese buyers. The investor requested, and was awarded, an exclusive right

for five-years to buy seaweed from five or six villages that are piloting seaweed production in collaboration with an NGO, that was itself financed by a EU-COI programme. At the condition that he follows the beach price of Zanzibar

### 5.12. Investors lacking in competence

Only 25% of new seaweed farming projects succeeds, and the reasons for this can sometimes include poor project implementation and management by the investor. More specifically...:

- The operator does not have the financial reserves to sustain the inevitable losses that usually characterize in the initial three or four years of a seaweed enterprise;
- The operator knows nothing about seaweed farming;
- Often the investor is a relatively small-scale businessman with little previous experience of management of an SME with a large number of employees;
- Sometimes there can be a lack of mutual understanding with the local population the investor is seeking to work with;
- There may also be a lack of investment in sufficient numbers of competent technical staff (one technician per ~30 families may be required); and finally,
- An investor may allow the size of the enterprise to expand too quickly and when that happens accidents and mistakes take place that result in everyone losing money and becoming discouraged.

## 6. Best Practices in Seaweed Farming

Where to find a good site, motivated would-be farmers and how to increase their capacity to 'win' 2% of additional growth per day (review again Table 2)?

This 2% additional growth can augment the production of each harvest by up to 100%;

This 2% growth is the result of presence (shadow) of the farmers in the seaweed plots armed with the best practices taught them by the technicians; and,

It is vital for the farmers and the investor to gain this 2% growth per day.

### 6.1. Finding the right site

A good site is simply an environment where seaweeds grow well, that is to say, with an annual mean growth rate of  $\geq 4\%$  per day.

It is essential to test the growth rate with lines of cuttings in control test plots placed in different locations within the lagoon or bay. It is also necessary to ensure the following characteristics of the site:

- That it is not located near a river mouth so that, a) the salinity stays between 23 and 38ppm, and b) the turbidity of the water is within reasonable limits;
- That the species of seaweeds already growing in the area are flourishing (e.g. *Enhalus*, *Thalasia*, *Syringodium*, *Cymodocea*, *Halodule*, *Dictyota*, *Hypnea*, *Acanthophora* and *Grailaria*)  
*For example, The island of Rodrigues (Mauritius) has missed out on seaweed farming because of the evidence of the small size of existing seaweeds in the lagoon, that suggests a sufficient growth rate would not be attained.*
- That the water temperature remains between 20° and 32°C throughout the year; and,
- That there is enough current and tidal exchange, because seaweeds obtain the necessary nutrients for growth directly from the water. It is necessary therefore that this water is flushed and replaced.

### 6.2. Finding a site with motivated would-be farmers (i.e. villages with few other economic opportunities)

The investor must understand the selected villages and it is often useful to commission some sort of preliminary rapid rural appraisal or social study. In the WIO, the buying price for dried seaweed direct from farmers (the beach price) is US\$120/mt for *Spinosum* and US\$200/mt for *Cottonii*. Given these basic economics, a motivated farmer (remember, typically only about 20% of the initial farmers), producing 10mt/year can expect a revenue of US\$1,200 per year for *Spinosum* and US\$2,000 per year for *Cottonii*.

The investor will quickly ascertain whether the level of revenue will be sufficient to motivate farmers. Rodrigues Island, again, is an example of a site where the expected revenue of US\$2,000 per year was not sufficient to motivate local people to engage in the necessary hard work.

### 6.3. Training the Technicians

Assume that 1 technician is required to support ~30 farmers during at least the first three years.

The technicians are the keys to success, and they need to be well trained.

For example, in Madagascar, the Institut Halieutique des Sciences Marines (IHSM) offers a fee-based, one-month training course on theory and practice for prospective seaweed farming technicians.

Train the best people available.

### 6.4. Start the farms slowly, step-by-step, and with small groups of well-motivated and well-trained farmers.

Establish clear 'rules of the game' from the start and don't persist with unmotivated farmers.

### 6.5. Training the Farmers

The monitoring and support of farmers through the year is indispensable. Recall that the success comes from the presence of the farmers in the plots; it relies on their work in the sea.

### 6.6. Use the right Tie Tie - the 'Loop Knot' (and forget all other means of attaching the seaweed).

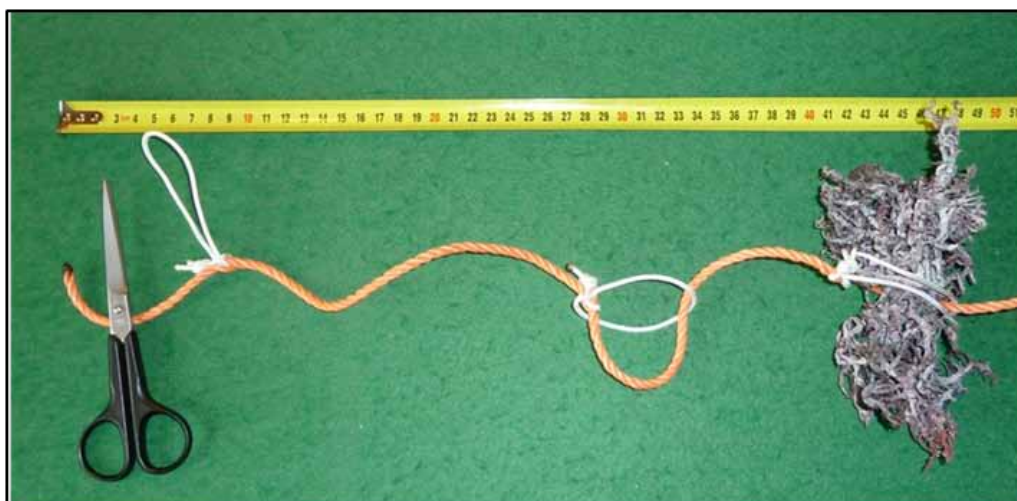


Figure 86: The introduction of the Loop Knot is recent and is more and more commonly used in seaweed farming.

6.7. Attach the cuttings without stressing the seaweed to avoid losing days on each harvest. Take another look at Figure , which clarifies the issue. And, utilise young, healthy cuttings.

### 6.8. Right from the beginning, for management facility, use the basic unit of 100 m ligne.

It will standardize the delivery of farming inputs and facilitated greatly the follow up of the individual farmers. The 100 m ligne (500 cuttings) is also the working unit for the farmer.

### 6.9. Harvest once the cutting has attained a weight of one kilogramme.

Above that weight, the overall growth rate slows down because pieces of seaweed tend to detach. Explain clearly to farmers that it is not a more profitable strategy to let the seaweed grow to several kilogrammes in weight.

6.10. Keep records throughout the year and prepare simple tables or graphs on temperature, salinity, bad weather and infestations by algal parasites (species, dates and duration).



Information should also be collected on grazing by herbivorous fish, on the fortnightly growth rate, and on the appearance of Ice Ice and, if possible, on its causes. This information and analysis will guide future growing and harvesting strategies and can support profitability and expansion.

**6.11. Keep an eye on the weather forecasts** and monitor the El Niño and La Niña phenomena, which can affect water temperature.

### **6.12. Use of Floats**

The use of floats is essential for the longline method. But too many farmers neglect to use them in the post and line (off-bottom) method. This is inefficient because, a) floats keep the lines shallow, and therefore closer to the sunlight (for photosynthesis) in stronger currents (for nutrients) and, b) keeping the seaweed higher in the water column also reduces proximity to benthic pest seaweeds and herbivorous fish and invertebrates. It is therefore important to ensure the availability of plenty (1,000s) of small floats for the farmers to use.

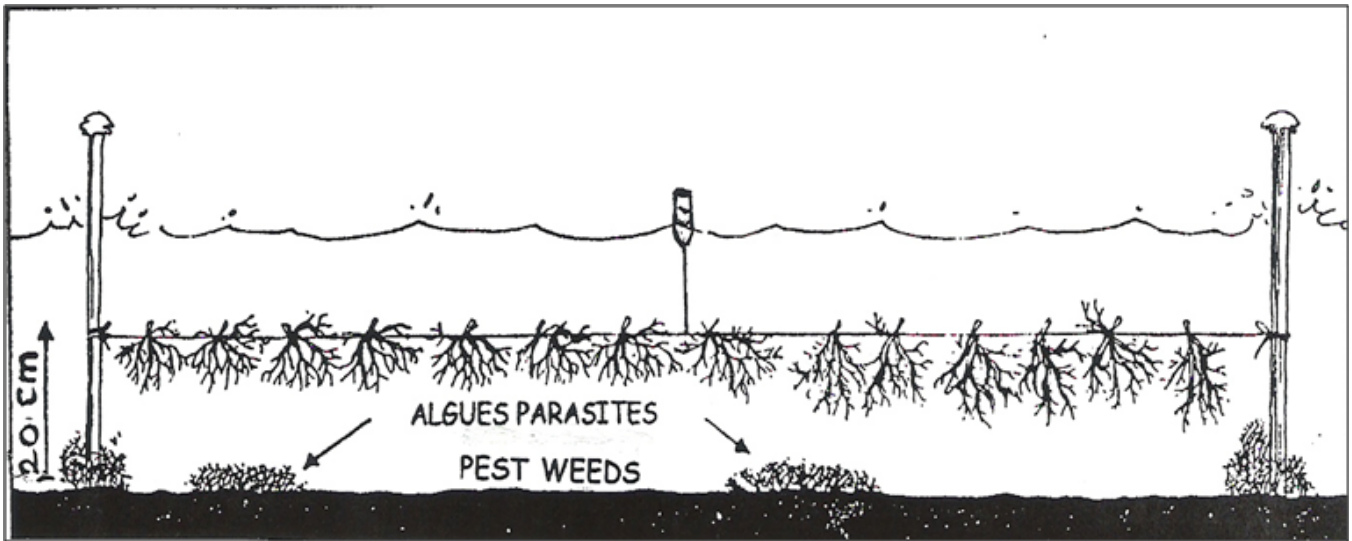


Figure 97: An off-bottom line with a float attached; one of the ways to promote the extra 2% in the daily growth rate.

### **6.13. Diversification of farm sites**

The requirement to diversify the plots will be obvious following the first infestation of parasitic algae. However, it is usually difficult to organise village farmers without first convincing them of the benefit.

**6.14. Protect a stock of cuttings** in deeper water during periods of warmer water.

This until the water temperature falls again below 31°C

### **6.15. The proper solar drying of seaweed is crucial**

This is because it determines the quality of the final product and thus its price. Eight to ten kilogrammes wet-weight of seaweed will yield one kilogramme dry-weight after about three-days in the sun. It is necessary to pay attention during this process because farmers are paid by weight and so it's in their interests to sell seaweed before it is fully dehydrated.

**Properly dried seaweed will be prickly when crushed in the hand.**

International buyers require a product with a 30% moisture content and of a high standard of cleanliness and quality. This can be achieved only by drying on a drying table, to avoid contamination with animal droppings, for example, which may contain fecal coliform bacteria. **Drying seaweed directly on the ground should be avoided at all costs.**

In Zanzibar, drying is done on platforms (~20cm high) built of stones and surrounded by barb-wire. These platforms have the advantage of being long-lasting and are not eaten by termites.

During the drying process, seaweed must never be rained-on or be exposed to morning dew because this risks a loss of quality of the final carrageenan gels that are produced.

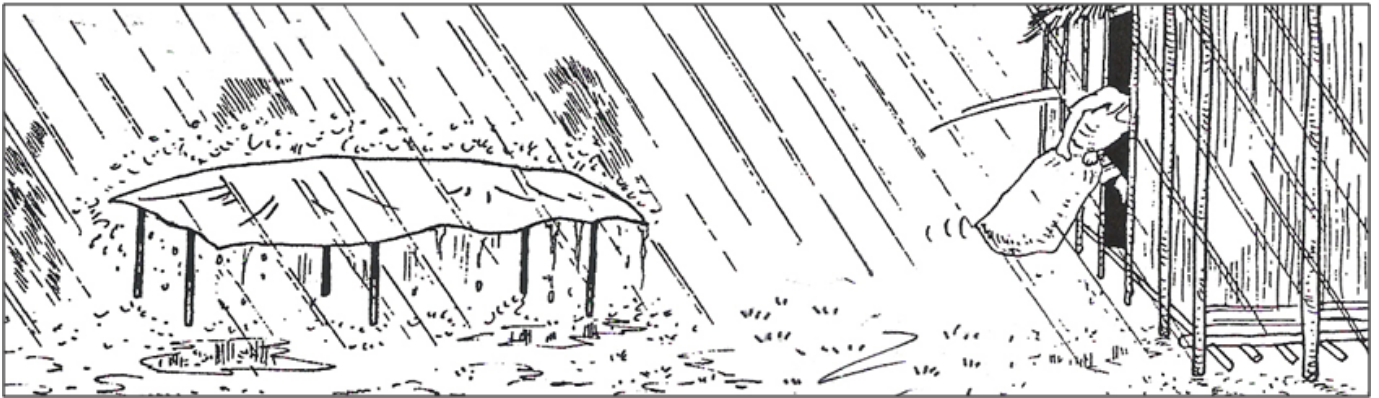


Figure 108: Seaweeds exposed to freshwater become bleached and not suitable to be sold.



Figure 19: Seaweeds on a drying table after one day (top) and two days (bottom) in the sun. The drying takes three-days and 8-10 kilogrammes wet-weight of seaweed yields one kilogramme dry-weight at 30% moisture content. Properly dried seaweed will be prickly when crushed in the hand.





Figure 110: Drying tables in Pemba, Zanzibar. NB: To produce 1,000mt dry-weight of seaweed, 8,000-10,000mt wet-weight needs to be produced, which equates to 45,000m<sup>3</sup> of seaweed that must be physically transported from the sea.

### 6.16. Securing an accessconcession.

Apart from the technical aspects of seaweed farming already discussed, it is important to ensure that some sort of concession on access to coastal sites suitable for farming is secured. This is usually achieved through liaison with government and/or local government authorities (see Section 9) and though specific agreements with partner villages.

## 7. After the Harvest: The Next Steps for Investors

### 7.1. Post-harvest treatment of Seaweed

#### **7.1.1. The quality of the dry seaweed**

Drying is managed at the level of the primary producers, the farmers, and it is essential that the techniques employed by them result in the required quality standard (30% moisture content, no damage from freshwater and the absence of sand and other foreign bodies) and the required sanitary standard (e.g. no fecal material from domestic animals). These strict requirements demand active quality control by the technicians in charge of buying, including a mechanism for tracing seaweed back to the specific farmer, as well as a series of final checks before the purchased seaweed is pressed into bales.

#### **7.1.2. Storage**

The seaweed bales should be stored in a some sort of 100% watertight shed or warehouse. It is not recommended to store bales of seaweed for more than 6-months and they must be kept dry to avoid the onset of fermentation that could degrade the quality of the carrageenans.



### 7.1.3 The Seaweed Press

The purchase of a press (~ US\$5-7,000) should be seriously considered; they can sometimes be obtained second-hand from sisal or cotton mills. But a suitable press can also be built locally.

In fact, it is best to export the seaweed as quickly as possible to maintain a cash-flow for the enterprise. And a twenty-foot (6m) container is able to hold 20-22mt dry-weight of seaweed.



Figure 121: A seaweed press built in Madagascar.

### 7.1.3. Planning for Export

One would expect to be able to fill the first container after 12-18 months and the second container three to six months later. The objective is to reach a production level of one container per month within 2 1/2 years.

## 7.2. Marketing

It is important to begin identifying potential outlets right from the start, but this is not straightforward because international buyers know that typically only 25% of seaweed start-up companies will succeed. And, as a rule of thumb, international buyers are only interested in producers who can provide a regular and high quality production of at least 1,000mt per year.

### 7.2.1. Multinational Buyers

Multinational buyers, who can be counted on the fingers of one hand, are typically not interested until a producer can guarantee one container a month.

The end users of carrageenan are becoming more demanding on quality of the product and this has a direct implication for the producers of raw materials and the processing plants. So multinationals are developing closer links with their best producers.

A final point on equal product quality - multinationals usually have a policy to favour the reliable producers with long-term supply contracts.

### 7.2.2. Chinese Buyers

Chinese buyers are increasingly active in East Africa. But even though they will generally offer a higher beach price to farmers, they offer only approximately 50% of the international market price to buy seaweeds from a private-sector company and, as noted previously, will invest little or nothing in supporting local production.

### 7.2.3 Seaweed Processing Factories

Seaweed processing factors are located in The Philippines, Europe, in the USA and in China and they require a reliable and a high-quality supply of thousands of tonnes per year. Their position is that they establish contracts for the delivery of final products that are agreed at least 12-months in advance and with very specific pricing structures. This is the case for FMC who provide, amongst others, carrageenan for Colgate toothpaste.

## 7.3. The Price of Seaweed

It was discussed previously that seaweed quality can have a strong influence on the price. But the sale price of seaweed is generally quite volatile and depends also on a number of climatic and environmental factors that in turn determine the outputs of the major producers (i.e. The Philippines and Indonesia). Typically, the international price of Cottonii is more than double that of Spinsum.

In East Africa, taking into account transportation costs, one could expect a sale price of US\$350-450/mt for Spinsum and US\$700 to 1,000 for Cottonii. In some situations, the price for Cottonii can exceed US\$1,000/mt for the highest quality seaweed (i.e. with good, viscose gels), but this price has not yet been obtained in steady production in the WIO.

## 8. The Response of Villagers to New Sources of Revenue

A concept that is sometimes difficult for profit-seeking investors is that it appears that the majority of village-based farmers are satisfied with a certain minimum level of income. Once that is reached, this majority tend to lose their motivation. It is for this reason that 80% of production is, on average, delivered by the remaining motivated 20% of the farmers. The causes of this difference in motivation are varied, including the need for money to invest some sort of project and to pay for their children's education.

Logically, an increase in beach price may actually lead to an overall fall in production of the less motivated 80% of farmers.

Another limiting factor is the risk-aversion of villagers who, quite understandably, are unwilling to jetison the relative familiarity of their more traditional income-earning activities for a new venture.

The overall conclusion is that an investor must focus on motivated, and able, farmers. These farmers need to be trained in order to attain that all-important 2% extra growth per day and they need to be provided with the materials in order to do so. Working together with these individuals can promote the development of an important mutual confidence. To the extent that it is feasible, it is also sensible to promote the participation of migrant labour who are typically more financially motivated, but this comes with some responsibility to facilitate their integration into the local community.

## 9. Advice to Governments and Donors on Supporting the Development of Seaweed Farming

### Aide Mémoire

- Launching a seaweed farming enterprise without a serious investor who exercises proper control risks and are able to lose money for three to five years;
- It is necessary to produce hundreds of tonnes of dry seaweed and therefore thousands of tonnes of wet seaweed simply to reach financial breakeven;
- It is necessary to be cautious, because villages that experience an initial failure are unlikely to re-engage with the activity for some years. And that bad experience can also rub-off on neighbouring villages.

## 9.1. The Role of Government

The primary role of Government is to support the development of seaweed farming and it can do this through the following interventions:

- In most countries, the coastal waters are property of the State. But rights of management may be partially devolved to district or village governments, and perhaps even to private investors in specific cases, to secure the access to the lagoon or bay for seaweed farming;
- Provide a certain degree of protection to investors in seaweed farming by creating exclusive operating (buying) zones, albeit with some conditions attached relating to a minimum tonnage to be produced and the duration of the exclusivity agreement;
- Create a platform (or forum) where the three main stakeholders (farmers, investors and the government) are able to discuss the development of the industry in an open and constructive manner. And provide scientific support to the sector through the platform.
- Ensure that the prices paid to the farmers (called the 'beach price') are in the same range as those paid in the WIO region as a whole;
- Capitalise on the opportunity to introduce some compensatory fisheries and/or coral reef management measures, once the seaweed farms are operational and profitable for local people; and,
- Limit the burden of long and costly Environmental Impact Assessments (EIA) but nevertheless monitor the outcomes of the development of the industry. For example, in Tanzania the requirement for an EIA for village-level seaweed farming has recently been abandoned.

## 9.2. The Donors and NGOs.

The intervention of donors is welcome, and may even be indispensable at the outset, in order to encourage the interest of an investor or large-scale buyer. But an NGO cannot replace an investor.

It is also necessary to ensure, during the implementation, effective coordination with any private sector already involved in seaweed farming. This is in order to avoid the situation that developed in south-west Madagascar, for example, where some associations and donor projects provided seaweed farming materials with little thought towards training the farmers in their use, or even about village site selection. Through these projects, hundreds of individuals took-up seaweed farming but lost everything with the first problem that arose. The result is that entire villages now reject seaweed farming and will likely continue to do so for many years.

**For the Donors and NGOs, there is one partnership that is essential to respect, particularly at the outset, which is between the duo of the investors& buyers, and the farmers.**



# LIST OF PUBLICATIONS – LISTE DES PUBLICATIONS

## SmartFish Programme

1. *Report of the Inception / Focal Point Meeting of the SmartFish Programme – Flic en Flac, Mauritius, 15th-16th June 2011*. REPORT/RAPPORT: SF/2011/01. August/Août 2011. SmartFish Programme. Indian Ocean Commission (55 pages).
2. *Report of the First Steering Committee Meeting of the SmartFish Programme – Flic en Flac, Mauritius, 17th June 2011*. REPORT/RAPPORT: SF/2011/02. August/Août 2011. SmartFish Programme Indian Ocean Commission (51 pages).
3. *Rapport de la réunion de présentation du programme SmartFish aux points focaux – Flic en Flac, Ile Maurice, 15-16 juin 2011*. REPORT/RAPPORT: SF/2011/03. August/Août 2011. SmartFish Programme. Indian Ocean Commission (55 pages).
4. *Eco-Certification for the Tuna Industry, Technical Assistance for Implementation of a Regional Fisheries Strategy for ESA-IO (IRFS)*. REPORT/RAPPORT: SF/2011/04. May 2011. SmartFish Programme. Indian Ocean Commission (40 pages).
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7. *Gouvernance des Pêches Maritimes dans l'Ouest de l'Océan Indien*. REPORT/RAPPORT: SF/2012/07. June/Juin 2012. SmartFish Programme. Indian Ocean Commission (101 pages).
8. *Value Chain Assessment of the Artisanal Fisheries – Mauritius*. REPORT/RAPPORT: SF/2012/08. June/Juin 2012. SmartFish Programme. Indian Ocean Commission (85 pages).
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11. *A Review of Somalia's & (Semi-Autonomous Regions) Fisheries Legislation and Management*. REPORT/RAPPORT: SF/2012/11. June/Juin 2012. SmartFish Programme. Indian Ocean Commission (49).
12. *Assessment of IUU Activities On Lake Victoria*. REPORT/RAPPORT: SF/2012/12. June/Juin 2012. SmartFish Programme. Indian Ocean Commission (130 pages).
13. *Review Of The Legal Framework for the ESA-IO Region*. REPORT/RAPPORT: SF/2012/13. June/Juin 2012. SmartFish Programme. Indian Ocean Commission (149 pages).
14. *Comprehensive capacity review to implement effective MCS in the ESA-IO Region*. REPORT/RAPPORT: SF/2012/14. June/Juin 2012. SmartFish Programme. Indian Ocean Commission (101 pages).
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16. *Spirulina – A Livelihood and a Business Venture*. REPORT/RAPPORT: SF/2012/16. SmartFish Programme. June/ Juin 2012 Indian Ocean Commission (39 pages).
17. *Diversification Study (Eco-Tourism and Recreational Fisheries)*. REPORT/RAPPORT: SF/2012/17. June/Juin 2012 SmartFish Programme. Indian Ocean Commission (76 pages).
18. *Value Chain Analysis of Fisheries Sector for Rodrigues*. REPORT/RAPPORT: SF/2012/18. June/Juin 2012 SmartFish Programme. Indian Ocean Commission (78 pages).
19. *Dagaa Value Chain Analysis and Proposal for Trade Development*. REPORT/RAPPORT: SF/2012/19. June/Juin 2012 SmartFish Programme. Indian Ocean Commission (45 pages).
20. *Operationalization of Fish Auction Market. (Feasibility Study)*. REPORT/RAPPORT: SF/2011/20. December/ Décembre 2011 SmartFish Programme. Indian Ocean Commission (45 pages).
21. *Options to Reduce IUU Fishing in Kenya, Tanzania, Uganda and Zanzibar*: REPORT/RAPPORT: SF/2012/21. August/Août 2012 SmartFish Programme. Indian Ocean Commission (101 pages).
22. *Revitalization of Fisheries Research in Mauritius*. REPORT/RAPPORT: SF/2012/22. August/Août 2012 SmartFish Programme. Indian Ocean Commission (58 pages).
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27. *Report of the Second Steering Committee Meeting of the SmartFish Programme*. REPORT/RAPPORT: SF/2011/27. August/Août 2012. SmartFish Programme Indian Ocean Commission (24 pages).
28. *The Farming of Seaweeds*. REPORT/RAPPORT: SF/2011/28. August/Août 2012. SmartFish Programme Indian Ocean Commission (24 pages).

La bonne gouvernance et de la gestion des pêches et de l'aquaculture permettent d'améliorer la contribution du secteur à la sécurité alimentaire, au développement social, à la croissance économique et au commerce régional ; ceci en assurant par ailleurs une protection renforcée des ressources halieutiques et de leurs écosystèmes.

La Commission de l'Océan Indien (COI) ainsi que la COMESA (Common Market for Eastern and Southern Africa), l'EAC (East African Community) et l'IGAD (Inter-Governmental Authority on Development) ont développé des stratégies à cette fin et se sont engagés à promouvoir la pêche et l'aquaculture responsable.

SmartFish supporte la mise en œuvre de ces stratégies régionales en mettant l'accent sur le renforcement des capacités et des interventions connexes visant à :

- mettre en place des mécanismes pour la gestion et le développement durable des pêches ;
- développer un cadre de gouvernance des pêches au niveau régional ;
- renforcer le suivi-contrôle-surveillance pour les pêcheries partagées ;
- développer des stratégies et supporter des initiatives propres à accroître le commerce régional du poisson ;
- contribuer à la sécurité alimentaire en particulier par la réduction des pertes après captures et la diversification de la production.

SmartFish est financé par l'Union Européenne dans le cadre du 10<sup>ème</sup> Fond Européen de Développement.

SmartFish est mis en œuvre par la COI en partenariat avec la COMESA, l'EAC et l'IGAD et en collaboration avec la SADC. Une collaboration étroite a également été développée avec les organisations régionales de pêche de la région. L'assistance technique est fournie par la FAO et le consortium Agrotec SpA.

By improving the governance and management of our fisheries and aquaculture development, we can also improve food security, social benefits, regional trade and increase economic growth, while also ensuring that we protect our fisheries resources and their ecosystems.

The Indian Ocean Commission (IOC), the Common Market for Eastern and Southern Africa (COMESA), the East African Community (EAC) and the Inter-Governmental Authority on Development (IGAD) have developed strategies to that effect and committed to regional approaches to the promotion of responsible fisheries and aquaculture.

SmartFish is supporting the implementation of these regional fisheries strategies, through capacity building and related interventions aimed specifically at:

- implementing sustainable regional fisheries management and development;
- initiating a governance framework for sustainable regional fisheries;
- developing effective monitoring, control and surveillance for transboundary fisheries resources;
- developing regional trade strategies and implementing regional trade initiatives;
- contributing to food security through the reduction of post harvest losses and diversification.

SmartFish is financed by the European Union under the 10th European Development Fund.

SmartFish is implemented by the IOC in partnership with the COMESA, EAC, and IGAD and in collaboration with SADC. An effective collaboration with all relevant regional fisheries organisations has also been established. Technical support is provided by Food and Agriculture Organization (FAO) and the Agrotec SpA consortium.

## Contact :

Indian Ocean Commission – SmartFish Program  
Blue Tower, 5<sup>th</sup> floor, Institute Road - Ebène, Mauritius  
Tél: (+230) 402 6100 Fax: (+230) 465 7933

