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Development of seaweed cultivation in Tanzania: the role of the University of Dar es Salaam and other institutions

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Summary

Seaweed farming in Tanzania was initiated through research by a University of Dar es Salaam (UDSM) professor in the 1970s and early 1980's. This was followed by commercial cultivation, which was started by private entrepreneurs in 1989. By 1996 seaweed was being farmed all along the coast of Tanzania. Production in 2008 was 6000–7000 tonnes annually, with *Eucheuma denticulatum* and *Kappaphycus alvarezii* as the main cultivated species. Tanzanian seaweed is exported mainly to the USA, France, Denmark, and Spain. While UDSM continues to play a big role in this industry through research and development working with coastal communities, the government and other institutions also play a big role in not only research and development but also uniting farmers and exporters, and providing extension service. This case study looks at the start and running of the seaweed farming industry and the role of the UDSM and other institutions on the development of seaweed farming in Tanzania.

Development of seaweed cultivation in Tanzania: the role of the University of Dar es Salaam and other institutions

Background

Seaweed farming in Tanzania started with initial studies by Prof Keto Mshigeni of the University of Dar es Salaam (UDSM) who was studying for his PhD in Hawaii. Working under one of the best known seaweed farming experts, Prof Maxwell Dotty, Prof Mshigeni was studying his degree on seaweed cultivation and explored the potential of cultivating seaweed in Tanzania. He wrote two scientific papers in 1973 and 1976 (Mshigeni, 1973, 1976). In 1983 he wrote a book in Kiswahili on seaweed farming and its benefits (Mshigeni, 1983). The first experiments on seaweed farming were reported by Mshigeni in 1985. In these experiments, the author planted seaweed (Eucheuma) in three pilot areas in Tanzania; two on Zanzibar Island (also known as Unguja) and one on the mainland in Kigombe, Tanga (Mshigeni, 1985). Following these initial efforts, commercial seaweed farming in Tanzania began in 1989 when private entrepreneurs started commercial farms in Zanzibar.

For the commercial cultivation that started in 1989, two species of seaweed, *E. denticulatum* and *Kappaphycus alvarezii* were imported from the Philippines. It was necessary to import the *Eucheuma* strain because the native strain could not grow under cultivation. The seaweed was planted in Paje and Jambiani on the east coast of Unguja, Zanzibar. The first private entrepreneurs were from the Philippines and Denmark. Farming then expanded to the Island of Pemba and then to the mainland in 1992. The main markets for Tanzanian seaweed are the USA, Denmark, France and Spain. Seaweed production changed from about 800 tonnes annually in early 1990s to the current 6000–7000 tonnes with the highest production ever of 9000 tonnes in 2002 (Msuya, 2006a). About 15,000–20,000 people, 90% of whom are women, are involved in seaweed farming in Tanzania.

Table showing chronologically the majore events in the development of seaweed farming in Tanzania

Area	Activity	Result/Year	Reference
Initial theoretical studies			
-	Theoretical studies	Publications, 1973, 1976	Mshigeni (1973, 1976)
-	Theoretical studies	Kiswahili booklet, 1983	Mshigeni (1983)
The first experiments			
Zanzibar, Tanga	First experiments	Research report, 1985	Mshigeni (1985)
Commercial cultivation			
Zanzibar	Nursery farms/expansion	1989	Eklund and Pattterson (1992)
Mainland-Tanga	Feasibility studies & expansion	1992	Zuberi (Pers. Comm.)
Mainland-Bagamoyo	Expansion	1992	Personal observations
Mainland-Mtwara/Lindi	Feasibility studies & nursery farms	1995	Msuya (1995)
Mainland-Mtwara/Lindi	Expansion	1996	Msuya (1996)
Mainland-Tanga	Deep water bamboo rafts	2000	Zuberi (2000)

Mainland-Bagamoyo	Deep water floating systems	2005	Msuya et al. (2007)
Zanzibar	Deep water floating systems	2006	Msuya (2006a)

Description

Farming techniques

Seaweed is usually farmed in shallow intertidal areas where there is frequent flushing of water for good growth. Farming is done during spring low tides when the tide is out. At this time, the water level is about one to one-and-a-half feet; the seaweed needs to be submerged all the time to avoid excessive exposure to the air that can lead to stress and disease. When the tide comes in the farmers have to go out to the farms and carry the harvested seaweed home. Areas suitable for farming are those with sandy substratum to enable the fixing of wooden pegs in the substratum. A new technique of farming in deeper waters has been introduced and is discussed below. For ideal seaweed farming areas, the water is clean, free from pollution and turbidity as the seaweeds farmed are sensitive to pollution and need enough sunlight for growth.

Entry to seaweed farming is free. Any villager can go into the sea and start a farm where there is space. The farmed area then will belong to the farmer. The rural codes of the farmers help in protecting each others' farms and farming areas against intruders. People from the same village/area can give 'a farming space' to a fellow villager. Usually farmers do the farming in the same areas where they live. Someone from another area can ask for farming space from the farmers of a particular area. There are no licenses or sea bed land purchases.

The method of farming seaweed in the shallow intertidal areas is referred to as the peg and line or off-bottom method. In this method, nylon ropes with seaweed are tied between two wooden pegs. The pegs are from mangroves or land-based plants. In this method, seaweed 'branches' are used as seed. The branches, which are typically of the same stock imported from the Philippines, are obtained from other farmers. Sometimes new seed is imported. Initial seed is sometimes from the buyers who also provide free farming materials (ropes and tie–ties) to the farmers. Of course, the buyers can also take seed from one area to the other. A farmer provided with farming materials free of charge from a particular buyer will then have to sell the seaweed produced to that buyer. The branches are usually from older plants, although sometimes farmers are forced to use younger branches where seed scarce.

Branches of about 100 g are tied in 4-mm diameter nylon ropes that are usually 4–20 m long depending on strength and the farmer's preference. The branches (usually 11–15 in a 4-m line) are tied at 20-cm intervals using a thin nylon rope known as tie tie. The ropes (lines) holding the seaweed branches are tied between two wooden pegs of about 60 cm in length that are fixed in the sediment. A farm (or plot) has about 50 lines but may vary depending on the farmer's preference. Some farmers can also have between 100 and 300 lines and all this depends on a farmer. After planting, farmers need to take care of the farms by working at every low tide. Low tides occur two times a month and each low tide takes 7 days, thus farmers work for 14 days per month. Low tides last about 4 h. Farm management usually involves shaking the seaweed line to remove sand and debris, removing entangling and fouling (wild) seaweeds, tying new branches, where the initial ones have broken away because of strong winds or grazed upon by sea urchins, and re-fixing the pegs.

Seaweed is harvested after 4–6 weeks, depending on the farming site and the rowth rate of the seaweed. The harvesting involves untying the lines from the anchorage pegs and

then removing the seaweed. This is followed by tying new branches that are taken from the harvest, and fixing the line back to the pegs. The tying-in of new branches can be done on site, the farmer sitting in shallow water, or at home after finishing the work in the sea. The extra harvest is taken home for drying and selling.

Seaweed is spread out on mats, coconut branches, or on grass to dry. Some farmers spread the seaweed on sand. The seaweed is sun-dried. The drying takes 2-3 days in sunny weather, but may take up to 7 days in rainy seasons. When the seaweed is dry, it is sorted to remove any dirt and shaken to remove sand, etc. Drying in the sand increases the time spent to sort the seaweed as the seaweed becomes dirtier. It is then stored at home or sold directly depending on how much is harvested.

The selling is done in the villages where the seaweed is farmed. Buyers usually have store rooms in the villages where they employ a local villager who buys the seaweed from the farmers. The seaweed is collected and stored until it is collected by truck and transported to warehouses for bailing and shipping. Sometimes if the funds are not taken to the village in time, a farmer can stay for up to three months without selling. This is something that the buyers usually make efforts to avoid.

Marketing arrangements

The seaweed farmed in Tanzania is sold in bulk as a cash crop and exported mainly to the USA, France, Denmark and Spain. Marketing is arranged so that small companies in Tanzania export to larger, multinational, sister companies abroad such as FMC BioPolymer (USA, www.fmcbiopolymer.com), Copenhagen Pectin A/S (Denmark, www.cpkelco.com) and Cargill Texturizing Solutions (France, www.cargilltexturizing.com). The Tanzanian companies purchase the seaweed and export it to the mother companies. Currently there are six companies that buy seaweed. Seaweed prices in 2008 are 160 Tsh (1 Tsh = approximately US $0.16) for Eucheuma denticulatum (commercial name, Spinosum) and 260 Tsh for *Kappaphycus alvarezii* (commercial name, Cottonii). The price difference between the two species is caused by preference in the world market due to the latter's stronger kappa carrageenan compared with the former's weaker iota kappa carrageenan. The world prices vary from US $350–450 per tonne.

Uses of seaweeds

Extracts from the two seaweeds are used in a number of industries as thickeners, emulsifiers, and stabilisers. In the pharmaceutical industry they are used to make medicines for treating heart problems. In cosmetics they are used in body lotions, shampoos and toothpaste. For example, it is used in Colgate toothpaste to increase its shelf-life in the home by preventing hardening. Colgate is the main user of Tanzanian Spinosum. The food industry is also a good user of the seaweeds where they are applied in many foods, for example, ice cream, which does not harden because of the seaweed extracts added during the manufacturing process. It is also applied in soups, cakes, crackers, soft drinks, and others. In the textile industry extracts are used to thicken clothing materials. The seaweeds are also used as fertilisers and as cattle feed, especially in Europe when fodder is scarce.

Recent effects and developments

World seaweed prices and seaweed die-offs

While *K. alvarezii* fetches higher prices, it is the same species that faces massive die-offs in many areas in Tanzania. In some areas such as Tanga, Pemba, and Songo Songo Island in the south, seaweed cultivation has been reduced to very low production, and, as a result, an unprofitable activity. Studies have shown that the main causes of die-offs are rapid changes in salinity and temperature following ebbing and flooding of the tides, heavy

rainfalls, high temperatures as well as fouling (Mmochi et al., 2005). However, the die-offs occur 5-10 years after the start of farming in an area, which indicates that, in some areas, the cause could be environmental changes that are more complex than previously thought. It has been shown that when the tide is out, water temperatures can reach as high as 33°C, which is harmful to the seaweed. In 2008, temperature recordings in Zanzibar and Songo Songo showed temperatures of 36-38°C in January and February. These temperatures have resulted in increased die-offs of *K. alvarezii*; the seaweed is absent in areas where it used to be farmed. From various studies it has been shown that the seaweed grows well during the cold season (June–September), when temperatures are 25–30°C and also during short rains (October–November), while low growths are recorded during the hot season (December–February, temperatures above 30°C) and long, heavy rains (March–May).

The role of the University of Dar es Salaam and other institutions in addressing problems in commercial production and seaweed die-offs

The University of Dar es Salaam (USDM)
UDSM was involved in pioneering seaweed farming in southern Tanzania in 1995/96 through consultancy with the then Finnish funded project Rural Integrated Project Support (RIPS) Programme. The work involved conducting a feasibility study and establishing nursery farms in Mtwara and Lindi Regions (Msuya 1995). This was followed by expansion of the farming in 1996 when seaweed was planted in 15 villages, with 21 more villages earmarked for expansion (Msuya 1996). By 1997 there was commercial production in three districts.

Studies on the causes of die-off and advice to farmers
UDSM has taken a key role in investigating the causes of die-offs and what can be done to alleviate the problem. Researchers from the Institute of Marine Sciences (IMS, www.ims.udsm.ac.tz) of the UDSM working with the USAID-funded project, Smallholder Empowerment and Economic Growth through Agribusiness and Association Developments (SEEGAAD, http://www.acdivoca.org), studied the causes of die-offs (Mmochi et al., 2005). In this study the researchers found that while the problem of world market preference of K. alvarezii had a negative impact on the farmers, the die-off problem has worsened the situation. The farmers spend a lot of time trying to grow K. alvarezii seed and by the time they want to expand the farms, the season is gone and farmers loose all the seed. Farmers waste a lot of time, energy, and resources trying to get seed. The authors advised the farmers to use the good growing seasons for large-scale farming, even if they were to use seed from other villages/areas. A more recent study by a researcher from IMS looked at the causes and effects of, and possible methods of prevention of die-offs in Songo Songo Island Msuya (2009). The results showed high temperatures to be the main cause of seaweed die-off in Songo Songo, and also implicated man-made pollution as another causative factor. Suggestions for alternative methodology using the results of the study will be made in due course following a collaborative project involving UDSM and the Memorial University of Newfoundland, Canada (http://www.mun.ca).

Modifications of the farming method
The IMS working with the Western Indian Ocean Marine Science Association (WIOMSA, www.wiomsa.org) and the University of Rhode Island, Coastal Resources Centre (URI-CRC, www.crc.uri.edu) conducted a project called Sustainable Coastal Communities and Ecosystems (SUCCESS) to try and solve the problem of seaweed die-off and increase seaweed production. In this project, conducted during 2005-2009, the deep-water floating lines system technique was introduced as a way of solving the die-off problem and allowing the farmers to cultivate K. alvarezii. The technique involves farming seaweed in water depths of 2.5 to 6 m, depending on the tide. The floating systems are made of nylon, ropes thus reducing the cutting of mangroves and other trees for pegs usually used in the traditional off-bottom method. The technique was introduced in Bagamoyo on the mainland coast in 2005 and then to two areas in Zanzibar. Using the new technique the die-off problem has been reduced to a minimum and farmers can now harvest K. alvarezii

throughout the year. Farmers using this technique do not have to wait for low tide; they can use it at any time of the month. However, boats or canoes are needed to go into deep waters. This may be a challenge to the coastal communities in Tanzania but with more effort and entrepreneurship, the farmers are able to posses at least one boat/canoe per family or per group. In addition, an economic comparison of off-bottom against floating lines systems has shown that the floating lines technique produces more seaweed per unit area (0.35 kg per meter line per year) than the off-bottom method (see Msuya et al., 2007). The report (Msuya et al., 2007) is prepared to teach farmers the benefits of using the new technique in terms of their time, resources, and profit. The report can be downloaded from: www.wiomsa.org and www.crc.uri.edu/download/Seaweed_Economic_Analysis_Final_July20_07.pdf.

The deep-water floating lines system is constructed by using materials that can be obtained locally by farmers. Floaters or buoys are made of recycled plastic mineral water bottles and recycled cooking oil cans while anchors are made of plastic fertilizer bags filled with sand. Materials for constructing a 20 × 12-m floating system are shown in the table. One of these systems costs approximately US $60.

Materials for constructing a 20 x 12 m deep water floating system for seaweed farming

Item	Material
Frame of the system	Nylon ropes – 12 mm diameter
Anchor lines	Nylon ropes – 12 mm diameter
Anchors	*Plastic bags filled with sand (50 kg fertiliser bags)
Floaters – at the four sides	4 large buoys (20-L cooking oil containers can be used)
Floaters at the seaweed lines	Plastic bottles (at least two 1.5 L bottles)
Planting	Rope for tying seaweed seed (4 mm diameter) - 'tie tie'

*In areas where the sediment contains a high percentage of clay, stones may be used instead of the plastic bags to avoid frequent replacement of the anchors (Msuya, 2006a).

To try and solve the die-off problem further and increase the production of K. alvarezii, the IMS working with the College of Engineering and Technology (CoET) also of UDSM have started the Zanzibar Seaweed Cluster Initiative (ZaSCI). The ZSCI was formed under the Innovation Systems and Clusters Programme in Tanzania (ISCP-Tz), coordinated by CoET and funded by Sida Sweden. Under the ZaSCI researchers at IMS are continuing with the adoption of the deep-water floating systems and are also involved in value addition on the seaweed.

The floating lines technique and its adoption
Following the success of the floating lines technique on the mainland and two areas in Zanzibar, the ZSCI is expanding the use of the technique in Zanzibar. The technique is now being used in four areas in Zanzibar two in Menai Bay (southwest coast), one on the northwest coast, and one in Chwaka Bay in the east. The initial introduction in Bagamoyo showed that as the seaweed grows on the floating systems, it forms shade, which attracts fish and thus fishermen who destroyed the systems using fishing nets. The researchers then worked with farmers to construct basket fish traps and place them under the floating systems to catch fish. Traps are emptied every two days. In Bagamoyo, for example, the farmers obtained 86 kg worth US $150 of fish after harvesting for one week. Farmers in Zanzibar have also used these traps to catch fish, which they either used for home consumption or sold for cash. The integration of seaweed farming and fishing involves constant patrolling by the farmers that may help reduce the problem of destructive fishing.

Zoning of the farming areas
The attraction of fish to the shade formed under the floating systems, caused fishermen in Bagamoyo to fish with nets under the systems, destroying them and causing loss of the planted seaweed. This necessitated the zoning of the bay to protect the seaweed farmers.

The IMS researchers working with farmers in three villages in Bagamoyo have zoned the bay and drawn maps that are to be placed in every village to show the areas earmarked for seaweed farming, fishing, and channels and so on. It has been recommended in the researchers' report (Msuya et al. 2007) that zoning of the areas where seaweed is farmed by using the floating lines technique is necessary in every area in the country to avoid possible conflicts between seaweed farmers and fishermen.

Value addition for seaweed products

For many years different stakeholders have expressed the need to add value to the seaweeds farmed in the country. Since the start of seaweed farming in 1989 the seaweeds have been harvested, sold as cash crop, and exported in bulk. This, among other things, leads to low prices paid to the farmers. Researchers, the government, seaweed buyers, and other stakeholders have been addressing the issue of adding value since the late 1990's. Recently, in 2008, the dream of the researchers and other stakeholders came true when value addition was implemented by the Zanzibar Seaweed Cluster Initiative (ZaSCI) in Zanzibar. The value addition involves making seaweed soap where the seaweed is added to the soap in powder form. Since April 2008, more than 2000 soap bars worth 2,000,000 Tsh (about US $2,000) have been produced and marketed by a group of women seaweed farmers in northern Zanzibar called the "Tusife Moyo", which translates as "We should not loose heart (or hope)". Contacts are P.O. Box 612, Zanzibar, Tanzania, Tel: +255 777 220165 (group leader), or +255 777 490807, flowereze@yahoo.com (ZaSCI Facilitator). Other seaweed, value-added products, which have already been tried and are to be escalated to large-scale production under the ZSCI are; desserts, seaweed powder and shampoo. Those that have been identified and are to be tried include; sweets, biscuits, liquid soap, lotions, powder soap, soft drink, and massage oil. The methods used to make these products are typical village level recipes that can be afforded by farmers in Tanzania.

The making of seaweed value added foods such as desserts, candies, and biscuits is a first step towards semi (and full) processing of the seaweeds. Most foods are made by boiling the seaweeds to extract the gel, which is then added to the products. Small-scale household extraction of the gel can be scaled up to large-scale extraction operations. In the future, a seaweed processing plant could be placed on the mainland as a way of increasing the income of the farmers through exporting semi-processed seaweed.

The first study on environmental impact of seaweed farming

In 1994-1996, UDSM scientists conducted the first study on the impact of seaweed farming on the environment. This was an after-effect study as there were no such studies conducted before seaweed farming started. By comparing farming and reference sites, this study showed that seaweed farming caused reduced seagrass and macroalgae cover as well as reduced numbers of macrophytes (Msuya et al., 1996). It was recommended that the areas where seaweed was not farmed should not be touched so as to preserve the marine organisms. This information is important for the government and other stakeholders in developing plans for integrated coastal zone management.

Follow-up studies by UDSM researchers and others showed similar results, with fewer microorganisms (Olafsson et al., 1995), young seagrasses and macroalgae (Lyimo et al. 2006, Eckloff et al. 2006) in farmed areas. All the studies to date have demonstrated the importance of conserving the parts of ecosystem that have not been used for seaweed farming.

Studies on socioeconomic impacts

UDSM and other researchers studied the impact of seaweed farming on the social and economic lives of the farmers and coastal people in general. Results showed that seaweed farming has proved to be a valid economic activity that has improved the living standards of the people and given economic power to the coastal women who were otherwise depending solely on their husbands. See Eklund and Pattersson (1992), Msuya et al. (1994; video on www.etiis.org.uk, www.ims.udsm.ac.tz), Shechambo et al. (1996) and Msuya (2006b).

Quality of carrageenan against environmental parameters and nutrients
The IMS researchers working with Cargill Texturizing Solutions (http://www.cargilltexturizing.com/) of France have also carried out research to address the changes in quality and quantity of carrageenan. The importance of this work is based on the fact that there could be a time in the future where the value of seaweeds is based on the amount and quality of its carrageenan rather than biomass. It was found that more carrageenan and of higher quality is produced during the short rains and mild temperatures (25–29°C) between October and December (Msuya and Kyewalyanga, 2005), although this is associated with low growth, and consequently less seaweed biomass for the farmers. Higher carrageenan yield was also found to be high in seaweeds cultivated for two months, a cultivation time longer than that used by farmers (4–6 weeks). The researchers recommended that farmers may well be advised to maintain the seaweeds for longer to satisfy the requirements of some buyers in the future.

The research work has shown that the addition of nutrients into the off-bottom method of seaweed cultivation does not increase the growth rate or carrageenan content of seaweeds. It is suggested that adding nutrients in land-based systems or set-ups, which are different from the off-bottom systems, would lead to higher growths of the seaweeds, providing more biomass for the farmers. This information can be found in Msuya and Kyewalyanga (2005).

Effects of seagrass cover
There has been a long debate on whether farmers should clear seagrasses when they want to start farms, with farmers claiming that they do not need to. IMS researchers carried out studies in 2003 and 2007 (Mtolera, 2003; Msuya and Salum, in press) to look at the impacts of seagrass cover on the farmed seaweeds. In both studies, no significant effect was found of seagrasses on the growth of seaweeds that would necessitate their removal, at least for small-sized seagrasses, such as Thallassia and Cymodocea, over which seaweed farms are commonly placed. Msuya and Salum recommended a similar study in areas where farms are placed on larger seagrasses such as Enhalus and Syringodium.

Basic science studies
UDSM scientists also conducted basic research on stress and stress-related issues that could bring the problem of 'ice-ice' disease on the farmed seaweed. Signs of ice-ice disease include white patches and dying or disintegration of the thallus. It is one of the major outbreaks frequently observed on high density farms (Vairappan et al., 2008). Ice-ice is observed in stressed Kappaphycus alvarezii during, for example, abrupt changes in temperature and/or salinity. According to Ask and Azanza (2002) the term 'ice-ice' was coined by farmers in the Philippines in describing senescent pigment without pigment using the English word 'ice'. The ice-ice problem was first reported in 1974 during the start of commercial seaweed farming in the Philippines and has reportedly wiped out entire farms (Largo et al., 1995). Doty (1987) reported that the onset is a loss of thallus colour until it becomes white. The segment may remain for a day or two before it dissolves away, separating the two adjacent parts of the thallus, which seem to be otherwise unaffected. Ice-ice is mostly thought to be a disease symptom rather than a disease because of little evidence of (bacterial) infection but some studies (e.g. Largo et al., 1995) give evidence of the presence of bacteria in the affected parts. The results of these studies and those of, for example, Mtolera et al. (1995), when disseminated, give farmers ideas on what to look for in the farms and take necessary actions when disease signs are observed.

Other institutions

The government
The governments of mainland Tanzania and Zanzibar play significant roles in the development of seaweed farming through the Departments of Fisheries and Trade and Industry act (www.tanzania.go.tz/naturalresources), which links farmers and exporters (buyers). The government's role is to negotiate with buyers on prices and to control taxes, revenue, and the importation of seaweed strains for cultivation. Government also helps the farmers with obtaining farming materials, markets, etc. Seaweed farming in Tanzania is mainly based on a monopsony system where farmers depend on the buyers to provide

them with farming materials such as ropes and tie ties. Working with institutions such as Marine and Coastal Environment Management Project (MACEMP, www.nemctan.org, macemp@zanlink.com) and Participatory Agricultural Development and Empowerment (PADEP, www.agriculture.go.tz/Projects/PADEP), funded by the World Bank (WB) and others, and Tanzania Coastal Management Partnership (TCMP, www.nemctan.org, www.usaid.gov/our_work/environment/water/tcmp, www.crc.uri.edu), the two governments have helped farmers by providing farming materials and trying to reduce their dependency on buyers for farming materials. This apart, the two governments saw the importance of increasing the production of K. alvarezii. They produced a Seaweed Development Strategic Plan (SDSP) that states the amount of seaweed each farmer should produce per month, setting a target of 500 kg per farmer per month by 2015. The process of developing the SDSP involved all stakeholders from farmers to universities, with discussions, interviews, feedback, etc. Unfortunately it is written in English and many farmers depend on others to translate it for them. It is high time that it is translated into Kiswahili, the local language spoken by all Tanzanians. The SDSP can be downloaded from: www.crc.uri.edu/download/Seaweed_ Development_Strategic_Plan.pdf.

Exporters
Exporters (buyers) also play a role in trying to develop seaweed farming through ensuring the provision of the farming materials. Although this is more of their benefit as business people, it is also a way of helping the coastal communities in Tanzania. Apart from providing farming materials, the buyers give extension support to farmers through private extension agents stationed in the farming areas and paid by the buyers. In Tanzania, buyers, in collaboration with government departments, also bring in new strains of Kappaphycus or new species in an effort to minimise the problem of die-off of K. alvarezii. So far one species, K. striatum, has been successfully introduced. More strains that will be more successful are planned to be imported and tried.

Other Universities and research and development institutions

Medical research
There have been trial extractions of the gel, carrageenan, from the seaweeds for use in medical research experiments. The experiments are reported by, for example, Muhimbili College of Health Sciences (www.muchs.ac.tz), Sokoine University of Agriculture (www.suanet.ac.tz), Tanzania Industrial Research Development Organisation (www.tirdo.org), among others. Medical applications may contribute to the future of seaweed farming in Tanzania.

NGOs
NGOs such as Smallholder Empowerment and Economic Growth through Agribusiness and Association Developments, Sustainable Environmental Management through Mariculture Activities (www.acdivoca.org), and the, then, Tanga Coastal Zone Conservation and Development Programme have carried out community-based work helping the farmers to start farming in new areas and offering extension services (Well et al., 2007).

Other institutions such as Action Aid (www.actionaid.org/tanzania) and the Foundation for International Community Assistance (www.villagebanking.org) have been providing small credits to farmers to help them purchase farming materials and market the seaweeds mainly on the mainland. Others are the then Zanzibar Zoological Society and Japan Social Action Fund on Zanzibar. There are many other institutions involved in seaweed farming in Tanzania that the author may not be aware of.

The future of seaweed farming in Tanzania

With the world preference of K. alvarezii over E. denticulatum, the future of seaweed farming in Tanzania will depend on increasing the production of K. alvarezii and adding value to the seaweeds. In essence, almost all the sites that are good for off-bottom farming have been farmed in Zanzibar and only limited sites are available on the mainland. Thus, one of the best ways of increasing seaweed production is to investigate deeper

waters for exploitation. The use of the floating lines technique would be the best way to farm seaweed in deep water. Value addition on the seaweeds is another way of promoting seaweed cultivation in Tanzania. Apart from making value-added products, semi-processing of the seaweed, such as extraction of the gel for export rather than exporting in bulk, would increase further the value of seaweeds. Genetic engineering could give resistant varieties of farmed seaweeds, especially those of K. alvarezii. Other seaweed species such Gracilaria can be farmed for production of agar that can be used for culturing microorganisms in hospitals, schools, universities, mushroom farming, and for food processing.

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Illustrations



Kappaphycus alvarezii farmed in Tanzania

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Eucheuma denticulatum farmed in Tanzania

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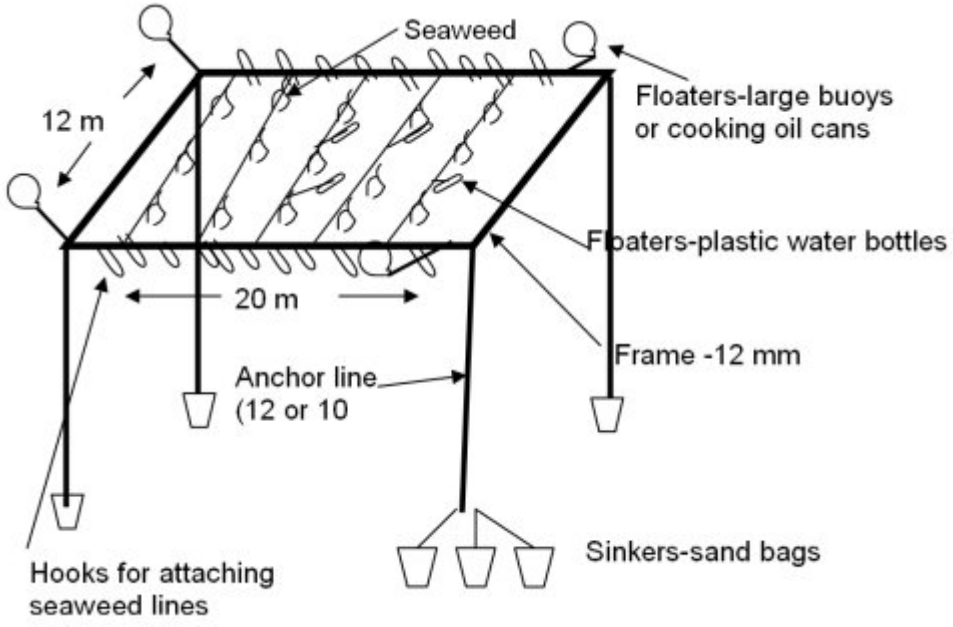
The peg and line (off-bottom) method of farming seaweed in Tanzania

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Seaweed farmers tying seed in the sea

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The deep-water floating lines system used in Tanzania

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Kappaphycus striatum introduced as an alternative to *K. alvarezii*

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Amina Khamis Makame, a seaweed farmer from Bweleo village, Zanzibar

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A seeweed, Kappaphycus thallus showing signs of ice-ice disease

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Organizations

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Western Indian Ocean Marine Science Association	P.O. Box 3298, Zanzibar, Tanzania	+ 255 24 2233427; Fax: 2233582	www.wiomsa.org
Innovation Systems and Cluster Programme (ISCP), College of Engineering and Technology (CoET), University of Dar es Salaam (UDSM)	Coordinator, ISCP, CoET, UDSM, P.O. Box 35031, Dar es Salaam, Tanzania	Coordinator, +255 784 524291	coet.udsm.ac.tz/clusters
Zanzibar Seaweed Cluster Initiative	Facilitator, Zanzibar Seaweed Cluster Initiative, *P.O. Box 668, Zanzibar, Tanzania*	+255 786 629374/ 754 550834/ 777 490807	www.zanzibarseaweedcluster.co.tz (under construction)
Sustainable Empowerment and Economic Growth through Agribusiness (former SEEGAAD)	*PO Box 829, Tanga, Tanzania*	+255-27-264-7261,Fax: +255-27-264-7231	http://www.acdivoca.org
Action Aid			www.actionaid.org/tanzania
Foundation for International Community Assistance			www.villagebanking.org
Fisheries Department, Ministry of Agriculture and Rural Development,	P.O. Box 2462, Dar es Salaam, Tanzania		www.agriculture.go.tz
Memorial University of Newfoundland,	Merylin Porter, A1C 5S7	Tel: 709-737-8000. Fax: 709-737-4569	http://www.mun.ca

Coastal Resources Centre, University of Rhode Island			www.crc.uri.edu
Food Manufacturing Company (FMC BioPolymer, USA)			www.fmcbiopolymer.com
Copenhagen Pectin A/S (Denmark)			www.cpkelco.com
Cargill Texturizing Solutions (France)	Raw Materials Procurement Cargill Texturizing Solutions 50500 Baupte FRANCE	Tel: +33 2 33713400 Fax: +33 2 33713465	www.cargilltexturizing.com
Marine and Coastal Environment Management Project			www.nemctan.org , macemp@zanlink.com
Participatory Agricultural Development and Empowerment Project			www.agriculture.go.tz/Projects/PADEP
Tanzania Coastal Management Partnership	P.O. Box 71686, Dar es Salaam, Tanzania	255-24-223305 401 874-6411. Fax: 401 789-4670	www.nemctan.org , www.usaid.gov/our_work/environment/water/tcmp , www.crc.uri.edu
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Appendix: A successful seaweed farmer who has turned into a seaweed marketing vendor in Zanzibar, Tanzania

Amina Khamis Makame is a woman seaweed farmer from Bweleo village in Zanzibar, Tanzania. Born in 1964 she is divorced and has 2 boys who are 18 and 22 years of age, respectively. Amina studied up to Form III (three years of secondary school). This is the standard school leaving time for children in the education system in Zanzibar, if not selected to go to Form IV and then high school. She started a small business of pottery in 1990 and sold in a shop where the owner bought wholesale. She used the money for food and hospital bills for the children. In 1992 she started farming seaweed. She owned a plot (containing 50 lines, each of 4-m long; this is a standard size of a 'plot' in Zanzibar) and later added more plots. She now has 16 plots with 800 lines. She sells about 100 kg dry seaweed per month, earning about 160,000 Tsh (US$ 160). Her family (children and brother) help her with the farming when it is appropriate; they help in planting, harvesting, carrying the wet seaweed home from the sea, drying, and sorting. Just like many farmers who spend money from seaweed farming to send their children to school, she does not allow her children to work on week days when they are supposed to be in school.

Amina spends 4 h in the sea every day when harvesting and replanting seaweed; she leaves at about 7:00 in the morning and comes back at noon. When the children were small, she used to leave them with her mother but later she took them to nursery school. When she comes back, she collects her children herself or asks her mother to bring them back. Now her children live in town with her sister so they can attend their secondary school in town. In the evenings the children go to evening classes (commonly called 'tuition classes') and visit their mother on weekends, holidays or whenever they can, for example, to help her with seaweed farming at a low tide. Apart from farming seaweed, she also has a small business of making and selling washing soap, poultry products, and products from bee-keeping. She does these activities as a member of a particular group. The soap making group is called 'Bado tupo Bweleo', which translates as 'We are still here Bweleo' (14 members). Their poultry group is called 'Imara' (20 members). The Bee-keeping group is called 'Muliwezaje' (20 people). These last two are new activities and members are yet to make a profit, although the soap group already has US $135 in the bank. She is also a member of a credit cooperative credit system (SACCOS) with 138 members, which was started by the people of Bweleo village.

In 2006 she joined the Zanzibar Seaweed Cluster Initiative (ZaSCI) in a group of 10 members. Under the ZaSCI she participated in trainings, meetings, workshops, and conferences and was exposed to a number of business opportunities. Later, in 2007, she realised that in her village, Bweleo, which sells seaweed to three companies, some farmers stayed long before the buyers could buy their seaweed. She saw that these people would need money but they were not able to sell (this is mainly because of the farmer-buyer bond in farming materials provision). She, thus, decided to look for a company in Zanzibar town, which will buy from her as a middleman. This was successful and she started to buy seaweed from villagers who needed money and sold to the company at a profit. She sells the seaweed to a company called Zanzibar Shell. She buys at 160 Tsh per kg and sells at

200 Tsh per kg, a profit of 40 Tsh for each kilogram that she sells. Her brother helps her with the buying when she is not at home, for example, attending meetings or taking products to market. After one year she now sells about 40-50 tonnes seaweed, worth about US $6000. She earns between US $140 and US $150 per month. Smiling to show her happiness with her business, she is now seeking help to expand the business.

Amina explains that seaweed farming has helped her a lot in the education of her children and buying food and clothes. “Seaweed farming has enabled me to buy school uniforms, books, and pay fees for my children. I can now buy my own clothes and food at home”, she explains. “With seaweed selling business I am making door frames for my house, I do not want to spend any other money on my house except from seaweed business so I can see the results of my efforts” she adds.

She also points out that there are problems with seaweed farming; one being the low price of seaweed. She feels that the amount of money that she gets from selling seaweed as a farmer is not equivalent to the work that she puts in. She is glad to be a seaweed seller as this business increases her income. Other problems are strong winds that break the seaweed, forcing her to re-plant and debris that sometimes causes rotting of the seaweed especially during hot seasons. She also says that during rainy seasons it is hard to dry the seaweed because she does not have tarpaulins to cover the seaweed; if the seaweed gets wet with rain water, it gets bleached, rots and cannot be sold. Sometimes she gets a lot of seaweed and it takes a long time to carry it home because she does not have a boat.

Amina has recently participated in a business plan called Business Development Gateway where she submitted two proposals, one being that of her seaweed selling business. She has already reached a stage where she was selected in a group of 23 people from 532 people. She is now preparing her detailed proposal. Training on business planning and how to develop proposals under BDG will start soon and, if successful, she could win her 2,500,000 Tsh (US$ 2,500) for her business. She is looking forward to a more successful business in seaweed farming and selling.

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