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European Journal of Phycology

ISSN: 0967-0262 (Print) 1469-4433 (Online) Journal homepage: http://www.tandfonline.com/loi/tejp20

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To cite this article: Flower E. Msuya & Anicia Q. Hurtado (2017) The role of women in seaweed aquaculture in the Western Indian Ocean and South-East Asia, European Journal of Phycology, 52:4, 482-494, DOI: 10.1080/09670262.2017.1357084

To link to this article: http://dx.doi.org/10.1080/09670262.2017.1357084

Published online: 10 Oct 2017.

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EUROPEAN JOURNAL OF PHYCOLOGY, 2017
VOL. 52, NO. 4, 482–494
https://doi.org/10.1080/09670262.2017.1357084

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The role of women in seaweed aquaculture in the Western Indian Ocean and South-East Asia

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ABSTRACT

In most developing countries, the majority of people involved with seaweed farming are women. Their immense contribution to the industry has been widely demonstrated and evaluated in successful examples/case studies. These 'seaweed women' have made significant advances in the sustainability of seaweed farming for more than four decades and their dedication, patience and resilience illustrate tenacity in the face of crises. The roles of women are complex, including hands-on farming activities as well as small-scale processing to produce value-added products based on the seaweed biomass cultivated. We detail the role of women in seaweed aquaculture in the Western Indian Ocean (WIO, including Africa and India) and South-East Asia. In Africa, there are significantly more women than men employed, and their roles are more varied, whilst in South-East Asia, men and women are involved in almost equal numbers at the various levels of the seaweed industry. Seaweed farming in SE Asia is carried out by family-owned businesses which involve all working age members of the family, be it nuclear or extended family members, as compared with the WIO region. Five case studies of individual women are provided to show how they have been and continue to be the pillars of the seaweed farming industry. Economic gains from seaweed farming in both regions have provided positive and favourable changes in the quality of life (e.g. food, shelter, clothing, health care and social acceptance) of the family members involved. The case studies point to the commitment of women as the driving force of the seaweed industry, adding value to seaweeds, especially in the WIO. With such women spearheading the seaweed industry, the benefits will continue to be shared with whole families as well as other community members, as mothers are strong anchors of the families in many communities in developing countries.

ARTICLE HISTORY Received 16 March 2017; revised 14 May 2017; accepted 9 July 2017

KEYWORDS Africa; climate change; seaweed farming; success stories; value addition; women

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Introduction

Global seaweed farming

Global seaweed farming is dominated by the red seaweeds *Kappaphycus* and *Eucheuma* followed by the brown algal genus *Laminaria* (including *Saccharina*) with production rising to 11 M and 8 M tonnes fresh weight (fwt) respectively between 2005 and 2014 (Fig. 1; FAO, 2016).

The cultivation of the red seaweeds *Kappaphycus* and *Eucheuma* on a global scale is said to have started in the Philippines in the 1960s with the first commercial production in the 1970s. Information on the origins of aquaculture in this group is provided in the *Taxonomy of Economic Seaweeds* series initiated by Isabella Abbott and Jim Norris (Abbott & Norris, 1985; Lim *et al.*, in press). In Asia and Africa, most of these seaweeds are produced in Indonesia, the Philippines and Tanzania (Fig. 2; Porse & Rudolph, 2017).

It has been shown that in general in Asia the gender balance is about even amongst seaweed farmers. However, women are in the majority in Africa (see e.g. Neish, 2013; Eranza *et al.*, 2015; Msuya *et al.*, 2016). This paper reviews the role of women in various levels of seaweed farming in Asia and the Western Indian Ocean.

Seaweed farming in the Western Indian Ocean

Most seaweed farming in Africa is undertaken in the Western Indian Ocean (WIO) region with efforts focusing on the red eucheumoid seaweeds *Kappaphycus* and *Eucheuma*. The possibilities of domestication and farming of various species and strains of these two seaweed genera were documented in the 1970s in Tanzania (Mshigeni, 1973, 1976), followed by experimental cultivation in the mid-1980s (Mshigeni, 1992). Commercial seaweed farming started on Zanzibar (Unguja) Island in 1989 and expanded to Pemba Island and mainland Tanzania around 1994. As in many other countries, the strains of *Kappaphycus* farmed in the WIO region were imported from the Philippines. By 1990, farmed seaweed was commercially exported from the WIO region. From Tanzania, seaweed farming expanded to other local, African countries,

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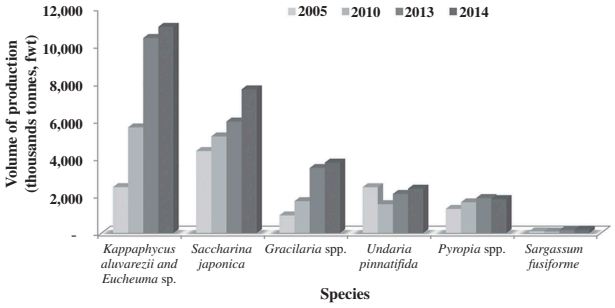


Fig. 1. Development of global seaweed production (wet weight) between 2005 and 2014. Source: FAO (2016, table 7; *Pyropia* spp. reported as *Porphyra* spp.; *Saccharina japonica* as *Laminaria japonica*).

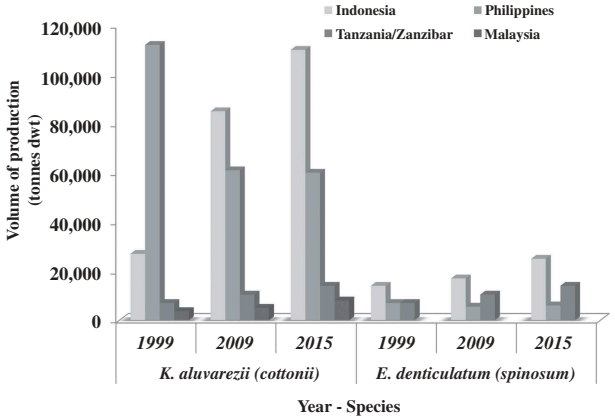


Fig. 2. The most productive countries for cultivation of the seaweeds *Kappaphycus alvarezii* ('cottonii') and *Eucheuma denticulatum* ('spinosum') in SE Asia and Africa (dry weight of crops). Source: Porse & Rudolph (2017), based on industry data.

e.g. Mozambique, Kenya and Madagascar. At the time of writing, farming is undertaken in Tanzania, Kenya, Madagascar, and to a limited extent Mozambique, although farming efforts have almost stopped there because of marketing problems (Msuya *et al.*, 2014). The commercial eucheumatoids which are cultivated are *E. denticulatum, K. alvarezii* and *K. striatus*. Mauritius also started seaweed farming, producing the red seaweed *Gracilaria*, mostly for domestic use (AREU, 2011; Msuya *et al.*, 2014). Attempts were made in Mayotte (a country located between northern Madagascar and northern Mozambique which is also an overseas department of France), focusing on their native species only (eucheumatoids are not native there: CEVA, 2011). Seaweed farming is practiced on the South Atlantic coasts of South Africa, however these efforts mostly produce the green alga *Ulva* as an aquaculture feed (for abalone). Tanzania remains the largest producer of eucheumatoids in the WIO region, with production of 11,000 t dw reported in 2016 (Ministry of Agriculture, Natural Resources, Livestock and Fisheries, MANLF, Zanzibar). Although this figure apparently conflicts with some of the reported FAO data (Fig. 2), it is believed to be correct. Mainland Tanzania produces less than 1000 t dw (Msuya *et al.*, 2014).

Methodology

The information contained in this paper was collected using three methods: literature review, interviews (face to face and telephone conversations), and personal experience/observation. The literature review included published and grey literature, including material received directly from the authors. Interviews were conducted to obtain data for the case studies. The interviewees were selected according to the experience of the authors with women who have made a difference in the seaweed farming and value addition activities. Interviews were carried out by visiting the women (when working with some projects) or telephone calls.

The role of women in seaweed farming activities: Western Indian Ocean

Tanzania

Seaweed farming in Tanzania started commercially in 1989 and is mostly performed on the Zanzibar Islands (i.e. Unguja and Pemba) where according to MANLF it is currently the third largest industry that brings in foreign revenue (after tourism and the clove trade).

Available data suggested that there were larger numbers of women farmers than men farmers on both Unguja and Pemba. Gender data obtained from the MANLF in Zanzibar showed that the seaweed industry employed 26 000 farmers of which 78% were women; mainland Tanzania has a total of 5000 farmers, 90% of whom are women (Ritha Mally, personal communication). The number of women farmers in 2012 (according to 2012 statistics, MANLF) was 8094 on Unguja and 10 378 on Pemba, as compared with 605 and 4612 men respectively, shown as percentages in Fig. 3a, b.

It is interesting to note that when seaweed farming started, equal numbers of men and women entered into farming activities, however the gender balance slowly shifted, with men pulling out on the basis that seaweed farming was said to be 'a slow business'. In general, the men required money on a daily basis (Msuya, 2016*a*). Men expressed their opinion that women were 'more patient' when involved with the process of farming – seeding lines, tending lines, harvesting, drying, selling, etc. – all of which required

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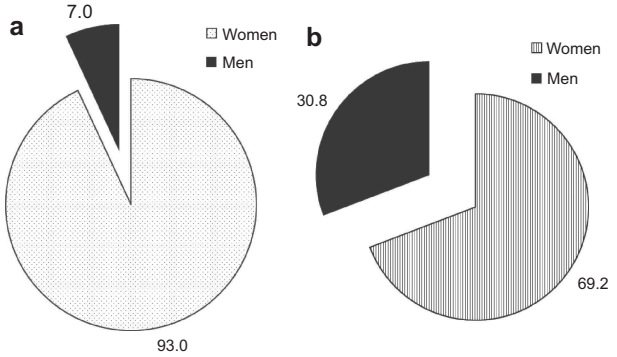


Fig. 3. The percentage of female seaweed farmers in (a) Unguja (n=8699), (b) Pemba (n=14990). Source: Ministry of Agriculture and Fisheries, Zanzibar.

considerable effort and time before they derived an income from their labours (Msuya *et al.*, 1994; Msuya, 2013). Women were indeed patient and persisted with the new techniques for farming; with time they were successful and, based on their ability to generate a stable income, even became heads of their family units (a marked shift from the prevalent patriarchal system). For example, it was shown that initially almost all families were headed by men, however, as seaweed farming activities progressed and became established, more and more families were headed by women (Shechambo *et al.*, 1996). It is common knowledge that women who were either divorced or widowed turned to sustainable seaweed farming as a means to sustain their family needs. Shechambo *et al.* (1996) showed that most women farmers who were also heads of households were widowed, divorced or unmarried.

Prior to the introduction of seaweed farming, the various cultures, mores and traditions of Zanzibar did not allow women to leave their houses, instead they were to stay indoors and wait for their husbands to bring home all household requirements. However, after seaweed farming began, women started to leave their houses to farm seaweed, sometimes even causing conflict with the husbands (Eklund & Pettersson, 1992; Shechambo *et al.*, 1996; Msuya, 2012). The current situation is that women have become part of the 'bread-winning economies' of their families, in some cases working with their willing husbands and sharing home economics. This transition gave women a different, elevated, more respected status in their communities.

As of 2017, seaweed farming has proved to be of great economic importance to women: the income generated by their activities and entrepreneurship in sustainable seaweed farming enabled them to improve their standards of living, by providing them with income which could be directed to schooling for their children, medical attention and general marked improvements to housing and clothing (Pettersson-Löfquist, 1995; Shechambo *et al.*, 1996; Msuya, 2006*a*, 2011*a*, 2012; Eklöf *et al.*, 2012). For more than two decades, it was reported that ownership of items such as radios, cloth (mostly khanga, which is traditional for women to tie around their waists or wrap over their bodies), kitchenware, bicycles, motorcycles, furniture, etc., was significantly higher after seaweed farming began and could be attributed to the derived economic income (Shechambo *et al.*, 1996). Msuya *et al.* (1994) showed that women who had owned less than five pairs of khanga before gaining income through seaweed farming could then own up to 30 pairs, which was a very prestigious situation for women on Zanzibar. Msuya (2013) stated that women farmers pointed out that they had 10–30 pairs of khanga before they started farming seaweed but now they own 30–150 pairs and were planning to buy up to 200 pairs. In 2017, the situation remains the same: women earn enough cash from seaweed farming activities to cater for their daily needs. Females are said to have 'money power' and have become principal 'breadwinners' in their families (see e.g. Msuya, 2006*a*, 2012, 2013). Msuya (2010*a*) recorded statements by women such as: 'When a child asks for books, or even a pen for school, the father tells him/her to go the mother' and 'How can you stop a woman from doing her own work, will you be able to give her all that she needs?'. On getting enough money to buy items needed for their day to day activities, comments such as: 'If one gets 100 000 Tsh. in two weeks' time why not buy a bicycle?' were recorded. These types of statement showed a devoted engagement by women in their seaweed farming activities, and some of the many benefits of their being able to actively participate in a cash-based economy to help their families.

Kenya

Commercial seaweed farming in Kenya started in 2010 on the south coast and also involved mainly women. In 2014, it was reported that there were seven villages practising commercial seaweed farming in Kenya, although only three (e.g. Kibuyuni, Mkwiro and Nyumba Sita) had the substantive production required to support commercialization of the harvested biomass. Efforts to support commercial production were made by a number of organizations, e.g. Act, Change, Transform (ACT-Kenya), Sudra (a religious organization) and the East African Wildlife Society (EAWS). Around 2014, commercial farming was supported by the Kenya Coastal Development Project (KCDP), funded by the World Bank. Kenya had a local buyer, East African Seaweeds, which solved the problem of dependency on buyers from Tanzania. The Food and Agriculture Organization (FAO) came to support commercial

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production through training in best management practices and value addition during 2015–2016 (Msuya, 2016*a*,*b*).

Mauritius and Rodrigues

On Mauritius and Rodrigues, the efforts of the Mauritius Research Council (MRC) to start seaweed farming involved feasibility studies to provide inventory reports on their native seaweeds which could be cultivated for domestic uses. During that time, there was ongoing use of *Gracilaria* spp. in order to make pickles (e.g. mango pickle) for the domestic market (AREU, 2011; Msuya *et al.*, 2014). Following feasibility studies, the MRC sponsored training on sustainable seaweed farming. The first part was training of trainers which brought research assistants from Mauritius to Zanzibar, Tanzania for on-site tutorials. The second part was conducted in Mauritius and Rodrigues. In both sessions, on Mauritius (where professionals such as university lecturers and business people were involved), 33% of the 40 participants were women, whilst on Rodrigues, where the training was specifically for fisherfolk, there were 26 women, 43% of the total of 61 people (Msuya, 2011*c*,*d*).

Madagascar

Commercial production of seaweed in Madagascar began in 1997 using a local strain of *Kappaphycus striatus*, however in 1998, a strain of *K. alvarezii* was imported from Tanzania since the local variety was unable to produce enough biomass on a commercial scale (Randriambola & Rafalimanana, 2005). The seaweed business there was started by programmes promoting sustainable eucheumatoid cultivation as a means of improving (cash) income for coastal communities and was supported by the European Development Fund and the Food Manufacturing Corporation (FMC, USA). There were several commercial initiatives based in three different locations. However, after pursuing cultivation opportunities for three years, only one initiative survived. Production of biomass was reported to be significant in the north, especially from 2006 onwards when new varieties of *K. alvarezii* and *E. denticulatum* were imported from Tanzania. Production of eucheumoids peaked at 2290 t (DW) and involved more than 300 farmers in 2009, but fell drastically to 844 t in 2012 because of epiphyte infestation (Msuya *et al.*, 2014). A push in 2010 to boost production of *K. alvarezii* specifically involved investment from the private sector and NGO partners. By 2012, it was reported that about 200 t (DW) of *K. alvarezii* were produced (Msuya *et al.*, 2014).

There is no specific information available concerning the involvement of women in seaweed farming on Madagascar, however, most projects there had a focus on women and their welfare. For example, according to Blue Ventures (2015), 50% of the 700 farm owners and farm workers who were integrating seaweed and sea cucumber aquaculture operations were women.

India

The involvement of women (or the potential for women's involvement) in the seaweed industry of India was reported by Immanuel & Sathiadhas (2004), who stated that 5000 women were dependent on seaweed-related activities and the income derived for their livelihoods. At that time the seaweed sector employed about 10 000 people of whom 50% were women.

The first experiments, in 2004, into seaweed cultivation in India were conducted by the Central Marine Fisheries Research Institute (CMFRI) and the Central Salt and Marine Chemicals Research Institute (CSMCRI), working with other organizations mainly using *Gelidiella* spp. and *Gracilaria* spp. (Kaliaperumal *et al.*, 2004; Krishnan & Narayanakumar, 2010). However, the cultivation techniques applied had already been developed during the 1970s (Krishnan & Narayanakumar, 2013). The first experimental cultivation of *K. alvarezii* was undertaken in 2002, with some earlier preliminary experiments documented by Krishnan & Narayanakumar (2010).

The role of women in seaweed farming in India is largely demonstrated by the projects specifically developed for women fisherfolk. For example, the Self-Help Groups (SHG) projects were earmarked for helping women's groups. The Tamil Nadu Women's Empowerment Project was an International Fund for Agricultural Development (IFAD)-supported project implemented through the Tamil Nadu Corporation Development of Women (TNCDW). This was said to be the first project in India that incorporated the SHG concept (Krishnan & Narayanakumar, 2010), and it was stated that 50% of the group members should be women. Another example was the involvement of the State Bank of India in promoting working with the Aquaculture Foundation of India, an NGO based in Chennai, in 2006. Working through the Self-Help Groups, the Bank provided loans to 540 000 groups, amongst which 80% were women (Krishnan & Narayanakumar, 2010). The authors discussed the involvement of the National Fisheries Development Board (NFDB), a government agency formed in 2006. Through this seaweed cultivation scheme, training programmes were created to 'preferentially target women'.

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The CMRI then developed seaweed farming training in Ramanathapuram, which also had a 'strong gender bias' towards women (Krishnan & Narayanakumar, 2010). The authors pointed out that: 'The concept of SHG was founded on the basic premise that women are more responsible and have a better disposition to work towards achieving social and economic independence'. The authors reported that: 'In the case of seaweed farming, rather than assuming a leadership role, men in fishing households followed their women. The initial success of women in seaweed farming motivated men to enter the activity as well'.

Examples of success stories

Case # 1 Safia Hashim Makame

A good example of a woman who has changed her life situation and that of her family tremendously is Safia Hashim, living in Bweleo Village on the south-west coast of Zanzibar, who was interviewed recently (aged 53, married, with 6 children). Safia is a seaweed farmer. When she married, she and her husband lived with their in-laws and their children, and their life was 'not so good', as she explained. She slowly started to diversify into value addition to her cultivated seaweed biomass through the Zanzibar Seaweed Cluster Initiative (ZaSCI), around 2006. Safia belonged to a large group, with 80 members, who were involved in both seaweed farming and value addition. Over time, she realised that most members of the group were not active enough – they waited for others to work and they reaped the benefits from the activities of others. Her efforts to explain to the other members that they had to work effectively and be transparent in the required collective work unfortunately did not bear much fruit. Therefore, she decided to leave that group and form her own called 'Ukweli Ni Njia Safi' (which translates as 'Truth is the Clean Way'). She and two children were the initial members of this group. Over time, the group expanded to 10 members, with whom she produces seaweed (*Eucheuma*)-derived, value-added products including soap bars, liquid soap, shampoo, body cream and food, e.g. juice, cakes and cookies. Safia is now planning to expand into making seaweed-based tomato sauce and tomato paste.

With the income derived from her entrepreneurship, Safia was able to build her own house where she even installed a tiled floor (for context this normally could not be afforded by the 'common man'). She has enough rooms in the house that she can rent to 2–3 students who come to do research on Zanzibar. Safia explained that her life has changed completely – she credited the knowledge of value-addition processes she acquired through ZaSCI. Similarly, she trained her children and they are also engaged in seaweed value addition. Safia is now a 'trader' in seaweed-based, value-added products on Zanzibar and mainland Tanzania, as well as in Kenya. She attends exhibitions in East African Countries (e.g. Uganda, Rwanda, Burundi, Kenya etc.) in order to showcase her products. Most frequently she sells her products via telephone calls as a direct result of her efforts which have established marketing linkages and networking capacity.

Case # 2 Sitara Khamis Omar

A woman from Kiuyu Mbuyuni village in Pemba who was also interviewed during the writing of this paper is Sitara Khamis Omar, age 44, married with four children. She started farming seaweed (both *Kappaphycus* and *Eucheuma*) in 1993 when the price of seaweed was 20 sh. per kilo and now she sells her seaweed for 400 sh. She now produces only *Eucheuma* following the failure of *Kappaphycus*. The price of *Eucheuma* increased from 250–400 sh. in 2011 and to 700–800 in 2015, and Sitara earned enough money from seaweed sales to open a shop selling kitchen utensils. She also bought a deep freezer and started a juice-selling business. She further obtained a loan of 2 000 000 sh. from a Savings and Credit Cooperative Societies (SACCOS) of Kiuyu Mbuyuni village of which she is a member. She used 1 000 000 sh. to buy more kitchen utensils for her shop and the other 1 000 000 for school needs for her children.

When the price was 700 sh. per kilo she was producing 3 t dw per year but since mid-2016 the price has gone down to 400 sh. and the seaweed is affected by ice-ice disease and epiphytes; she now produces 2 t. Sitara explained that when the situation in the farms is not good she concentrates on her shop and the juice business. At the time of interview Sitara mentioned that the hot season is affecting seaweed and that she is waiting for the rainy season when the seaweed will grow well again. (The price fall was due to the declining world market; some exporters stopped buying seaweed for some time. There is a world trend of decreasing quality of seaweed caused by effects of climate change, which has also affected the seaweed business in Tanzania.)

Case # 3 Amina Khamis

This woman (according to Msuya, 2010*a*) lived (and still lives) in the same village as Safia, in Bweleo, and eventually became a seaweed trader. Amina is a divorcee with two male children. She began her journey as a farmer in 1992, went into some processing and later became a seaweed trader. Amina joined the ZaSCI when it started in 2006. Through this association, she

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underwent training in entrepreneurship and how to run a business; these courses encouraged her to become a seaweed trader. She was involved in buying cultivated raw materials from her fellow women farmers, which she then sold on to exporters. Amina was able to make up to US$500 per month through her sales of seaweed. This was more than the US$160 which she used to earn farming seaweed and was much greater than the US$50–100 that a woman seaweed farmer generally received on Zanzibar. Amina used and continues to use the money to educate her children, renovate her house and cater for her family's needs.

The role of women in seaweed farming in South-East Asia

Philippines

The earliest system of commercial seaweed farming of *Kappaphycus* and *Eucheuma* in the Philippines began in the early 1970s and was called corporate farming (Solante, personal communication). Large companies such as Shemberg, Genu, Marine Colloids (Philippines) were given government permits to farm several shallow reef areas (I.C. Neish, personal communication). The seaweed farmers were then hired as labourers for cutting, tying of propagules, tying lines to the stakes, tending the crop whilst it grew, harvesting, drying, packing and storing. This was a male-dominated activity at that time. The men were paid monthly and provided with free food and accommodation. However, this model of seaweed farming did not prosper because it was not economically profitable for the sponsoring companies. As a result, the family unit format of seaweed farming emerged. A typical nuclear family in the Philippines and elsewhere in the South-East Asian (SEA) region consisted of father, mother, 5–7 children, plus an extended family of grandparents, uncles, aunts and sometimes distant relatives, all living under one roof. The strong sense of kinship of South-East Asians is well exemplified in this type of livelihood and its communal units (Barraca & Neish, 1978; Hurtado, 2013). In these traditional situations the man was the (patriarchal) head of the family, however, the woman had a great influence in decision-making (Aming, 2004), for both domestic concerns and the collective farming activities. Aming (2004) described the following roles of women in seaweed farming and this was confirmed by Hurtado (2005) in her studies of Zamboanga city, Bongao and Panglima Sugala, Tawi-Tawi:

(1) Many of the challenges faced by Filipino Muslims in Sitangkai were common amongst women in other municipalities in the Sulu Archipelago (i.e. Sulu and Basilan) and other Muslim-dominated towns in the Zamboanga Peninsula. Over time, the forces of social and economic change had in many ways intensified the demands placed upon women in their varied roles to promote and improve their social and economic conditions, in order to attain family solidarity and stability.
(2) The Muslim concept of the female gender allowed for a range of possible expressions of ideal female behaviour. Hence, mature, rural, women running a business or selling in the market was one version of acceptable behaviour. Likewise, the active participation of women in seaweed production, in partnership with their husbands, was a common occurrence.
(3) Men and women were often found in the scenario of co-operation and co-production, rather than competition and conflict.
(4) Women seaweed farmers were equally involved with their husbands in the decision-making processes on matters pertaining to household and seaweed farming activities. However, the involvement of women in decision-making pertaining to seaweed farming activities was consultative in nature.
(5) Filipino Muslim women were faced with many constraints in order to achieve their primary developmental goals of self-reliance, largely due to their limited knowledge, lack of skills, training and lower levels of education than their male counterparts. Muslim women relied on acquiring learning through self-initiatives and hands-on activities.
(6) The studies cited revealed that tradition and attitude towards non-seaweed farming activities were significantly adjusted and this was related to the nature and extent of participation by women in seaweed farming operations. Similarly, the average level of productivity of a seaweed farm was significantly associated with jointly made husband and wife decisions and the degree of exposure of those women to various forms of print media like training brochures and flyers provided and distributed by the government and non-government agencies.

The significant and positive roles of women in seaweed farming were further demonstrated after the super-typhoon 'Haiyan' which ravaged the eastern Visayas, western Visayas and MIMAROPA (Mindoro, Mariduque, Romblon and Palawan) regions in November 2013. In the post-disaster situation, women were heavily involved in the rehabilitation of their damaged seaweed farms. The resilience of Filipino womenhood, as seaweed farmers, especially in the affected regions, that allowed them to rise above the crisis, was formidable. Whilst the damage to seaweed farming activities was indeed

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extensive, it also presented opportunities during the recovery and rehabilitation period to introduce better farming practices. Training was provided by the FAO on the selection of the most suitable farming sites, the preparation of healthy seedlings for growing-on, general farm maintenance and how to gain access to markets for the cultivated biomass. The FAO included seaweed farming packs which consisted of nylon lines, floats and other planting materials, along with home-based, seaweed drying facilities and also the establishment of seaweed nurseries which enabled diversification and culture of a variety of seaweed species (FAO, 2013). Several local and international organizations provided considerable support to the Haiyan victims.

There are many Philippines success stories of women in seaweed farming, two of which are presented here.

Case #1 Jessica Paguia

Jessica Paguia, 31 years old from the Tagbanua, an indigenous group on the island of Coron, Palawan, has farmed seaweed as a family enterprise for 20 years. It has been the main source of income in their small coastal community.

When typhoon Yolanda (Haiyan) struck on 8 November 2013, their house and all their farming materials were wiped out by it. She did not know where to start, because they had lost everything and had relied on seaweed farming for their income for so many years. Everyone in the northern part of Palawan was affected and the disaster crippled the income stream for every Filipino coastal farmer.

Jessica was one of the beneficiaries of the FAO cooperation with the Bureau of Fisheries and Aquatic Resources (BFAR) that provided livelihood and rehabilitation assistance to 2900 seaweed farming beneficiaries across Palawan (Region VI-B) and Panay Island (Region VI). She received the training and farming materials. She learned the proper way of cutting cultivars, transferring to nursery grounds, and the recommended periods for best growth and development of *Kappaphycus* and *Eucheuma*. Prior to receipt of the training, she and the rest of the community were just haphazardly harvesting the seaweed after different growth periods and drying them without proper handling, thus, there were losses with financial implications.

Jessica is thankful to FAO and BFAR for their assistance after the typhoon Haiyan crisis. 'Without their support, we wouldn't have a source of livelihood', she said. Furthermore, 'We can now expand our seaweed farms through the variety of techniques that we've learnt and adapt these strategies according to climate conditions'.

Jessica does not know what the future holds, but she is sure about one thing: 'We are now able to meet our basic needs every day and the materials (received in support) are also sufficient capital for us to be able to recover from what we lost.' Jessica exemplifies the innate resilience of a typical Filipino woman to rise above a crisis and the importance of income from sustainable seaweed cultivation is clearly demonstrated (FAO, 2015).

Case #2 Ronalyn Madrazo

Ronalyn Madrazo is married with four children and resides at Brgy Rizal, Barobo, Surigao del Sur. As of April 2017 she was the President of the Rizal Community-Based Resource Management Peoples Organization (RCBRMPO).

Ronalyn and her husband started planting *Kappaphycus* and *Eucheuma* seaweeds in 2008 with a capital outlay of US$40. After 15 days, they observed that "ice-ice" and epiphytes had infected their seaweeds. They harvested that biomass prematurely and sold it to local traders, however they lost their capital. For the next cropping season, they spent another US $40 for seedlings and unfortunately experienced the same failure. After this they decided to stop seaweed farming.

In 2011, the Partnership for Development Assistance in the Philippines (PDAP) Inc. came to their area to conduct a three day 'Seaweeds Training' workshop in Lianga, Surigao del Sur. This meeting paved the way to improved farming practices and literally changed the quality of life of that community. In the training, Ronalyn learned improved ways of seaweed farming, as compared with their traditional farming practices, such as: (1) shorter lengths of cultivation line, reduced from 200 to 50 m each, which facilitated easier monitoring, maintenance and cleaning of the cultivars; (2) the distance between propagules was standardized at 12 inches apart; and (3) a new fast-growing, pest-resilient and higher yielding variety called 'giant' was provided for seedstock. The training she received gave her the confidence to invest again in seaweed farming, so she made an initial capital investment of US$300 and with three harvests per year and her persistence and diligence she was able to derive a net income of US$1200.

Ronalyn, as the President of their organization with the assistance of PDAP, led the establishment of a seaweed nursery as an additional source of income, in May 2014. Since then, the nursery has generated an income from the sale of seedlings. Moreover, other seaweed farmer members were able to access healthy and reliable seedlings from her nursery. It is interesting to note that payments to the nursery were only made after the farmers had made their harvests and sold their biomass.

Ronalyn also coordinated the marketing of the organization's dried seaweed to a local consolidator;

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this was far more efficient than when farmers had to make their own negotiations to sell their crop. As the president of the organization and leader of the community, she recognized and acknowledged the role of PDAP in capacity building and technical advancement in seaweed farming. Ronalyn, as a woman of courage, integrity and leadership, has the capability to improve the lives of many other coastal families; her efforts are certainly inspiring and worthy of emulation (www:pdap.net/category archives).

Indonesia

There are few documented reports of the involvement of women in seaweed farming in Indonesia (Neish, 2013) and their roles are often only mentioned in passing (Zamroni & Yamao, 2011). A quantitative analysis reported by Eranza *et al.* (2015) documented the participation of women in seaweed farming in the region of Jenoponto, South Sulawesi, Indonesia. The authors reported that: (1) the proximity of farming villages to a capital town or city did not increase the probability of women becoming employed in paid jobs unrelated to seaweed farming; (2) age was found to be critical in the participation of women – as their age increased their probability of being involved with seaweed farming decreased – there was an inverse relationship; (3) education had a negative relationship with women's participation – this simply indicated that a higher level of education did not necessarily increase their prospects of finding employment opportunities in seaweed farming; (4) the size of the family unit was positively correlated, i.e. the larger the family unit, the higher was the probability of their womenfolk participating in seaweed farming. In addition, the greater the number of working hours, the more women participated in seaweed-derived forms of employment in order to derive higher income. The authors concluded that the participation of women in seaweed farming resulted in job satisfaction and recognition by their peers, which was a common feature also recorded in the Philippines and Malaysia.

Malaysia

Seaweed farming in Malaysia has been largely concentrated in eastern Sabah, since it was first introduced during the late 1970s (Sade *et al.*, 2006; Suhaimi, 2011). It became successful in part because it was an enterprise that could involve the whole household. The ability to rely on boating skills of women and their labour within households was a key factor in the successful adoption of seaweed farming at Kaligau, Bangi Is. (Cooke, 2004). The author also claimed that further success was dependent on the extent to which those women (whose availability for labour was also being divided between their family responsibilities and the vigilance required for seaweed cultivation) could be organized to be continuously motivated. What was keeping women working with seaweed, despite the relatively low return for their investment of hours and effort for the labour required, was the social status that came to be associated with the crop. These benefits included the elevated social status attached to the '*surau*' (Prayer room) and the sense of group-worth which emanated from the Bajau interpretation of governmental and non-governmental assistance as a sign of their being accepted as worthy citizens (Cooke, 2004).

The introduction in 2009 of the 'Mini-Estate System' for the cultivation of carrageenophyte seaweeds in Sabah opened up further opportunities for the involvement of women in order to achieve sustainable productivity that could be enhanced (Hussin *et al.*, 2015). However, despite good intentions, unfortunately the initiative was flawed and did not operate for any length of time (Azhnar, personal communication).

The effects of climate change on women in seaweed farming

Western Indian Ocean

In Africa, the effect of climate change (i.e. increased surface seawater temperature, SST) on seaweed farming and the farmers (the majority of whom are women) has been demonstrated in a number of publications. It has been shown that as a direct result of climate change, the female farm operatives could no longer produce the higher-value *Kappaphycus* (a source of kappa carrageenan) and were therefore forced to produce the lower-value *Eucheuma* (source of iota carrageenan), which provided them with less income for similar levels of effort required to grow the crops. In a study by Msuya (2011*a*) women stated that when they produced *Kappaphycus* (and the price was high), they were able to build new houses and buy fishing boats for their husbands, etc. However, increased SST threatened the economic power of the women in particular. The ensuing effects of increased SST included negative impacts of epiphytes and outbreaks of ice-ice disease on *Kappaphycus* in particular (Msuya, 2011*b*; Eklöf *et al.*, 2012). In the period 2013–2017, even the lower-value *Eucheuma* was also affected during the hot season, December to March. During those months, a number of farmers maintained their seedstock in deeper, cooler oceanic water awaiting the cooler influence of the rainy season (April) before restarting their farming activities in the shallower coastal waters (Msuya, personal observation). In a sense those farmers were beginning the practice of 'shift cultivation', where the farms

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were moved to different areas depending on the seasonal local conditions which were most suited to the cultivation of the seaweed stocks they had available (Msuya & Porter, 2014; Msuya *et al.*, 2014).

Many women members of the Zanzibar Seaweed Cluster Initiative participated in the development of new technologies to be used to farm *Kappaphycus* in deeper, cooler waters as a way to ensure some production of this higher-valued seaweed. Nevertheless, it was still difficult to produce *Kappaphycus* so some of the more entrepreneurial women engaged in value-addition in order to produce seaweed value-added products, thus ensuring their income. Examples are seaweed powder that sold at 10 000 sh. (US$6.4) compared with the 500 sh. (US$0.3) for 1 kg of dry seaweed (1 kg of powder is produced from 1.75 kg dry seaweed) and seaweed soap bars that sold at 1000–1500 sh. (US$0.5–0.7) per piece (Msuya *et al.*, 2014).

Interventions to help the farmers were initiated and continue to be undertaken by the governments and national and international organizations, as well as NGOs. Governments in Africa are revising and formulating policies on seaweed farming with the main aim of protecting the farmers and ensuring fair prices. Direct interventions included helping by providing materials such as ropes, harvesting barges and also training in how to add value to the dried cultivated biomass, e.g. The Revolutionary Government of Zanzibar (RGoZ), working with FAO, trained farmers on Best Management and Business Practices (BMBP) including an 'Ecosystem Approach to Aquaculture' and produced multiple training manuals. In fact, most of the aquaculture enterprise in Zanzibar was dominated by seaweed farming; animal aquaculture is still only a recent start-up (Msuya *et al.*, 2016). RGoZ also worked with UNIDO to train the farmers in value-addition opportunities. Most of those people trained were in fact women. Similar initiatives were undertaken by the Kenyan Government which also worked with the FAO to provide training in best farming practices and value-addition.

Recently, the FAO began working with RGoZ to investigate seaweed diseases which were affecting seaweed productivity and quality and beginning to disproportionately impact on the ability of women to be involved with income-generating activities. The seaweed disease project will look at the effects of ice-ice and damaging epiphytes in order to recommend positive interventions, e.g. how to cope, or engagement in alternative economic activities. Further aspects of the health of the farmers needs to be investigated, in particular the problem of itching skin caused by exposure to toxic microalgal blooms. This is a sign that all is not well in the coastal marine environment and perhaps a number of issues co-related to climate and anthropogenic impacts need to be recognized and addressed.

Asia

At the 32nd FAO Regional Conference for Asia and the Pacific held in Ulaanbaatar, Mongolia in March 2014, member countries (Bangladesh, Indonesia, Philippines, Sri Lanka, Vietnam and Timor-Leste) endorsed the regional initiative for sustainable intensification of aquaculture for Blue Growth (i.e. as part of the Blue Growth Initiative, BGI-FAO), in order to improve fish supply for food and nutrition, increase livelihood opportunities and contribute to the coastal economy through more efficient and sustainable use of aquaculture resources, one of which would be cultivated seaweed.

The objectives of the regional BGI program were stated as to:

(1) Improve the utilization efficiency of aquaculture resources.
(2) Improve production efficiency with reduced impacts on the environment.
(3) Increase the resilience of the farmers and the sector in general.
(4) Improve the equity and social acceptability along the aquaculture value-chain.

The major areas of work required were stated to include:

(1) Support member countries in identifying options for addressing key governance issues in achieving sustainable aquaculture growth through an appropriate, regional and national consultation process, develop relevant regional and national policy, strategy and an action plan.
(2) Increase farmers' adaptability to climate change impacts and their resilience to natural disasters and socio-economic risks through the development and promotion of innovative aquaculture management and practices.
(3) Reduce the negative environmental and social impacts of intensive aquaculture through promoting innovative farming technologies and best management practices, establishing effective aquaculture bio-security and disease surveillance and control systems, application of appropriate planning and management tools and responsible use of resources.
(4) Support the member governments in improving the access of poor, rural aquaculture farmers to quality production inputs, sustainable production technologies and marketing for improved productivity and economic efficiency.

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(5) Improve management of forestry (specifically coastal mangroves), water, land and rights of tenure which would contribute to sustainable intensification of multiple aquaculture opportunities.

In response to this programme, FAO, in collaboration with the BFAR, through the Inland Fisheries and Aquaculture Division of the Philippines conducted a two day workshop on: 'Climate Resilient Aquaculture Operations for Building Capacities for Climate Resilient Seaweed Farming' in April 2016. Participation included leaders of the seaweed farmers' association from the three major producing areas: Palawan, Zamboanga and Bohol. Of the nine participants, there were only three women leaders. Issues regarding these areas were tackled after lectures from invited resource speakers on water quality monitoring and evaluation, the ecophysiology of *Kappaphycus*, *Eucheuma* and *Gracilaria* and the weather and climate phenomena affecting the growing regions. At the end of the workshop, the seaweed farmers had to identify and describe the following: (1) Immediate impacts of weather systems in the marine environment, with special reference to the major seaweed cultivation sites; (2) The farmers' adaptive responses to short-to-medium term weather events; and (3) Generalized aquaculture farm emergency response advisories against adverse weather/climatic conditions. From these inputs, FAO/BFAR are preparing an educational document for climate change resilience in seaweed farming (Ortega, personal communication; will be made available at www.bfar.da.gov.ph).

In addition, USAID initiated the Adapt Asia-Pacific program and FAO further empowered women in coastal communities around the Arafura and Timor Seas, Indonesia, by assisting national government agencies to design clear, budgeted gender-based activities as part of the adaptation projects (see USAID Adapt Asia-Pacific; www.adaptasiapacific.org/) which specifically set the agenda to support women in order to better and more sustainably respond to the impinging, negative effects of climate change. Specific activities were designed by prioritizing the needs of women, which included targeted job skills training and capacity building of local women's groups for greater civic participation. These activities enhanced the participation of women, improved their access to economic opportunities and reinforced their business and financial skills for more secure livelihoods.

One of the recommended interventions to support the empowerment of women involved strengthening Indonesia's Forum Perempuan Masyarakat Adat Aru – the Women's Forum for Customary Communities in Aru. The Forum worked to raise awareness regarding women's rights for the use of natural resources by working directly with, and empowering, local women involved in coastal and fisheries management (www.adaptasiapacific.org). This intervention specifically addressed the different gender-related roles in fisheries management, i.e. where men go on boats to fish, whilst women do most of their fishing in the coastal, shallow waters. Women, however, continued to be sidelined from any real decision-making on the uses of coastal and marine resources. This activity also aimed to help the women and men of Aru understand, and appreciate, the specific inputs of women to decision-making. Another intervention sought to increase the resilience of coastal communities through livelihood diversification. These interventions were intended to improve market access and financial management and know-how of local women involved with seaweed farming and other home-based businesses, in order to help them increase sales and cash revenues. Anticipating the effects of climate change, local women were also encouraged to diversify their products, moving away from a reliance on climate-susceptible marine resources to more sustainable ones.

The role of women in adding value to seaweed resources

Africa

Seaweed value-addition, as carried out by farmers, especially women, began with ZaSCI in 2006. The aim of ZaSCI is to bring innovation into the seaweed industry, in particular taking into consideration the challenges linked to the impacts of climate change and volatility of the world market that directly affect the farmers. ZaSCI operates in a Triple Helix model, linking the 'Business' (which includes farmers, processors and exporters) to 'Government' (i.e. departments responsible for seaweed farming) and 'Academia' (university and research institutions; Msuya, 2006*b*). ZaSCI works in two areas of innovation: developing new farming methods and value-addition to the cultivated biomass.

ZaSCI began its value-addition activities with a group of 21 women in the village of Kidoti, northern Zanzibar (Msuya, 2006*b*). The first activity produced seaweed powder which was used to make seaweed soap and body cream. The group had to grind the seaweed and the machines for making seaweed soap were acquired under ZaSCI. This equipment included a solar seaweed drier, grinder, a soap mixer and soap bar-cutter. The solar drier was important to further dry seaweed to a crisp state so that it could be ground. Financial support for the acquisitions was provided by SMEs Competitiveness Facility (SCF) and the machines were made by the College of Engineering and Technology, University of Dar es Salaam (CoET-

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UDSM). Trials were done in 2006, and after acquiring the machines in 2008 the first seaweed products, powder and soap, produced by a Zanzibari (and Tanzanian) seaweed farmer were marketed. ZaSCI is the first initiative to produce a seaweed value-added product in Tanzania and it was produced by the Kidoti women! After this success, more farmers were trained by ZaSCI during the period 2008–2009. Later the other villages joined ZaSCI and at the time of writing there were about 300 people in Tanzania who make seaweed value-added products, either as groups or individuals. In 2006, there was only one product, the dry seaweed; in 2008, there were four products, dry seaweed, seaweed powder, soap and body cream produced by people in a single village; in 2017, more than 50 products (mostly cosmetics and food products) are produced in more than 10 villages.

Most of the value-added products made using seaweed have been documented (Msuya, 2010*b*, 2016*b*; Msuya *et al.*, 2014). The products fall into two categories, i.e. cosmetics and food. In Tanzania, products made for cosmetic purposes thus far include seaweed powder, soaps, body creams, liquid soaps, shampoos, massage oils, facial scrubs and body lotions. In the food category, products included seaweed juice, jam, cake, cookies, salad and cooking the seaweed as a vegetable. New products were added over time by the innovative women; e.g. Msuya (2010*b*) documented that, of the seaweed products available in Tanzania, none were for cosmetic purposes. Subsequently, Kenyan farmers were also trained on how to produce the products found in Tanzania (Msuya, 2016*b*); Mauritius produces mainly pickles using their *Gracilaria* biomass. The marketing of the seaweed products is still not satisfactory. The women sell their products mostly to tourists, passers-by and in exhibitions both in the country and neighbouring countries such as Burundi, Rwanda, Kenya and Uganda.

In Tanzania, most of the people working on value-added products from seaweeds are women. Using the ZaSCI as an example, data obtained through telephone conversations show that the percentage of female, small-scale processors varied between 57–100%; half of these had above 80% women participation (Fig. 4). For example, in Kidoti village (North), the group that deals with value-addition consists of 19 members (plus two recently passed away), all of whom are women; in Paje (East) there are 36 members, all women, in Bweleo (South-west) there are about 30 participants, of whom only two are men and in Fujoni (near Stone Town) there are 15 members and only one is male. There are also those adding value to cultivated biomass who are not farmers. At the time of writing, there were three (located in Zanzibar town) and at least 60% of them are women.

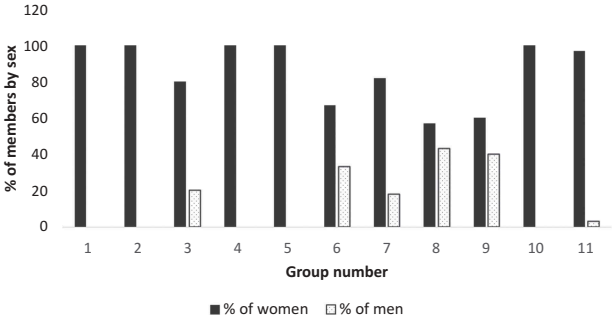


Fig. 4. Percentage of females involved in seaweed value-addition in Tanzania. Source: Interviews in this study. Numbers indicate the groups, as follows: 1=Ukweli Ni Njia Safi, Bweleo; 2=Bado Tupo Bweleo, Bweleo; 3=Jitegemee, Bweleo; 4=Tusife Moyo, Kidoti; 5=Furahia Wanawake, Paje; 6=Ulezi Una Kazi, Fujoni; 7=Sie Kwa Sie, Uroa; 8= Tumeendelea, Muungano; 9=Zaidat Products, Chukwani; 10=Huasa Za Trading, Amani; 11=Umoja wa Mwani Makangale (UMWAMA), Pemba.

In Kenya, amongst the farmers who were trained in value-addition during the 2015 FAO Technical Cooperative Projects (Msuya, 2016*a*,*b*), the percentage of women participants in the first training course (n=70) was 61%; in the second course (n=80), 64% were female. Since the course some of the women have started to produce and sell value-added products within Kenya. Mozambique reported that it would undertake market studies in order to initiate value-addition to their cultivated seaweed raw materials (INAQUA, 2011).

South-East Asia

Only anecdotal observations attest to the involvement of women in seaweed-carrageenan value-addition in SE Asia. Several women in the Bicol region were trained in making seaweed noodles and pasta (Hurtado, personal observation). Though home-made seaweed pickles, candies and jams were prepared by women in the villages, no official report has been made as to the acceptance of the products and success of the sales efforts. Processing of seaweed to carrageenan is mainly undertaken by large companies (local and multi-national) in the South-East Asian region.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Author contributions

F.E. Msuya: reviewed and analysed information on Western Indian Ocean and and collated the general review; A.Q. Hurtado: reviewed and analysed information on

South-East Asia; both authors are responsible for the original review concept.

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References

Abbott, I.A. & Norris, J.N. (1985). *Taxonomy of Economic Seaweeds: With Reference to Some Pacific and Caribbean Species*. California Sea Grant Program, La Jolla, California.

Aming, N. (2004). *Participation of Filipino Muslim women in seaweed farming in Sitangkai, Tawi-Tawi, Philippines*. PhD dissertation, University of the Philippines in Los Banos, Laguna, Philippines, 129 pp.

AREU – Agricultural Research and Extension Unit (2011). *Uses of Seaweed in the Food Sector in Mauritius*. Mauritius Research Council, Mauritius.

Barraca, R.T. and Neish, I.C. (1978). *A survey of* Eucheuma *farming practices in* Tawi-Tawi. I. The Sitangkai, Sibutu, Tumindao *Region*. Report, Marine Colloids (Phils.) Inc., Philippines, 65 pp.

Blue Ventures (2015). https://bjyv3zhj902bwxa8106gk8x5-wpengine.netdna-ssl.com/wp-content/uploads/2015/10/BV-Aquaculture-Factsheet-2015.pdf.

CEVA - Centre for the Study and Promotion of Algae (2011). *Study of Algal Biodiversity for Economic Development in Mayotte. Volume 1: Preliminary Study of Existing Algal Species*. CEVA, Pleubian, France.

Cooke, F.A. (2004). Symbolic and social dimensions in the economic production of seaweed. *Asia Pacific Viewpoint*, **45**: 387–400.

Eklöf, J.S., Msuya, F.E., Lyimo, T.J. & Buriyo, A.S. (2012). Seaweed farming in Chwaka Bay: a sustainable alternative in aquaculture? In *People, Nature and Research in* Chwaka Bay, *Zanzibar, Tanzania* (de la Torre-Castro, M. & Lyimo, T.J., editors), 213–233. WIOMSA, Zanzibar Town.

Eklund, S. & Pettersson, P. (1992). Mwani is money: the development of seaweed farming and its socio-economic effects in the village of Paje. Development Studies Unit Working Paper No. 24, Department of Social Anthropology, Stockholm University.

Eranza, D.R.D., Alin, J., Bahron, A. & Mahmud, R. (2015). Determinants of women's participation in seaweed farming in the Regency of Jenoponto, South Sulawesi, Indonesia. *Mediterranean Journal of Social Sciences*, **6**: 43–45.

FAO (2013). *Helping Seaweed Farming Flourish after Typhoon hits Philippines*. www.fao.orn/in-action/helping-seaweed-farming-flourish-after-typhoon-hits.

FAO (2015). *Typhoon Haiyan – Portraits of Resilience*. FAO, Manila.

FAO (2016). *The State of World Fisheries and Aquaculture 2016. Contributing to Food Security and Nutrition for All*. FAO, Rome. 200 pp.

Hurtado, A.Q. (2005). *The Role of Women and Children in Seaweed Farming Activities in the Philippines and Environmental Impacts of Seaweed Farming*. Technical Report to IFC, CIDA and AusAid. 43 pp.

Hurtado, A.Q. (2013). Social and economic dimensions of carrageenan seaweed farming in the Philippines. In *Social and Economic Dimensions of Carrageenan Seaweed Farming* (Valderrama, D., Cai, J., Hishamunda, N. & Ridler, N., editors), 91–113. Fisheries and Aquaculture Technical Paper No. 580. FAO, Rome.

Hussin, R., Yasir, S.M., Kunjuraman D. & Hossin, A. (2015). Enhancing capacity building in seaweed cultivation system among the poor fishermen: a case study in Sabah, East Malaysia. *Asian Social Science*, **11**: 1–9.

Immanuel, S. & Sathiadhas, R. (2004). Employment potential of fisherwomen in the collection and post harvest operations of seaweeds in India. *Seaweed Research and Utilization*, **26**: 209–215.

INAQUA (2011). *Estudo de mercado, estratégia de adição de valor e comercialização de algas marinhas. Relatório final*. National Institute of Aquaculture, Mozambique.

Kaliaperumal, N., Kalimuthu, S. & Ramalingam, J.R. (2004). Present scenario of seaweed exploitation and industry in India. *Seaweed Research and Utilization*, **26**: 47–53.

Krishnan, M. & Narayanakumar, R. (2010). *Socio-economic Dimensions of Seaweed Farming in India*. Central Marine Fisheries Research Institute (CMFRI) Special Publication No. 104, Kochi, ISSN 0972 – 2351, 99 pp.

Krishnan, M. & Narayanakumar, R. (2013). Social and economic dimensions of carrageenan seaweed farming in India. In *Social and Economic Dimensions of Carrageenan Seaweed Farming* (Valderrama, D., Cai, J., Hishamunda, N. & Ridler, N., editors), 163–184. Fisheries and Aquaculture Technical Paper No. 580. FAO, Rome.

Lim, P.-E, Yang, L.-E., Tan, J., Maggs, C.A. & Brodie, J. (in press). Advancing the taxonomy of economically important red seaweeds (Rhodophyta). *European Journal of Phycology*.

Mshigeni, K.E. (1973). Exploitation of seaweeds in Tanzania. The genus *Eucheuma* and other algae. *Tanzania Notes and Records*, **72**: 19–36.

Mshigeni, K.E. (1976). Seaweed farming: a possibility for Tanzania's Coastal Ujamaa villages. *Tanzania Notes and Records*, **79/80**: 99–105.

Mshigeni, K.E. (1992). Seaweed farming in Tanzania, a success story. In *Proceedings of the First International Workshop on Sustainable Seaweed Resource Development in Sub-Saharan Africa* (Mshigeni, K.E., Bolton, J., Critchley, A. & Kiangi, G., editors), 221–245. Windhoek, Namibia.

Msuya, F.E. (2006a). The impact of seaweed farming on the social and economic structure of seaweed farming communities in Zanzibar, Tanzania. In *World Seaweed Resources: an Authoritative Reference System* (Critchley, A.T., Ohno, M. & Largo, D.B., editors). ETI BioInformatics, Amsterdam.

Msuya, F.E. (2006b). The Seaweed Cluster Initiative in Zanzibar, Tanzania. In *Proceedings of the 3rd Regional Conference on Innovation Systems and Innovative Clusters in Africa* (Mwamila, B.L.M. & Temu, A.K., editors), 246–260. Dar es Salaam, Tanzania.

Msuya, F.E. (2010a). Development of seaweed cultivation in Tanzania: the role of the University of Dar es Salaam and other institutions. In *Aquaculture Compendium*. CABI, Wallingford.

Msuya, F.E. (2010b). Innovation of the seaweed farming industry for community development: The case of the Zanzibar Islands, Tanzania. In *Proceedings of the 1st Annual Agricultural Research Review Workshop, "Agricultural Research - A Gateway towards the Green Revolution"* (Mnembuka, B.V., Akil, J.M., Saleh, H.H. & Mohammed, M.S., editors), pp. 59–74.

Msuya, F.E. (2011a). The impact of seaweed farming on the socioeconomic status of coastal communities in Zanzibar, Tanzania. *World Aquaculture*, **42**: 45–48.

Msuya, F.E. (2011b). Environmental changes and their impact on seaweed farming in Tanzania. *World Aquaculture*, **42**: 34–37.

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Msuya, F.E. (2011c). *Seaweed Farming in Mauritius and Rodrigues. Phase II: Hands-on Training Workshop on Seaweed Farming for Stakeholders/fisher Groups in Mauritius and Rodrigues*. Consultant Report Submitted to Mauritius Research Council – MRC, Mauritius, 80 pp.

Msuya, F.E. (2011d). *Seaweed Farming in Mauritius* and Rodrigues, Phase I: Capacity Building *in Seaweed Farming for Technical Personnel of Mauritius and Rodrigues in Zanzibar*. Consultancy Report Submitted to the Mauritius Research Council – MRC, Mauritius, 39 pp.

Msuya, F.E. (2012). *A Study of Working Conditions in the Zanzibar Seaweed Farming Industry*. Women in Informal Employment: Globalizing and Organizing (WIEGO), Manchester.

Msuya, F.E. (2013). Opportunities in the aquaculture sector of Zanzibar: youths and women in seaweed farming. Report submitted to Food and Agricultural Organization, FAO, 36 pp.

Msuya, F.E. (2016a). Mission report for FAO-KENYA TCP, Mission 2, Consultant in: Seaweed Culture, Processing, Product Development and Marketing expert. Report to Food and Agriculture Organization, FAO Kenya, FAO, 32 pp.

Msuya, F.E. (2016b). Final mission consultancy report, submitted to Food and Agriculture Organization (FAO). Project: FMM/GLO/112/MUL, FAO, 27 pp.

Msuya, F.E. & Porter M. (2014). Impact of environmental changes on farmed seaweed and farmers: the case of Songosongo Island, Tanzania. *Journal of Applied Phycology*, **26**: 2135–2141.

Msuya, F.E., Dickinson, T. & Whittick, A. (1994). *Community in Transition: The Impact of Seaweed Farming on the women of Paje, Zanzibar, Tanzania*. Video, Institute of Marine Sciences, Zanzibar, Tanzania.

Msuya, F.E., Buriyo, A., Omar, I., Pascal, B., Narrain, K., Ravina, J.J.M., Mrabu, E. & Wakibia, J.G. (2014). Cultivation and utilisation of red seaweeds in the Western Indian Ocean (WIO) Region. *Journal of Applied Phycology*, **26**: 699–705.

Msuya, F.E., Muumin, H., & Hamed, S. (2016). Status of aquaculture in the Zanzibar Islands, Tanzania. *World Aquaculture*, **47**: 25–29.

Neish, I.C. (2013). Social and economic dimensions of carrageenan seaweed farming in Indonesia. In *Social and Economic Dimensions of Carrageenan Seaweed Farming* (Valderrama, D., Cai, J., Hishamunda, N. & Ridler, N., editors), 61–89. Fisheries and Aquaculture Technical Paper No. 580. Rome, FAO. 204 pp.

Pettersson-Löfquist, P. (1995). The development of open-water algae farming in Zanzibar: reflections on the socioeconomic impact. *Ambio*, **24**: 487–491.

Porse, H., & Rudolph, B. (2017). The seaweed hydrocolloid industry: 2016 updates, requirements, and outlook. *Journal of Applied Phycology*. doi:10.1007/s10811-017-1144-0

Randriambola, T. & Rafalimanana, T. (2005). L'algoculture ou la culture d'algues rouges du genre Eucheuma. Premier atelier national sur l'aménagement de la pêcherie de céphalopodes, 28–29 juillet 2005. Toliara, Madagascar. 8 pp.

Sade, A., Ali, I. & Mohd. Ariff, M.R. (2006). The seaweed industry in Sabah, East Malaysia. *Jati*, **11**: 97–107.

Shechambo, F., Ngazy, Z. & Msuya, F.E. (1996). *Socio-Economic Impacts of Seaweed Farming in the East Coast of Zanzibar, Tanzania*. Report submitted to the Canadian International Development Agency (CIDA), Institute of Marine Sciences, University of Dar es Salaam, Zanzibar, Tanzania, IMS 1997/06, 81 pp.

Suhaimi, Y. (2011). NKEA – Agriculture EPP 3 – Seaweed mini estate (Community based – Commercial approach). Paper presented in National Key Economic Area (NKEA) Workshop by Department of Fisheries Malaysia, 25–27 January 2011, Melaka.

Zamroni, A. & Yamao, M. (2011). Coastal resource management: fishermen's perception of seaweed farming in Indonesia. *World Academy of Science Engineering and Technology*, **5**: 2011–2020.

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