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Seaweed mariculture as a development project in Zanzibar, East Africa: A price too high to pay?☆

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ABSTRACT

Seaweed mariculture has been promoted as a development project in tropical countries and Zanzibar, Tanzania, is commonly presented as a successful story. However, the results of the present research provide a nuanced picture of the activity identifying serious health problems among farmers. Semi-structured interviews were conducted with female seaweed farmers (n = 140) and non-seaweed farmers (n = 140) in Zanzibar to evaluate health and working conditions. In-depth interviews with additional 28 female seaweed farmers were performed to deepen the understanding of the working conditions and related problems. The research was undertaken at seven different locations to cover areas where seaweed is extensively executed during August to September 2009 and May to June 2010. Seaweed farmers considered their health significantly poorer than non-seaweed farmers with fatigue, musculoskeletal pain, hunger, respiratory problems, eye related problems, injuries from hazardous animals and sharp shells in the water and allergies as the most serious issues ($p<0.05$). Income was further reported below the extreme poverty line. Since seaweed farming affects thousands of households in the tropics these results should encourage changes towards better working conditions and sustainability.

1. Introduction

There is an urgent need in tropical developing countries to create new alternative livelihoods that are able to break poverty traps and promote local development (e.g. Cinner et al., 2010; de la Torre-Castro and Lindström, 2010). Seaweed farming is one such activity and in the last decades it has expanded rapidly from its original production in the Philippines (Doty and Álvarez, 1975) to a wide variety of locations practically covering most tropical areas. Commercial production is found in China, French Antilles, Indonesia, Kiribati and Malaysia (Ask and Azanza, 2002 and references therein). Cambodia, Fiji, South Korea, the Solomon Islands and Vietnam are other important production sites (McHugh, 2006). As the demand for carrageenan (i.e. a polysaccharide used as stabilizing, emulsifying and thickening agent in food, cosmetics and pharmaceuticals) increases, new areas are continually explored for commercial production. For example, research is undertaken in Brazil (Pellizzari and Reis, 2011), India (Bindu, 2011), Kenya (Wakibia et al., 2006), Madagascar (Msuya, pers. comm.), and Mexico (Muñoz et al., 2004). Tanzania has further been an important global producer (Lirasan and Twide, 1993; McHugh, 2006) with much of the product deriving from Zanzibar. In Zanzibar, the commercial activity was introduced in 1989 and research shows that it has been strongly encouraged as a sustainable form of aquaculture with high socio-economic benefits (Bryceson, 2002; Pettersson-Löfquist, 1995). With the support of USAID, seaweed farming was soon promoted and implemented as a "development project" on the Island (Forss, 2010) and has become widely established in the coastal villages as one of the most important economic activities (de la Torre-Castro and Rönnbäck, 2004; Lange and Jiddawi, 2009) involving nearly 20 000 people of which a clear majority are women (Jiddawi and Khatib, 2007). The immediate effects, such as creating working opportunities for women and increasing the quality of life in rural households, have been documented (e.g. Msuya, 2006; Pettersson-Löfquist, 1995). This documentation has further been used to illustrate seaweed production in Zanzibar as a "success story" in aquaculture and as a tool for coastal

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development (e.g. Bryceson, 2002; Costa-Pierce, 2010; Pellizzari and Reis, 2011). However, follow up in-depth studies on the continuity of the alleged initial benefits, including the present situation, are limited. A "seaweed farming discourse" has evolved to portray the activity as positive despite the lack of recent empirical data to back up the affirmations (Forss, 2010). In addition, concerns have been raised regarding the social-ecological impacts of the activity (e.g. de la Torre-Castro, 2006; Eklöf, 2008). Rönnback et al. (2002) draw the attention to the neo-colonial exploitation policy of the multinational companies operating in Zanzibar; Bryceson (2002) points out the problem of low income, multinational domination and the women quitting the activity due to non-benefits compared to workload. Pettersson-Löfquist (1995) warned about the market effects on women and the huge social and cultural societal changes accompanying the activity. Questions related to the health of women working on the farms have also been raised (de la Torre-Castro, 2006; Forss, 2010). Regarding the environmental effects, it has been shown that the seaweed farms could have negative effects on seagrasses (Eklöf et al., 2006a), macrofauna (Eklöf et al., 2005, 2006a), meiofauna (Ólafsson et al., 1995), microbial processes (Johnstone and Ólafsson, 1995), and changing fish community assemblages (Bergman et al., 2001; Eklöf et al., 2006b). In addition, Collén et al. (1995) and Mtolera et al. (1995) reported the formation of hydrogen peroxide and halogenated compounds negative for seagrasses and other organisms.

The objective of this study was to address female seaweed farmer's health status in Zanzibar. Health issues as an externality of seaweed farming have hitherto more or less been overlooked locally, regionally, and globally. Although health problems are mentioned in previous studies (de la Torre-Castro, 2006; Forss, 2010) an in depth systematic study has to our knowledge not been done. Previously identified health problems include back pain, eye related problems, headache, injuries caused by sharp shells (e.g. pen shells, Pinnidae) and hazardous animals (e.g. stone fish and sea urchins), and the exposure to toxic vapors released by the algae (hydrogen peroxide and halogenated compounds) (e.g. de la Torre-Castro, 2006; Forss, 2010). These problems are clearly associated with poor working conditions, intensive work and long exposure to sun, wind and seawater. In the present research, a list of health problems was developed (Table 1), and an analysis was done to identify to what extent these health problems are present among seaweed farmers compared to non-seaweed farmers. More specifically, this was tested empirically by using semi-structured and in-depth interviews to 1) obtain a general overview of seaweed farmers working conditions, 2) identify occupational health problems among seaweed farmers, and 3) identify possible differences in health between women involved in seaweed farming *only* and women involved in seaweed farming *and* additional livelihoods. The results were then placed in a broader social-ecological perspective in an effort to understand environment, health and sustainability links.

The issue of health-related problems linked to environmental sustainability has been prioritized in the research agenda globally (IHDP UPDATE, 2011). Research about health-related problems in aquaculture is scarce but recently it has been raised as a crucial part of the aquaculture industry problems (Cole et al., 2009). For example, occupational hazards were found to be higher in aquaculture than in agriculture and similar issues as the above were identified, i.e. risk of drowning, musculoskeletal injuries, heavy lifts, repetitive motion tasks, long-term exposure to strong sun, wind, water, etc. (Cole et al., 2009; Douglas, 1995). Shimada et al. (1990) also identified similar health issues among men and women involved in seaweed farming in Japan. Since seaweed farming has implications for thousands of poor households worldwide and the Zanzibar case is normally used as a positive example, the results and discussions in this paper should provide a nuanced picture that helps change the trajectory of this important livelihood towards improved working conditions and sustainability. The revaluation of this activity further requires a revision of seaweed farming contributing to coastal development.

2. The seaweed farming cycle in Zanzibar

Two species of seaweed are farmed in Zanzibar, *Kappaphycus alvarezii* (formerly known as *Euchema cottonii*) and *Euchema denticulatum* (formerly known as *Euchema spinosum*) (Lirasan and Twide, 1993). The world demand is higher for *K. alvarezii* than for *E. denticulatum* since the gel extracted from the first is stronger and of higher quality. The price per dry kg of seaweed in Tanzania when the study was conducted was 240 Tanzanian shillings (TZS) for *K. alvarezii* and 160 TZS for *E. denticulatum* (one USD was equivalent to about 1200 TZS) (Department of Fisheries and Marine Resources (DFMR), pers. comm.). However, *K. alvarezii* is sensitive to adverse conditions, which has led to disease problems and die-offs and today the less valuable species *E. denticulatum* is widely grown in Tanzania (Msuya et al., 2007). All seaweed in Zanzibar is for export and no processing of seaweeds into carrageenan takes place on the Island, thus except for seaweed soap and some locally consumed food products (Msuya, 2010, 2011) no added value is produced (de la Torre-Castro, 2006). The most commonly used farming technique is the "off bottom" method (Figs. 1 and 2), carried out in shallow intertidal areas. The method is relatively simple: once a cultivation area is selected seaweeds are tied to plastic strings (locally known as tie-ties) and further tied to nylon ropes stretched between mangrove or land-based wooden sticks inserted into the sediment (Lirasan and Twide, 1993). A "plot" (farm) consists of 25–50 lines; farmers can own many plots depending on the farmer's strength/assistance received. The seaweeds are grown for five to six weeks until they are harvested. During this period

Table 1
Health problems associated with seaweed farming.*

Health problems	Possible cause
Allergies	Exposure to salt water
Asthma	Exposure to toxic vapors when algae are stored in the household
Respiratory problems	Exposure to toxic vapors when algae are stored in the household
Parasites	Exposure to seawater and contact with the substrate
Bladder infections	Pathogenic organisms (bacteria, fungi, or parasites) in the urinary tract. Also by waiting too long to urinate
Skin problems	Exposure to salt water and sunlight
Ear infections	Exposure to salt water
General eye problems	Exposure to strong sunlight and reflection in the water
Hunger	Long workdays with insufficient or no food
Headache	Long workdays without access to drinking water, food and time to rest
General fatigue	Long hours and labor intensive work
Back pain	Deep forward bending postures during farming process. Also heavy lifting of seaweed over head and shoulders
Other pains (hips, leg, neck, waist)	Deep forward bending postures during farming process. Also heavy lifting of seaweed over head and shoulders
Hazardous animals /sharp shells	Injuries by sharp shells and various hazardous animals hidden in the bottom vegetation in the farming areas
Other problems (diabetes, high blood pressure)	Labor intensive work with little time to eat, drink and rest properly

* Developed from: de la Torre-Castro (2006), Forss (2010) and Shimada et al. (1990).

the farms need maintenance such as retying lost seaweed and clearing of sediments and epiphytes (Pettersson-Löfquist, 1995). The farmers normally work according to a rotational scheme so that one part of the farm is ready to harvest every fortnight (Forss, 2010). At harvesting, seaweeds are removed from the line and some shoots are re-tied. The seaweeds are then carried or dragged to the beach, or home, for drying and storage. The dry seaweeds are packed in sacks of 25–50 kg and sold to local representatives of the transnational companies. Farming activities usually take place during spring tide, which allows farmers to work efficiently with harvesting activities for up to 5 h per day (Pettersson-Löfquist, 1995). During neap tides they normally clean and sort the dried seaweeds and prepare nylon ropes (de la Torre-Castro and Rönnbäck, 2004).

Despite the relatively simple farming technique the amount of work is substantial and puts a lot of physical stress on the body (de la Torre-Castro and Lindström, 2010). During preparation of ropes, planting, maintenance and harvesting activities farmers adopt unfavorable body postures, i.e. forward bending for long hours, while exposed to sun, wind and seawater which result in musculoskeletal pains, headache, general fatigue and eye injuries (de la Torre-Castro, 2006; Forss, 2010). The transportation of heavy seaweeds from the water to the beach and household (ranging from a few hundred meters to several kilometers, pers. observation) adds to the workload (Forss, 2010). In addition, farmers and their families are exposed to toxic vapors when seaweeds are stored at home (de la Torre-Castro, 2006).

3. Methods

The study was based on a triangulation of data based on semi-structured interviews, in-depth interviews and participant observation (e.g. Denscombe, 2007; Kvale, 1994). In addition, information and documents from the Department of Fisheries and Marine Resources (DFMR) in Zanzibar was gathered. Interviews were carried out in seven different villages (Chwaka, Kidoti, Marumbi, Nyamanzi, Paje, Uroa and Uzi island) on Zanzibar island (Fig. 3) during August to September 2009 and May to June 2010. Seaweed farming is performed throughout the year with some variation in work inputs depending on the amount of precipitation (less input is made during the rainy periods). For the purpose of the study, it was considered that this temporal variation would not affect the farmers' overall opinion about their general health status. The sites were selected to cover areas around the Island where seaweed farming is widely practiced, i.e. representative for the study. Farming activities were dominated by women in all seven villages and semi-structured interviews were held with female seaweed farmers (n = 140) and non-seaweed farmers (n = 140) (control group). Twenty-eight additional female seaweed farmers were further interviewed using the depth-interview technique. All interviews were performed in Kiswahili with the assistance of a local interpreter and answers were recorded for further analysis using a dictaphone. About one week was spent in each village, which helped to establish a better contact with the respondents. Duration of interviews was 30 to 40 min, on average.

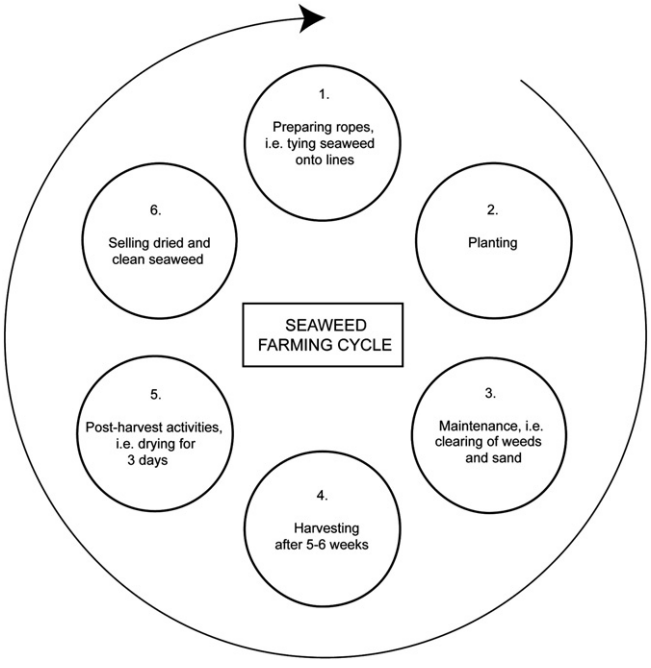

Fig. 1. The seaweed farming cycle illustrating the off-bottom method.

3.1. Semi-structured interviews

Twenty female seaweed farmers between age 18 and 80 (median 37 years) and 20 women between age 19 and 80 (median 31 years) involved in other various livelihoods (e.g. small-scale business, dressmaking, teaching and agriculture) were interviewed in each of the seven villages, summing up to a total of 140 women in each group. The interviews were designed to capture information on seaweed farmers' general work situation and health status. Questions about personal background information (age, number of children, household size) and work situation (years active in the industry, farming alone or in group, workload, income, involvement in additional livelihood activities) were also asked (Appendix A). Background information about the control group is found in Appendix B. The same questions regarding health, based on Table 1, were asked to both groups in order to make comparisons; by default the control group interviews were shorter (i.e. the questions related to seaweed farming did not apply).

3.2. In-depth interviews

To deepen the understanding of the situation, four in-depth interviews in each village were carried out with additional seaweed farmers. A total number of 28 female seaweed farmers between age 16 and 80 (median 40 years) participated in the in-depth interviews. The women participating in the in-depth interviews were different from the women who participated in the semi-structured interviews. The discussion mainly focused on three thematic areas: the reason for becoming a seaweed farmer, how they perceive their work situation, and the reason for continuing farming seaweed. These interviews differed from the semi-structured interviews in that the women were able to speak freely on each theme with little direction from the researcher/interpreter.

3.3. Statistical and qualitative interview analysis

The answers provided on health issues in the semi-structured interviews were transcribed and coded into answer groups ("positive" and "negative") to perform further analysis. Bivariate statistics were used to determine the differences between perceived health status of seaweed farmers and non-seaweed farmers. The Fisher exact test was then used to determine significant differences between the groups. In order to further analyze the seaweed farming group, a distinction was made between seaweed farmers with farming as *sole* activity (n = 28) and those working with seaweed *and* were engaged in additional livelihoods (n = 112). These two sub-groups were however unbalanced in that most seaweed farmers also engaged in additional livelihood activities. However, this imbalance was considered

Fig. 2. Photos of seaweed farming activities: A) the seaweed farms in Kidoti are situated far from the village, B) seaweed farms located in the intertidal zone in Uroa, C) a woman harvesting seaweed in Uzi island, D) a woman is filling old rice-sacks with seaweed in Uroa, E) carrying the sacks to the beach or F) dragging the whole nylon rope with attached seaweed to the beach, G) seaweed placed on the ground to dry in Chwaka village, and H) seaweed being dried at home to be cleaned and sorted before selling.
Photos: S. Fröcklin.

when performing the analysis. The statistical analyses were performed with the “”Stata version 11-programme. In-depth interviews were transcribed and thoroughly analyzed by developing categories according to the statements and the relevance for the study. Categories included seaweed farmer's thoughts about e.g. income, workload, health problems and the lack of other economic activities.

4. Results and discussion

4.1. General work situation of seaweed farmers

The most common response from the respondents regarding work situation was that seaweed farming was energy consuming and physically hard work in relation to the low income. However, they expressed that alternative economic activities were few and that the only income generating activities available in the villages were: agriculture, handicraft, cutting firewood and charcoal, collecting invertebrates, cooking and selling food. Yet, few other activities generated any regular income and to secure household income most women had no other choice but to engage in seaweed farming despite its perceived negative aspects. However, many women expressed a wish to engage in small-scale business, such as selling local fabrics (*kangas*), but the lack of financial resources hindered them. The following quotations illustrate the general work situation of seaweed farmers:

“The price (of the algae) is low compared to the work load. Seaweed has no profit…” Female seaweed farmer in Chwaka village, 70 years old (2009).“Seaweed farming is a very long process such as cutting sticks, tying seaweeds, planting, waiting for the seaweed to grow and then harvesting, filling and carrying the sacks. We get some income but it's not enough…” Female seaweed farmer in Kidoti village, 29 years old (2010).

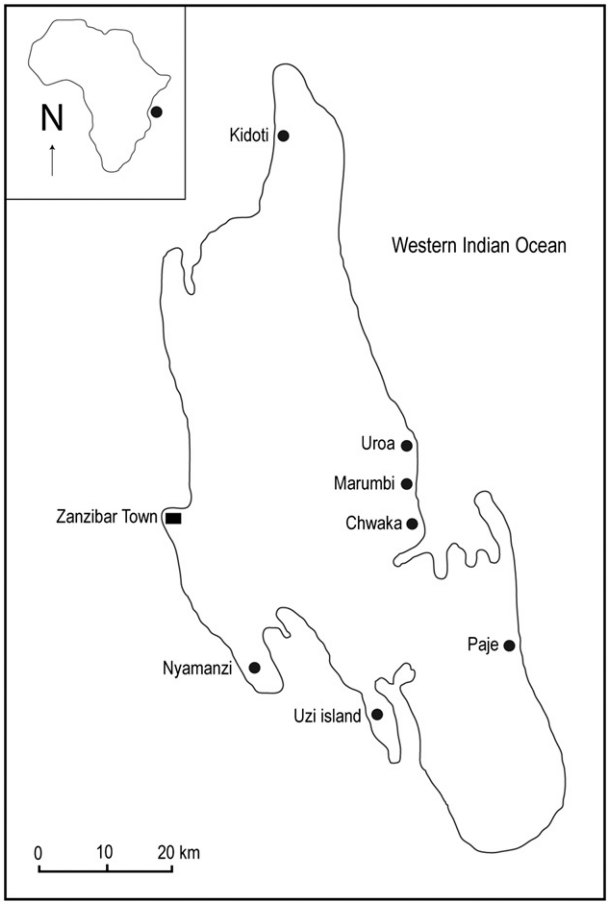

Fig. 3. Study area Unguja island (Zanzibar, Tanzania). 6° 8′ 0″ S. 39° 19′ 0″ E. Sampled villages (n = 7) are shown with blackdots.

Farming activities were spread throughout the day depending on the tides and planned work. Women accompanied each other to the farms while 68% worked alone. This was reported to be due to poor health, which made it hard to match the capacity of group members, or simply because they did not want to share their income. The results further show that women spent on average three and a half hours per day on planting, maintenance and harvest activities. When they returned from the sea they spent an additional two and a half hour on post-harvest activities. In addition to time spent on the activity the income generated was reported as extremely low. The calculations showed a median daily income of 1480 TZS (equivalent to approximately one USD). An average basket trap fisherman earns approximately 3000 TZS per day (about three USD) (de la Torre-Castro and Rönnbäck, 2004). Thus, most seaweed farmers' earnings were below the absolute poverty level and only 15% reported that they could not rely on seaweed farming as a single income. To survive on seaweed farming only, the farmers needed to maintain a large number of plots, which is difficult for single farmers. Accordingly, 65% of the farmers were involved in additional livelihoods to make ends meet. Cooking, baking, embroidery, invertebrate collection, small scale agriculture, cutting mangroves and charcoal were reported to be important activities adding to the total household income. In the control group only 37% of the women were engaged in additional livelihoods.

About half of the seaweed farmers (46%) considered seaweed farming a good job. When asked to describe the pros and cons associated with the activity most women answered income as the only pro. Even though the income was low, and not enough to sustain a household, it still supported children's education and contributed to the household income. However, the list of cons is longer. The low price of seaweed in relation to workload was an issue of great concern. Many women also complained about harsh weather conditions, which destroyed the seaweed and thereby reduced the income. In the villages where boats are required to reach the farms, women mentioned problems with transportation. Others were worried about the lack of farming materials. However, the most serious issue that was identified was occupational health hazards. Tiredness and various forms of pains were among the most frequently mentioned problems. Consequently, 75% of the seaweed farmers clearly demonstrated a wish for their children to get an education in order to have a good job so as to avoid getting involved in seaweed farming. Paradoxically, most young girls follow the same path as their mothers and the women said that if there were no other jobs available at that time, they would prefer their children to engage in seaweed farming rather than “hang around doing nothing”. In addition, the women in the control group reported health problems and hard work in relation to low income as the main reason to *not* engage in seaweed activities. Some of the women in the control group have previously been involved in seaweed farming, while others based their assumption on hear-say. The findings were supported by the in-depth interviews and the most common responses to the question of how they got involved in seaweed farming and how come they continue farming seaweed were:

“I continue because I have nothing else to do. Even though the price is very low I still continue. But I also make local hats and farm cassava.” Female seaweed farmer in Paje village, 34 years old (2009).“Farming seaweed is very difficult. It takes a lot of energy to work in the sea and carry the seaweed from the water to the shore. But we have nothing else to do. Concerning the health… it's not good! It's a long distance from the sea to the village. The profit is also very low…” Female seaweed farmer in Uzi island, 38 years old (2010).

4.2. Occupational health problems

According to the semi-structured interviews women involved in seaweed farming activities perceived their health to be poorer than non-seaweed farmers (Table 2; Fig. 4). When they were asked to describe their general health status only 46% of the seaweed farmers answered that their health was good compared to 84% of the non-seaweed farmers. In addition, 46% of the women in the control group perceived their health to be better than seaweed farmers. The following quotations illustrate general responses given by seaweed farmers on the issue of health problems:

> *"I get pain in my legs when farming seaweed and I have also been stung by a poisonous fish three times." Female seaweed farmer in Paje village, 34 years old (2009)."If you think that seaweed farming is hard, it will be hard. I try to think that it's easy to learn and I combine it with studies so I manage quite well. But the seaweed farmers seem to have bad health, and look old even if they're young." Female seaweed farmer in Chwaka village, 16 years old (2009).*

Differences in health status were further significant for nine of the 15 listed health problems (Table 2; Fig. 4). The most frequently reported problems were general fatigue ($p<0.0001$), pain in leg, neck, waist, and ribs ($p<0.001$), hunger ($p<0.0001$), low back pain ($p=0.001$), respiratory problems ($p<0.0001$), eye related problems ($p<0.01$), injuries caused by sharp shells and hazardous animals in the water ($p<0.0001$), allergies ($p<0.0001$) and headache ($p=1$). These results were also supported by in-depth interviews where 23 of the 28 interviewed seaweed farmers indicated that they associated seaweed farming with poor health and identified a number of risks related to farming activities (Table 3). Furthermore, according to the semi-structured interviews 44% of the women considered seaweed farming as having negative effects on children. This was also supported by the in-depth interviews where women reported how children show symptoms such as coughing and fever when seaweeds are stored at home. A possible explanation to these problems could be the exposure to toxic vapors released from the algae during the drying process (de la Torre-Castro, 2006; Forss, 2010). Similar health problems have also been shown among fish farm workers due to the exposure to toxic chemicals (Cole et al., 2009) and terrestrial farm workers when working in dusty fields and when handling e.g. moldy hay (Grisso et al., 2009).

Asthma, skin problems and bladder infections were among the least reported health problems among seaweed farmers and showed no significant differences compared to the control group. Small differences in asthma between the groups may be related to generally poor living standards and exposure to dust and airborne

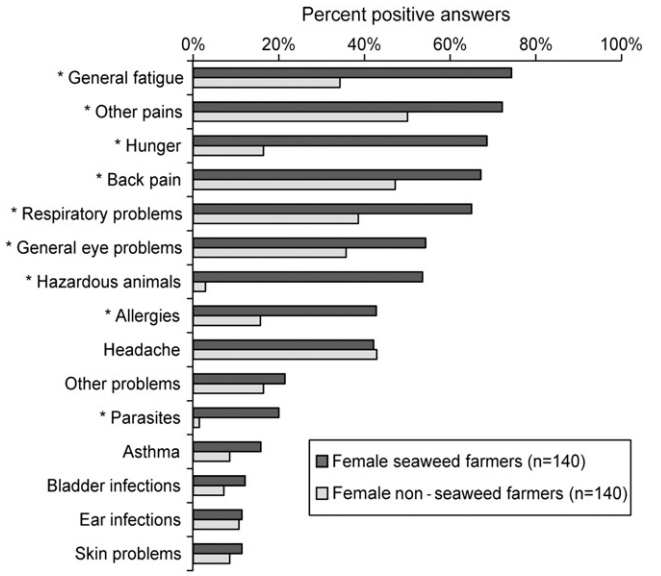

Fig. 4. Differences in health problems between female seaweed farmers (n = 140) and female non-seaweed farmers/control (n = 140). Significant values $p<0.05$, shown as *.

Table 2
Percentage of all participants (seaweed famers vs. non-seaweed farmers/control) who chose each problem from a list in response to the question; "Do you suffer from any of these health problems?".

Health problems	Seaweed farmers (%) n = 140	Non-seaweed farmers (%) n = 140	Significant differences (p-value) between the two groups*
General fatigue	74	34	<0.0001
Other pains (hips, leg, neck, waist)	72	50	0.0002
Hunger	69	16	<0.0001
Back pain	67	47	0.0010
Respiratory problems	65	39	<0.0001
General eye problems	54	36	0.0026
Hazardous animals/sharp shells	54	3	<0.0001
Allergies	43	16	<0.0001
Headache	42	43	1
Other problems (diabetes hypertension)	20	16	0.3601
Parasites	20	1	<0.0001
Asthma	16	9	0.0696
Bladder infections	12	7	0.2239
Ear infections	11	10	1
Skin problems	11	9	0.5508

* p-value in Fisher's exact test. Significant values at <0.05.

Table 3
Number of seaweed farmers who during in-depth interviews, independently and spontaneously, listed various health problems as directly linked to seaweed farming practices.

Health problems	Seaweed farmers n = 28
Other pains (hips, leg, neck, waist)	18
Headache	13
Back pain	12
Chest pain	10
General fatigue	8
General eye problems	5
Hazardous animals/sharp shells	3
Other problems (diabetes, high blood pressure)	2
Hunger	1
Allergies	0
Asthma	0
Bladder infections	0
Ear infections	0
Parasites	0
Respiratory problems	0
Skin problems	0

Table 4
Differences in health status between women working with seaweed farming only and women working with seaweed farming and additional livelihoods.

Health problems	Seaweed farming and additional livelihoods (%) n = 112	Seaweed farming only (%) n = 28	Significant differences (p-value*) between the two groups
General fatigue	77	70	0.226
Other pains (hips, leg, neck, waist)	77	71	0.019
Back pain	70	62	0.261
Hunger	70	69	0.651
Respiratory problems	68	64	0.186
General eye problems	58	56	0.091
Hazardous animals/sharp shells	49	54	0.037
Headache	46	42	0.054
Allergies	44	41	0.525
Other problems (diabetes, hypertension)	23	17	0.441
Parasites	22	23	0.198
Asthma	17	16	0.566
Ear infections	14	12	0.042
Bladder infections	13	14	1.000
Skin problems	10	9	0.315

* p-value in Fisher's exact test. Significant values at <0.05.

particles, which affect all women. The low number of affected women could further be a result of the difficulty to distinguish between asthma as a chronic condition and respiratory problems, including a wide range of health problems from colds to permanent lung damage such as Farmer's lung (Grisso et al., 2009). In terms of skin problems general climate features, such as hot and humid weather, may explain the small differences between the two groups. However, hot and humid weather in combination with the exposure to wet working conditions may contribute to the risk (Belsito, 2005). Apparently, bladder infections affected women of all occupations to a similar degree which is probably a result of poor sanitation and crowded conditions at housing sites, which increase the risk for infectious diseases and bacterial growth (National Center for Farmworker Health (NCFH), 2009). Yet, there is a small overrepresentation of seaweed farmers compared to the control group (12 to 7), which could be due to the offshore locations of farms and lack of toilets, in combination with the exposure to seawater.

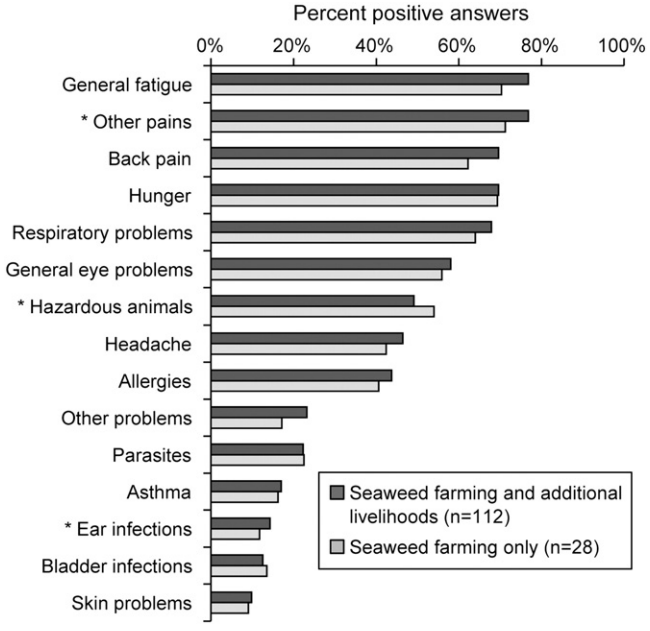

Fig. 5. Differences in health status between female seaweed farmers with additional livelihoods (n = 112) and female seaweed farmers involved in seaweed farming activities only (n = 28). Significant values p<0.05, shown as *.

To isolate the effects of seaweed farming, the differences between women working with seaweed *only* and women involved in seaweed farming and other livelihood activities were analyzed. The analysis revealed that there are hardly any differences in health between the two groups (Table 4; Fig. 5). These results were surprising as it was expected that the engagement in several livelihood activities would significantly affect the health status as the workload increases. Apparently, seaweed farming alone, regardless of additional activities, has serious negative effects on farmer's health. The main conclusion from this analysis is that adding more activities increases the burden, but it seems that the major burden is already set by the heavy work associated with seaweed farming. Despite poor health far from all respondents (33%) visits the doctor when sick. To the contrary, most women work despite illness or pregnancy due to poor living standards and the risk of losing income.

The results from this study show that seaweed farming negatively affected women's health, regardless of age and time spent involved in the activity. This corresponds to the results found by Shimada et al. (1990), where also younger farmers showed musculoskeletal injuries as a result of intensified work under harsh conditions. It was further demonstrated that back pain was caused not only by heavy physical work but also by lighter workloads. In addition, dizziness, headache, general fatigue and a greater tendency to catch colds were identified as closely related to the work environment. Apparently, health hazards are present in a short time perspective but what are the long-term consequences of poor health? Seaweed farming shows similar features to agriculture and numerous studies on occupational health problems among land farmers show that constant bending, twisting, carrying and handling of heavy objects, and repetitive motions during long hours, result in musculoskeletal injuries (Earl-Richardson et al., 2003). Furthermore, intensified work in combination with hot weather may cause body heat to rise, which could lead to dehydration, electrophyte imbalance, multi-organ failure and even death (Belsito, 2005). Also, waiting too long to urinate promotes chronic urine retention and increases the risk for bladder infections. Urinary retention in turn promotes bacterial growth and stretches and weakens the bladder wall, which promotes chronic infections (NCFH, 2009). Eye problems caused by wind, sun, water and allergenic agents may result in eye infections such as cataracts, which could eventually lead to blindness (Luque et al., 2007). As the narratives of women are alarming and illustrate

the negative health effects, and since comparable problems have been found in other forms of aquaculture, and in similar sectors such as agriculture, this study suggests that there are enough reasons to acknowledge health problems among seaweed farmers. Thus, they must be seriously considered and evaluated in order to prevent negative situations in a short *and* long term perspective. Cole et al. (2009) further argue that occupational health and workplace safety programs need to be better organized and extended around the world in order to improve the situation for workers and reduce the number of injuries within the aquaculture sector.

4.3. Seaweed farming in a broader perspective

Despite a decreasing health status the number of women involved in seaweed farming is still substantial. The lack of stable economic activities and the abandoning of traditional activities force women to continue and unless society's differentiations of gender change, this complex situation will most probably remain the same. Another central issue is related to the low price of seaweed. For example, in Tanzania there are indications that the major seaweed companies controlling most of seaweed production deliberately have kept prices down to increase profits (Bryceson, 2002) and real competition among actors have been difficult to establish (DFMR seaweed farming senior official, pers. comm.). In addition to these issues, seaweed farming can also have various negative effects on the environment such as reduced seagrass biomass, canopy height, shoot density and effects on associated macrofauna and fish assemblages, as demonstrated by Eklöf et al. (2005, 2006a,b). If the latter results are scaled-up, hypothetically seaweed farming may affect the whole coastal zone structure and function. Wide scale effects of aquaculture in the tropics have been seen for example in the transformation of natural habitats such as mangroves for other purposes like shrimp production (Naylor et al., 2000). These negative impacts not only affect surrounding ecosystems, but also local communities as the flow of goods and services might be reduced. Thus, social–ecological aspects of the industry need to be considered and discussed in a more nuanced way. A key aspect of the social–ecological systems approach is the promotion of social–ecological resilience. As it is now, it seems that the activity decreases ecological resilience since the effects of the farms on key ecosystems (e.g. seagrasses) and associated animal species (e.g. micro, macro-fauna and fish) showed to be detrimental. In the social sphere, the health of women might be jeopardized. These issues are of critical importance for policies promoting seaweed farming as an important alternative livelihood. Alternative and sustainable livelihoods should be encouraged; however, policy advice has to be based on solid empirical data that is revised over time and not solely rely on rapid appraisals (de la Torre-Castro and Lindström, 2010). More than twenty years have passed since seaweed was introduced in Zanzibar, but it is still predominantly portrayed as a success. The initial positive effects associated with seaweed farming, such as creation of new job opportunities for women, which increased household income and family welfare, are not obvious today. Instead, as the interviews show, farmers' income was so low that they were forced to engage in additional livelihoods to support their families. Thus, it appears that the social and environmental costs of farming seaweed are substantial and eventually could surpass the actual benefits.

5. Conclusions

This study shows that there is an obvious need to include health issues in the seaweed research, discourse and consideration as a development alternative. In terms of direct effects on communities, and more specifically the farmers themselves, this study points out a number of negative externalities related to farming activities. First, there is a substantial difference in health between seaweed farmers and women involved in other activities, which is the result of poor working conditions such as handling of heavy objects, intensive work, limited access to drinking water for long hours in combination with the exposure to strong sun, wind, seawater and toxic vapors. These health hazards are found in e.g. agriculture as well (e.g. Belsito, 2005; Grisso et al., 2009; NCFH, 2009), but apparently the risks associated with seaweed mariculture, compared to other livelihoods, might be even higher. The most prominent health problems include general fatigue, musculoskeletal pains, hunger, respiratory and eye related problems, injuries from sharp shells and hazardous animals in the water, and allergies. Poor health was reported by women of all ages and regardless of time spent on this activity, which shows that seaweed farming has negative impacts also in a shorter period of time. Second, the income generated from seaweed farming is very low in proportion to the workload and most women are thus engaged in additional livelihood activities. The major burden to women's health seems to be already set when women engage in seaweed farming; further activities do not significantly add to the already poor health but increase the general workload. Third, most women work despite pregnancy or illness, which is most likely a consequence of poor living standards and the risk of losing important income. However, reduced work capacity not only affects the individual woman, but also the whole family's welfare. Arguably, a decrease in health will have repercussions for the society at large and for development; which is the contrary to what planners promote. It is important to improve the understanding of the effects of seaweed farming activities on women's lives and this research thus recommends comprehensive medical studies, management considerations and a thoroughly revision of the activity as a tool for development in tropical areas. There are also indications of an exploitation policy from the companies buying carrageenans, which is shown in a quotation from FMC-Biopolymer: “As a potential seaweed supplier trying to find the best village to work in, you should be delighted to find a village populated by consumers with no or little livelihood options. In this case we call *cottonii* and *spinosum* farming the livelihood of last resort. Today we find the most productive and consistent farmers from villages like these… In these places it is too arid to farm or the soil is unsuitable, and the reefs have been destroyed and fish stocks decimated. Your ultimate goal is to make seaweed farming become a way of life for the villagers. This happens after five or so years. At this stage people don't think too much about the price, they just farmed because they have always farmed. Their children will follow them into that career” (Rönnback et al., 2002). This exploitative attitude of the multinational corporations is important to consider. This study does not aim to draw conclusions at a general level; the results refer only to the island of Zanzibar. However, since several countries globally use similar farming techniques, the findings from this study are believed to be of great value for the industry as such and for the discussion concerning development in coastal areas.

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Appendix A. Background information of female seaweed farmers who participated in the semi-structured interviews (n = 140)

Background information	Chwaka (n = 20)	Kidoti (n = 20)	Marumbi (n = 20)	Nyamanzi (n = 20)	Paje (n = 20)	Uroa (n = 20)	Uzi island (n = 20)
Average age	31.4	39.6	37.1	42.4	45.1	41.4	33.8
Average no. of children	3.4	5.3	4.9	4.4	4.4	3.5	4.0
Average no. of people in the household	6.2	5.9	5.5	5.0	5.7	6.0	5.3
Proportion households where seaweed farming is main income	0.1	0.15	0.15	0.25	0.25	0.1	0.15
Average no. of years active in the industry	9.6	14.2	13.4	6.0	14.5	13.3	12.3
Proportion seaweed farmers who are working alone or in group, respectively	0.45	0.3	0.85	0.85	0.80	0.6	0.6
	0.55	0.7	0.15	0.15	0.20	0.4	0.4
Workload (average no. of hours spent in water and land per day, respectively)	3.5	5.2	3.1	4.2	3.5	3.7	3.9
	2.2	3.2	2.0	2.6	1.8	1.8	2.8
Median daily income from seaweed (USD)	1.9	1.2	2.4	0.6	0.7	0.5	1.7
Proportion respondents involved in additional income-generating activities	0.75	0.7	0.65	1	0.9	0.95	0.55

Appendix B. Background information of women not involved in seaweed farming who participated in the semi-structured interviews (n = 140)

Background information	Chwaka (n = 20)	Kidoti (n = 20)	Marumbi (n = 20)	Nyamanzi (n = 20)	Paje (n = 20)	Uroa (n = 20)	Uzi island (n = 20)
Average age	39.6	30.6	33.9	35	35	40.8	31.6
Average no. of children	5.1	2.1	1.3	3.3	3.5	1.4	2.8
Average no. of people in the household	6.0	5.3	4.9	5.0	5.3	4.9	4.6
Main profession							
Small-scale business	0.70	0.10	0.15	0.20	0.45	0.20	0.40
Dressmaker		0.10	0.15		0.15	0.25	0.25
Teacher	0.05	0.10	0.20	0.10	0.10	0.20	0.10
Farmer	0.15	0.25	0.10		0.05		
Shop employee			0.10	0.05	0.10	0.05	0.05
Cutting firewood/corals			0.15	0.55	0.05		
Employed by the Government			0.10				
Invertebrate collector							0.05
Housewife		0.30		0.05	0.05	0.10	0.15
Assistant (e.g. babysitter)		0.05			0.05	0.05	
Other	0.15	0.10	0.05	0.05		0.15	
Proportion respondents involved in additional income-generating activities	0.40	0.35	0.25	0.50	0.45	0.30	0.40

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