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Social and economic implications of small-scale mud crab (*Scylla serrata*) aquaculture: the case of organised community groups

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Received: 16 October 2013 / Accepted: 24 February 2014 / Published online: 5 March 2014
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Abstract Small-scale mud crab aquaculture was introduced in East Africa in late 1990s as a mangrove friendly aquaculture to improve the livelihood of coastal communities through organised community groups (OCGs). The OCGs approach was a strategy aimed at ensuring benefits to the village and regulating access to the open access resource (land in mangrove forests). A social and economic assessment was conducted at Majaoni, Makongeni, Ihaleni and Dabaso along the Kenyan coast. The paper looks at the social and economic characteristics of the groups, their management systems, contribution of mud crab aquaculture to the livelihoods of local communities and policy issues related to the interventions. There is wider involvement of the mijikenda community in mud crab farming; however, the level of women participation is low. A strong market link exists between the groups and the different market outlets, where hotels and exporters offer the highest prices. Regional price variations existed and may need networking between the groups. The paper concludes that national policies may need to be redirected to support small-scale aquaculture development and ensuring capacity building for women, operation and management of groups, provision of extension services, data management and provision of user rights for communities working in the mangrove environment.

Keywords Aquaculture · Community based · Mud crab · Small-scale · Social and economic

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Introduction

The future of capture fisheries production in tropical countries is challenged by increasing demand for resources combined with the effects of global climate change thus on the declining trend (Francis and Bryceson 2001; Cheung et al. 2010; Worm and Branch 2012; Mirera et al. 2013). Indeed, most of the tropical countries are socio-economically vulnerable and thus need to develop adaptive strategies to cope with climate change and declining fisheries. Small-scale aquaculture development is one of the adaptations due to its positive contribution to the welfare of communities in developing countries (Ahmed and Lorica 2002). Globally, small-scale aquacultures are seen to be fundamental for the livelihood, welfare and food security of some of the poorest communities in third world countries (Brummett and Williams 2000). In addition, it has the ability to act as a buffer for excess labour in the community and turn it into meaningful production (Bene 2005). However, this has not been achieved in Africa since aquaculture has developed only recently and has so far made only small contribution to economic development and food security (Brummett and Williams 2000). Whereas past development initiatives have failed to achieve sustainability due to lack of fish farming culture in addition to political and socio-economic constraints, technological progress in aquaculture has been observed to be a powerful method to alleviate poverty, improve financial situations and enhance social well-being in many developing countries (Jiang 2010).

Mud crab culture was initiated along the coast of Kenya as a small-scale community intervention that could act as a source of food and income to the local communities through the silvofisheries technology (Primavera et al. 2000; Mirera 2009, 2011b). The intervention could also meet the increased demand from tourism, export and promote conservation of the degrading mangrove ecosystem through the silvofisheries technology (Mwaluma 2002; Mirera and Mtile 2009; Mirera 2009, 2011b). The industry for the production and consumption of aquatic crustaceans is truly globalised, with separation of net producer and net consumer nations requiring significant transboundary movement of live animals (Bondad-Reantaso et al. 2012). Initial culture methods targeted sub-adult crabs of 150–350 g for culture to market size (>0.5 kg) in drive-in cages and pens (Mwaluma 2002; Mirera 2009, Mirera and Mtile 2009). However, recently, juvenile mud crab are being cultured in earthen ponds to attain market size in about 8 months (Mirera 2011b; Moksnes et al. 2012).

Significantly, technological advancement, changes in information and communications and globalisation all underscore the need for developing countries to improve food security of low-income people (Pinstrup-Anderson 1999). Hence, the reason why cereals and crop commodity supply perspectives of food security has now changed to include products such as fish as in the case of the economic stimulus programme of the Kenyan government, which was implemented through the ministry of fisheries development from 2009 (Ahmed et al. 1999; Delgado et al. 1999; Ndanga et al. 2013). Consequently, aquaculture is increasingly being recognised as the generator of food and income for households. Although it is not the main source of income, it makes an important contribution to the income of households in rural settings (Ahmed and Lorica 2002; Shelley 2008; Mirera and Ngugi 2009; Ndanga et al. 2013).

There are a lot of similarities between small-scale fisheries and small-scale aquaculture in that both are scattered and unorganised thus making them difficult to monitor. Also, communities carrying out small-scale activities consist of the rural poor who in most cases face social and political marginalisation (Pauly 1997). In addition, they exist in data poor conditions which makes it difficult to capture both socio-economic contributions leading to their under valuation and un-appreciation by policy makers in many countries (Gillett and

Lightfoot 2002; Andrew et al. 2007). In Kenya and other countries of East Africa, the situation is more worrying along the coastline due to the social and cultural constraints that have slowed the pace of mariculture development as opposed to other areas where freshwater aquaculture has progressed (Brummett and Williams 2000; Mirera and Ngugi 2009; Mirera 2011a, b; Mirera et al. 2013; Ndanga et al. 2013). Indeed, African mariculture development is small and only reached 24,000 metric tons in 2007, which is 3 % of overall aquaculture production (FAO 2010). Small-scale community-based mud crab aquaculture may be a potential livelihood option for coastal communities in East Africa and has been introduced through several development, research and conservations programmes in the region (Mwaluma 2002; ACDI/VOCA 2005; Mirera and Samoilys 2008; Mirera 2009, 2011b). In order to manage small-scale mud crab aquaculture to contribute to coastal livelihoods, it is necessary to understand the magnitude and extent of their socio-economic dynamism. To date, there is limited information on the socio-economic status of small-scale mud crab culture in East Africa. Thus, the study objective is to provide information on the role of organised community groups (OCGs) in mud crab culture, social acceptability and contribution to the livelihood of coastal communities.

In essence, small-scale aquaculture involves production systems operated by small-holding farmers, using locally available feeds and that are easy to culture for example mud crab and milkfish (Mirera and Samoilys 2008; Mirera and Ngugi 2009). Investment is in form of land, water and labour, and in most cases, production is for home consumption; however, at times little cash is involved (Brummett and Williams 2000). For small-scale aquaculture to be effective, it requires enabling policies that support acquisition of these basic investment facilities. Indeed, equitable and fairer access to resources utilised for aquaculture is an important policy issue. Thus, the study provides information on the policy factors affecting adoption of small-scale mud crab culture and its impact on the poor coastal communities.

Materials and methods

Survey design

The research involved four organised community groups along the Kenyan coast which had some experience in mud crab culture, i.e. were involved in mud crab culture or had previously participated in mud crab culture as a livelihood intervention (Fig. 1). The community groups selected for the socio-economic study were: Dabaso, Ihaleni, Majaoni and Makongeni. To assess the social, cultural and economic dimensions, the groups were drawn from the south (1 group) and north coast (3 groups) of the Kenya coast and had been in operation for different time periods (Table 1).

Sampling design

Semi-structured interviews, focus group discussions (FGD) and key informant interviews were used to collect primary information from the community groups. The semi-structured interviews (Bunce et al. 2000; de la Torre-Castro et al. 2007) used interview guides (open-ended questions) that were prepared beforehand to gather information on the social, cultural and economic perspectives of small-scale mud crab farming in addition to challenges, weaknesses and opportunities of the group. FGD (Krueger and Casey 2000; Start and Hovland 2004; de la Torre-Castro et al. 2007) were used with open-ended questions to

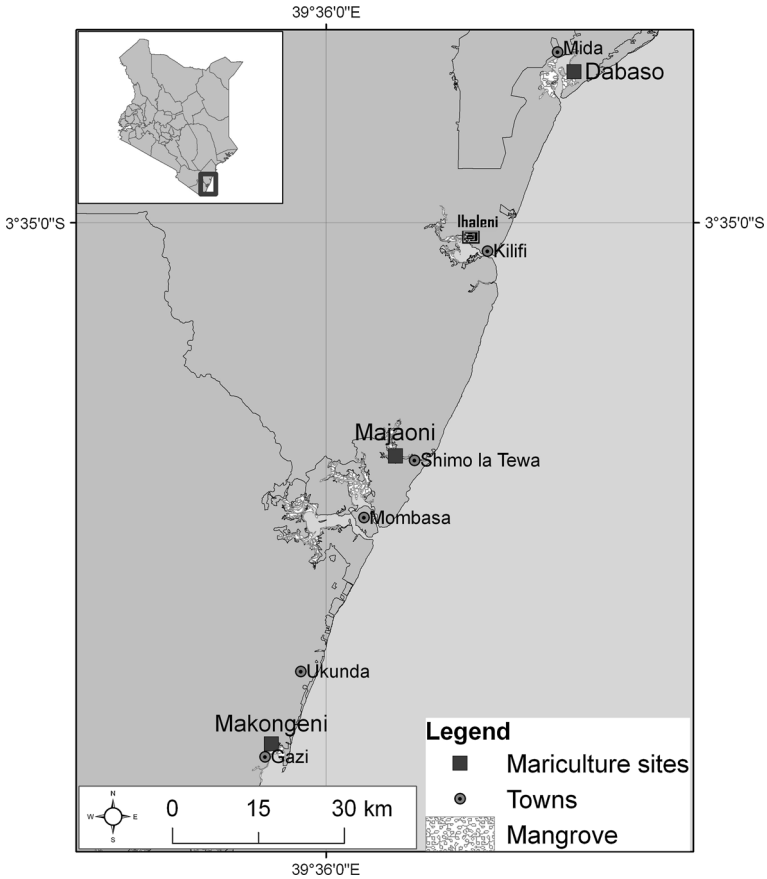


Fig. 1 Map with details of the different community groups undertaking small-scale mud crab aquaculture along the coast of Kenya

Table 1 Description of the different community groups in relation to their administrative areas and year of initiation

Name of community group	Village	Location	County	Year of initiation
Majaoni youth development (<i>Mtwapa creek</i>)	Majaoni	Bamburi	Mombasa	2003
Ihaleni conservation (<i>Kilifi creek</i>)	Ihaleni	Mavueni, Takaungu	Kilifi	2011
Makongeni, Baraka conservation (<i>Gazi bay</i>)	Makongeni	Kinondo	Kwale	2004
Dabaso mangrove conservation (<i>Mida creek</i>)	Dabaso	Watamu	Kilifi	2000

prompt participants into free discussions on the mud crab culture issues. This also created room for two-way interactions and exchange of information between the interviewer and the respondent. Two moderators were used where one ensured that the gathering

progressed smoothly, while the other facilitator probed to get clarification on questions. This enabled the facilitators to get more detailed information on topics of interest and at the same time as also ensuring that all questions were tackled. Members who participated in the FGD were randomly selected in a group meeting to avoid bias in representation. The participants in a focus group discussion ranged between 5 and 10 and two FGD were conducted per group. Representation of official, ordinary members, gender and age was taken into consideration.

Key informant interviews (Bunce et al. 2000; de la Torre-Castro et al. 2007) were also conducted for each of the groups. These are knowledgeable people in the society who command some respect and could be taken as spokes persons of the community, in addition they had a good understanding of the group activities. The key informants were, however, not group members to avoid biased assessment. The snowball method was used to identify key informants in the villages where the groups operated. The information provided through this method provided a lot of insight into many issues on attitudes and perceptions of the community towards small-scale mud crab farming and the group itself. The method was used to cross-check and validate information collected using FGD.

All the FGD were done at or near the mud crab culture sites. Thus, direct observation was used to assess the cohesiveness of the group and to ascertain existence of activities on the ground.

Data analysis

Since FGDs were mainly used to collect information from the field, data analysis was done descriptively using content analysis whereby the main themes and sub-themes emerging from the field notes were identified and examined. Quantitative and qualitative data were analysed using descriptive statistics and graphics and presented in narratives, tables and graphs. With the help of Graph Pad Prism 6 program, graphical data were explored.

Results and discussion

Group dynamics and characteristics

The groups were formed at different time periods ranging from 2 years ago to 12 years ago (Table 1) thus comprising of different levels of experience though with a common goal of attaining a livelihood out of mud crab farming. The entry of new groups into mud crab farming as late as 2 years ago supports the fact that aquaculture development is increasingly being recognised as a source of food and income to rural households (Ahmed and Lorica 2002; Ndanga et al. 2013). Membership is drawn from the wider mijikenda community, and Majaoni youth development had the highest diversity of mijikenda tribes (Table 2).

Dabaso and Ihaleni groups developed as conservation community groups, while Majaoni youth development and Makongeni, Baraka were self-help groups. Although later, Makongeni, Baraka self-help changed its name to attract donor funds. Non-conservation groups were self-initiated to help address common challenges in their communities such as unemployment and poverty, while conservation groups were spearheaded by local non-governmental organisations (NGOs) to execute funded projects. Researchers and/or NGOs introduced small-scale mud crab farming to the groups as a mangrove friendly aquaculture that can promote conservation and improve livelihoods (Primavera 2006). The respondents

Table 2 Dynamics of the community groups involved in small-scale mud crab culture along the coast of Kenya and type of intervention for income generation

Name of community group	Community integration	Percentage of women	Percentage of men	Group interventions generating funds
Majaoni youth development	Kauma Chonyi Giriama Digo	23	77	Milkfish farming Mangrove nursery
Ihaleni conservation	Giriama Kauma	35	65	Mud crab and milkfish farming
Makongeni, Baraka conservation	Digo Duruma	80	20	Milkfish and mud crab farming
Dabaso mangrove conservation	Giriama Watha	43	57	Mud crab farming Mangrove restaurant Eco-tourism

elucidated that because of their existence and influence, active conservation community groups were often targeted for getting involved in the mud crab farming interventions.

Two groups had more than 30 % women representation, which is the minimum threshold according to the current national constitution for Kenya, while the others had under representation (Table 2). Other than Makongeni, Baraka conservation that had a woman as chairperson and treasurer, all other groups had men in all administrative positions with women existing only as members. The study showed varied levels of formal education in the groups: In Majaoni youth development, 80 % of the members had attained education above secondary school, 60 % in Dabaso conservation, 5 % in Makongeni, Baraka conservation and 20 % for Ihaleni conservation. Most of the community members with formal education beyond secondary and up to college level were mainly men; women contributed only 1 % and youth (24–40 years) comprised 80 % of the educated population. The observed gender disparities in level of education suggests that there is a constraint in access to education for women at the coast of Kenya which may be a major contributor to their marginalisation in decision-making (Ndanga et al. 2013). Lack of education and training for women has also been observed in Southeast Asia, where women have assumed a critical role in aquaculture development (Nash 1995; Ahmed and Lorica 2002).

Membership was observed to decrease overtime, and Majaoni youth development had the greatest change compared to the others, while Ihaleni and Makongeni, Baraka conservation had the least decline (Fig. 2). The faster decline in Majaoni was associated with the youthful population that sort for jobs and moved from the village in addition to conflicts among members. Ihaleni was considered to be relatively new in mud crab culture interventions and thus may have less experience in aspects related to group management and group fall-out. The stability of Makongeni, Baraka conservation was linked to high percentage of women 80 % which is a positive indication of resilience in aquaculture development. The study by Ndanga et al. (2013) established that women have a greater opportunity in aquaculture developed through participation as fish farmers or marketers. The current study associated the decline of membership to a number of factors, i.e. the length of time taken to realise financial benefits, and thus diversion to personal activities,

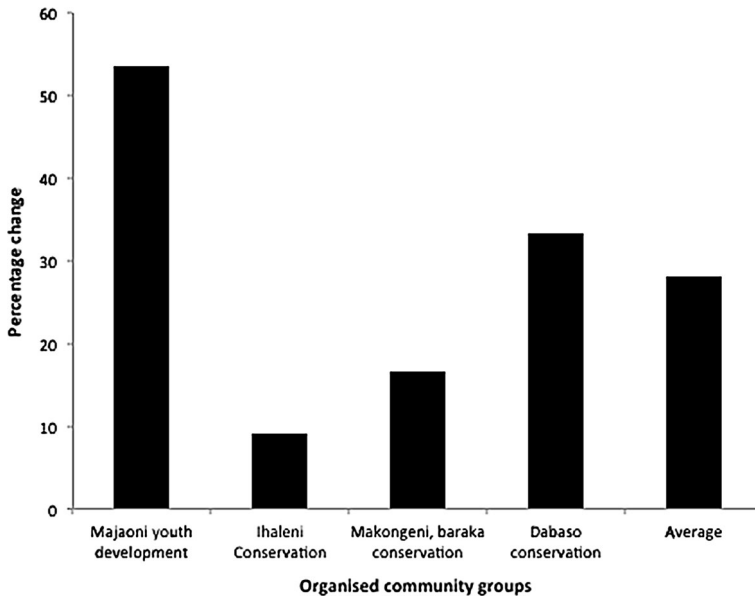


Fig. 2 Percentage change in membership number among the different OCGs assessed from initiation to current (2013)

the nature of work (tedious and dirty) discouraged others, group conflicts and some especially men looked at it as a female activity or for those who cannot go fishing.

To attain viability, the groups were involved in other activities such as milkfish farming, eco-tourism, mangrove nursery establishment and running of mangrove restaurants (Table 2). The groups also engaged in other livelihood activities such as artisanal fishing, peasant agriculture, beekeeping, fish trade, tourism and farm forestry among others. Indeed, Ahmed and Lorica (2002) argued that even though aquaculture is being recognised as a generator of income, it is necessarily not the main source of income. Consequently, Bene (2005) found that small-scale aquaculture alone may not be able to lift farmers out of poverty, but can help to sustain livelihoods and prevent households from falling deep into deprivation.

Management and operational capacity

It was clear that the groups lacked capacity to manage the funds transparently, effectively and efficiently, which could lead to poor management of group resources and mistrust among members. By appreciating that these communities consist of the rural poor who face social and political marginalisation (Pauly 1997), it is necessary to develop policy intervention to ensure that training is provided in management.

Results from FGD indicated that groups with less training in mud crab culture experienced high mortalities in their culture systems (sometimes more than 60 %) leading to loss of hope among group members. Specifically, the mortalities were linked to poor handling, poor construction of culture structures leading to cannibalism or escape, inadequate feeding or feeding at the wrong times. The past aquaculture development initiatives may have failed due lack of a farming culture in Africa (Brummett and Williams 2000);

therefore, it is important to empower farmers with the most recent technologies in aquaculture to minimise poverty, improve financial situation and enhance social welfare (Jiang 2010). Government extension support was indicated as weak in all groups, whereas it has been known to be key in adoption of technologies (Lionberger and Gwin 1991). In addition to developing appropriate policies for provision of extension services, it is important to have simple culture manuals developed in all local languages (Kiswahili and English) to facilitate adoption of technology especially to the less literate that are significant in the current study (Mirera and Samoily 2008).

The community groups operated under a constitution that outlined their operations, terms of office, elections, meetings, contributions, membership, activities and penalties. Only one group had its constitution written in the local language, Kiswahili, while the other three were in English. Other than Majaoni youth development and Dabaso conservation, where most of the members understood their constitution, most members in other groups were not aware of the contents nor was there an understanding of how it is used to run the day to day activities and as a benefit sharing tool. It is thus important for groups to involve all members in collective decision-making through understanding the constitution to promote unity even though at times collective decisions may need to be minimised (Katz 1961). Therefore, a risk was observed where constitutions could be developed only as tools for registration and not for group management. Coupled with the high illiteracy level among members, this may be a conduit to exploit the weak and poor among the groups by the few elites, a fact supported by Kent (1976) who established that technological knowhow could be used against the less privileged in society (the poor).

Most members were dissatisfied with their democratic rights of electing office bearers despite the many years of operations. There are consistent conflicts associated with election of office bearers that have weakened some groups such as Majaoni youth development due to selfish interest and desire to remain in office by some officials. In addition, the legal avenues to solve such disputes are limited and there is lack of clear management systems to monitor performance of groups. Whereas the government has provided guidelines on registration and renewal of group licence, conversely there exist no guidelines to monitor operations. Therefore, there exists a policy gap to strengthen the organisational nature of small-scale mud crab farming through OCGs which occur in poor rural areas that face social and political marginalisation (Pauly 1997). Unlike in small-scale fisheries, if well empowered, the groups will help to capture the economic and social contribution of mud crab farming that may be currently under valued or un-appreciated (Andrew et al. 2007).

Social and cultural aspects

There were variations in experience, skills and understanding of mud crab farming among the different communities. The economic contribution of mud crab farming compared to other mariculture-related interventions is different between communities. However, all communities showed interest to learn about grow-out farming technology that could involve culture of juvenile crabs in ponds. More than 70 % of the respondents indicated that culture of juvenile crabs in earthen ponds could be more viable. This could therefore supplement crab fattening because the seeds are abundant and labour requirement is low during the culture process, but more training was required to equip the farmers with the required skills. This will involve simplification of mariculture technology for adoption by coastal communities that has been a call by most of the communities interested in small-scale mariculture development along the East Africa coast (Mirera and Samoily 2008).

The respondents concurred that the involvement of women in mud crab farming was initially (about one decade ago) impacted by religious and social norms among the coastal communities. But due to economic challenges and declining fishery resources, the women are slowly being allowed to participate in livelihood interventions related to marine resources such as mariculture, a fact that has been underscored by different studies in the region and outside (Nash 1995; Ahmed and Lorica 2002; Ndanga et al. 2013).

Negative attitudes from other community members were experienced when mud crab farming was first introduced. There were conspiracies that lead to theft of farmed crabs either a few days after stocking or a few days before harvest. In some instances, theft was planned and executed from within the group members especially when harvesting was near, a fact that was associated with lack of effective benefit sharing mechanism and management of group conflicts. Due to the general community involvement and as an awareness creation strategy, it became a challenge to handle theft cases through police arrests since it could lead to social instability. To avert the situation, more time was spent in community meetings “*Baraza*” to explain the need for respecting the interventions in addition to putting guards on site. Theft is an act of poverty, food instability and labour redundancy that could all be addressed through small-scale mud crab farming that has the capacity to serve as a buffer for the excess labour in the community (Bene 2005). Mud crab farming may also produce a series of backward linkages such as hatcheries, nurseries, seed collectors, feed and input deliveries and forward linkages such as harvesting, post-harvest handling and marketing that will absorb community labour and create income for all community members (Lewis et al. 1993, 1996).

In addition, there were also conflicts on usage of culture sites: The fishers feared loss of their fishing routes and grounds. Landowners became jealous of the interventions and claimed ownership of the areas that are managed by the government under the law. This scenario underscores the importance of awareness creation when introducing any small-scale mariculture intervention and the need for appropriate policies to safeguard the interventions. Also it is a challenge for small-scale interventions that may not directly benefit all stakeholders especially when implemented in “free access” areas such as the mangrove ecosystems or open sea. Globally, access to resources utilised for aquaculture such as water and land (pond) has been a major policy issue and in essence it helps to determine who benefits from aquaculture (Ahmed et al. 1993; Lewis 1998; Ndanga et al. 2013). It is also evident that in areas where landless and poor people may be holding ponds and sections of water bodies through lease or other arrangements, the rich owners will always exert claims over them once profitability is attained (Lewis 1998).

Most mud crab farms have been on and off due to lack of financial and expertise support. In addition, farms were initiated as pilots and thus relatively small in capacity to meet group needs. Due to lack of funds or credit facilities, farms have remained small in 50 % of the groups, while communities that had up-scaled their culture farms are able to meet some basic needs from farm proceeds; thus, more expansion is needed for sustainability. The issues of limited credit facilities to facilitate small-scale aquaculture interventions have been highlighted also in Ndanga et al. (2013) for freshwater aquaculture in Kenya. Indeed, even though the government of Kenya through the economic stimulus programme provided a subsidy for small-scale farmers that was not sufficient and only supported freshwater aquaculture (Anon 2010; Ndanga et al. 2013). Hence, there is a special need for policy direction to make available credit facilities for small-scale farmers to increase production capacity.

It was also observed that exaggerated publicity of profitability is at times made in the media to meet donor demands that have reduced the morale of most group members over

time. Other factors associated with temporal closure of farms include, weak management structures of the groups and internal conflicts, seasonality of market, lack of seeds for stocking and repair of culture facilities.

Initial mud crab farming interventions were not received well by the Kenya Forest Service (KFS) that holds the mandate of protecting all the mangrove forests in the country. Even though most of the groups were initially involved in mangrove conservation, a lot of resistance was experienced when establishing culture farms. This continues to be a major drawback to development of small-scale mud crab farming. However, the situation has improved through the Kenya Forest Act of 2007 that introduced participatory management of the mangrove forests (co-management) where user groups such as small-scale mud crab farmers were allowed. But the bottleneck to the new strategy is the aspect of user groups making payments for activities carried out in the mangrove environment. The introduction of forest user levy's may put out small-scale mud crab farmers who have nurtured the technology over time and give way to the rich who are able to pay levy's. This will bring about commercial productions for higher profitability of the few rich but at the expense of the environment and livelihoods of coastal communities (Lewis 1998; Ahmed and Lorica 2002; Primavera 2006).

Economic and livelihood dimension

Out of the four communities along the coast of Kenya, only two have an active mud crab farming activity. However, the communities consider mariculture as a viable alternative livelihood option to fishing households due to declining catch and sizes caught from their traditional fishing grounds (Primavera 2006; Primavera et al. 2010; Mirera 2011b; Worm and Branch 2012; Mirera et al. 2013). Thus, crab farming acts as a new way of maximising the value of crabs in the domestic and export markets, and it is integrated easily because it complements or adds value to the artisanal mud crab fishery (Mirera 2011b; Bondad-Reantaso et al. 2012; Moksnes et al. 2012). Drive-in cages, floating cages and earthen ponds are the main culture systems used in mud crab farming along the Kenyan coast (Table 3). The systems are constructed using locally available materials, in addition, easily and less expensive to construct. All the culture systems are run in small-scale and extensively by group members.

According to the groups, mud crab culture is viewed to have a multidimensional approach towards addressing poverty reduction and food security. Other than food supply and income provision to the members, small-scale mud crab culture provides employment and conserves the mangrove environment that has multiple values for the coastal communities. Figure 3 provides a detailed view of the connectivity encompassing the socio-economic benefits originating from small-scale mud crab culture along the Kenyan coast. It has been established that to reduce vulnerability of coastal artisanal fishing communities and their coastal support ecosystems, alternative livelihoods such as small-scale mud crab culture are able to aid in sustaining coastal peoples' income and food supply (Giasuddin and Alam 1991; Kador 1991; Primavera et al. 2000, 2010; Primavera 2006; Mirera 2009, 2011b).

Communities have developed a market link to supply tourist hotels in addition to other market avenues such as middle agents, domestic homes, exporters, group mangrove restaurants and respective households. Prices varied greatly for the different market outlets and among the groups (Table 4). Regional variability in prices offered for mud crabs within the same country has also been observed in other studies mainly being guided by size and accessibility to markets (ACDI/VOCA 2005; Richmond et al. 2006; Petersen et al. 2011;

Table 3 Mud crab culture systems and methods used by the community groups operating at the Kenyan coast

Name of community group	Systems	Methods
Majaoni youth development	Drive-in cages and ponds	Extensive
Ihaleni conservation	Drive-in, floating cages and ponds	Extensive
Makongeni, Baraka conservation	Drive-in, floating cages and ponds	Extensive
Dabaso mangrove conservation	Drive-in and floating cages	Extensive

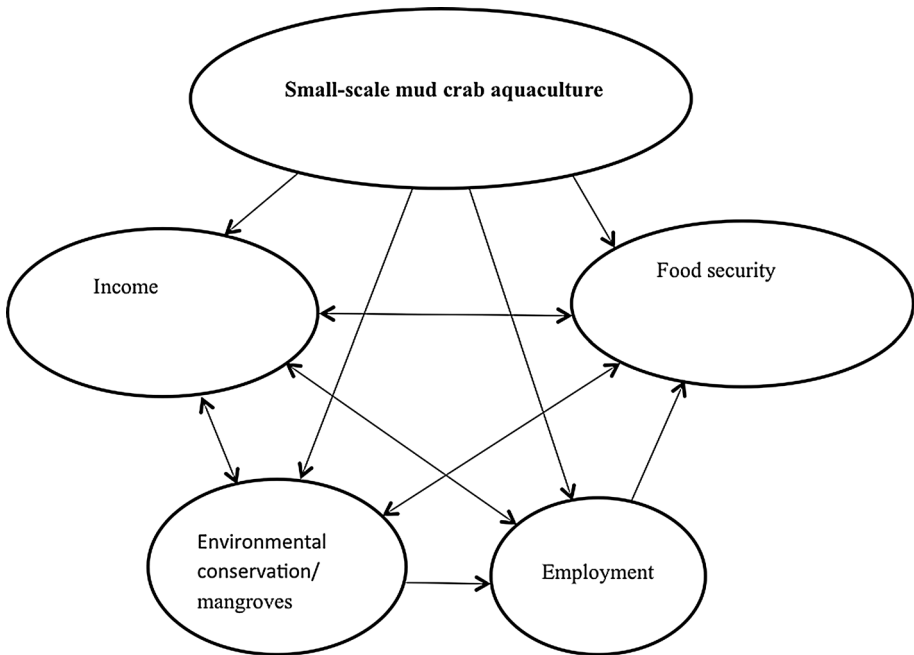


Fig. 3 Framework for small-scale mud crab aquaculture showing linkages to the socio-economic welfare of coastal communities in Kenya as elucidated by the community groups. The *size* of the *circles* shows the significance attached to the different socio-economic pillars

Moksnes et al. 2012); however, current variations may not be associated with size variation since all cultured crabs are of similar sizes, and thus, other factors may have influenced the price variations. Ndanga et al. (2013) also realised that prices of farmed fish varied between regions and associated it to urbanisation or production capacity. Highest prices were attained when crabs were sold at individual mangrove restaurants, but the market was noted to be seasonal and only available at Dabaso conservation group. Hotels and exporters provided second level prices and middlemen and domestic homes offered the lowest prices. Other than Dabaso conservation, all the other groups did not attach any price tag to what was consumed at the respective households. Despite the variations, the prices found in this study were similar to those observed by Moksnes et al. (2012) in Kenya and Tanzania for both wild and cultured mud crabs but vary from those recorded by Mirera (2011b) in some aspects such a export markets which could be associated with lack of exposure by the most groups to the outlet.

Table 4 Market outlets and price offered for farmed crabs in the different study sites along the coast of Kenya

Name community group	Middle agents	Hotels	Domestic homes	Exporters	Subsistence consumption	Owned restaurant
Majaoni youth development	2.4–2.9	2.9–4.1	1.8–2.4	3.5–5.9	Not costed	–
Ihaleni conservation	1.8–3.5	3.3–4.1	–	–	Not costed	–
Makongeni, Baraka conservation	2.4–4.1	4.5–5.3	–	–	Not costed	–
Dabaso mangrove conservation	–	4.7–5.9	–	–	3.5–4.7	9.4–11.8

1USD = 85 Kshs

Table 5 Percentage of income derived from mud crab culture compared to other mariculture-related activities for each community group

Name of community group	Mud crab (%)	Milkfish/prawns (%)	Fingerlings (milkfish) (%)	Eco-tourism (%)	Seedlings (mangrove) (%)
Majaoni youth development	5	60	–	–	35
Ihaleni conservation	51	49	–	–	5
Makongeni, Baraka conservation	7	55	38	–	–
Dabaso mangrove conservation	70	–	–	30	–

Subsequently, price variations in mud crabs may be affected by demand and supply and could also be an aspect of societal status based on the market outlets established in the current study and as documented by Mirera (2011b). However, the prices obtained in the current study are similar to what is being offered for farmed crabs in Southeast Asia (Cholik 1999; Trino et al. 1999). Despite the fact that the price of mud crabs is almost double, that of finfish, which is an incentive for mud crab farming, there is a need to develop policies that will protect farmers from unfair competition for profitability (Mirera and Samoilys 2008).

Initial mud crab culture interventions involved use of sub-adult and earlier adult crabs that were not market size for culture into the required market sizes, i.e. above 500 g (Mirera 2009, 2011b). It was difficult for the farmers to collect these from the wild thus relied on buying from fishers. This approach proved expensive and time wasting due to unavailability of required sizes and thus a constraint to the expansion of crab farming. However, recent interventions where juveniles are cultured in ponds may be a viable approach that could ensure sustainability because seeds are abundant and accessibility of collection areas is easy (Moksnes et al. 2012). The pond culture system will supplement cage culture to attain constant supply of the mud crabs to the market. Pond culture has been observed to be viable in culture of small juvenile mud crabs into market size (300–450 g) for a period of 4–6 months in Asia–pacific and viable profits obtained (Trino et al. 1999; Rodriguez et al. 2001, 2007; Christensen et al. 2004; Petersen et al. 2011). However, in the current study, no cost benefit analysis was done to establish viability of the small-scale mud crab culture because of lack of organised data with the groups nor was data submitted

to the fisheries department thus an indication of groups operating in data poor conditions as had also been established by Gillett and Lightfoot (2002). Currently, only Dabaso and Ihaleni conservation groups obtain more than 50 % of their incomes from mud crab farming (Table 5). With the new intervention of pond culture, the groups anticipated to gain more from small-scale crab culture compared to other mariculture-related activities. However, in the long-term policies and investment approaches need to be developed to ensure hatchery systems are established for constant seed supply and or for restocking wild stocks (Le Vay et al. 2008; Leбата et al. 2009; Mirera and Samoilyls 2008) to avoid the negative impacts of aquaculture observed elsewhere (Keenan 1999; Fortes 1999).

Overall, the respondents felt that small-scale mud crab culture has the potential to enable them achieve economic sustainability and food security, in addition to promote management, restoration and conservation of the mangrove forest. They were also categorical that once sustainable benefits are attained membership fluctuation may be minimised. Through the multiplier effect, the surrounding communities could also benefit from either produced resources, change in expenditure, established business or improved fish resources or mangrove poles from a well managed mangrove ecosystem (Kairo et al. 2001; Shelley 2008; Mirera et al. 2010; Mirera 2011b; Ndanga et al. 2013). Successful establishment of small-scale mud crab culture was also seen as an avenue for other income generating activities such as eco-tourism noted in some groups thus providing good market for their products.

Conclusion

The results show that small-scale community-based mud crab farming has the potential of improving the welfare of coastal communities. Community groups spearheading the interventions have realised initial benefits and have a vision of helping their communities out of poverty. Clear market outlets have been established under the organisation capacity of community groups, and prices offered for farmers are good but can be improved and harmonised for the different regions by strengthening the networks to provide competitive bargaining power. Even better prices for mud crabs have been attained by communities through establishment of their own restaurants, an aspect that is worth encouraging through appropriate policy structures to attain sustainability. Also through involvement of men, women and youth in the community, redundant labour was well utilised.

Also challenges were evident that may hinder development of small-scale community-based aquaculture development under the umbrella of community groups. Whereas the organisational capacity is paramount, transparency and accountability were seen to be weak in most community groups. Therefore, policies should be directed towards ensuring that community groups after registration are accountable for their actions, proper conflict resolutions mechanism are in place, the constitution is understood by all and constitutional democracy is promoted within groups. Other policy issues that may need to be addressed include community user rights in the mangrove environment and payment of levy to the KFS by user groups.

Deliberate effort should be made to empower communities with management and technical skills. Most of the groups expressed high levels of illiteracy especially women that hinder aquaculture operations. Indeed, even records (data) were poorly kept and in some instances missing which made it difficult to evaluate the economic viability of the interventions. Empowerment of OCGs should also involve ability to follow laid down objectives with minimal drifting towards donor demands as observed in the present study.

In order to build a reliable database and establish trends in small-scale mud crab culture, there is need to make it mandatory for licensed groups to provide data on production to the fisheries department. Further, proper arrangements and policy need to be developed to allow various market outlets keep data on the sources of crabs bought and prices offered to help address issues of farmed crab consumption.

Acknowledgments The authors are indebted to Western Indian Ocean Marine Science Association (WIOMSA) through the Marine Science for Management (MASMA) that funded part of this work and Kwetu training centre through the Toyota environmental grant programme. Special appreciation is extended to Kenya Marine and Fisheries Research Institute (KMFRI) and Linnaeus University (LNU) for the provision of necessary support to carry out the study and develop the write-up. We also wish to thank colleagues and members of the organised community groups (OCGS) that were involved in this study.

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