



THE BARACHOIS PROJECT
 Republic of Mauritius
Barachois of Residences La Chaux Mahebourg



PILOT STUDY OF COMMUNITY-BASED AQUACULTURE DEVELOPMENT

CORE INFORMATION

Project Title:	Establish a sustainable and collaborative management model for community-based aquaculture development to support local livelihood, in a marine coastal wetland adjacent to Residences La Chaux, Mahebourg.	
Project focus:	Community based aquaculture (Component 2 of The Barachois Project)	
Project Location:	Grand Port Region Residences La Chaux Mahebourg	
Project Sector:	Integrated Coastal Zone Management	
Target group:	Local community of Residences La Chaux, Mahebourg	
Leading organisation:	Environmental Protection & Conservation Organisation (EPCO) DEJA Estelle Project Manager Tel: 59248897 E-mail: estelledeja.epco@gmail.com	
Affiliated entity:	Cooperative of Residences La Chaux and Mahebourg Arcante Jacques Andre President Tel: 58288467 Local community of Residences La Chaux Monrose Sandy Secretary Tel: 57907131	
Project Duration:	10 Months	

TABLE OF CONTENTS

EXECUTIVE SUMMARY	3
I BACKGROUND.....	4
1.1 The current situation	4
1.1.1 Global.....	4
1.1.2 National.....	6
1.1.3 Local	7
1.1.4 The local community of Residences La Chaux	11
II THE PROPOSED INTERVENTION	15
2.1 The Barachois Project	15
2.2 The aquaculture initiative	17
III PROJECT CURRENT STATUS	20
3.1 Baseline studies.....	20
3.2 Management activities	22
3.3 Local participation and involvement	23
IV COMMUNITY-BASED AQUACULTURE STRATEGY	24
4. 1 Goal	24
4.2 Objectives and respective activities	24
4.2.1 Component 1: Rehabilitation of the marine coastal wetland for aquaculture development.....	25
4.2.2 Component 2: Implement pilot study of mud crab aquaculture	27
4.2.3 Component 3: Build local capacity for community-based aquaculture development and management.	33
4.2.4 Component 4: Develop a collaborative management system for community-based aquaculture.....	38
4.2.5 Component 5: Awareness raising towards the present study.....	42
V MONITORING AND EVALUATION STRATEGY	43
VI RISKS AND ASSUMPTIONS.....	46
VII TIMEFRAME	47
VIII INNOVATION	49
IX SUSTAINABILITY AND REPLICABILITY.....	50
REFERENCES	51

EXECUTIVE SUMMARY

Environmental Protection and Conservation Organisation (EPCO) is implementing The Barachois Project, since February 15th, 2016. The project aims to establish a sustainable and collaborative development model for the restoration, conservation and active management of degraded natural resources, ecological processes and biodiversity of a marine coastal wetland in order to support local livelihood and enhance quality of life. It also aims to promote poverty alleviation, at local level, through the development of improved and diversified livelihood system as well as income generating activities for the residents of the community adjacent to the wetland.

The present aquaculture pilot study concept has been developed during the first phase of the project (Planning & design). This initiative is part of the various management activities that will be conducted in the marine coastal wetland to reach The Barachois Project goal. This pilot study will be conducted over a period of 10 months, from April 2018 to January 2019, and aims to establish a sustainable and collaborative management model for community-based aquaculture development in a marine coastal wetland to support local livelihood. Its design and planning is based on biophysical, governance and socio-economic data and information collected through different baseline studies and various consultation strategies with local residents and other stakeholders. These strategies allowed to gather traditional knowledge as well as technical advices and expertise.

This proposal provides detailed information that will guide the development of community-based crab aquaculture in the marine coastal wetland. The main objectives identified to ensure study effectiveness and success include: (1) Rehabilitate entirely and suitably the existing mangrove ponds, adjacent to the barachois, for aquaculture development; (2) Implement pilot study on crab aquaculture in the mangrove ponds and test other species cultivation in the barachois area; (3) Build local capacity to equip the community, particularly fishers, with the necessary skills and knowledge in the operations of aquaculture product development and enterprise; (4) Facilitate partnerships between all stakeholders for collaborative management of the aquaculture initiative and; (5) Strengthen awareness at local national and global levels of the need and approaches for sustainable and community-based aquaculture of mangrove resources.

All management activities and actions have been designed and planed in constant collaboration with the community based on local needs, wants, opinions and visions. They will be implemented by the local

residents including fishers, women and youth. Local participation, involvement and support in the aquaculture initiative is critical to ensure project effectiveness and sustainability.

I BACKGROUND

1.1 The current situation

1.1.1 Global

Aquaculture has been around for a long time, initially in small rural settings, but now it has expanded worldwide into a commercial activity for the global market. Over the last decades, aquaculture has gained impetus worldwide as a viable method to produce seafood. It has turned out as a major food production sector, having recorded an annual average growth rate of nearly 8% since 1950 (MATF, 2007). Aquaculture is often considered as the fastest growing primary production sector and it now accounts for about 50% of the global food fish consumption (FAO, 2006). Therefore, it is estimated that 52% of captured fisheries worldwide are fully exploited and 25% are either over-exploited or recovering (FAO, 2004). In light of future shortage of seafood harvests, it is anticipated that aquaculture initiatives will intensify considering the expected increase demand for seafood (MAFT, 2007; Troell, 2009), the expansion of the fishers' population as well as the advance in technology and innovation (FAO, 2004). The future challenge of aquaculture which is doubling its production within the next 30 years is probable (FAO, 2006). Most likely, this will occur in brackish and marine waters because of a worldwide reduction of adequate freshwater (Troell, 2009).

Aquaculture initiatives, however, have caused significant mangroves degradation and deforestation in tropical zones during the last two centuries (Hamilton *et al.*, 1989; Spalding *et al.*, 1997; Primavera, 1998; Alongi, 2002). Indeed, wetland ecosystems, which include ponds, marine water areas, marshes, rivers, flood basins with a depth at low tide which do not exceed 6 meters, are widely recognized as the most diverse and productive ecosystems on earth (Convention on Wetlands, 1971). It is estimated that wetland covers 6% of earth's surface corresponding to more than 900 million ha around the world and 250,000 km² in Africa (Jodi *et al.*, 2005; Mdamo, 2003). However, wetland areas are being modified or reclaimed, often for economic and financial purposes (Munishi *et al.*, 2003; Kirsten 2005; Kent and Mast 2005). It is estimated that more than 50% of the wetlands worldwide have been, damaged, degraded or lost in the past 150 years (O'Connell, 2003) due to a traditional and commercial overexploitation worldwide (Alongi, 2002). These threats are causing change in water regime and water quality and

introduction of Invasive Alien Species (IASs). Degradation from land catchments, salt mining and urban development are also contributing to the destruction of the mangrove ecosystems worldwide (Hambrey, 1996; Fast & Menasveta, 2000). The lack of recognition towards the mangrove forest as source of valuable natural products and ecosystem services has been emphasized as one of the main reason for this massive destruction (Barbier, 2007; Ronnback, 2001; Ronnback & Primavera, 2000; Thornton *et al.*, 2003).

Global awareness is raising regarding wetlands for their important role in providing various ecosystems services that enhance human well-being and generate income for many coastal communities (Kirsten, 2005). Such services include fish, plant resources, clay, fiber, water supply and purification, nutrient retention, climate regulation, flood regulation, coastal protection, recreational opportunities and tourism attraction (Barbier, 1993; Gayatri, 2000; Oglethorpe *et al.*, 2000). It is also a source of wood for cooking and building infrastructure (Alongi, 2002), timber to make many products including charcoal, tannins and resins for furniture, boats, fish traps, alcohol (Kathiresan & Bingham, 2001) and traditional medicines (Wells *et al.*, 2007). The importance of wetland in livelihood is particularly significant in developing countries where local communities are highly dependent on its adjacent natural resources.

Moreover, climate change and unsustainable use of coastal and marine resources are contributing worldwide to the degradation of this ecosystem as well as coral reefs (Salm *et al.*, 2000) and further reducing fish stock worldwide (Campbell *et al.*, 2006). Such threats have an adverse effect on the economies making poorer many vulnerable coastal communities more marginalized (Campbell *et al.*, 2006). As a result, it is now widely recognised that emphasis should be placed on moving local people, particularly fishers, towards alternative or supplemental livelihoods (Giasuddin & Alam, 1991; Kador, 1991; Campbell *et al.*, 2006).

Small-scale aquaculture is seen as a strategy that reduces vulnerability of the coastal fishing community and their surrounding ecosystems by sustaining local people 's income and food supply(Giasuddin & Alam 1991; Kador 1991; Primavera *et al.*, 2000, 2010; Primavera, 2006; Mirera 2009, 2011). It is seen as crucial for the livelihood, well-being, food security and long term health of the poorest coastal communities around the world (Brummett & Williams, 2000). For instance, community-based mariculture is considered promising in East Africa for poverty alleviation, economic development and the promotion of environmental sustainability (Mirera & Samoilys, 2008).

1.1.2 National

Government's overruling strategy is to promote commercial development of sustainable aquaculture in the Republic of Mauritius as well as in its extensive Exclusive Economic Zone (EEZ). The EEZ comprises of 1.9 million km² of the waters surrounding Mauritius, Rodrigues, St Brandon, Agalega, Tromelin and Chagos (BOI, 2007). There is no doubt that aquaculture can be a big boost to fisheries production in the country since aquaculture is seen as an activity with high economic potential. It can also contribute to the objective of attaining sea food self-sufficiency and at the same time limit lagoon stock depletion, giving the fish stock a better chance to replenish through marine ranching. Further, it is believed that aquaculture will empower by offering better opportunities to fisher's communities in terms of employment, training and capacity building. The choice of aquaculture is dictated by the rapid pace of aquaculture development in the world on one hand and the untapped potential of marine aquaculture in Mauritius. This potential has come to light after the successful attempt by the private sector to produce red drum, sea bream and rabbit fish in floating cages both on a commercial and small scale level.

In Mauritius, fish culture practices date back to the French occupation period (Ministry of Environment and NDU, 2007). Traditional barachois aquaculture consisted in using shallow brackish or saltwater lagoons enclosed by semi-permeable rock dykes fitted with gates consisting in small size grid which allow tidal exchange of water. It is estimated that 30 to 50% of water is changed with each tide in the barachois. The process was to allow fingerlings of various fish species to enter the barachois through the gates, stock them in order to allow them to fatten so they are not able to escape and rejoin the sea (Ministry of Environment and NDU, 2007).

Presently, there are 33 recorded barachois around the coasts of Mauritius, out of which 21 are property of the Government and 12 are privately owned (Ministry of Environment and NDU, 2007). The area of these water bodies varies from 0.5 to 50 ha. Only half of them are actively maintained while others are neglected. These marine coastline wetlands have been overfished and are now being over exploited for other natural resources such as wood for cooking and collection of bait. All existing infrastructure such as retention walls, fencing, and waterways are no longer functioning and the ecosystem is unable to provide the basic ecosystem services. Moreover, these wetlands are now subject to solid waste pollution and soil degradation caused by incompatible wastes from demolished buildings and economic development, mainly hotels, along the coastline of the island. Invasive Alien Species (IAS) competing with native and endemic species are causing water and land ecosystem degradation and considerable

damage to the few remaining mangrove plantations. Rodents, termites and other pests also infest the site, which is gradually becoming a health hazard for surrounding community. In addition, climate change with extreme events, change in hydrological patterns and increasing frequency and severity of natural processes such as coastal erosion, storms, droughts and sea water intrusions, may be further impacting these natural settings, leading to biodiversity loss.

Most of the barachois, in Mauritius, are surrounded by mangrove areas. There are two identified species of mangrove that grow around Mauritius; *Bruguiera gymnorrhiza* (L.) Lam., and *Rhizophora mucronata* Lam (Sauer, 1962), the second being more dominant (Fagoonee, 1990). Mangrove forest play a significant role in the coastal area of Mauritius (Anon, 1991). Indeed, they provide habitats for birds, reptiles and mammals (Alongi, 2002) and act as nursery grounds and hatcheries for juvenile fish, crabs and shrimp (Anon, 1991; Appadoo, 2003). They protect coastal areas from erosion and stabilise the intertidal mud banks. They filter runoff before it reaches the sea by accumulating sediments, contaminants and nutrients (Appadoo, 2003; Ministry of Environment & NDU, 2007). They serve as substrates for oyster spat fixation. They provide foods and detritus trapped among their roots for various marine species (Appadoo, 2003). They are also the home of various species including birds and reptiles offering high potential for eco-tourism. The massive destruction of mangrove forests, which covered most of the coastline of Mauritius in the past, is recognised to be in part responsible for the declining fish stocks in the lagoon (Appadoo, 2003). According to the Fourth National Report on the Convention on Biological biodiversity in 2010, 30 % of mangrove cover has been lost in 7 years (1987-1994) (Ministry of Environment & NDU, 2007). In Mauritius, the main causes are illegal cutting for firewood, infrastructural development and the making of passages for boats (Anon, 1991; Ministry of Environment & NDU, 2007). Emphasis should be placed on restoring, conserving and restoring them at a national level.

1.1.3 Local

The targeted study area is located in the district of Grand Port, in the south-east of Mauritius Island (fig.1). The study area comprises the barachois of Mahebourg / Residences la chaux, its adjacent mangrove forest and the local community of Residences la Chaux, covering a surface of approximately 55 ha. This coastal wetland is home to the two species of mangroves found in Mauritius, namely *Bruguieragymnorrhiza* and *Rhizophoramucronata*.

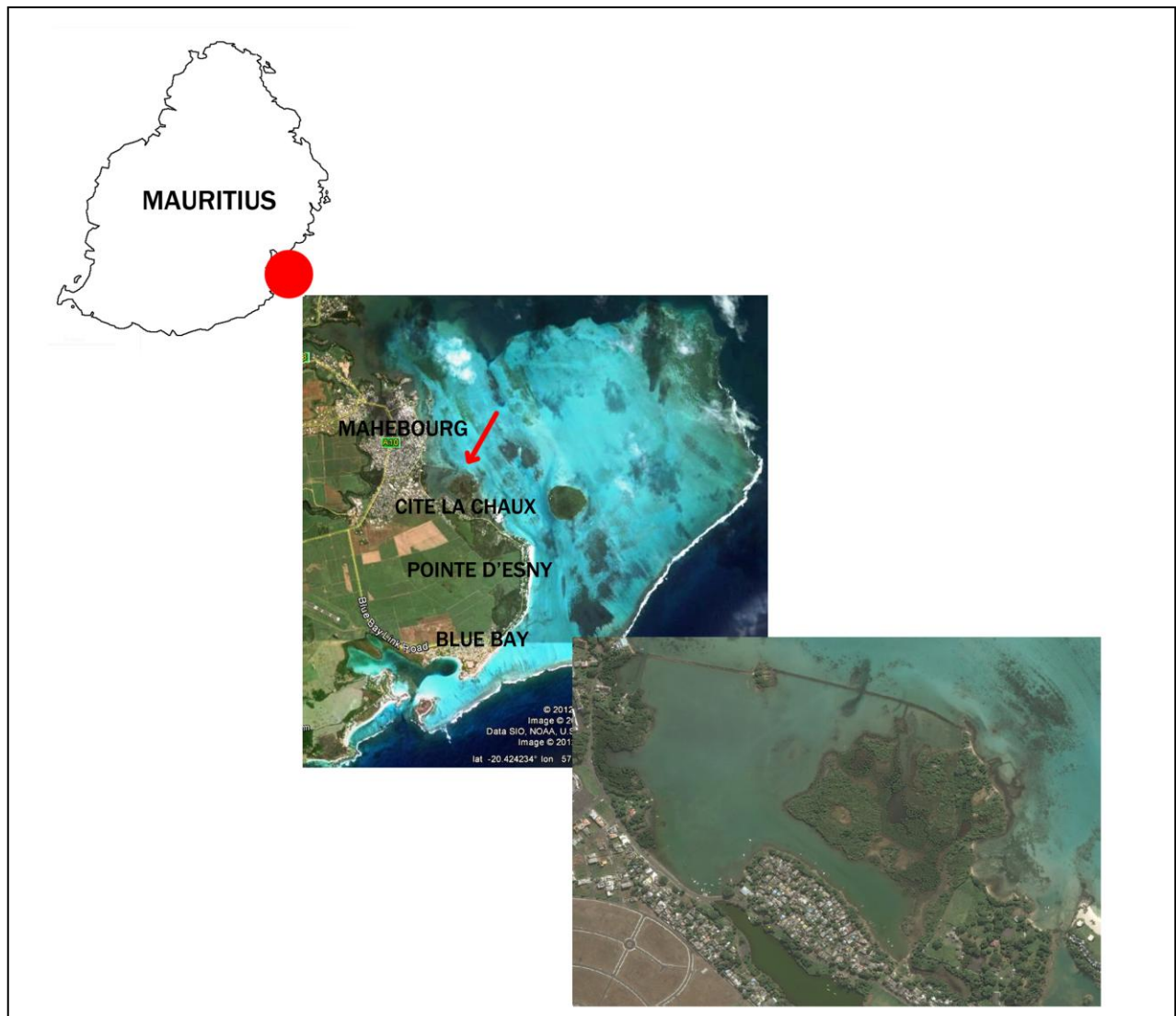


Figure 1: *Compilation of maps displaying the area of operations at different scales.*

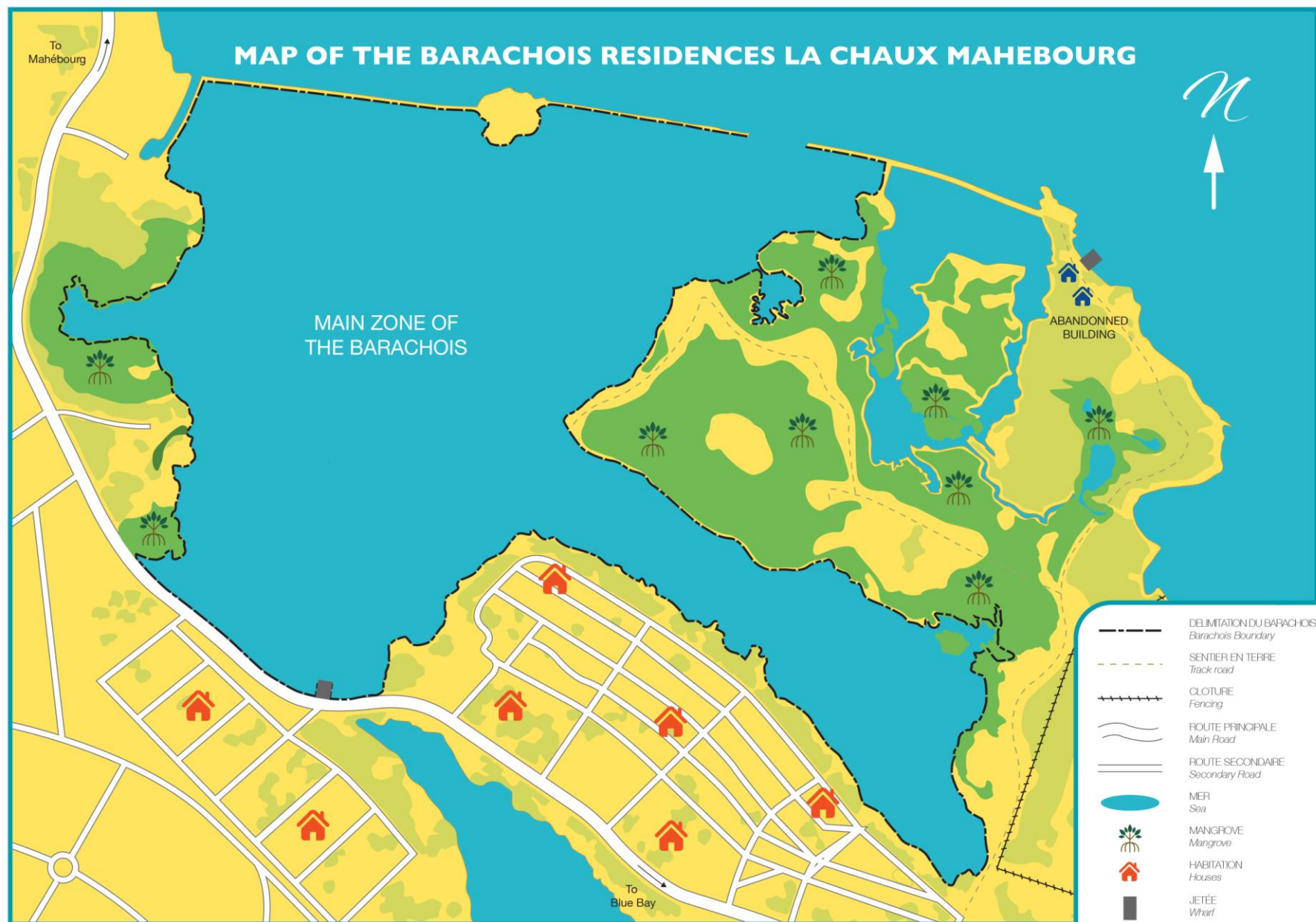


Figure 2: Map of the study area providing features and boundaries.

In the 1960s, the present coastal wetland ecosystem was fully functioning and productive, and was providing proper ecological ecosystem services. Information obtained from old fishers and other sources living in the vicinity of the site confirmed that sound functioning of the wetlands used to produce a variety of fishes and other seafood products in the past.

Indeed, key informants interviews were conducted during the first phase of the project with local elders. The aim was to gather historical information regarding the barachois and its adjacent mangrove forest, locally named "Cot Nicole".

According to results of the interviews, the barachois of Résidences La Chaux, Mahébourg was the most productive government-run fish farm. Indeed, the Ministry of Fisheries used the barachois for experimental studies from 1965 onwards. An expert from Canada, named Henry Fougères, with the help of twelve staff members, designed the aquaculture activities targeting local species of fish, prawn, crab and oyster. A nursery was created in the building of the actual Fisheries Post. Fishing and swimming were prohibited. The barachois was entirely fenced, two enormous spotlight illuminated the entire barachois at night and guards were employed to conduct surveillance through day and night patrols. The activities in the barachois stopped because of poisoning in the barachois water in 1985. Since then, it has been abandoned.

Before the start of the project, the coastal forest consisted of an existing abandoned area which was an eyesore because it has gradually turned into a dumping ground. Valuable mangrove plants were being destroyed and the wetland ecosystems was in dire need of help.

Even though, it is clear that this area has a high potential to bring socio-economic development for the adjacent local community. The wetland includes beaches, walking tracks through the mangrove forests, breathtaking views on the Grand Port lagoon revealing possible eco-tourism and recreational opportunities. Moreover, the proximity of the barachois and the fishing community as well as the existing mangrove ponds demonstrated a potential for small-scale aquaculture in collaboration with the local fishers.

1.1.4 The local community of Residences La Chaux

Résidences La Chaux is located near the coast of the village of Mahébourg, in the south east of Mauritius and in the district of Grand port. The geographical location of the village is GPS position: 20025'03.35''S ; 57042'47.35''E. As mentioned previously, it is situated near the main coastal road and surrounded by a coastal wetland including the barachois and its adjacent mangrove forests.

During the first phase of the project (design & planning), a count of the population was undertaken based on a map which divided the community into 26 quarters (refer to fig.3). According to the results, there are 356 houses and 551 households totaling 2,140 people in the community. The population currently includes 1,533 adults and 607 children.



Figure 3: Map of the community divided into quarters (1-26).

Considering the lack of baseline socio-economic data and information regarding the targeted local community, a household survey was conducted over a period of 6 months between June 29 and December 19, 2016. A total of 76 questionnaire-based household surveys were completed totaling approximately 14 % of the total households of Résidences La Chaux. This study aimed to generate baseline on the socio-economic and livelihood status of the community, in terms of community profile, household incomes, occupational distribution as well as community skills and education levels. It also aimed to assess the resources and capacity of the community which enhanced the understanding of livelihood circumstances and strategies employed by this community.

The average household is made of 5 people with a minimum and maximum size of 2 and 13 respectively. The average amount of children of the surveyed households is 1.6. The study emphasized male dominance over the household with 82% and 18% of households managed by men and women respectively. Results of the study allowed the identification of the main issues faced and perceived by the community members. Such problems included: the low education levels; the lack of recreational activities and employment for the youth leading to significant drug dealing and consumption in the area; the lack of available land; the difficulty of permitting process; the lack of support and information to develop new livelihood opportunities in agriculture, aquaculture and forestry by community members; the lack of adequate infrastructure and; the lack of support from and interaction with governmental agencies and local NGOs. These statements may justified the fact that local people are unable to adopt alternative, innovative and sustainable livelihood opportunities to increase their income, wellbeing and quality of life.

Indeed, the findings of the study demonstrated that Résidences La Chaux is a poor coastal fishing community. The average income level is low with 61 % of women and 54 % of men receiving between MUR 4000 and MUR 8000 per month. However, some respondents found difficult to report monthly incomes due to the income fluctuation between winter and summer. For instance, fishers expressed a seasonal variation of their monthly income peaking during the winter season from November until April. Furthermore, 83 % of the surveyed household members reported income insufficiency to cover monthly expenses.

The main characteristics of the local livelihoods is the lack of diversification of primary occupations. The predominant household livelihood system for men is based on traditional fishing and manual works related to construction. The low diversity of the community livelihood system can be justified by the low education level mainly due to monetary constraints and the bad reputation of the community within the region. Indeed, only 52% of interviewed male and 53% of female have studied above primary school and 2% above the secondary school level. Results demonstrated strong similarity between male and female. According to the village council representative, many children study until the end of secondary school, after which many leave due to monetary constraints, the long travel time to the high school and the lack of support from the parents. Women occupational distribution is even less diverse with 46% of housewives, 10 % of multifunctional maids and 6% of cleaning ladies. According to local residents, many women of Résidences La Chaux used to easily find opportunities in textile factories. However, after the closure of the factories, a few decades ago, the local women faced difficulties to find another job due to

the lack of skills and qualifications. Some women are creating artisanal products but face difficulties in obtaining permits to be able to directly sell them to the tourists.

Results also clearly emphasized that there is a considerable local concern regarding the ineffective waste management system in the community. The facts that no domestic bins have been delivered to community households, no wastes is sorted locally; the low frequency of waste and big items collection, and the inadequate amount of public bins results in significant solid waste disposal and pollution in the surrounding environment. A lack of awareness and understanding towards the importance and benefits of conserving the environment including mangrove ecosystem was emphasized and may be due to the absence of environmental education and interaction with local environmental NGOs. Indeed, it has been acknowledged that the community has never benefited from some form of environmental education from external institutions such as environmental NGOs and governmental agencies. This may be one of the causes justifying the fact that the barachois and its adjacent mangrove forests have been considered as dumping ground for decades. Broken glass bottles, syringes are significant in the area and dead stray dogs constitutes a nuisance for the local residents. Moreover, the bushy forests of the wetland revealed significant spread of Invasive Alien Species (IASs) and pest species suggesting a lack of management and conservation measures by the relevant authorities.

These significant issues impacting the environment have influenced the way the local community uses and values the adjacent wetland. The results demonstrated that the frequency of visiting the coastal forest, by local household members, has reduced drastically over time. Indeed, 62% of respondents used to go often in the past while only 10% visit it at present. Moreover, approximately 40 % of household interviewed members do not go anymore to the forest while living a few hundred meters from it. The diversity of activities conducted by household members, in the forest, also decreased drastically over time. The local people used to carried out many recreational activities including fishing, shells, fruits and wood collection, swimming, diving, picnicking and camping. The number of responses regarding each activities had significantly reduced when talking about the present. Similarly, only 39% of the interviewed household members conduct activities in the barachois area, mostly fishing and swimming. As a result, the survey highlighted the fact that local people do not rely on wetland resources for their subsistence, basic needs and for income generating activities. Only few people supplement their livelihood by harvesting crabs, collecting bait and fishing. Most local fishers depend only on lagoon and outside lagoon fishing for their subsistence.

Indeed, another questionnaire-based interview survey was conducted with 76% of Residences La Chaux fishers and 96 % of the targeted fishers of Mahébourg. The 49 interviews were carried out between the 10th of March and the 23rd of July, 2016. The fishermen ranged in age from 36 to 79 years old, with an average age of 56. Results demonstrated clear dependency on natural marine resources for livelihood, as estimated by the number of registered and unregistered fishermen and associated family members who fish for a living. However, 61 fishers voiced that fishing conditions are currently difficult and 90% voiced that they have become more difficult due to overfishing and illegal activities, climate change and pollution. Moreover, 67% of fishermen from both communities have noticed a decrease in fish size compared to more than 10 years ago. Indeed, 100% and 75% of fishermen from Mahébourg and Residences La Chaux respectively, noted that they used to catch more. Declining fish catch has further exacerbated the economy of a fishers' community. Incomes from fishing are low and insufficient to cover day-to-day expenses of the family as voiced by 76% of fishers while the market demand is high at local level. Additional income generating activities are conducted by a small number of fishermen, emphasizing the difficulty in finding part-time income-generating activities and the significant dependency of marine natural resources. Finally, the government sets the bar high for new fisher licensing, causing it virtually impossible for the young to operate as a 'legal' fisher. This explain the fact that the average age of registered fishers is 56 years old and many young residents operate as illegal fishers.

Finally, it is to be noted that considering the past recreational activities of the local people in the coastal wetland, there used to be a cultural relationship between the wetland and the people which is decreasing since years due to the lack of conservation and management actions. If community lose access to the wetland, although no significant socio-economic impacts will occur on the coastal community, local residents are most likely to be resistant to any attempt to cut themselves from the wetland. This situation occurred in the past.

II THE PROPOSED INTERVENTION

2.1 The Barachois Project

In consideration of all of these deficiencies at global, national and local levels, The Barachois Project is a 3 years community-based project, currently developed, which aims to establish a sustainable and collaborative development model for the restoration, conservation and active management of degraded natural resources, ecological processes and biodiversity of a coastal wetland in order to support local livelihood and enhance quality of life. The project encompasses the following major components; (1) Restore and conserve degraded natural resources in the marine coastal wetland; (2) Develop community-based aquaculture in the barachois and adjacent mangrove ponds with local fishers; (3) Build local capacity for management, conservation and sustainable uses of coastal natural resources; (4) Develop alternative employment opportunities for local residents, including women and youth, through community-based recreational and ecotourism activities promoting natural, cultural and historical values; (5) Establish a collaborative management system for the targeted wetland involving the local community and other stakeholders and; (6) Raise awareness about the link between biodiversity conservation and local wellbeing to all stakeholders and the general public.

Various activities, designed and planned in collaboration of the local community, are currently conducted in the coastal wetland, including Invasive Alien Species removal and control, clean-up of the mangrove areas, endemic and native species planting, walking tracks rehabilitation, main access road renovation, and hydrological restoration. Moreover, community-based ecotourism initiative will be conducted in the coastal wetland and includes various recreational activities. Such activities will include visit guided in the wetland, the creation of a visitor centre including a local shop and traditional fishing museum, a barbecue area with traditional seafood and kayaking activities. The project intends to lay emphasis on sensitization of the community concerned and tourists so as to conservation of the environment. Education-based environmental programme will target mainly local children. Educational activities will partly occur within the mangrove area adjacent to the Barachois.

Day-to-day operations are conducted by the community members, including women and youth, selected through a voting process. Upon recruitment, they are appropriately trained and mentored by

local, national and international experts including. It is expected that they will then be able to pass on their knowledge and practices to future generations in order to meet the context of sustainability.

Giving a second life to the Barachois will make the area productive, healthy and more appealing, and demonstrate the tremendous contribution of biodiversity towards the achievement of sustainable economic development. This Integrated Coastal Zone Management (ICZM) project will empower the concerned fishing community to take their destiny in their own hands. It will give them the ability to conserve, manage and monitor their coastal resources sustainably and will ultimately alleviate poverty through alternative income generating activities and capacity-building..

As a result, the action is aligned with the National Biodiversity Strategy and Action Plan (2017-2025) of Mauritius, i.e. ' minimising the direct and indirect pressures on biodiversity and ecosystem services and; integration of the ecological, social and economic values of biodiversity into decision-making. Making these wetlands productive and conserving its biodiversity by promoting the wise use of the marine wetlands is supported by the policies ratified by the local government such as the Ramsar Convention on Wetlands, for the protection and conservation of wetlands across Mauritius. The action is in line with the following: the National Ramsar CEPA strategy plan for the wise use of wetlands, and the Millennium Development Goals (MDGs), i.e. 'to eradicate extreme poverty and hunger', 'to ensure environmental sustainability' and 'to develop a global partnership for development.' The action is also in line with the Convention of Biological Diversity, of which Mauritius is a signatory and is committed to safe guard all biodiversity including marine wetlands so as to maintain essential ecological processes and life support systems on which human survival depend. Moreover, the action is accordance with the AICHI Targets that is addressing the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society; reducing direct pressure on biodiversity and promoting sustainable use; improving the status of biodiversity by safeguarding ecosystems species and generic diversity; enhancing benefits for all from biodiversity and ecosystems services and also enhancing implementation through participatory planning knowledge management and capacity building. Furthermore, the action also adheres to the United Nations Programme of Action on the Sustainable Development of Small Island Developing States, popularly referred to as the Barbados Program of Action (BPOA) that seeks to comprehensively address the economic, environmental, and social developmental vulnerabilities facing islands, by outlining a strategy that seeks to mitigate those vulnerabilities. Recognizing the services that nature provides, the European Parliament adopted in April 2012 an EU Biodiversity Strategy to 2020; whereby the strategy highlights that 'the services provided by nature are not only crucial for the well-

being of human kind, they also represent an astronomical economic value'. The proposed initiative is also in line with the above mentioned strategy.

The project is currently funded through the GEF-Satoyama Project (Conservation International Japan), the Engineering Change Societe (Imperial College of London), the Ladies Circle 2 and G+F Architects Ltd. The Smartfish Project (Indian Ocean Commission) funded the development of the aquaculture feasibility study during the first phase of the project.



2.2 The aquaculture initiative

The community-based aquaculture initiative is related to the component 2 of the Barachois Project. It has been designed through a collaborative approach, in an environmentally sound manner. Aquaculture will be extensive and the targeted species for cultivation are already present in the study area. The first species that will be cultivated part of the present pilot study is the mud crab (*Scylla serrata*) as it represents a great potential for aquaculture considering its fast growth rate, its tolerance for a wide range of bio-physical parameters and its good taste and high demand on the local market.

A number of local people, mostly local fishers will be selected to become 'crab farmers'. They will be trained and subsequently assisted and mentored by local and national experts. As suggested by the local residents, the residents will conduct aquaculture activities, on a voluntary basis. Indeed, the promise of future job creation, has mobilized the community to volunteer their time during this pilot study. However, 50 % of the financial benefits of this activity will be shared with all participants through a benefits sharing mechanism that will be discussed and approved by the local management team. The only activity that will be paid on a regular basis (once a month) will be the night and weekends patrols, part of the surveillance strategy.

This small scale aquaculture initiative will develop two rearing systems for crab aquaculture. An open system of mangrove ponds and a closed system in which crabs will be held individually in cages. It is a mangrove friendly aquaculture initiative promoting wetland biodiversity restoration and conservation. Drive-in cage culture is considered worldwide as economically and ecologically viable as it is associated with mangrove area conservation (Mwaluma, 2002). Moreover, drive in cage culture has demonstrated better results, regarding growth (Chang & Ikhwanuddin, 1999) and is also low-cost and more profitable in the long run compared to studies of pen culture (Maluma, 2002).

If the present study is successful and local compliance and support enhanced, the aquaculture initiative is expected to be extended to the barachois area through polyculture of native fish species ("mulet, Gueule pave, Rouget and cordonnier") and prawn species ("sevette de mer and crevette keble") in order to spread out the risks against mortality, cannibalism, poaching and other uncertainties. A nursery for sea cucumber, has also been recommended by experts from the University of Mauritius (UOM), who conducted a marine environmental assessment of the barachois of Residences la Chaux, Mahebourg, in 2016.

Indeed, the number of alternative income generating activities that will be created, will highly depends on the financial benefits generated by the present pilot study. The limited number of aquaculture jobs created and the length of time to realize financial benefits can discourage and reduce local participation and support. To ensure viability, added value initiatives will be developed generating new income for local residents, including women and youth. Such sustainable financing mechanisms will be related to ecotourism and recreation (guided visits, recreational fishing, kayaking, museum, sales of artisanal hand-made products , sea-food barbecues cooked traditionally by local residents) as well as biodiversity conservation and education.

These strategies are in line with the Government's vision of an ocean state and priorities of developing the aquaculture sector with focus on the small-scale sector. In the Master Plan prepared in 2007 by IDEE, a French consultancy service, it was noted that barachois need to be developed with small aquaculture projects incorporating eco-tourism activities. This recommendation is in line with the report, in 2006, of the Fisheries Division of the Ministry of Agro Industry and Fisheries and the Ministry of Housing and Lands (BOI, 2007).

The diminishing catch from the overfished lagoon raises the question of whether the fisher is getting enough income to cater for the needs of his family and himself. This aquaculture initiative is need driven since it helps to alleviate poverty amongst the most needy, who are entirely dependent on natural resources such as the sea, to sustain their livelihoods and that of their families. It will create local community business and additional income through the means other than direct fishing for the most needy who are entirely dependent on coastal resources, which will in turn decrease pressure on lagoon fishing and will allow natural resources and biodiversity to gain ground. As a result, it will uplift the livelihoods of the community, particularly local fishers, by creating new activities that generate income, through sustainable use of wetland marine resources. Indeed, the direct beneficiaries of the aquaculture initiative will be the local residents, mainly fishers who will get direct employment in the first instance including those involved in the marketing of the fish, provision of equipment and technical know-how, sales of feeds and the population in general through increased volume of fish on the local market.

Moreover, the system is environmentally friendly and offers great potential for securing the livelihoods of adjacent communities (Baliao et al., 1999). Indeed, the aquaculture initiative will put value on the mangrove ecosystem encouraging conservation and re-planting as mangrove ecosystems are critical to sustain local fisheries.

III PROJECT CURRENT STATUS

The Barachois Project is divided into three specific phase. The first phase (design and planning) has been successfully completed. The second phase (implementation) is currently under development. Finally, the third phase of the project (long term management) will be achieved when the objectives will be reached, the operations mainstreamed and financially self sustainable.

3.1 Baseline studies

One of the two main objectives of the first phase of The Barachois Project was to collect and gather baseline biophysical, socio-economic and governance information and data of the targeted study area. The baseline was essential in understanding the key issues and needs of the study area, including the adjacent local community of Residences La Chaux and thus, critical to guide the design and planning of the project based on community wants, needs, opinions and visions.

Socio-economic information and data were collected through questionnaire-based interview surveys with local fishers, an household survey and many key informants interview. The results of these surveys allowed a clear understanding of the demographics, socio-economic conditions and livelihood of this fishing community; assess the scale of problems and causes; understand the local vision, priorities, needs, wants and ideas; and link these in relation to project design and planning. Additional information was also collected through many key informant interviews and through a workshop on the evaluation of indicators of resilience in SPELS. This four day's workshop was carried out with community representatives.

Baseline biophysical information and data were collected through different studies regarding the terrestrial and marine environment (refer to annex 1). Regarding the barachois area, the University of Mauritius (UOM) conducted a marine environmental assessment of the barachois between June and July 2016. This study is part of a feasibility study developed under the funding from the Indian Ocean Commission (IOC) - Smartfish Project, over a period of six months, which investigates aquaculture possibilities and assesses the adequacy and feasibility of developing community-based aquaculture activities in the barachois of Mahebourg / Residences La Chaux. As a result of many consultations strategies with local residents, local and national experts, site surveys, the positive outcomes included the need for creating new alternative livelihood opportunities for local residents; overall water and

sediment quality adequate for aquaculture supported by the presence of two mangrove species; availability of crablets; low-cost availability of feed; high market demand for seafood in Mauritius; proximity of customers; strong partnerships with others stakeholders; positive local perception toward the project and willingness to participate and; community awareness and support towards aquaculture. An aquaculture strategic plan was also developed through consultation strategies including group interviews with fishermen, participatory mapping, observational walks, and boat trips.

Aerial photographs, using drone, were carried out to provide baseline data that will help to identify project achievements over the long term through the visualization of existing structures and biodiversity (refer to fig.4).



Figure 4: Aerial photographs of the barachois and existing mangrove ponds.

Finally, baseline governance information was recorded continuously including meeting frequency, attendance lists in activities and meetings as well as scale and number of conflicts.

As a result, the majority of the baseline studies have been completed and will serve as a benchmark to evaluate project impacts on the study area. Indeed, after project implementation, the same surveys will be applied again and compared to the baseline in order to monitor achievement of results and gauge the impacts of the planned project interventions on the targeted wetland biodiversity and adjacent coastal community.

Finally, the University of Mauritius is currently conducting a bio-physical baseline study in the existing mangrove ponds of the coastal wetland.

3.2 Management activities

Many consultation strategies were conducted with the local community to discuss collaboratively project objectives and to design and plan project activities using a collaborative approach, based on local needs, wants, opinions and visions. A total of 30 focus group interviews with local fishers, 8 focus group interviews with local women, 13 community meetings, many key informant interviews, questionnaire-based surveys, participatory mapping, observational walks and boat trips were conducted with local residents, including women and youth. This management approach was critical in ensuring that the local community is part of the decision making process. The renovation of the barachois wall, by local residents, mainly fishers, started on November 1st, 2016. A total of 173 man/half days was conducted and about half of the wall length was completed. The hydrological restoration of the mangrove ponds started on February 14th, 2017 and consisted in creating waterways between each ponds in order to improve the natural circulation of water in the mangrove forest. After the collection of Strawberry guava stems in the Black River Gorges National Park, and bamboo stems on a voluntary basis, local fishers started the construction of cages of crab culture. The IAS removal and control programme started in May 2017 and consisted in cutting stems and removing roots of IAS species very commun in the coastal forest. A total of 291 man/half days were conducted by local residents. The renovation of the main access road, locally used as a dumping area has started to be renovated in May 2017. A total of 101 man/half days was conducted to renovate 90% of the road length. The rehabilitation of a walking track, located in the mangrove area started in July, 2017. In total, 73 man/half days were conducted by local residents including local fishers. Approximately 90 % of the track was rehabilitated. Four community-based clean-up event were held on October 22nd, 2016, April 24th, 2017, May 7th, 2017 and June 10th, 2017. The events were carried out by community members in collaboration with various stakeholders including the Ministry of Environment and Sustainable Development, the University of Mauritius, Atics Ltd, the Grand Port District Council (GPDC), the Company of Beau Vallon and many volunteers from local companies and NGOs. Two weeks and one week of clean-up were also conducted by local fishers and local women respectively. The waste was sorted into categories established by Belle Verte (recyclable waste, non-recyclable waste, big items and e-waste). Finally, nine anti-dumping awareness panels were created by local community members using wood pallets, donated to the Project, by Ground to Air and Cargo, two companies affiliated with the Airport of Mauritius. All the panels were placed in specific locations along the main road of the barachois in order to discourage illegal dumping in the barachois and increase awareness of local people

towards a better and healthier environment. Awareness raising activities and tools were created in order to increase local awareness and satisfaction towards the project. Two one-day community-based events were conducted on November 6th, 2016 and August 27th, 2017 gathering approximately 500 and 80 local residents respectively. The aims of the events were to provide information on project activities and achievements in order to influence positively local perceptions and attitudes towards the project. Communication tools included project panels, reports, a facebook page and press release and constant and continuous community meetings. Finally, the design of interpretative panels on wetland biodiversity has started in collaboration with a graphic designer. The panels will be disposed at specific locations along the walking track in the coastal wetland. A training programme was conducted between August 2nd and 21st, 2017. All community members were welcomed to participate. This short term program, of 9 sessions, was considered as pilot in order to guide the implementation of the long term training programme of the second phase.

3.3 Local participation and involvement

One of the main objectives of the first phase of the project was to ensure local community awareness, participation and involvement in the project design and planning as well as in management activities.

Indeed, many conflicts occurred at the beginning of the first phase of the project, particularly with the local fishers and few residents. This may be explained by various factors including a lack of awareness regarding project scope and objectives; a lack of trust regarding foreign management; previous negative experiences with projects that never materialized; as well as a concern that the targeted area will be taken away from the community.

In this context, constant and continuous consultation strategies were undertaken with the adjacent local community including focus-group and key-informant interviews, participatory mappings, observational walks and boat trips with residents including women and youth. These strategies helped to identify potential conflicts, seek solutions in advance, and ensure community leadership towards project design and planning.

Moreover, various communication tools were created in order to ensure increased local awareness and positive local perception towards the project scope and objectives. Such tools included community-based events, community clean-ups of mangrove areas, the facebook page and informative panels.

Finally, all management activities have been designed, planned and conducted by local residents themselves, including women and youth. The local community is now strongly aware of the project. Approximately 200 residents participated in the project activities demonstrating strong local willingness to participate. A petition list was conducted, in March 2017, totaling 600 signatures demonstrating positive local perception towards the project. Moreover, all the consultation strategies have allowed the residents to be part of the decision-making processes and project design and planning, in a collaborative manner, taking into account local needs, wants and opinions. The local residents strongly involved in project activities are now able and willing to resolve local conflicts themselves without intervention of the management team. This achievement was considered as the most difficult and critical strategy ensuring project effectiveness and sustainability.

IV COMMUNITY-BASED AQUACULTURE STRATEGY

4.1 Goal

The main goal of the pilot study is to establish a sustainable and collaborative management model for community-based aquaculture development to support local livelihood, in a marine coastal wetland adjacent to Residences La Chaux, Mahebourg.

4.2 Objectives and respective activities

1. Rehabilitate entirely and suitably the existing mangrove ponds, adjacent to the barachois, for aquaculture development.
2. Implement pilot study on crab aquaculture in the mangrove ponds and barachois.
3. Build local capacity to equip the community, particularly fishers, with the necessary skills and knowledge in the operations of aquaculture product development and enterprise.
4. Facilitate partnerships between all stakeholders for collaborative management of the aquaculture initiative.
5. Strengthen awareness at local national and global levels of the need and approaches for sustainable and community-based aquaculture of mangrove resources.

Expected outputs and respective activities are provided in the logical framework presented in annex 1 and can be summarized as follows:

1. The existing mangrove ponds are rehabilitated for aquaculture development.
2. Pilot study is of crab culture successfully implemented by local community members.
3. Local skills and knowledge developed for implementation and management of an aquaculture enterprise.
4. Local people and others stakeholders collaborate effectively and sustainably.
5. Local, national and global awareness and support for the community-based aquaculture initiative.

4.2.1 Component 1: Rehabilitation of the marine coastal wetland for aquaculture development.

Outputs 1: The existing mangrove ponds are rehabilitated for aquaculture development.

Three mangrove ponds were selected for crab culture. The ponds are deeper than the other place varying from a depth of approximately 50 cm to 6 meters. According to a local expert the minimum depth required for crab culture is 30 cm in king low tides. Moreover, the ponds are entirely surrounded by mangrove areas and have muddy sandy bottom.



Figure 5: *Picture illustrating one of the mangrove ponds located in the targeted coastal wetland.*

Hydrological restoration

The hydrological restoration of the mangrove forests has started during the first phase of the project and consisted in opening waterways that have been damaged over years in order to restore the natural circulation of the marine coastal wetland. However, the separation between each ponds still need to be rehabilitated and a stainless grid need to be set up to prevent escape and a bridge will have to be renovated to facilitate access between each ponds. The selected size of the stainless grid will be 1.5 cm mesh to ensure that the smallest legally collected crablets sized (approximately 2.5 cm) will not be able to escape. Local labour will be used for construction, particularly local residents who will be assisted and supervised by technically trained supporters

Renovation of the main access road

The renovation of the main access road is necessary to ensure proper access to the wetland and mangrove ponds. All the road has been completed during the first phase of the project. However, the structure need to be consolidated in case of extreme climatic events.

Walking tracks rehabilitation

The walking tracks which give accessibility to the different ponds need to be rehabilitated. This will consisted in renovating existing rock tracks and removal of Invasive Alien species.

Clean-up of the marine coastal wetland

Considering the significant amount of solid waste already collected on the working areas, it is clear that clean-up of solid waste will be another initiative that need to be conducted. Indeed, the site has been locally considered as a dumping ground for many years. As a consequence, two clean-up events will be organized in collaboration with the University of Mauritius and with the local community. The one-day community based event will be necessary to remove solid waste from the site. Moreover, the creation and the installation of waste sorting bins in different locations will be also carried out as part of an awareness campaign.

Finally, sediment and water quality as well as the evolution of the marine biodiversity of the barachois, mangrove ponds and near shore seas of the coastal wetland will be monitored, over the long term, through various methods. Results will provide information and data assessing the impacts of the project

activities on the marine environment. Indeed, it is important to notice that additional conservation measures including regular monitoring will be conducted while undertaking aquaculture activities to verify potential negative impacts on mangrove ecosystem.

4.2.2 Component 2: Implement pilot study of mud crab aquaculture

Output 2: Pilot study is of crab culture successfully implemented by local community members.

The first selected species for aquaculture is the mud crab *Scylla serrata* which is the most widely distributed species (Shelley, 2008) and the only species of the genus *Scylla* in the Indian Ocean (Mirera, 2009). Locally, it is called crab "carlet" or "asoir". The crab inhabits mangrove forests, usually burrowing in mud or sandy mud and has both ecological and economic importance to the adjacent coastal fishing communities (Keenan *et al.*, 1998). Indeed, its preference for estuarine habitat (Cowan, 1984), as well as its fast growth rate, less aggressive behavior and tolerance for a wide range of biophysical parameters make it valuable compared to other species. Moreover, it is considered as quality food for local community consumption and for sale in hotels as they have high value due to their excellent taste, texture and nutrition value (Cowan, 1984; Trino & Rodriguez, 2002).



Figure 6: Photograph of a mud crab (*Scylla serrata*).

The pilot study of crab aquaculture, in the selected mangrove ponds will be conducted over a period of 10 months between April 2018 and January 2019. Only grow-out operations will be conducted as hatchery and nursery operations have higher costs and infrastructure and expertise is lacking at national level. Consequently, the cultivation of crabs will consist in crabs collection, growth-out and harvest when reaching market size. Growth-out operations will be undertaken in two main systems: an open system of mangrove ponds and a closed system in which crabs will be held individually in cages.

Crablets collection from the wild



Figure 7: *Picture illustrating bait traps that will be used for crablets collection.*

This activity will rely on wild caught stocks and crab collectors. Three local fishers will be designated to collect mud crab for the project. Permit for crablets collection from the wild has been requested to the ministry of Ocean Economy, Marine Resources, Fishing and Shipping and is expected to be obtained in February 2018. The fishers will be engaged in part time collection. Crablets will be collected continuously between April and August 2018. According to a local expert, the peak harvesting season of crablets in Mauritius occurs between April and September. The availability of seed stock seems to be high according to local crab collectors. However, due to uncertainty of wild crab seed supply, local fishermen will start the collection simultaneously with the renovation of the ponds in April 2018. The gear for collection will include baited traps with small sized mesh (fig.7) and bait net with torch at night.

Stocking in mangrove ponds

Crablets of legal size (approximately 2.5 cm in carapace length), with mixed sex, will be collected, mainly at night, transported using a bucket and stocked in the ponds, in the morning, at a low density to reduce mortality. The smaller crablets collected will be stocked in the ponds while the bigger one will be disposed in individual cages for experimentation. The number of stocked crablets will be monitored. Each crablets will be examined for morphological condition, carapace length and width using a cernier calipers as well as sexed and weighted. After growing to maturity, as gauged by size, they will be transferred into individual cages to prevent the cannibalistic nature of crabs and predation.

Feeding and feeds

Crabs feed naturally on an omnivorous diet of a wide range of animal and plant resources (Hill, 1976) and grow well in aquaculture on a wide variety of feeds (Shelley, 2008).

During the first two months after stocking, wild-collected crablets will be fed once a day. After this interval, the crabs will be fed two times a day, before and during incoming tides, which are the times that mud crabs traditionally emerge in search of food. Crabs will be fed with trash fish including fish heads, fish skin, broken fish and fish entrails at 10% body weight. Feed will be chopped into small pieces before being weighted and spread in the ponds using feeding ropes. Feed will be attached to the feeding ropes using screw pine leaves (*Pandanus species*), locally named vacoas.

Feeding ropes will be set up in the mangrove ponds and supported by wooden post (with a diameter of approximately 10cm) that will be borrowed in the sandy muddy bottom. Vertical support wooden posts will be made of treated Strawberry Guava (*Psidium cattleianum*) to be resistant to marine borers. They will be interspersed 4m apart at various locations in order to ensure that most pond surface will be provided with feed. The stems will be collected by local residents in the Black River George National Park, under the clearance from the National Park and Conservation Services.

In keeping with the asset-based community development strategy of the project, feed will be sourced from local fishermen and local women, who have agreed to provide trash fish to the project at continuous and regular intervals.

However, research will be ongoing as to the optimal formulated feed to be use afterwards in the project; livestock feed has been already consulted and will be approached as a potential option.

Harvest for fattening system

It has been suggested that routinely undertaking partial harvests of crabs closed from the market-size crabs can be an effective strategy to minimize cannibalism in grow-out systems (Say & Ikhwanuddin, 1999). It will leave sub-harvest sized crabs to grow to harvest size in more space, with reduced incidence of predation and less competition for feed (Christensen, Macintosh and Phuong, 2004). As a result, crabs reaching size of approximately 10 cm in carapace length will be harvested and stocked in individual cages located at selected locations in the mangrove ponds. Moreover, stocking mud crabs in individual cages will make their assessment simpler. The frequency of feedings will be two

times per day. Based on best practices, mud crabs in the fattening system will be fed 10% of their total body weight per day using trash fish.

The size at harvest will be chosen according to the needs of local markets that the project is servicing. In Mauritius, the minimum market size is about 500g which crabs reach approximately 6 months after collection, if fed on a daily basis. When crabs of a marketable size are assessed as full, they will be removed from the cages, processed, secured and sold live.

Cages design and construction

Local residents, mainly fishers, will construct floating and drive-in cages. During the experimental study, the amount of cages including compartments that with a capacity to hold approximately 100 crabs in individual compartments. Experimental cages will be constructed using three different materials; (1) Plastic materials; (2) Strawberry guavas stems and; (3) PVC materials as suggested by local fishers.

The idea of constructing cages using bamboo stems is no longer considered as the durability of bamboo wood is short in marine water in comparison to the strawberry guava wood and require the same amount of labour.

Floating and drive-in cages will be located at different locations in the barachois area and will be used to address the cannibalism behavior of the species. The pictures cages in Strawberry guava stems, divided into 4 compartments, of (L=40cm, l=40cm and h=40cm) has been designed and made by local fishers during the design & planning phase of The Barachois Project. The cages are designed to be large enough for only one market-size crab to fit.

Cages will be sewn together using ropes created from plastic bottle and nylon. Cage covers will be permanently attached on one side and the other side tied with plastic rope. The movable covers will facilitate monitoring and feeding.





Figure 8: *Photographs of cages using strawberry guava stem and plastic, made by local residents.*

The cost and durability of cages will be the criteria used to select the adequate type of cages and materials for project sustainability. On a daily basis, the crab cages will be checked in order to ensure that no damage has occurred so the crab stock cannot escape.

As a result, this experimental study will allow to determine the performance of the mud crab rearing systems installed in mangrove ponds and evaluate the return on investment from cages with different construction materials.

Development of a surveillance strategy

Mud crabs are valuable on the local market, and therefore the local team will have to be vigilant to prevent and reduce losses from poachers. Surveillance and security will be most important when stock is nearing harvest and the mud crabs are considered the easiest to catch and market.

In addition to the national rules and legislations related to the protection and conservation of the marine and coastal biodiversity in Mauritius, voluntary-based rules in the coastal wetland will have to be developed and approved by all community members to ensure study effectiveness. Consultation strategies will include meetings with cooperative members, focus-group and key-informant interviews, participatory mapping and observational walks. The voluntary-based rules are expected to be designed and implemented by the local community itself.

During the experimental study, surveillance will be carried out only by night patrols and weekend patrols. The surveillance is expected to start in June 2017 when the risk of poaching is higher as the

crabs collected will increase in size. It has been decided that five fishers will be appropriately selected in a voting process and trained to become rangers. Three fishers will conduct surveillance at night and two will be responsible for day patrols during the weekend. During the week, as the management team will conduct many management activities in the wetland, this operation will not be necessary reducing surveillance cost. Training will cover verbal communication skills, education and awareness raising, and observation techniques. They will be paid personnel with 8 hours shifts and their role will be clearly defined using TOR, as mandated by the cooperative and fully understood by all stakeholders. The rangers will not undertake any direct enforcement actions but will be responsible for ensuring that the local people comply with the site regulations (national and voluntary-based) and ensure that fishing legislations are known, understood and respected by local people. They will also discuss infractions with offenders and record information regarding illegal activities.

It is critical to implement an awareness campaign to support the surveillance operations. Awareness raising on the benefits of the aquaculture project for the local community, and the rules created by the local team to avoid illegal poaching for project effectiveness will be critical and will be strongly disseminated in the local community through various communication tools, pamphlets, panels and informative consultations.

Finally, a community-based coastal watch strategy will be implemented, as suggested by the cooperative members in order to assist guard for the surveillance of the ponds. Indeed, the participation of the local people in increasing surveillance and disseminate information regarding the initiative and the need to support it will ensure project effectiveness and sustainability.

4.2.3 Component 3: Build local capacity for community-based aquaculture development and management.

Output 3: Local skills and knowledge developed for implementation and management of an aquaculture enterprise.

Provision of material and equipment

All the necessary material and equipment to develop aquaculture operations will be provided by the NGO to the cooperative (local committee) and used by the local team.

Training on grow-out operations

Local experts and national experts have been consulted and will guide and mentor the local team in developing the aquaculture strategy from crablets collection to harvest when reaching marketing size. Site visit to similar project will be conducted with the local team to enhance their skills and knowledge and focus on best practices aquaculture techniques in Mauritius.

Training on post harvest operations

As the majority of mud crabs are sold as a live product, the establishment of quality control systems with input from individuals or companies with professional experience is mandatory to ensure the delivery of a quality product to the customer.

All facilities and operating procedures will be developed to meet standards upheld by the government of Mauritius and minimize the transmission of food-borne diseases carried by crustaceans.

The mud crabs will be examined, cleaned and stored before being transported to the processing facility, and tied with string of rafia to ensure they do not cause mortality to the surrounding crabs. Crab size and fullness will be monitored to ensure they are suitable for market resale, and placed into containers as previously described. The priority throughout the supply chain will be to reduce post-harvest mortalities by minimizing stress to the crabs post-harvest.

Various guidelines on mud crab culture have been consulted to develop strategies to minimize stress on crabs throughout the supply chain, including maintenance of temperature post-harvest, reduction of ammonia accumulation, maintenance of moisture, use of a recovery tank to hold mud crabs, and storage in mud or hessian-lined containers to avoid draughts (Shelley & Lovatelli, 2001).



The processing of crabs will be standardized, with records kept on a receiving form as part of the overall quality control system. The temperature of containers during processing will be monitored, and crabs will be maintained at temperatures between 18 and 30 degrees Celsius to minimize stress. All containers will be weighed, and transporters will obtain receipts, with containers being taken to a cool room to maintain crabs in a low-stress environment and ensure that the ideal temperature range is not exceeded. Processing will be done in dedicated clean, tidy and organized areas including crates, rubbish bins, scales, pallets and forms, and appropriate sanitary measures, including closing doors to exclude flies or vermin, will be taken. The product will be monitored through the facility with details of the grading, sorting and processing of the crabs recorded.

Preliminary grading of mud crabs will be carried out before the packing stage. The grading system will be appropriately documented, with checklists and posters describing the process, and graders trained to be proficient in following these regulations.

Based on published guidelines (Shelley & Lovatelli, 2011), the table below provides the procedure for allocating grades to harvested mud crabs.

GRADES	CHARACTERISTICS
Grades A, B (further sorted by sex/ size/ weight)	Lively/robust with claw intact and strong leg and antennae movement ➤ Packed for market
One claw (separately graded)	Lively/ robust but missing a claw ➤ Packed for market
Slow ("Crab lage")	Leg and antennae movement slow or weak when handled or legs will not walk if placed on surface. Crab that show "bubbles" from around the mouthparts. ➤ Send to grow-out system under strong management
Commercially unsuitable crab (CUC)	Soft-shell or empty that have moulted on the way to the processing facilities ➤ Sent back to the fattening system Bleeding crabs ➤ send to freezing for crab meat production Crab with holes in crab's shell / old crabs covered with dark marks or worn claws / crab with unacceptable appearance ➤ Send to freezing for crab meat production
Discard	Dead or diseased ➤ Send to waste immediately in strong plastic bags. Bins will be emptied regularly to prevent bad smell, flies or vermin.

All employees will be adequately trained in basic hygiene and food handling with regard to their personal responsibilities, including washing, wearing protective clothing, and preventing diseases. Procedures will be developed to reduce the risk of mud crabs being contaminated, including sanitizing all surfaces prior to mud crab exposure. Supervisory staff will consistently monitor and update these protocols, which will be visibly posted.

Crabs will be packed by grade into cartons and polystyrene crates for transportation to local markets immediately after harvest. The boxes will be prepared prior to crab and prawn harvesting by staff who take appropriate safety measures of protective clothing and footwear.

Crabs will be packed into plastic cages (Fig.9). The crabs will be packed with their head and claws tilted toward the top of the box to minimize stress and potential damage to the carrying containers. Each box will be clearly labeled as to the grade, harvest date and weight of the product inside, as well as logistic information on the packer and receiver.



Figure 9: *Picture illustrating plastic cage that will be used for crab transportation.*

The crabs will be immediately transported after harvest and packaging to markets. The purchase of a transport will be necessary to reduce the transport duration, ensuring that crabs are not exposed to temperatures outside their preferred range and minimizing stress.

Training for implementing a marketing strategy

In Mauritius, *Scylla serrata* is most commonly harvested at weights over 500g. Price will vary depending on weight and grades. Local prices for mud crab (grade A & B) are provided in the table below. Weights are presented in grams (g) and kilograms (kg).

Weight	500g	750g	1kg	1.25kg	1.5kg	2kg	2.5kg
Market Price	MUR 300	MUR 400	MUR 800	MUR 1000	MUR 1200	MUR 1400	MUR 2000

Crabs with a missing claw will fetch a lower price. Crabs with two missing claws cannot be sold and will need to be returned to the grow-out system for their claws to regenerate. Both females and males are usually sold locally at the same price, however, customers seem to have more interest in purchasing females.

Every seafood species produced in the barachois and adjacent mangrove ponds are expected to be labeled as part of a marketing strategy. The labels currently being considered are:

"Community-based aquaculture"

"Based on fair market"

"Mangrove friendly aquaculture"

Various marketing tools will be used to increase awareness and market demand toward the crab aquaculture initiative. Information and communication tools will be developed and include pamphlets, brochures, business card, website, exhibition day, facebook page, short documentaries as well as various consultation strategies with the targeted customers.

At present, the market is expected to be conducted at a national level. The targeted customers include hotels, restaurants, shopping centers, markets, individuals and middlemen. In 2014, a list of potential customers was obtained through consultation strategies. Five local hotels, five local restaurants and three local supermarkets were responsive and interested in the potential products of the project. A secondary consultation with the targeted customers will be conducted in the coming phases of the project.

4.2.4 Component 4: Develop a collaborative management system for community-based aquaculture.

Output 4: Local people and others stakeholders collaborate effectively and sustainably.

This pilot study actively encourages the participation of other stakeholder groups including community members, local fishers and others resources users as well as government agencies and local NGOs. Indeed, It is now globally acknowledged that successful management of wetland requires an integrated approach that relies upon effective protection and conservation of biodiversity and the constructive engagement and participation of local communities (Williams, 2002). Community-based conservation is a better alternative compared to central level management and is an effective and sustainable tool solving conflicts and engaging community involvement for wetland resources protection (Trisurat, 2006). It has been acknowledged that the higher the level of community engagement, the higher their compliance to the natural resources conservation (Andrade & Rhodes, 2012). Such management system will ensure that local people have a stake in, and benefit from it either directly, or indirectly through a more productive and healthier environment and the introduction of alternative livelihood opportunities that reduce pressures on coastal resources. As a result, emphasis will be placed in ensuring strong involvement, participation and support from the local communities to ensure study effectiveness and sustainability.

Management structure in place and effective

A cooperative has been established in January 2018 and comprises 50 community members including fishers, women and youth. The election of cooperative's representatives has been conducted in December 2017, through a voting process. After consultation with local residents, it has been decided that the cooperative will form the local committee is part of the decision making process for the project design, planning and management. The local committee will manage and meet once a month, the local team.

Indeed, the present study will be developed by selected local residents who form the local team. The day-to-day operations of will be undertaken, on a voluntary basis except the surveillance patrols. Only five selected residents will be paid, on a monthly basis, to conduct surveillance at night and during the weekends. The surveillance will start two months after crablets stocking in the mangrove ponds, when the risks of poaching will be higher as the crablets will increase in size. All candidates, who form the local

team, will be appropriately trained to conduct their respective work and will meet once a week to discuss activities' updates and advancements. The local team will meet once a week the Project Manager. The local committee and the local team will be continuously mentored and assisted by the Project Manager, volunteers and interns as well as experts and scientists.

Finally, the Collaborative Management Area Committee (CMAC) will comprises representatives of all stakeholders' groups of The Barchois Project. Stakeholders' groups include governmental agencies, social and environmental NGOs and associations, experts and scientists, the private sector, the general public, Environmental Protection & Conservation Organisation (EPCO) as well as the local community, represented by the local committee (Refer to table). The CMAC will meet once every four month workshop to brainstorm project study activities and planning, build collaboration and partnerships and enhance local support from stakeholder groups.

Project's organogram

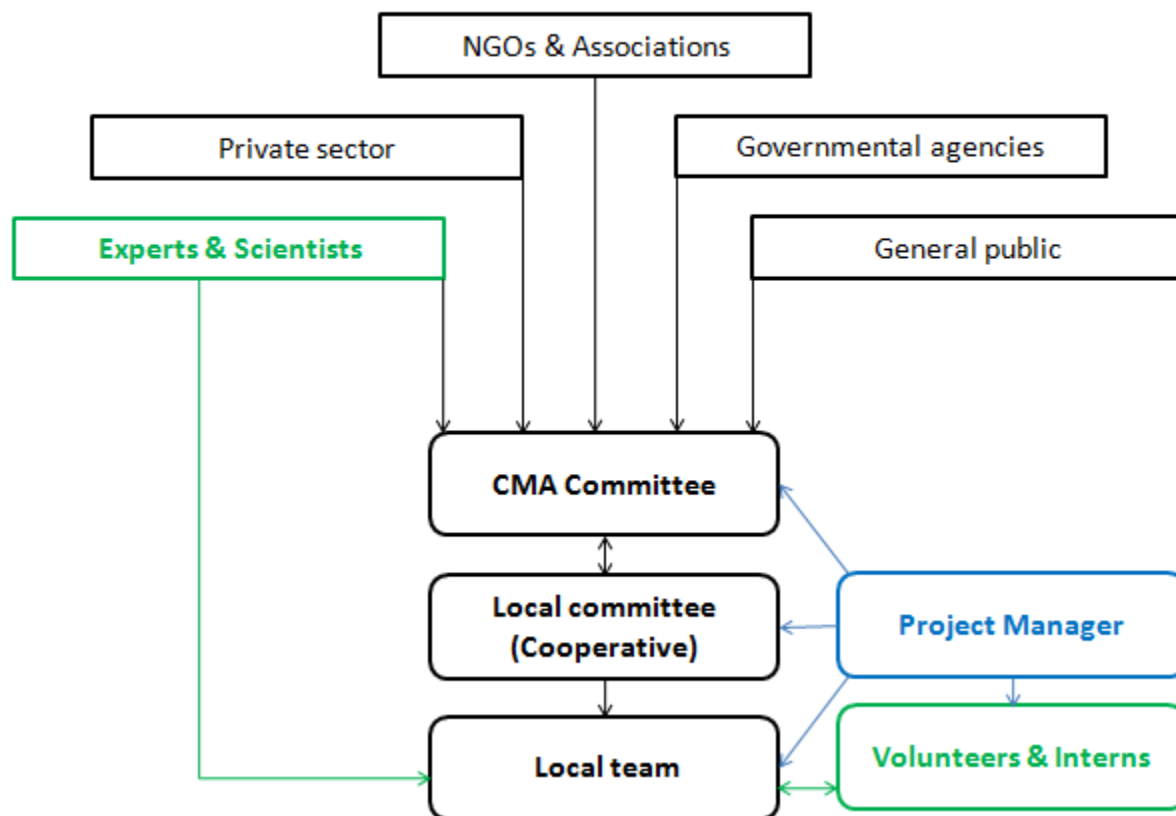


Figure 10: Organizational structure of management over the project's period.

Stakeholders analysis

STAKEHOLDERS	ROLES
Local community	<ul style="list-style-type: none"> On-ground management Information dissemination among community members Traditional knowledge Decision making
Albion Fisheries Research Centre (AFRC)	<ul style="list-style-type: none"> Technical advice and expertise Aquaculture facilities Permitting process Training Decision making
Ministry of Ocean Economy, Marine Resources, Fisheries and shipping	<ul style="list-style-type: none"> Permitting process Decision making
Ministry of Agro-Industry and Food security	<ul style="list-style-type: none"> Decision making
Ministry of Environment and Sustainable Development	<ul style="list-style-type: none"> Decision making
Fisheries Post of Mahébourg	<ul style="list-style-type: none"> Technical advice Enforcement
National Coast Guard (NCG)	<ul style="list-style-type: none"> Enforcement Training
University of Mauritius (UOM)	<ul style="list-style-type: none"> Volunteering & internship Technical advice and expertise Monitoring & evaluation strategy Decision making
Local environmental NGOs	<ul style="list-style-type: none"> Volunteering Networking Training Awareness raising and dissemination Decision making
Local associations	<ul style="list-style-type: none"> Networking Volunteering Awareness raising and dissemination Support on project activities Decision making
Mauritius Oceanographic Institute (MOI)	<ul style="list-style-type: none"> Technical advice and expertise Networking
District Council of Grand Port (DCGP)	<ul style="list-style-type: none"> Clean-up material and facilities Permitting process
Local and national experts for aquaculture development	<ul style="list-style-type: none"> Technical advice and expertise Training
Private sector (CSR and other companies)	<ul style="list-style-type: none"> Funding Networking Marketing and customers Volunteering
Volunteers and Interns (foreign students)	<ul style="list-style-type: none"> Support on project activities

Table 1: List of the main stakeholders of the present study.

As a result, the management structure of the present study comprises a hierarchy of three levels of management (fig.10) which collaborate effectively and sustainably to develop and manage community-based aquaculture activities, part of The Barachois Project.

Aquaculture management plan

A management plan for community-based aquaculture will be developed and finalized at the end of the study. The plan will cover all aspects of management including day-to-day operations, business and financial management. It will facilitate continuity in the case of staff changes, and improve communication and information dissemination with all stakeholders over the long term and clarify objectives and set priorities for improving human and financial resources, and guide the management team. Moreover, it will provide the constitution outlining local team, Local Committee and CMA Committee responsibilities and activities, elections, meetings, Terms Of References (TORs) and penalties. The management plan will be included in the CMA Management plan that will be developed at the end of the three's year project based on lessons learns and best practices. It will have to be renewed by the local management team, once every 6 years to ensure effectiveness and sustainability.

4.2.5 Component 5: Awareness raising towards the present study.

Output 5: Local, national and global awareness and support towards the present community-based aquaculture initiative.

Considering the anthropogenic causes of degraded resources of wetlands and lagoon in Mauritius and worldwide, it is critical to develop awareness raising strategies at local, national and global levels, regarding the need to project, conserve, manage and use coastal and marine resources sustainably for poverty alleviation and enhanced quality of life of the local communities directly dependant. Moreover, in order to secure the success and sustainability of the community-based aquaculture operations in the mangrove ponds and potentially in the Barachois of Residences La Chaux, Mahebourg, local people need to have increased knowledge and awareness of the need for conservation, protection and sustainable use of biodiversity in order to enhance and diversify the livelihood systems of the community which will in turn increase the local wellbeing.

Implement an awareness raising strategy with the adjacent local community and other stakeholders

Various communication tools will be developed to ensure that the local people is aware of the management activities and the potential benefits. Such tools will include, progress report, facebook page, interpretative panels, pamphlets and press release.

Convene stakeholders and community members to exhibition day

Two exhibition day will be conducted with local community members and stakeholder groups ' representatives to show the activities on the ground, the infrastructure established and to be able to have interaction between stakeholders and fish farmers.

Constant reporting with all stakeholders

Constant progress report and a study report will be developed and shared with all stakeholders in order to increase awareness and support. It will include updates on what has been achieved and updates regarding the activities.

Compile and publish technical paper on project issues, lessons learnt and best practices

In pursuit of efforts to replicate and extend the approaches of the aquaculture initiative , technical papers o advocate experiences, techniques, best practices and lessons learnt will be published and disseminated to the relevant institutions and practitioners.

V MONITORING AND EVALUATION STRATEGY

A monitoring and evaluation (M&E) strategy will be implemented as soon as the study start. The methods used to evaluate socio-economic, governance, biophysical and aquaculture performance indicators will be simple and suitable to ensure its continuation over time so that long term comparison can be made. It will be participatory as local people will be trained and actively involved to conduct the programmes This process will indicate how well the pilot study meets its objectives and consequently to identify weaknesses and gaps, within the context of adaptive management.

Biophysical monitoring will be conducted in collaboration with the Ocean Study department of the University Of Mauritius (UOM).

The tables below provide the type of monitoring, the indicator and dataset associated.

Aquaculture performance	Growth rate	Date of crablets stocking Number of crablets stocked Average size and weight of crablets stocked Average size and weight of crablets (Once a month)
	Ratio of gain in body weight to the weight of feed provided (FCR)	Type and weight of supplementary feed provided per day Feed used / feed left on feeding ropes Average size and weight of crablets (Once a month)
	Mortality rate (f)	Number and mass of crablets stocked Number and mass of crabs harvested Any signs of disease
	Poaching rate	Number of crabs missing (in cage only)
	Farming effort	Date, time, type and duration of each operation Identity, number and schedule of staff members responsible for each operation Type of gears, equipment and boat used for each operation
	Surveillance effort	Date, time, duration of operation Identity, number and schedule of rangers per night
	Costs and revenues	Market price Number and price of individual sold Labour cost Gear cost Fuel cost Maintenance cost Wages Net and gross benefits
	Trade development	Number and nature of markets
	Market response	Stock sold/stock left overs

Bio-physical	Change in water quality	Temperature / salinity/ pH / dissolved oxygen / turbidity
	Change in sediment quality	pH & electrical conductivity Total Organic Carbon (TOC) & Total Nitrogen (TN) Sulphur / Total phosphorus Heavy metals
	Evolution dynamics of marine biodiversity	Fish species diversity and abundance Coral diversity and percentage cover Algal diversity Invertebrate diversity and abundance Crab density

Socio-economic	Skills and knowledge development at local level	Number of training conducted Attendance at training Attendance at site visits
	Awareness raising at local level	Number, frequency and type of communications tools provided Attendance at exhibition day and other awareness raising activities
	Level of community involvement and participation in aquaculture activities	Participation list at all consultations strategies Number of supportive initiatives Number and identity residents involved in paid activities Number and identity of residents involved in voluntary-based activities
	Income generating activities created for local residents	Number of income generating activities created Identity of salaried staff Number of fish farmers, on a voluntary basis Financial benefits received to all participants at the end of the study Number of income generating activities created post study

Governance	Degree of stakeholders' involvement	Adequacy and effectiveness of decision making process Frequency of meetings and consultation with stakeholders Attendance and participation at consultation strategies CMA committee, local committee and local team meetings (frequency, attendance, minutes) Perceptions and satisfaction towards Collaborative Management
	Level of conflict over resource uses	Identification of stakeholders concerned Identification of the issue at stake in the conflict Time period and intensity of the conflict How the conflict has been managed and resolved
	Local understanding of regulations	Dissemination of information (rules/legislations/institutions) Local awareness and understanding towards the CMA rules
	Compliance and enforcement	Degree of information dissemination encouraging compliance Level of surveillance (patrol, coastal watch) Number of recorded incidents of illegal practices Source of information regarding incidents Measures taken to curb the observed incidence

VI RISKS AND ASSUMPTIONS

<u>RISKS</u>	<u>LEVEL</u>	<u>MITIGATION STRATEGIES</u>
Social conflict and negative local perception and attitudes towards the project	Medium	<ul style="list-style-type: none"> • Regular and continuous interaction with local residents through consultation strategies • Pro-active socio-economic monitoring • Participation of local community in all restoration and conservation efforts • Constant and regular communication and information tools provided on update and progress • Interpretative panels • Weekly meeting local team and monthly meeting with cooperative • Understanding and taking into account local views, opinions, needs and wants
Illegal fishing activities and detrimental natural resources use in the coastal marine wetland	Medium	<ul style="list-style-type: none"> • Continuous and regular sensitization of local residents • Awareness emphasis will be placed on how the project will benefit the local community • Pro-active governance monitoring • Selected local fishermen will be trained to become rangers • Daily and nightly patrols • Implementation of participatory coastal watch surveillance strategy
Diseases (presence of pathogens and diseases problems)	Low	<ul style="list-style-type: none"> • Training and implementation of risk management strategy to reduce risks (health certification, strict hygiene, careful disinfection of gears and materials) • Pro-active monitoring of water quality and species health • Use of proper diagnostic tools based on expertise • Limitation of cultured species based on carrying capacity • Immediate removal and isolation of diseased species • Sanitary disposal of mortalities
Solid waste disposal	Low	<ul style="list-style-type: none"> • Conduction of community-based clean-up event • Regular and continuous sensitization of the community
Cyclones, hurricanes and storm surges	Medium	<ul style="list-style-type: none"> • Proper design and renovation ponds dykes based on technical expertise taking into account extreme climatic events (e.g. appropriate dykes height to avoid flooding) • Proper design and renovation of all structures and facilities based on expertise and taking into account extreme climatic events.

VII TIMEFRAME

[illegible]

Creation of an aquaculture management plan										
Governance monitoring										
Awareness raising towards the present study										
Awareness raising with the local community										
Exhibition day with community										
Exhibition day with all stakeholders										
Press release										
Progress report										
Study report										
Publish technical papers										

VIII INNOVATION

- The present initiative will implement pilot innovative community-based and collaborative management schemes for aquaculture activity in Mauritius.
- This pilot project will develop and test suitable techniques for aquaculture of crab "carlet" using different grow-out strategies in the barachois.
- The project will pilot innovative participatory biophysical, socio-economic, governance and aquaculture monitoring programme.
- It will demonstrate and disseminated information on aquaculture best practices and lessons learned that can be replicated on other unused barachois and degraded coastal wetlands in Mauritius.
- The project will also promote fair trade in a safe, healthy and clean environment.
- It will also enhance the promotion and consolidation of public and private sector partnerships that are innovative and primordial for the project's success and sustainability.
- This project will support the development of innovative integrated management for sustainable coastal wetland based on best practices and Monitoring and Evaluation (M&E) strategy that can be replicated on other.

IX SUSTAINABILITY AND REPLICABILITY

The gradual transition from community-based aquaculture initiative with external technical assistance to a mainstream operation in which the local community permanently conducts and manages day-to-day operations will be supported by the development of added value initiatives to generate new income from “No take” products. Such sustainable financing mechanisms, include ecotourism (guided visits and other activities such as recreational fishing, kayaking), and the sale of traditional items that are hand-made by the community and inspired by the biodiversity of the site as well as sea-food barbecues cooked traditionally by local residents, which will further encourage the sustainable use of natural resources without causing biodiversity loss.

All local residents will be trained and subsequently assisted and mentored by national and international experts during the implementation phase of the project. It is expected that they will then be able to pass on their knowledge and practices to future generations in order to meet the context of sustainability.

An environmental education programme targeted towards primary school children will be also developed in the area. The children are targeted due to their proximity, because they are the future 'coastal resources managers' and their ability of influencing their parents on attitudes and behaviours towards the environment.

Additionally, the management plan which will be developed based on the monitoring & evaluation strategy of the project will be a crucial tool to guide the long term management of the project and disseminate all aspects to stakeholders to ensure effectiveness, transparency and sustainability.

This pilot project is, thus, expected to serve as a trigger that will pave the way for the development of a national programme to encourage and sustain the development of others aquaculture initiatives in unused barachois along the Mauritian coast. This project bears the potential of becoming a reference to guide other on collaborative management project planning for community initiatives nationally and internationally. It also highlights the benefits of collaborative management as an effective and sustainable way to manage marine and coastal resources and acknowledgement of the same reflected through changes in national legislation and policies. It will also pilot reinstating ecosystem services offered by coastal wetlands to strengthen local and national capacity, and to harmonise policy and institutional frameworks.

REFERENCES

Anon (1991). *State of the Environment in Mauritius*. Ministry of the Environment, Quality of life, Government of Mauritius.

Anon (2001). *Annual Report*, Ministry of Fisheries, Albion Fisheries Research Centre, Albion, Mauritius.

Alongi DM (2002). *Present state and future of the world's mangrove forests*. Environmental Conservation 29 (3): 331–349 © 2002 Foundation for Environmental Conservation.

Appadoo C (2003). *Status of Mangroves in Mauritius. Journal of Coastal Development*. Volume 7, Number 1, October 2003 : 1- 4.

Baliao DD, De Los Santos MA, and Franco NM (1999). *Pen culture of mudcrab in mangroves*. Aquaculture extension manual, No. 29, March 1999. 10 pp.

Barbier EB (2007). *Valuation of ecosystem services supporting aquatic and other landbased food systems*. In D.M. Bartley, C. Brugere, D. Soto, P. Gerber and B. Harvey (eds). Comparative assessment of the environmental costs of aquaculture and other food production sectors: methods for meaningful comparisons. FAO/WFT Expert Workshop. 24-28 April 2006, Vancouver, Canada. FAO Fisheries Proceedings. No. 10. Rome, FAO. 2007. pp. 71–86.

Board Of Investment (BOI), (2007). *Potential for Sustainable Aquaculture Development in Mauritius*. Ministry of Agro-Industry and Fisheries (Fisheries Division). Board of Investment. December 2007.

Board of Investment (BOI) & IDEE (2007). *Développement de l'aquaculture à L'Ile Maurice Etude du potentiel aquacole. Rapport final*. November 2007.

Brummett RE and MJ William (2000). *The evolution of aquaculture in African rural and economic development*. Ecol Econ 33:193–203

Fagoonee I (1990). *Coastal marine ecosystems of Mauritius. Hydrobiologia*, 203: 55-62.

Campbell J, E Whittingham and P Townsley (2006). *Responding to Coastal Poverty: Should We be Doing Things Differently or Doing Different Things?* In Hoanh CT, TP Tuong, JW Gowing and B Hardy (eds) *Environment and Livelihoods in Tropical Coastal Zones*. CAB International, London.

Cowan L (1984). *Crab farming in Japan, Taiwan and the Philippines*. Queensland Department of primary Industries, Brisbane, QLD. Australia Information series Q 184009.

Fast AW and P Menasveta (2000). *Some Recent Issues and Innovations in Marine Shrimp Pond Culture*. Reviews in Fisheries Science, 8(3): 151–233.

Food and Agriculture Organization of the United Nations (FAO) (2004). *The State of World Fisheries and Aquaculture: 2004*. Rome.

Food and Agriculture Organization of the United Nations (FAO) (2006). *State of world aquaculture: 2006*. FAO Fisheries Technical Paper 500. FAO Fisheries Department, Rome.

Giasuddin M and MF Alam (1991). *The mud crab (Scylla serrata) fishery and its bio-economics in Bangladesh*. In: Angel CA (ed) *The mud crab: a report on the seminar convened in Surat Tahi, Thailand*, Nov 5–8, 1991, pp 29–40.

Hambrey J (1996). *The mangrove question*. Asian Shrimp News, Asian Shrimp Culture Council, Bangkok, Thailand, Issue No. 26, 2nd Quarter, pp. 43-47.

Hamilton L, J Dixon and G Miller (1989). *Mangroves: an undervalued resource of the land and the sea*. Ocean Yearbook, 8: 254- 288.

Kador A (1991). *Mud crab—a potential aquaculture resource of Bangladesh*. In: Angel CA (ed) *The mud crab: a report on the seminar convened in Surat Tahi, Thailand*, Nov 5, 1991, pp 95–102

Kathiresan K and BL Bingham (2001). *Biology of mangroves and mangrove ecosystems*. Advances in Marine Biology 40: 81–251.

Keenan CP, Davie PJF, and Mann DL (1998). *A revision of the genus Scylla De Haan, 1833 (Crustacea: Decapoda: Brachyura: Portunidae)*. Raffles Bull. Zool. 46, 217-245.

Marine Aquaculture Task Force (MATF) (2007). *Sustainable Marine Aquaculture: Fulfilling The Promise; Managing The Risks*. Report, January 2007.

Ministry of Environment and NDU (2007). *National Status Report on the Marine and Coastal Environment*. NAIROBI Convention. Republic of Mauritius. October 2007.

Ministry of Environment and Sustainable Development (2010). *Fourth National Report on the Convention on Biological Diversity*. Republic of Mauritius, August 2010.

Mirera OD (2009). *Mud Crab (Scylla serrata) Culture: Understanding the Technology in a Silvofisheries Perspective*. Western Indian Ocean J. Mar. Sci. Vol.8, No. 1, pp.127-137, 2009.

Mirera OD (2011). *Trends in exploitation, development and management of artisanal mud crab (Scylla serrata-Forsskal-1775) fishery and small-scale culture in Kenya: an overview*. Ocean Coast Manag 54:844–855

Mirera DHO and MA Samoilys (2008). *Natural resource dependence, livelihoods and development: Mariculture exchange between Kenya and Tanzania*. IUCN ESARO 2008.

Mwaluma J (2002). *Pen Culture of the Mud Crab Scylla serrata in Mtwapa Mangrove System, Kenya*. Western Indian Ocean J. Mar. Sci. Vol. 1, No. 2, pp.127-133 , 2002.

Primavera JH (1998). *Mangroves as nurseries: shrimp populations in mangrove and non mangrove habitats*. Estuar. Coast. Shelf Sci., 46: 457-464.

Primavera JH (2006). *Ocean and coastal management*. Overcoming Impact Aquac Coast Zone 49:531–545

Primavera JH, LMB Garcia, MT Castanos and, MB Surrtda (2000). *Mangrove-friendly aquaculture*. In: Proceedings of the workshop on mangrove-friendly aquaculture organized by the Seafdec aquaculture Department, Jan 11–15, 1999. Iloilo, Philippines

Primavera JH, JB Binas and GPB Samonte-Tan, MJJ Lebata, VR Alava, M Walton and L Levay (2010). *Mud crab pen culture: replacement of fish feed requirement and impacts on mangrove community structure*. *Aquac Res* 41:1211–1220

Rönnbäck P (2001). *Shrimp aquaculture - State of the art*. Swedish EIA Centre, Report 1. Swedish University of Agricultural Sciences (SLU), Uppsala. (ISBN 91-576-6113-8).

Rönnbäck P and JH Primavera (2000). *Illuminating the need for ecological knowledge in economic valuation of mangroves under different management regimes—a critique*. *Ecological Economics*, 35: 135–141.

Salm RV, J Clark and E Siirila (2000). *Marine and Coastal Protected Areas: A guide for planners and managers*. IUCN. Washington DC. xxi + 371pp.

Sauer JD (1962). *Effects of recent tropical cyclones on the coastal vegetation of Mauritius*. *J.Ecol.*50:275–290.

Shelley C and A Lovatelli (2011). *Mud crab aquaculture – A practical manual*. FAO Fisheries and Aquaculture Technical Paper. No. 567. Rome, FAO. 2011. 78 pp.

Spalding M., F Blasco and C Field (1997). *World Mangrove Atlas*. The International Society for Mangrove Ecosystems, Okinawa, Japan, 178 p.

Thornton C, M Shanahan and J Williams (2003). *From wetlands to wastelands: Impacts of shrimp farming*. *SWS Bulletin*, 20(3): 48–53.

Trino AT, Rodriguez EM (2002). *Pen culture of mud crab Scylla serrata in tidal flats reforested with mangrove trees.* *Aquaculture*. 211:125-134.

Troell M (2009). *Integrated marine and brackishwater aquaculture in tropical regions: research, implementation and prospects.* In D. Soto (ed.). *Integrated mariculture: a global review. FAO Fisheries and Aquaculture Technical Paper*. No. 529. Rome, FAO. pp. 47–131.

Wells S, S Makoloweka and M Samoilys (2007). *Putting Adaptive Management into Practice: Collaborative Coastal Management in Tanga, Northern Tanzania*, x+197p.

Annex 1: Completed studies and reports (2016 - 2017)

- **Marine Environmental Assessment of a barachois at Cite La Chaux, Mahebourg.**
Nazurally Nadeem & Bhoyroo Vishwakalyan, University of Mauritius, August, 2016
- **Interview survey with local fishers: Report**
Estelle Deja, EPCO, September, 2016
- **Feasibility Study: Developing community-based aquaculture in the Barachois of Residences la Chaux Mahebourg: Final report.**
Estelle Deja, EPCO, September, 2016
- **Indicators of Resilience in Socio-ecological Production Landscapes and Seascapes. Assessment Workshop Reporting form.**
Estelle Deja, EPCO, April 2017
- **Household Survey report**
Estelle Deja, EPCO, May 2017

- **Floristic Survey / Weed Management and Conservation Plan**
Nazurally Nadeem & Bhoyroo Vishwakalyan, University of Mauritius, May, 2017
- **The Barachois Project - Bird species present in the barachois**
Antoine Riviere, Intern, University of Reunion, July 2017 (English & French version)
- **The Barachois Project - Highlight report of the Design & Planning phase**
Estelle Deja, EPCO, July 2017
- **The Barachois Project - Baseline Study - Alien species - Terrestrial plants**
Giles Atkinson, Intern, University of Bristol, England, September 2017
- **The Barachois Project - Baseline Study - Native and endemic species - Terrestrial plants.**
Giles Atkinson, Intern, University of Bristol, England, September 2017
- **Protocole de suivi de la dynamique de la végétation sur la zone du Barachois Cité la Chaux à l'Île Maurice. Mise en place d'un quadrat permanent.**
Loup Spadola, Intern, University of Reunion, November 2017 (French version)
- **The Barachois Project - Guideline for creation of a nursery**
Denoyelle Anne, Intern, University of Reunion, November 2017 (French version)