

Recognising the local values of coastal wetland biodiversity for sustainable economic and livelihood development at Résidences La Chaux ‘*Barchois*’, Mauritius

Lead authors:

Estelle Déja^{1*}, Devon Dublin², Yoji Natori², Yasuo Takahashi³

¹Environmental Protection & Conservation Organisation (EPCO), Mahebourg, Grand Port, Mauritius

²Conservation International Japan, 6-7-1-507 Shinjuku, Shinjuku-ku, Tokyo, 160-0022 Japan

³Institute for Global Environmental Strategies (IGES), 2108-11 Kamiyamaguchi, Hayama, Kanagawa, 240-0115 Japan

Corresponding author:

*estelledeja.epco@gmail.com

Abstract

Barchois features Mauritian historical seascape, which is composed of brackish water lagoons enclosed by stone walls traditionally used for fish rearing under French rule before 1800, as well as patches of mangroves and coastal woodlands surrounding the lagoons. They, however, are now mostly abandoned and turned into waste dumping ground. The Environmental Protection & Conservation Organisation (EPCO) initiated a community-based project to pilot the restoration of the *barchois* seascape that enhances its socio-economic, cultural, aesthetic and environmental values and thus to improve local people’s livelihoods and promote biodiversity conservation. As a part of the project appraisal and implementation process, the project investigated multiple values that stakeholders in the target community associate with the *barchois* seascape by household surveys and focus-group discussions. All stakeholder groups that we investigated, i.e., fishers, tourist boat skippers, women, youth and elders unanimously noted the importance of the two major functions of the *barchois* seascape. These were shelter against coastal hazards such as cyclones and storms; and fish reproduction. *Barchois* also produces crabs, which were mainly harvested by youth for household consumption. Some value aspects were perceived differently among stakeholder groups. Tourist boat skippers appreciated the value of the *barchois* waterbody and endemic birds as tourist attractions. Women and elders tended to appreciate the beauty of the seascape and animals. Women emphasized the importance of *barchois* for children to learn swimming and to understand natural environment. The recognition of the values that *barchois* seascape entails for the local community enabled the project to draw stronger commitment of a wide range of stakeholders to the restoration of *barchois* and sustainable resource management in it, resulting in the establishment of a local cooperative. This process has improved local decision-making capacity and will contribute to the harmonization of legislation in the future.

Keywords: Barchois; Local Values; Wetland Biodiversity; Restoration; Mauritius

Country	Republic of Mauritius
District	Grand Port
Size of geographical area ¹	Approximately 70 hectares
Number of indirect beneficiaries ²	2,140 persons (Local community)
Dominant ethnicity	Creole
Size of case study/project area ¹	70 hectares
Number of direct beneficiaries ²	115 persons (number of residents who gain additional income by conducting on-the-ground project activities)
Geographic coordinates (longitude and latitude)	20°25'01.6"S 57°42'52.7"E
Dominant ethnicity	Creole



Figure 1. Map of the country and case study region



Figure 2. Land/sea use and cover map of case study site

1. Introduction

Although threatened, wetlands constitute some of the most important ecosystems on earth for biological, hydrological, socio-economic, cultural and aesthetic reasons (Terer, Ndiritu & Gichuki 2004). Fish, clay, fibre, water supply and purification, nutrient retention, coastal protection, climate and flood regulation, recreational opportunities and tourism attractions are wetland ecosystem services that enhance human well-being and livelihoods (Gayatri 2000; Oglethorpe & Miliadou 2000). Wetland ecosystem goods and services are essential for sustaining livelihoods (Costanza et al. 1997), particularly in developing countries where local communities are highly dependent on natural resources.

However, it is estimated that more than 50 percent of wetlands worldwide have been degraded or lost in the past 150 years (O'Connell 2003) due to anthropogenic factors primarily resulting from a lack of awareness of their ecological and socio-economic value (De Groot, Wilson & Boumans 2002; Terer, Gichuki & Ndiritu 2005). Environmental degradation occurs worldwide and tends to create severe economic and social impacts resulting in ecological conflicts (Armiero & Sedrez 2014; Martinez-Alier, Temper & Demaria 2016). Conflicts are the consequences of differing perceptions of value by different groups of stakeholders. Reaching consensus among all stakeholders on multiple values is often neglected in the decision-making process (Iniasta-Arandia et al. 2014; Phelan & Jacobs 2016; Villegas-Palacio et al. 2016). It is thus critical for decision-makers to recognize and integrate the values perceived differently by all stakeholders to ensure effective and sustainable wetland conservation and management planning.

In Mauritius, *barachois* are marine coastal wetlands and refer to parts of coastal lagoons established for fish rearing and segregated from the ocean by permeable stone walls, mostly constructed before 1800 under French rule (Paul & Balkema 1987). *Barachois* are Mauritian coastal socio-ecological systems, with rich biodiversity and productivity characterized by complex brackish water ecosystems. They have become increasingly abandoned mainly due to management difficulties and have been turned into waste dumping sites. In 1965, the Ministry of Fisheries took the *barachois* of Mahebourg and started aquaculture experiments using fish, crabs, prawns and oysters (see Fig. 3). Only for experimental purposes, the effort did not provide any benefits to adjacent communities. Subsequently, there were frequent incidents of poaching by local people, regardless of fences and patrols by security guards and dogs. The experiment was terminated in 1985 when someone poisoned the *barachois* waters. This case clearly revealed that the decision-making process of the *barachois* restoration planning, which was



Figure 3. Aerial view of Mahebourg barachois (Photo by John Olsen)

carried out by governmental agencies and experts without community participation, had led to ineffectiveness and unsustainability.

There are 33 *barachois* along the coastline of Mauritius, located in estuaries or nearby groundwater outlets where complex brackish water ecosystems are formed (Coche 1982). To halt the degradation of these critical ecosystems, and in response to depleting inshore fish stocks, attention is increasing being paid to the rehabilitation and enrichment of *barachois* for boosting aquaculture production and diversifying the livelihoods of local fishing communities (Rawson 1988).

2. The *barachois* project

The Environmental Protection & Conservation Organisation (EPCO) developed a pilot project aiming to implement a sustainable and collaborative *barachois* management model. To make degraded *barachois* seascapes productive and appealing again, the project started with an investigation into the vital role of the seascape in biodiversity, local livelihoods and well-being. In this vein, the project also aimed to alleviate poverty in the fishing community, which was critically important to decrease fishing pressure in the lagoon. The project consists of six major components:

1. Restore and conserve natural resources of the marine coastal wetland;
2. Develop community-based aquaculture in the *barachois* and adjacent mangrove ponds;
3. Build local capacity for management, conservation and sustainable use of natural resources and equip the community with the necessary skills and knowledge in enterprise development;

4. Develop community-based recreational and tourism activities promoting natural, cultural and historical value;
5. Facilitate partnerships between all stakeholders and establish a collaborative management system for the targeted wetland;
6. Strengthen awareness at local, national and global levels of the link between biodiversity conservation and the well-being of local communities.

In order to ensure the effectiveness and sustainability of the restoration interventions, gaining the positive perception and attitude of the local people was crucial, especially fishers who are the main resource users living in the vicinity of these wetlands. Although often neglected by the national government, integrating local values into restoration design and planning is critical to ensure success. This study addresses this gap and presents an overview of the approaches that aimed to examine the multiple values perceived differently within and among different stakeholder groups. It also explains how an understanding of multiple local values was integrated into the planning and design phase of the project, leading to improved community participation, support and engagement.

3. Methods

3.1 Study site

The study site is located on the south-eastern coastline nearby Mahebourg, within the district of Grand Port, on Mauritius Island (see Fig. 1). It includes the *barachois* waterbody (24ha), mangrove and dry scrub forests (13 and 6

ha), and the adjacent coastal community (18ha) and extends to an islet and coral reef lagoon (app. 10 ha, see Fig. 2).

The *barachois* area had been abandoned for more than 30 years. At the start of the project, the permeable stone walls had collapsed due to waves. The degradation continued with an increasing volume of solid waste being dumped there by the local people. Portions of mangroves had been damaged or cut down. Although some endemic and native plant species were observed, such as the portia tree (*Thespesiapopulnea*), beach cabbage (*Scaevolataccada*), pemphis (*Pemphisacidula*) and the critically endangered endemic *Polysciasmaraisiana*, a widespread invasive alien plant scrub was noticed in the surrounding coastal lands (Atkinson 2017).

Approximately 2,140 local people, including 607 children, inhabit the coastal community of Résidences La Chaux, where 551 households live in 356 houses (Déja 2017). Disadvantaged by their Creole origin and past migrant history (i.e. under French rule from 1715 to 1810 and British from 1810 to 1968) (Hollup 2000), the coastal fishing community has limited access to decent job opportunities, financing and government support. The predominant livelihoods for men are artisanal fishing and construction labour. Livelihood opportunities are even less diverse for women, as 46 percent are housewives, 10 percent multifunctional maids and 6 percent cleaners. Low education level and a lack of skills and qualifications are additional reasons resulting in this low job diversity. Finally, about 30 percent of the workforce is engaged in the fisheries and tourism sectors, which directly utilize natural capital in the Mahebourg coastal ecosystems (Déja 2017, see Fig. 4).

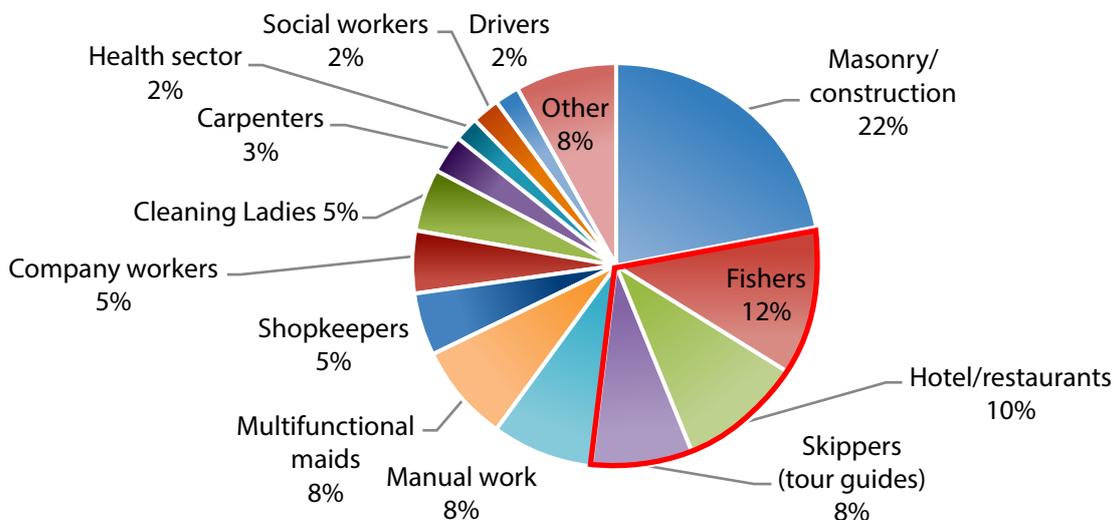


Figure 4. Major occupations of Résidences La Chaux community members (Déja 2017)

The coral lagoon outside the *barachois* harbors economically important marine vertebrate and invertebrate species (Appendix 1), and is used as the main fishing ground by local artisanal fishers. However, the abundance of lagoon corals and fishes has been in continuous decline as recorded since 1970 (Fagoonee 1990). The causes of fish catch decline and degrading lagoon ecosystems include: overfishing; past use of explosives for fishing; coral collection for ornaments and construction; water pollution by outflows from massive sugar cane fields, and sugar factory and domestic water discharges, among others (Rawson 1988; Fagoonee 1990; Hollup 2000). Declining fish catch has further exacerbated the struggling economy of the fishing community. Moreover, the government sets the bar high for new fisher licensing, making it virtually impossible for youths to operate as “legal fishers”.

3.2 Data collection

In this context, to achieve restoration and conservation, the project’s targets and activities needed to be valued and approved by all groups of the community. Ensuring positive local perception and attitude toward the project was considered to be critical before starting any on-the-ground restoration interventions. We employed multiple methods to comprehensively understand the value that local people associate with the *barachois* seascape. For baseline data gathering and building trust in the local community, we carried out surveys and a series of community consultations. For value elicitation, we used focus-group interviews. Furthermore, we conducted key-informant interviews with government institutions that have a stake in the Mahebourg *barachois* to gather data on the governance scheme. The scope of our analysis included the three major ecosystem domains that constitute the seascape, i.e., the *barachois* waterbody inside the stone walls; the lagoon outside the *barachois* and within the coral reef margins; and a mosaic of mangrove and coastal dry scrub vegetation patches along the *barachois* water fringes. Prior to the on-site data collections described above, we also conducted an online survey to inform the development of the field methodology.

3.2.1 Surveys and community consultations

Throughout the project, we conducted a series of surveys and community consultations to accumulate baseline data and to accommodate the reality, needs and aspirations of the local community in the project design and implementation process. These included a household survey, fishers’ survey and community feedback sessions.

A questionnaire survey was conducted for fishers from March to July 2016. A total of 49 fishers participated, representing

80 percent of all fishers in the target community. The survey asked both closed and open-ended questions, falling under eight question groups: (1) socio-economic attributes; (2) income from fishing; (3) income from other activities; (4) location of fishing; (5) fishing gear type; (6) state and trend of fish catch; (7) interactions with other stakeholders; and (8) perception of and expectation for the project (Déja 2016).

We also conducted a household survey from June to December 2016. In this survey, we interviewed 76 households, which represent 14 percent of all households in the target community. The survey asked closed and open-ended questions falling under seven sections: (1) socio-economic attributes; (2) income; (3) education and skills; (4) perception of and willingness to participate in the project; (5) perception of own community and surrounding environment; (6) use of coastal resources; and (7) views on the management of the *barachois* seascape (Déja 2017).

Alongside, we held regular consultations with the local community between February 2016 and March 2019. These meetings covered various topics, including feedback on survey results and focus-group discussions. As needed, we employed participatory appraisal methods, such as transect walks and boat trips. The utmost effort was made to involve as many community members as possible using various communication methods, such as direct letters, information panels at gathering places, distribution of calendars and by word of mouth.

3.2.2 Value elicitation

We conducted focus-group interviews to elicit the values that different stakeholder groups associate with the *barachois* seascape. We identified five stakeholder groups to represent the community, i.e., fishers, skippers, women, youth and elders (see Table 1), referring to the household survey results. In each focus group interview, we developed an exhaustive list of values that the participants associate with the *barachois* seascape based on the nature’s contributions to people (NCP) framework (Díaz et al. 2018). We then asked participants to rank the importance of each value item using a ten-point scale, i.e., 1 (unnecessary) to 10 (indispensable). The NCP framework evolved from the ecosystem service categories used in the Millennium Ecosystem Assessment (2005), but more explicitly captures the non-materialistic values that people perceive through their interactions with nature. Hence, the NCP framework is suitable for understanding how people in the target communities perceive the value of nature through their day-to-day interactions with the surrounding *barachois* seascape.

Table 1. Stakeholder groups and their attributes

Groups	# participants	Attributes
Fishers	8	Aged between 33 to 66, all male
Skippers	12	Aged between 15 and 60, all male, mainly engaged in taking tourists to islets and off-shore tourist spots
Women	8	Aged between 15 and 60, occupations varied, including maids, social workers, housewives and an EPCO employee
Youth	14	Aged between 15 and 25, 12 males and 2 females. Occupations varied, including fishers, skippers, construction workers, hotel workers, housewives and students.
Elders	7	Aged between 55 and beyond 61, four males and three females
Total	49	Aged between 15 and 66, 36 males and 13 females

3.2.3 Governance

To collect information on the institutional setting and policies relating to *barachois*, we conducted key-informant interviews with the public authorities that have a stake in the *barachois* seascape. These included the Ministry of Social Security, National Solidarity and Environment and Sustainable Development (MSSNSESD); Ministry of Agro-industry and Food Security (MAIFS); Ministry of Ocean Economy, Marine Resources, Fisheries and Shipping (MOEMRFS); and the Mahebourg Fisheries Post.

4. Results

4.1 Multiple values of the *barachois* seascape

Through key-informant interviews, we identified multiple values that local people attribute to the *barachois* seascape and species present in the study area, as well as their linkages with different components within the study area and the NCP categories (Figure 5). Results highlight that food and feed (NCP 12) was the value commonly derived from all ecosystem domains. Other values included

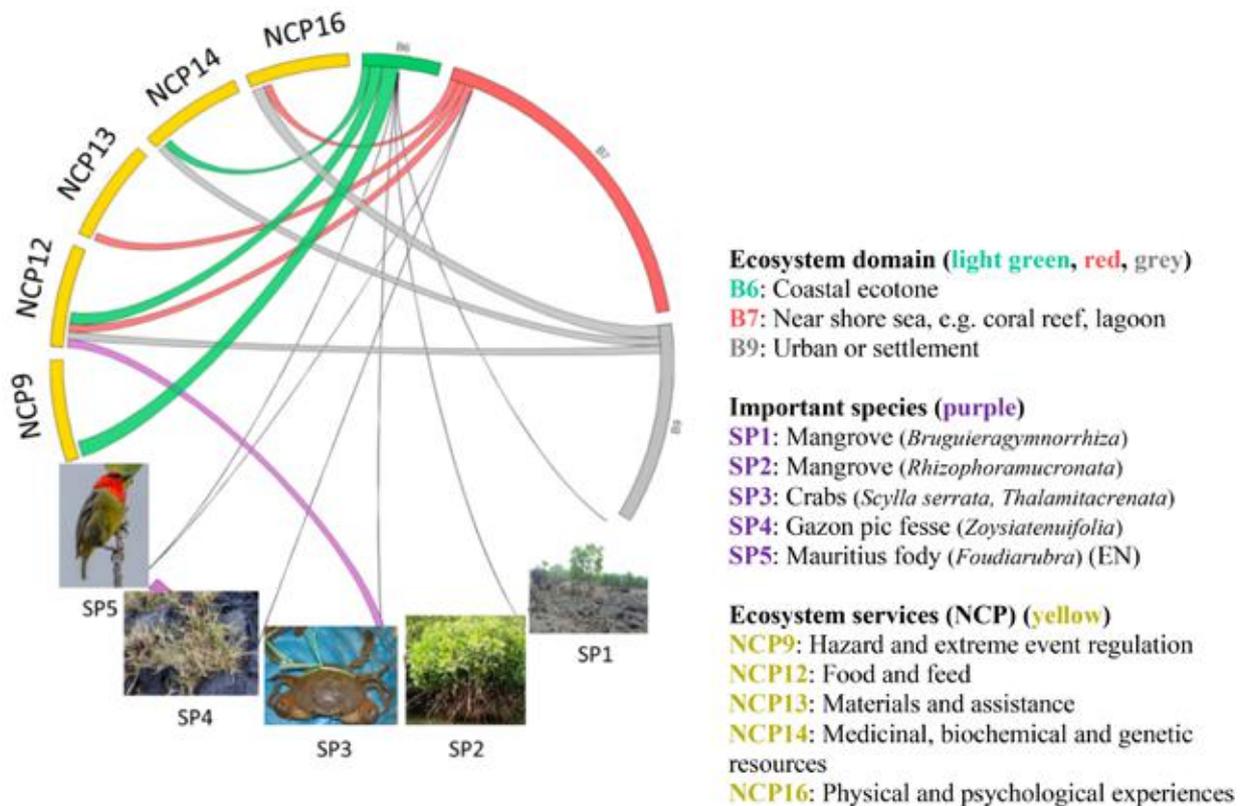


Figure 5. Connection between ecosystem domains, species and ecosystem services (NCP). The top-right arcs show the area of different ecosystems in proportions; the bottom arcs, the species present in these ecosystems that were recognized as important either for biodiversity conservation or for local people (connected to their habitat ecosystem domains by thin lines); and the top-left arcs, the value of these ecosystems and species for local people per the NCP categories (connected to the ecosystem domains and species from which these values are derived).

mitigation of storm and cyclone hazards (NCP 9) and medicinal ingredients from mangrove tree roots (NCP 14), derived from the mangrove ecosystem. Likewise, sea urchins and shells for ornament crafts (NCP 13) from the lagoon, and recreation for local people and tourists (NCP 16) was linked to the *barachois* and lagoon. We also found that commodities brought in from outside the seascape and opportunities for recreation available within the town were also important for the local community.

Focus-group interviews revealed the differences in the values that the five stakeholder groups attribute to the three ecosystem domains: coastal ecotone, near shore sea, and urban or settlement (see Table 2; Fig. 6). All five groups pointed to the importance of mangroves as nursing grounds for fish, through the provision of nesting sites, shade and protection from predators. The fishers' group stressed the undiscovered value of *barachois*, as they are still learning how to wisely utilize the site.

Table 2. Description of the values that five community groups associated with three ecosystem domains in the barachois seascape

Ecosystem	Species	NCP category	NCP description	Beneficiaries
Mangrove		01.Habitat creation and maintenance	Nursery for juvenile fish, crabs and shrimps -mangroves protect them from predators and provide shade to keep water temperature stable. Bird nests in mangroves. Important for maintaining all elements people obtain in coastal sea (maintain coastal ecosystem functioning)	Fishers
		07.Regulation of freshwater and coastal water quality	Filtration of water	
		08.Formation, protection and decontamination of soils and sediments	Prevents erosion	Whole community
		09.Regulation of hazards and extreme events	Barrier against cyclone/storm waves, surge and wind	Fishers and skippers
		15.Learning and inspiration	Parents teach their children not to cut mangrove trees	
		16.Physical and psychological experiences	Beautiful scenery -tourists visit to take pictures	Tourists
		17.Supporting identities	Beauty (seascape)	Whole community
	Mangrovetree (<i>Bruguieragymnorrhiza</i> ; <i>Rhizophoramucronata</i>)	14.Medicinal, biochemical and genetic resources	Mangrove roots used as medicinal ingredient for diabetes treatment	Whole community
	Crabs	12.Food and feed	Supplemental food for local people (Kids collect crabs at night and sell them for pocket money)	Whole community
	Fish, shrimp, worms, small crams/snails, algae, crabs	12.Food and feed	Baits for fishing (fish, shrimp, worms, etc.)	Fishers
<i>Barachois</i>		09.Regulation of hazards and extreme events	Safe place to keep and repair boats. Boats owned by hotels are kept in the <i>barachois</i> when cyclones come	Fishers, skippers and boat owners
		12.Food and feed	Worms used for fishing bait	Local community
		15.Learning and inspiration	Kids learn swimming and fishing	Local community (mostly kids)
		16.Physical and psychological experiences	Relaxation and recreation, e.g. safe place for elders and kids to swim, picnics, recreational fishing	Local community
		16.Physical and psychological experiences	Tourist destination, e.g. kayaking	Skippers

Ecosystem	Species	NCP category	NCP description	Beneficiaries
		18.Maintenance of options	People are still learning to use <i>barachois</i> more effectively with undiscovered values anticipated by some	Whole community
	Crabs, fish	12.Food and feed	Mollusks (<i>tektek</i> , <i>bigorno</i>), sea urchins, fish, crabs, eels, and shrimps are harvested and collected by local people, especially for coping with temporary periods of unemployment. Kids collect crabs and sell for pocket money.	Whole community
	Gazon pic fesse	08.Formation, protection and decontamination of soils and sediments	Prevents coastal erosion	Whole community
	Migratory birds	16.Physical and psychological experiences	Some local people are curious about the birds that are only seen during limited periods (summer) of the year	Whole community
Lagoon		16.Physical and psychological experiences	Tourist destinations (coral reefs, lagoons and islands) and activities, e.g. diving and sailing. Not only used as tourist destinations, but also used by locals for boat trips and fishing for leisure. Beautiful seascape.	Tourism sector (e.g. skippers)
		13.Materials and assistance	Sea urchins and shells harvested for manufacturing ornaments. Used for room decorations and for presents	Tourists, local beach hawkers and craftspeople
	Fish, octopus	12.Food and feed	Fish, lobsters, squids, octopus and other seafood species	Local fishers /whole community
	Dolphins	16.Physical and psychological experiences	Tourist attraction (tourists pay tips to skippers when skippers successfully locate and show dolphins to them)	Tourists, skippers
N/a	Mauritius fody (EN)	16.Physical and psychological experiences	Tourist attraction	Skippers

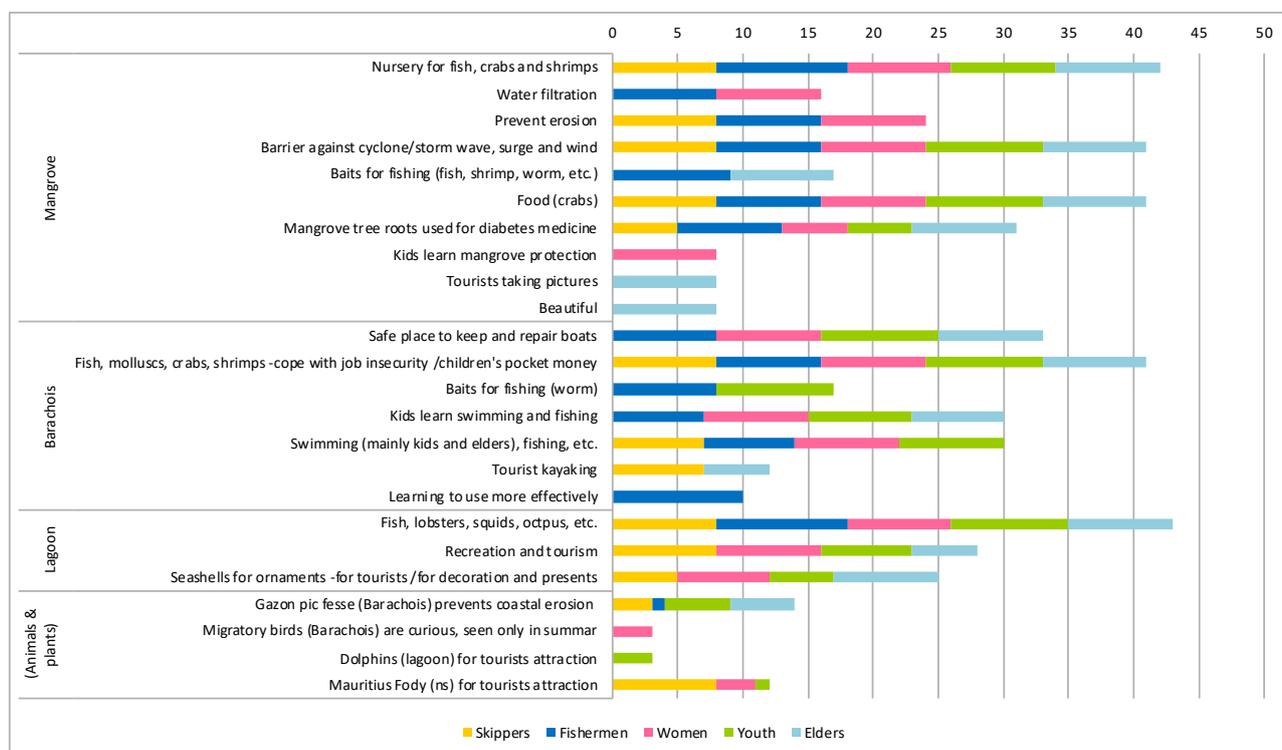


Figure 6. Aggregate of the ecosystem value scores by five focus groups (The highest value score by individual group is 10. Thus, the highest aggregate score is 50.)

4.2 Governance and knowledge of the *barachois* seascape

Key-informant interviews with the government authorities clarified their respective jurisdiction relating to the *barachois*. MAIFS chairs the National Ramsar Committee, and thus oversees the administrative procedures regarding the *barachois*, as *barachois* are recognized as wetlands under national land use classification. MSSNSESD takes responsibility for administrative procedures including Environmental Impact Assessments (EIA) and other permits. MOEMRFS takes charge of all seawaters, including those in the *barachois* and lagoon. It regulates fishing activities by licensing, gear restrictions, seasonal restrictions and surveillance. The Fisheries and Marine Resources Act 1998 (FMRA) provides the legal framework for fisheries and marine living resources management. The Fisheries Protection Service (FPS) and the National Coast Guard (NCG) under the aegis of the MOEMRFS and the National Police Force respectively, enforce fishing regulations in lagoon and off lagoon. Officers of the FPS operate in a number of fisheries posts including the Mahebourg Fisheries Post, which controls fishing activities in the Mahebourg district (FAO 2006).

In 2014, the national government of Mauritius adopted a resolution that encourages aquaculture development in the state-owned *barachois*. Under the resolution, private proponents can lease state-owned *barachois* under a concession agreement with the government of Mauritius. Under this scheme, EPCO obtained a concession for managing the Mahebourg *barachois*. As EPCO's involvement is time-bound, the project established a local cooperative for *barachois* management that would take over the management after the project end. In an interview on 27 June 2017, MOEMRFS implied the enactment of new national legislation on fisheries co-management was implied. Once this takes place, the legislation is likely to support the cooperative and the management of the *barachois* based on a collaborative approach.

Our survey also indicated a limited body of traditional or local ecological knowledge regarding the management of the *barachois* seascape. Individuals, particularly elders, held knowledge on uses, e.g. mangrove roots for diabetes medicine, location of fishing grounds and fishing techniques such as the construction of crab cages. However, all focus groups unanimously agreed that they had not inherited any knowledge for proactively managing the seascapes from their ancestors. Instead, they claimed to have started learning and accumulating knowledge with the project.

The coastal artisanal fishers in Mauritius exploit the lagoon and outer lagoon coastal fisheries. Fishers are either self-

employed or under the aegis of a middleman upon whom they depend for cash advance, gear, boats, fuel, finance and marketing (FAO 2006). Others operate in fishery cooperatives. Artisanal fishery in and around the project area encompasses multi-species fishing, comprising mainly emperor fish (locally known as capitaine, dame berri, battadet, caya), parrotfish (cateau species), spinefoot (cordonnier), wrasse (madame tombee, colombine and lalo), goatfish (rouget species), grouper (vieille rouge, grise and voleur), unicornfish (corne species) and trevally (carangue), as well as shrimps, lobsters and octopus which are fished to a lesser extent (Déja 2016). Traditional means and methods of fishing are used. Hooks and lines, basket traps, large nets and gill nets are the most commonly used methods in the region. Artisanal fishers have traditional boats, locally known as pirogue, in wood or fiberglass, powered by outboard motors of 8 to 16 horsepower (Déja 2016). All registered fishers are legally obligated to take their catches to the prescribed fish landing stations, where officers of the FPS constantly record their attendance and information related to catch characteristics, fishing grounds and fishing efforts (FAO 2006). In 2016, 148 and 26 professional artisanal fishers operated from the landing stations of Mahebourg and Pointe d'Esny (i.e. Résidences La Chaux), respectively.

5. Discussion

Overall the five stakeholder groups agreed on the highest importance of two major functions of the coastal landscape. One is the mangroves' function to provide shelter against cyclones/storm waves, surges and wind. The other relates to fish reproduction and harvesting, where the functioning of the three ecosystem domains are slightly different but inseparably linked. Mangroves have a critical role in fish reproduction through the provision of spawning and nursing grounds, and produce crabs which are mainly harvested by youth for household consumption. The *barachois* provides a wider variety of marine vertebrates and invertebrates, such as molluscs, crabs, eels and shrimp, which community members harvest mainly for household consumption. This harvesting holds high importance, helping households to cope during periods of unemployment. The lagoon is the main fishing ground for professional artisanal fishers, and thus is the main source of cash income to the community.

The value scores across the five focus groups differed in several aspects of the seascape. Fishers stressed that they are still learning to utilize the *barachois* wisely, and thus placed a high value on it. They also pointed out the importance of live bait for fishing that they collect in mangroves and the *barachois*. Skippers appreciated the value of endemic birds and the *barachois* waterbody as a tourist attraction – an aspect that was entirely absent in the fishers' group.

The women's and elders' groups tended to appreciate the beauty of the seascape and animals. The women's group emphasized the importance of mangroves and the *barachois* for children to learn swimming, and to enhance environmental awareness. It is important to be inclusive of the views of all stakeholder groups in order to recognize the full value of the coastal ecosystem (Natori et al. 2018).

The understanding of multiple values that the local community associate with the biodiversity in *barachois* seascape, which differ across different groups in the community, was useful during the first phase of the project. This understanding helped and guided the project team to effectively determine the two main objectives of the project's design and planning: (1) developing the project strategic plan in a collaborative manner to ensure that the project's targets and activities fulfil local wants, needs, opinions and vision, and (2) increasing local awareness, participation, support and engagement in the project.

Indeed, understanding the multiple values held by various stakeholder groups guided the project organizers to use messages that appealed more effectively to all community groups and also to better understand the totality of the value of the seascape. For instance, organizers of the project initially assumed that conserving the *barachois* and developing aquaculture were important only for fishers. However, it turned out that the restoration and conservation of *barachois* were also important for women, for a clean and safer environment, and even for maintaining the site's beauty, as well as for a place for learning and recreation for children.

A comprehensive understanding of the multiple values of this SEPLS also allowed project organizers to foresee potential conflicts among community groups that could arise as a result of the project activities. For instance, the household survey highlighted that the local people do not rely on the resources in *barachois* for their livelihoods. Only a few people were harvesting crabs, collecting bait and fishing, while fishers depended only on lagoon and sea fishing. This implied relatively low socio-economic impact on the local community by restoring and conserving the *barachois*, which may require limiting access to its resources. On the contrary, the local people might be supportive of restoring and conserving the *barachois*, considering its recreational uses by the local community, which had been diminished due to deteriorating conditions. Similarly, when designing aquaculture activities in the *barachois* area, we carefully considered the fact that many fishers use the *barachois* waters to park their vessels, particularly when they face coastal hazards such as cyclones. This knowledge helped the project team to design aquaculture activities that do not to inhibit the use of the same water for other purposes

such as this. Further, to convince the fishers, we issued official letters that stipulated a mutual agreement between the project and the fishers, ensuring fishers' access to and use of the *barachois* water. Knowledge gained on multiple values also helped project organizers to deliver messages that effectively gained the positive attitudes and proactive involvement of the fishers in aquaculture development.

We confirmed that fishers have localized, or even personalized, knowledge on resources, including the location of fishing grounds, fish migration patterns, seasonal abundance of economically important species, as well as fish reproduction and feeding behaviours. We, however, were not able to identify knowledge for proactively managing the *barachois* seascape and for sustainable resource use. We attributed this to the relatively short history of the community. The community was established around 1960 when people from Pointe Canon migrated to the current area after Cyclone Carol ravaged areas throughout Mauritius. Neither institutional arrangements by the government, nor spontaneous initiatives by the local community, have been made since for sustaining the coastal resources. During the project, the five focus-group discussions significantly increased local awareness of the multiplicity of values perceived by different stakeholders. Indeed, by sharing perceptions of value, the voice of each participant increased overall understanding and knowledge of the socio-economic and ecological value of the ecosystem domains and species, and consequently has positively influenced the community's desire to conserve them to enhance associated benefits. The result was strong local engagement and willingness to act collectively for the restoration and conservation of the marine coastal wetland. This also allowed the establishment of a local cooperative that represents all major community groups, and enhanced their ownership of the enterprise in and the management of the *barachois*.

Finally, considering local needs and wants in the restoration interventions and the predictable provision of benefits ensured local interest in the success of the intervention and increased recognition given to the management team. A relationship based on trust and mutual support developed between the local people and the project team. The collaboration was consolidated based on the increased support and participation of the local people. Indeed, 96 adults carried out activities on a voluntary basis, a testimony to the value they attach to the site. Moreover, 336 residents participated in community consultations, equivalent to 15 percent of total residents of the targeted community, and 115 in field work. Moreover, integrating these values into restoration planning provided a sense of ownership in the local community, which ensured the project's sustainability.

In this context, the planning and design phase of the project led to a strong consensus between the scientists and local people on the multiple values elicited by the community groups. Although a time-consuming phase, significant effort in carrying out the surveys and community consultations was necessary to effectively develop the project strategic plan. The value assessment approaches were considered as critical baselines, which provided information on how people view and value their natural environment, as well as their priorities and preferences for development. Indeed, the starting point of the project was to develop a clear understanding of local needs, priorities, perceptions, knowledge and values. The project strategic plan, designed based on close collaboration between the NGO, the scientists and the local community in a collective decision-making process, is a key output that is likely to guarantee the social acceptability of future restoration and management interventions within the context of sustainability. (see Fig. 7)

This plan now serves as the foundation for the implementation phase and for future dialogue and collaboration between policymakers, scientists, the private sector and the local cooperative. The implementation phase will be undertaken by recognizing and building on what local people value, need and expect. The local cooperative will work with project's stakeholder groups through the Collaborative Management *Barachois* Committee, whose members consist of representatives of governmental agencies, NGOs, local associations, the private sector, and the general public, as well as experts and scientists, to implement project activities effectively. These representatives will participate in frequent meetings to effectively determine and coordinate project activities in a collaborative manner. Although the local cooperative is expected to be the implementing entity for on-the-ground activities, the committee, the direct beneficiaries of the initiative, will be critical to ensure that all requirements, including trainings, permits, funding, labor and expertise, are available to the local people. It is however important

to note that few local residents were found to have strong expertise related to wetland restoration and biodiversity conservation.

The present project framework places the local community in a central position to make decisions on planning and implementing the restoration and conservation activities (see Fig. 8). Indeed, the first phase of the project started with collaboration between the local community, NGO and scientists to elaborate on the project design and planning, with subsequent cooperation of other stakeholders including the government and the private sector, built on previous analysis of local values. The fact that the foundation of project implementation was initially based on local views has built trust between the local community and other stakeholders. This trust is considered to be critical for ensuring effective dialogue and collaboration during the implementation phase. Moreover, multi-stakeholder engagement was decisive in the enhancement of *barachois* management, where restoration and conservation priority-setting will reflect a wider cross-section of society. This will generate a constructive and effective seascape co-management alliance based on mutual support, as well as mutual sharing of knowledge and expertise, thereby enhancing the project's success in the long term. Mutual information-sharing between stakeholders will need to be carried out on an ongoing basis, through consultation and awareness-raising activities. This will build capacity and raise awareness among all stakeholders towards improved wetland biodiversity and the development of an environmentally, economically and socially sustainable seascape. The perceived values of the seascape, and consequently attitudes, will change over time and need to be monitored over the long term to gauge the seascape's management impacts on the local community. Similar approaches to assessing value will need to be repeatedly replicated to ensure long-term monitoring within the context of adaptive management.



Figure 7. Focus-group interview with local women and youth (also fishers, elders and skippers on other occasions) to elicit values associated to the *barachois* seascape.

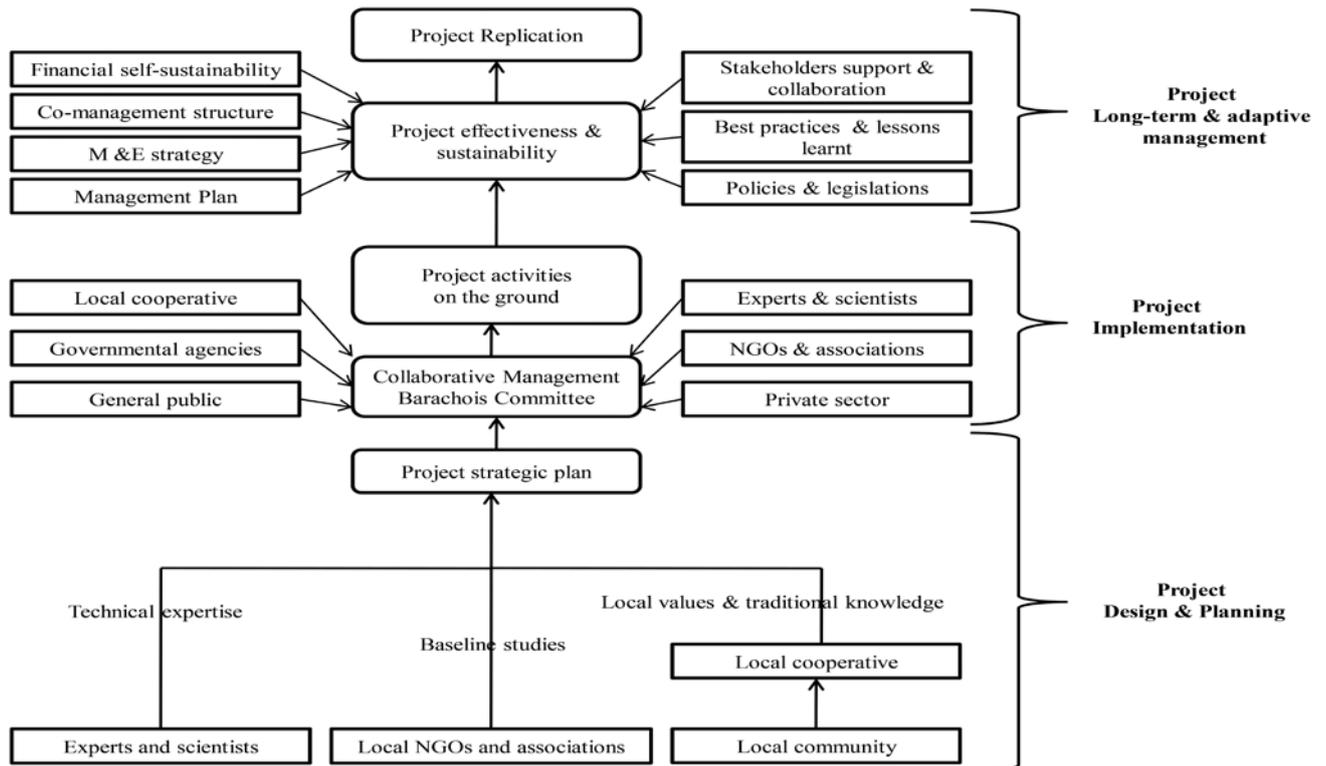


Figure 8. Proposed project development flowchart

The local cooperative developed and utilized in the design and planning phase can be used in the implementation phase to monitor the impacts of the project’s interventions and changes in the perception of value held among stakeholders over time. The local cooperative will be the generator of the shared understanding and holistic benefits. The success of the cooperative will be measured based on biophysical (measuring the ecosystem health of the *barachois*), and socio-economic (measuring livelihood and well-being enhancement of the local community) factors, as well as governance indicators.

6. Conclusion

This case study provides an overview of the different approaches that were used during the design and planning process of a wetland restoration project in order to ensure a clear understanding of the values communicated by different community groups. This understanding helped and guided the project team in many ways, particularly in selecting actions that guaranteed the strong participation, support and engagement of the local community. Integrating local values in the decision-making process of project design and planning was critical in successfully achieving objectives. This approach consolidated and enhanced the collaboration between the local residents and the project team and resulted in the development

of a project strategic plan which addressed community wants, needs, vision and opinions. This plan was developed considering the value of the SEPLS as perceived by both scientists and local people. The next steps will be to present the plan to the two remaining key actors in the process of wetland restoration, i.e. governmental agencies and the private sector. Once all the perceived aspects of value from the four key actors are integrated and merged into the plan, the implementation phase of the project can begin. In so doing, the implementation phase of the project is likely to be effective and sustainable. As part of a multi-stakeholder platform, the local cooperative is expected to drive the project to deliver impacts that benefit the entire community.

References

- Armiero, M & Sedrez, L (eds) 2014, *A History of Environmentalism: Local Struggles, Global Histories*, Bloomsbury, London.
- Atkinson, G 2017, *The Barachois Project – A Baseline Study – Native and Endemic Species – Terrestrial Plants*, Mahebourg, Mauritius.
- Coche, AG 1982, *Coastal aquaculture: development perspectives in Africa and case studies from other regions = Aquaculture côtière: perspectives de développement en*

- Afrique et exemples d'autres régions*, Food and Agriculture Organization of the United Nations.
- Costanza, R, d'Arge, R, de Groot, R, Farber, S, Grasso, M, Hannon, B, Limburg, K, Naeem, S, O'Neill, R, Paruelo, J, Raskin, R, Sutton, P & van den Belt, M 1997, 'The value of the world's ecosystem services and natural capital', *Nature*, vol. 387, pp. 253–60.
- Díaz, S, Pascual, U, Stenseke, M, Martín-López, B, Watson, R, Molnár, Z, Hill, R, Chan KMA, Baste IA, Brauman, KA, Polasky, S, Church, A, Lonsdale, M, Larigauderie, A, Leadley, P, Van Oudenhoven, A, Van der Plaats, F, Schröter, M, Lavorel, S, Ameeruddy-Thomas, Y, Bukvareva, E, Davies, K, Demissew, S, Erpul, G, Failler, P, Guerra, CA, Hewitt, CL, Keune, H, Lindley, S & Shirayama, Y 2018, 'Assessing nature's contributions to people', *Science* 19 Jan 2018, vol. 359, no. 6373, pp. 270–272, DOI: 10.1126/science.aap8826.
- De Groot, R, Wilson, M & Boumans, R 2002, 'A typology for the classification, description and valuation of ecosystem functions, goods and services', *Ecological Economics*, vol. 41, no. 3, pp. 393–408.
- Déja, E 2016, *Feasibility study: developing community-based mariculture in the Barachois of Résidences la Chaux, Mahebourg, Final Report*, Mahebourg, Mauritius.
- Déja, E 2017, *The Barachois Project Household Survey Report*, Mahebourg, Mauritius.
- Fagoonee, I 1990, 'Coastal marine ecosystems of Mauritius', *Hydrobiologia*, vol. 208, no. 1-2, pp. 55–62.
- FAO 2006, Fishery Country Profile: The Republic of Mauritius, viewed 15 May 2019, <<http://www.fao.org/fi/oldsite/FCP/en/MUS/profile.htm>> Food and Agriculture Organization of the United Nations
- Gayatri, A 2000, 'Approaches to valuing the hidden hydrological services of wetland ecosystems', *Ecological Economics*, vol. 35, no. 1, pp. 63–74.
- Hollup, O 2000, 'Structural and sociocultural constraints for user-group participation in fisheries management in Mauritius', *Marine Policy*, vol. 24, no. 5, pp. 407–421.
- Iniesta-Arandia, I, García-Llorente, M, Aguilera, P, Montes, C & Martín-López, B 2014, 'Socio-cultural valuation of ecosystem services: uncovering the links between values, drivers of change, and human well-being', *Ecological Economics*, vol. 108, pp. 36–48.
- Martinez-Alier, J, Temper, L & Demaria, F 2016, 'Social metabolism and environmental conflicts in India', in *Nature, Economy and Society*, eds N Ghosh, P, Mukhopadhyay, A Shah & M Panda, Springer, New Delhi, pp. 19–49.
- Natori, Y, Dublin, D, Lopez-Casero, F and Takahashi, Y 2018, *Socio-ecological Production Landscapes and Seascapes: Experiences overcoming barriers from around the world*, GEF-Satoyama Project, Conservation International Japan, viewed 25 April 2019, <<http://gef-satoyama.net/wp/wp-content/uploads/2018/11/GEF-Satoyama-Issue-brief.pdf>>.
- Nazurally, N & Bhoyroo, V 2016, Report: Marine Environmental Assessment of a Barachois at Cite La Chaux, Mahebourg. University of Mauritius, Reduit, Mauritius.
- O'Connell, M 2003, 'Detecting, measuring and reversing changes to wetlands', *Wetlands Ecology and Management*, vol. 11, no. 6, pp. 397–401.
- Oglethorpe, D & Miliadou, D 2000, 'Economic valuation of the non-use attributes of a wetland: a case-study for Lake Kerkiní', *Journal of Environmental Planning and Management*, vol. 43, no. 6, pp. 755–767.
- Paul, E & Balkema, A 1987, *Fisheries development and the food needs of Mauritius*, CRC Press, Rotterdam, the Netherlands.
- Phelan, A & Jacobs, S 2016, 'Facing the true cost of fracking; social externalities and the role of integrated valuation', *Ecosystem Services*, vol. 22(B), pp. 348–358.
- Rawson, G 1988, 'Future strategies for the fisheries of Mauritius', *Food Policy*, vol. 13, pp. 409–411.
- Terer, T, Ndiritu, G & Gichuki, N 2004, 'Socio-economic values and traditional strategies of managing wetland resources in Lower Tana River, Kenya', *Hydrobiologia*, vol. 527, no. 1, pp. 3–15.
- Terer, T, Gichuki, N & Ndiritu, G 2005, 'Role of wetlands in maintaining stability of tropical lakes: a case study of River Nyando Delta in Lake Victoria basin, Kenya', in eds Odada et al., *Proceedings of the 11th World Lakes Conference*, vol. 2, pp. 560 – 568.
- Villegas-Palacio, C, Berrouet, L, Lopez, C, Ruiz, A & Upegui, A 2016, 'Lessons from integrated valuation of ecosystem services in a developing country: three case studies on ecological, socio-cultural and economic valuation', *Ecosystem Services*, vol. 22(B), pp. 297–308.

Appendix 1. Description of ecosystems that constitute Mahebourg barachois seascape

Ecosystem type	Area (ha)	Fauna & flora	Sources
Near shore sea (lagoon)	approx. 10	<p><Fish species></p> <p>For sales: emperor (capitaine, dame berri, battadet, caya), parrotfish (cateau species), spinefoot (cordonnier), wrasse (madame tombee, colombine and lalo), goatfish (rouget species), grouper (vieille rouge, grise and voleur), unicornfish (corne species) and trevally (carangue)</p> <p>For household consumption: cordonnier, come, vieille, ourite, rouget, kato, capitaine, mougate</p>	Déja 2016
Near shore sea (barachois)	24	<p><Fish species></p> <p><i>Siganus</i> sp. (cordonnier), <i>Upeneus</i> sp. (rouget), <i>Valencienne</i> sp. (cabot), <i>Mugilcephalus</i> (mullet), <i>Siganus</i> sutor (rabbit fish), <i>Nasounicornis</i> (corne) and <i>Acanthurus</i> sp. (surgeon fish)</p> <p><Coral species></p> <p><i>Porites lutea</i>, <i>Cyphastreamicrophthalma</i>, <i>Porites rus</i> and <i>Montiporacalcareo</i>.</p> <p><Algal species> <i>Gracillaria</i> sp. (red algae)</p> <p><Sponge species> <i>Tethyarobusta</i>, <i>Axinyssatopsentia</i> and <i>Clathriafrondifera</i>.</p> <p><Crustaceans species> <i>Pilumnusverspertilio</i> (spider crab) and <i>Ucaannulipes</i>, <i>Aiptasia</i> sp. (sea anemones) and <i>Cassiopea</i> sp. (jellyfish)</p> <p><Mollusc species> <i>Annulus</i> and <i>Planaxissultanus</i></p>	Nazurally & Bhoorroo 2016
Coastal ecotone (mangrove)	13	<p><Flora></p> <p>loop-root mangrove (<i>Rhizophoramucronata</i>) (LC);</p>	Atkinson 2017
Coastal ecotone (coastal scrub)		<p><Flora> love-vine (<i>Cassythafiliformis</i>) (LC); grey nicker (<i>Caesalpiniaabonduc</i>) (LC); poorlandflatsedge (<i>Cyperuscompressus</i>) (LC); <i>Dendrolobiumumbellatum</i> (N/A); sticky hopbush (<i>Dodonaeaviscosa</i>) (LC); sea hibiscus (<i>Hibiscustiliaceus</i>) (LC); <i>Hilsenbergiapetiolaris</i> (LC); beach morning (<i>Ipomeapescaprae</i> subst. <i>brasiliensis</i>) (LC); seashore paspalum (<i>Paspalumvaginatum</i>) (LC); pemphis (<i>Pemphisacidula</i>) (LC); common purslane (<i>Portulacaoleracea</i>) (LC); beach cabbage (<i>Scaevolataccada</i>) (LC); spotted heart (<i>Strictocardiatilifolia</i>) (LC); bay cedar (<i>Surianamaritima</i>) (LC); <i>Tarennaborbonica</i> (endemic); portia tree (<i>Thespesiapopulne</i>) (LC); Mascarene grass (<i>Zoysiatenuifolia</i>) (LC);</p>	Atkinson 2017
Settlement/urban	18		
IUCN threatened species found in adjacent areas (e.g. Ile aux Aigrettes)		<p><Flora></p> <p>False olive (<i>Cassineorientalis</i>) (VU); Mauritian baobab (<i>Cyphostemmamappia</i>) (EN); <i>Diospyrosegrettarum</i> (CR); bois bete (<i>Dombeyaacutangula</i>) (CR); <i>Dracaneaconcinna</i> (EN); <i>Erica brachyphylla</i> (EN); <i>Eugenia</i> sp. (VU); stinkwood (<i>Foetidiamauritiana</i>) (EN); <i>Gagnebinapterocarpa</i> (VU); mandrinette (<i>Hibiscus fragilis/genevii</i>) (CR); bottle palm (<i>Hyphorbelaggenicaulis</i>) (CR); <i>Maytenuspyria</i> (VU); screw pine (<i>Pandanussp.</i>) (EN); <i>Protiumobtusifolium</i> (VU); baumbush (<i>Psiadiaargute</i>) (VU); <i>Terminaliabentzoesp. Bentzoe</i> (EN); <i>Turraeathouarsiana</i> (VU);</p>	