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“Development and Protection of the Coastal and
Marine Environment in Sub-Saharan Africa”

MAURITIUS NATIONAL REPORT PHASE 1: INTEGRATED PROBLEM ANALYSIS

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Executive Summary

This report is the result of an exercise that was undertaken in Mauritius as part of the GEFMSP project on Coastal Zone in the Sub-Saharan countries. The project consisted of three parts (i) Identification of sites and prioritisation of issues; (ii) Environment and socio-economic Impact analysis; and (iii) Causal chain analysis.

Six sites were selected from an initial list of ten for the first part of the work. The six sites were Grand Baie, Flic en Flac, Pointe aux Sables, Pomponette/Riambel, Palmar/Belle Mare and Rodrigues. These were then assessed for a range of issues based on the modified GIWA methodology using available literature and data. The issues were then scored for the actual impacts and perceived future changes. The three issues, identified as a result of this exercise were (i) Modification of ecosystems or ecotones; (ii) Shoreline Change; and (iii) Over-exploitation.

An environmental and socio-economic impact assessment of each issue was then undertaken. The impacts considered for shoreline change were destruction and loss of habitats, loss of beach, reduction of beach protection, aesthetic devaluation and damages to infrastructure. For over-exploitation the impacts assessed were identified as deterioration of water quality, destruction and loss of habitats and decline of fisheries. Destruction of habitats and breeding grounds and deterioration of water quality constituted the main impacts for the issue modification of ecosystems.

The causal chain analysis revealed that coastal urbanisation and industries (including the tourism industry) were the main sectors driving the three issues. The increase in coastal population, the non-implementation of the NPDP, the macro-economic policies favouring the tourism industry were the common root causes for the three issues. There exists a range of legislations under the responsibility of different ministries and institutions for the management of the coastal zone. However, the poor coordination between these stakeholders, poor demarcation of responsibilities, and the low level of enforcement have contributed to the environmental decline of the coastal zone.

This exercise has also revealed that the data on environmental issues related to the coastal zone is fragmentary. This is more so for socio-economic analysis. It is therefore recommended that efforts be made to bridge the gaps in our knowledge under different fronts and necessary steps be taken to curtail the environmental decline. This will ensure the long-term sustainability of the coastal zone through a more holistic management approach such as the ICZM.

Mauritius Country Profile



Geography and Environment

Surface area:	1,860 sq km
Coastline:	200 km
Maritime claims: <i>continental shelf:</i>	200 NM or to the edge of the continental margin
<i>exclusive economic zone (distance from shore):</i>	200 NM
<i>territorial sea:</i>	12 NM
EEZ (Exclusive economic zone):	1,700,000 km ²
Natural resources:	arable land, fish
Land use:	arable land: 49%
	permanent crops: 3%
	permanent pastures: 3%
	forests and woodland: 22%
	other: 23% (1993 est.)
Irrigated land:	170 sq km (1993 est.)
Environment - international agreements:	party to: Biodiversity, Climate Change, Desertification, Endangered Species, Environmental Modification, Hazardous Wastes, Law of the Sea, Marine Life Conservation, Nuclear Test Ban, Ozone Layer Protection, Ship Pollution
	<i>none of the selected agreements</i>
	<i>signed, but not ratified:</i>

Population	
Population:	1,193,000 (end of 2000)
Population growth rate:	0.88% (2001 est.)
Life expectancy:	70 years (2001)
Urban population (% of total)	40.5 (1995)
Urban population annual growth rate (%)	
1995-2015:	1.94%
% living on the coast	100%
Literacy:	total population: 82.9%
(definition: age 15 and over can read and write)	male: 87.1%
	female: 78.8% (1995 est.)
Economy	
GDP: purchasing power parity	- \$12.3 billion (2000 est.)
GDP - real growth rate:	- 6.4 % (2001.)
GDP per capita: purchasing power parity	- \$10,400 (2000 est.)
GDP - composition by sector:	agriculture: 10%
	industry: 29%
	services: 61% (1996) of which 5% is from tourism
Inflation rate (consumer prices):	5.3% (2000 est.)
Labour force:	514,000 (1995)
Labour force - by occupation	construction and industry 36%, services 24%, agriculture and fishing 14%, trade, restaurants, hotels 16%, transportation and communication 7%, finance 3% (1995)
	6.4% (1999 est.)
Unemployment rate:	food processing (largely sugar milling), textiles, clothing; chemicals, metal products, transport equipment, non-electrical machinery; tourism
Industries:	8% (2000 est.)
Industrial production growth rate:	1.26 billion kWh (1999)
Electricity - production:	fossil fuel: 91.27%
Electricity - production by source:	hydro: 8.73% (1999)
	1.172 billion kWh (1999)
Electricity - consumption:	0 million kWh (1999)
Electricity - exports:	0 kWh (1999)
Electricity - imports:	sugarcane, tea, corn, potatoes, bananas, pulses; cattle, goats; fish
Agriculture - products:	\$1.6 billion (f.o.b., 1999)
Exports:	clothing and textiles, sugar, cut flowers, molasses
Exports - commodities:	\$2.3 billion (f.o.b., 1999)
Imports:	manufactured goods, capital equipment, foodstuffs, petroleum products, chemicals (1996)
Imports - commodities:	Mauritian rupee (MUR)
Currency:	Mauritian rupees per US dollar - 30.300 (January 2002),
Exchange rates:	27.900 (January 2001), 26.250 (2000), 25.186 (1999), 22.993 (1998), 21.057 (1997),
Water Resources and Uses	
Internal flows billion cu. m. 1999	2
Flows from other countries billion cu. m. 1999:	0.0
Total resources per capita cu. m ³ :	1,873
Annual freshwater withdrawals:	0.4 billion cu m
% of total renewable resources:	16.4
% for agriculture:	77
% for industry:	7
% for domestic:	16

CHAPTER 1

1. Introduction

1.1 Geographic Location

The Republic of Mauritius consists of a main island, Mauritius (20°17' S, 57°33' E), and a group of small islands in the South West Indian Ocean namely Rodrigues, the Cargados Carajos, Agaléga, Tromelin and the Chagos Archipelago (Figure 1). The total land area is about 2040 km² whilst the marine exclusive economic zone covers an area of about 1.7 M km² extending from 10° S to 20° S and from longitude 55° E to 75° E. The main island Mauritius is 1865 km² in area, volcanic in origin and consisting of a central plateau (mean elevation 300-400 m) surrounded by mountain ranges and plains. The highest point stands at 828 m and a growth rate of 1.1%.

1.2 Climate

Mauritius enjoys a mild maritime climate with summer extending from October to April and winter from May to September. Trade winds are prevalent throughout the year but are stronger in the winter when strong anticyclones pass to the south of the island. In summer, the trade winds are weaker but the island is also under the threat of tropical depressions that can build up in cyclones. On average one cyclone passes within 100 km of Mauritius each year. Mauritius receives an average of 2100 mm rain with 70% of it occurring in the summer. Tropical depressions and cyclones bring abundant rainfall spread over a number of days. Mean maximum temperature reaches 31°C in the coastal areas during the peak summer months of January and February whilst the mean minimum temperature on the central plateau reaches 14°C in July and August.

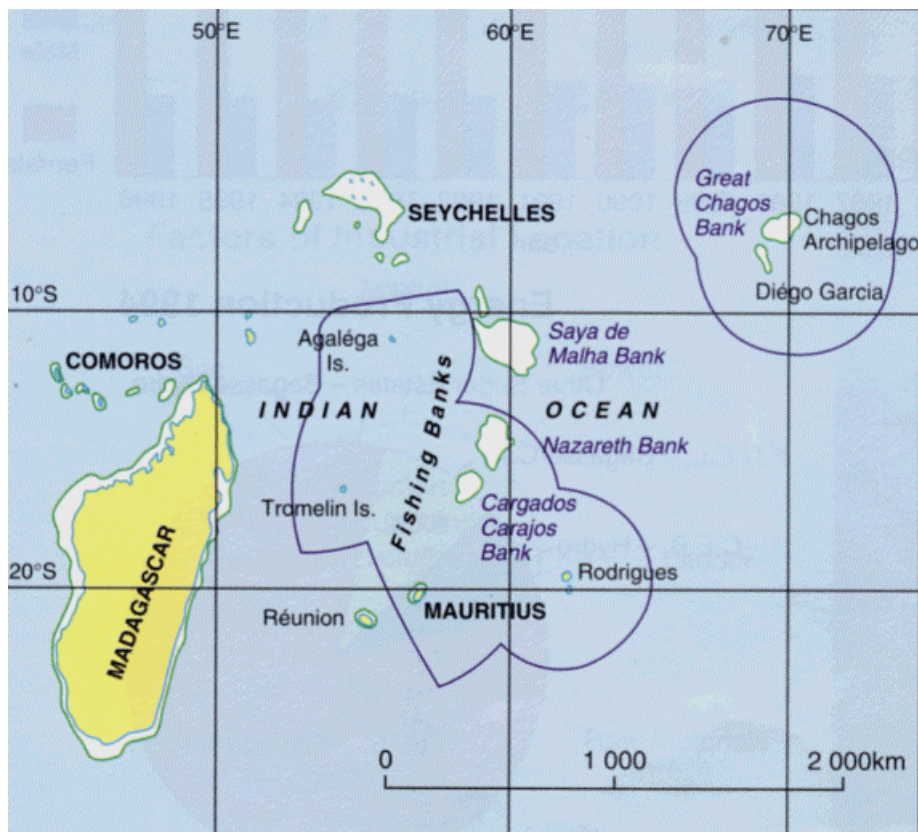


Figure 1. Map showing Mauritian Exclusive Economic Zone

1.3 Population

The population was 1.193 million towards the end of 2000 thus making Mauritius a country with high population density. Life expectancy, 70 years, is among the highest in Africa with males reaching 66 years and females 74 years. The population growth rate has declined over the years and has now stabilized around 1% since the 1990's.

1.4 Economic Background

The Mauritian economy has undergone several distinct development phases and in the process has diversified from a mono-crop economy relying on sugar export into manufacturing, exports, tourism and services. It has been growing at an average annual rate of 5.5% over the period 1998-2000. Real GDP expanded by only 2.1% in 1999, with sugar production decreasing by 45%. The total sugar produced in 1999 amounted to 373,294 tonnes as compared to 628,588 tonnes in the previous year.

In 2000, the economy grew by 8.9%, the highest growth registered since 1986. This was largely due to the recovery of the sugar sector increasing by 52.5%. Improved performances in other sectors such as "Hotels and restaurants" and "Transport, storage and communication" were partially offset by a deceleration in growth in the "Construction" and "Wholesale and retail trade" sectors.

1.5 Economic Prospects for 2001

The economy is expected to expand by around 6.4% in 2001. Total value added generated in 2001 is estimated at Rs 134.7 billion; per capita income reaching Rs 112,450, i.e. around the US\$ 4,000 mark.

1.6 Sectoral Performance

1.6.1 Agriculture

With the recovery of the "Sugarcane" sub-sector in 2000, total agricultural output registered a growth rate of 28.5%. The "Sugarcane" and "Other Agriculture" sub-sectors fared better with growth rates of 52.5% and 9.4% respectively. Assuming favourable climatic conditions in 2001, sugar production is projected to be around 620,000 tonnes implying a growth rate of some 8.9% for the sugar sector.

1.6.2 Manufacturing

The manufacturing sector, which represents around 25% of GDP, grew at a rate of 7.8% in 2000. The improved performance was mainly due to the recovery of the sugar-milling sector, which grew by 52.5% as compared to a contraction of 45% in the previous year. The EPZ sector registered a sustained growth of 6%.

The manufacturing sector is expected to expand by a slower rate of 6.8% in 2001, fuelled by a growth of 8.9% in sugar milling and a better performance in the EPZ sector. The EPZ sector is projected to grow by 6.5% with total EPZ exports estimated to reach around Rs 34 billion.

1.6.3 Tourism

During the past decade, the tourism industry has emerged as the fastest growing sector and has established itself as the third pillar of the Mauritian economy. It is also the second largest foreign exchange earner. The tourism sector recorded a growth of 11% in 2000, which is a marked up-turn in the declining trend registered since 1996. Gross receipts from tourism for 2000 amounted to around Rs 14,234 million, representing an increase of 4% compared to Rs 13,668 million in 1999. The total number of tourists visiting the country reached around 656,453.

Table 1. Tourism Main Indicators

		1998	1999	2000
Real growth	%	4.0	11.0	7.0
Gross earnings	Rs m	11,890	13,668	14,234
Tourist arrivals	No.	558,195	578,085	656,453
Expenditure per tourist	Rs	21,301	23,644	21,683
Employment (March)	No.	16,490	17,111	18,571

1.6.4 Financial and Business Services

With a view to set Mauritius on a higher growth path, the economy is being further diversified with emphasis on the services sector. The quaternary sector, comprising the stock exchange, free port activities and offshore businesses, is now the fourth pillar of the economy. With an average annual growth of around 10.5% over the past few years, its contribution to GDP has increased considerably to reach around 15% in 2000. Real output growth in the sector is estimated at 10.8% in the year 2000; an increase of one percentage point over the previous year. Sustained growths in the sub-sectors are likely to increase value added by 11.1% in 2001.

1.7 Savings and Investment

Gross national savings increased by 11.4% to reach Rs 30,789 million in 2000. The saving rate, calculated as the ratio of GNS to GDP at market prices, declined slightly to 25.3% from 25.4% in 1999. Savings is projected to soar by 10.8% to Rs 34,115 million. However, the saving rate will remain at the previous year's level of 25.3%.

Investment, measured by the Gross Domestic Fixed Capital Formation (GDFCF), fell slightly by 1.8% from Rs 29,676 million in 1999 to Rs 29,148 million in 2000. In real terms, total investment declined by 5.1%.

1.8 Consumption

The economy has been increasingly powered by strong domestic demand. Real final consumption expenditure increased by 5.3% in 2000 and is projected to grow by almost the same rate in 2001. Private consumption is expected to expand by 5.3% while public consumption will experience a lower growth of 4.3% compared to 5.4% in 2000. The share of final consumption expenditure in GDP at market prices remained high, above the 75% mark.

1.9 Inflation

The inflation rate, as measured by the percentage change in the yearly average consumer price index, stood at 6.9% in 1999, slightly above the rate recorded in the previous year. However, it was brought down to 4.2% in 2000. Tight monetary policy and the provision of subsidies to freeze bus fares and removal of VAT on water and electricity consumption have contributed to contain inflationary pressures.

Table 2. Selected Economic Indicators

		1998	1999	2000	2001
Population	000	1,160	1,175	1,186	
GDP Growth Rate	%	5.8	2.6	8.9	6.4
Saving Rate	%	26.1	25.4	25.3	25.3
Investment Rate	%	23.0	27.3	24.0	23.5
Fiscal Balance as % of GDP	%	-4.2	-3.8	-6.8	
Inflation Rate	%	6.8	6.9	4.2	
Unemployment Rate	%	5.9	6.4	8.0	
Balance of Payments	Rs m	-1,476	4,558		
Current Account Balance	Rs m	810	-408	1,065	
Net International Reserves	Rs m	19,894	26,051	33,554	

1.10 The Coastal zone

The coastline of Mauritius is about 200 Km long with a lagoon area of 243 Km². A fringing coral reef system almost completely surrounds the island; with the exception of areas opposite river mouths, estuaries and off the southern coast at two regions. These reefs have endowed Mauritius with protected bays, calm lagoons and some fine sandy beaches. In general, the lagoon is comparatively shallow with a depth of 1-2 m with the exception of Mahebourg where it attains 15 m in the inner reef pass.

The shoreline varies in extent, shape and regime. Dune and ridge complex characterize most of the beaches around Mauritius and the beach width varies from a few metres in the Eastern and Southern regions to about 25 m in the north. In general the sediments are coralline except at the mouth of rivers where they are muddy with a large component of silt and clay. In many places and in particular in the southern regions there are scattered low-lying basaltic rocks on the shoreline.

Mangroves used to cover a large part of the coastline in the past, but its area has decreased markedly with the development over the last three decades. Nowadays they are to be found at mouth of rivers and estuaries such as Riviere Noire, Baie du Cap, Trou D'eau Douce, Poste Lafayette, Bras D'eau and Poudre D'or. The two species occurring in Mauritius- *Bruguiera gymnorrhiza* and *Rhizophora mucronata* are not exploited. A replantation programme is now in progress in the areas where mangroves were thriving in the past.

There are some scattered pockets of coastal wetlands all around the island, particularly in the north, northeast and northwest regions. These ecologically important ecosystems are under the constant threats of coastal developments. Much of this precious natural filtration system has been reclaimed in the regions of Grand Baie and Flic en Flac.

1.11 Coastal Activities

Fishing, tourism, sand mining and recreation/sports are the main activities along the coastal zone. Lagoon fishing has declined in importance over the past years as a result of decreasing fish catch. In 1997, the total coastal fish catch amounted to 1246 tonnes compared to 1597 tonnes ten years earlier.

On the other hand tourism activities have increased significantly. The number of tourists arriving in Mauritius last year peaked at 656,453 with a room capacity of 8000. It is expected to rise by another 7% this year.

Sand mining has been practiced in the lagoons for numerous years. About 800,000 tonnes of sand are removed from the lagoon annually to be used in construction work. Twenty-five cooperative associations using 310 boats and employing nearly 1,000 people run this business with a turnover of US\$8 million. Owing to the devastating effects of this practice to the lagoon ecosystem, the government has banned sand mining with effect from 1st October 2001. The workers of this sector are being financially compensated and alternative jobs including training facilities are being offered.

Mauritius has witnessed a rapid increase in industrial and tourist development within the last two decades. These changes have increased the pressures on natural resources and have resulted in a negative impact on the environment, especially in the coastal zone. The problem is further aggravated by the scarcity of land and the unplanned development of prime coastal land in environmentally sensitive areas. Because of the size of Mauritius and the proximity of any land point from the sea, the entire island can be considered as coastal zone. As such most land-based activities have a direct or indirect impact on the marine environment. Some of the activities directly affecting the marine environment include fishing, beach hotel activities, wetland loss, tourism, sand mining, untreated sewage discharges and agrochemicals. Coastal area use in Mauritius is shown in Figure 2.

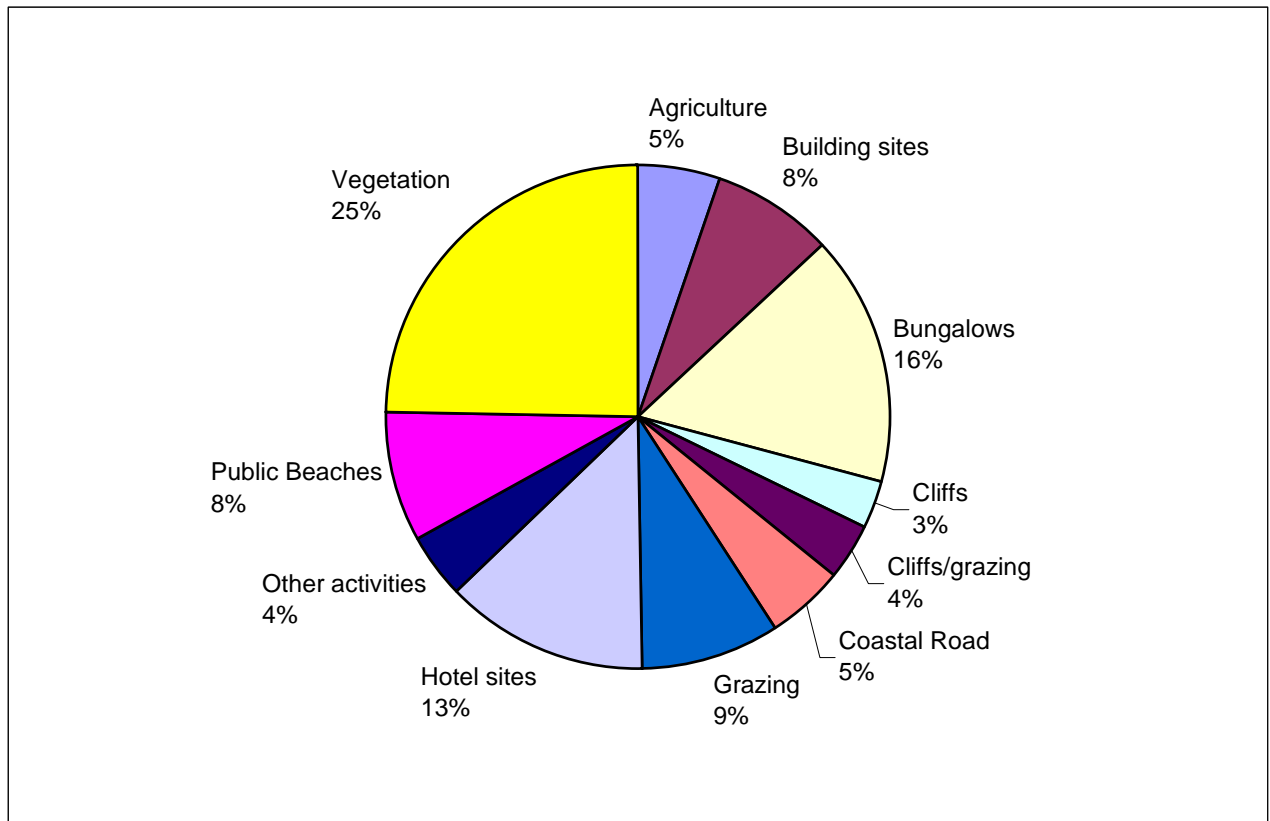


Figure 2. Distribution of Coastal land of Mauritius in 1998

CHAPTER 2

2. Scoping and Description of the Methodology

2.1 Identification of Hotspots, Sensitive Areas and Overriding Issues

The scoping and scaling exercise of Integrated Problem Analysis was undertaken during the First National Meeting for Mauritius, on the 28th April 2001. Prior to this meeting, the national team met informally on 21st April 2001 and the National co-ordinator, Dr Dulymamode introduced the GEF MSP Sub-Sahara Africa Project on Integrated Problem Analysis. It was agreed that the team members would give thought to the selection of sites and that this issue would be taken up in depth at the National meeting. Relevant papers were distributed to members of the team in view of the next meeting.

The team coordinator welcomed the team members and opened the meeting. The first issue to be raised was the identification of sites. The coordinator explained that owing to the restricted time factor, the process of identification and prioritisation of sites had to be shortened. It was also felt right at the beginning of this exercise that the demarcation between hot spots and sensitive areas was not clear and that for Mauritius all the sites could well be taken as hot spots.

2.2 Prioritisation of Hot spots

Following a survey of some relevant literature, team members agreed on the list of potential sites for consideration. These were:

- Flic en Flac;
- Balaclava;
- Grand Bay;
- Le Morne;
- Blue Bay;
- Grand Gaube;
- Palmar-Belle Mare;
- Riambel-Pomponette;
- Pointe aux Sables; and
- Rodrigues.

Thus list was collectively examined and following joint discussions six sites were selected for the next part of the work. These were:

- Flic en Flac;
- Grand Bay;
- Palmar-Belle Mare;
- Riambel-Pomponette;
- Pointe aux Sables; and
- Rodrigues.

The Identification sheets (Annex I) were completed for the six sites.

2.3 Relevance of GIWA List of Issues

In general the GIWA list of issues were considered very useful and easy to apply to the local context. However for two major issues, the national team modified or added to the GIWA list.

According to the GIWA list, over-exploitation refers only to living resources and to their Maximum Sustainable Yield (MSY). However, in the case of Mauritius, it was felt that in spite of the fact that the living resources were not over exploited, the site itself was overexploited as an economic resource for tourism or for other purposes. This in general gave rise to environmental problems linked to overuse of resources. Therefore the existing GIWA Issue for over-exploitation has been modified to include not only living resources but also non-living resources.

The national team also preferred to treat beach erosion as shoreline change (IssueNo.23) under others in the GIWA list. This was felt necessary to cover the range of causes of this issue locally. Beach erosion as presented in the GIWA list is more inclined towards global changes such as sea-level rise. Whilst this is also of some concern to the local context, it is not, however, the major driving force behind shoreline changes.

2.4 Constraints

The major constraint affecting the work of the national team turned out to be the limited time factor at the disposal of the members. It is to be noted that team members spent a lot of time to look for the relevant documents. A positive point was that the team members could meet regularly and discuss about the work on an ad-hoc basis because of the proximity of their work places.

2.5 Scoping: Prioritisation of Issues

The methodology prescribed was quite useful and straightforward to apply where data was available. The relevant steps in the scoping exercise were carefully executed. The scoring of the issues was done on the basis of available information from relevant literature. However, the socio-economic analysis proved to be more problematic mainly because of lack of appropriate data.

Following this exercise the ranking of the issues was as follows:

- a. modification of ecosystems or ecotones;
- b. shoreline change;
- c. over-exploitation;
- d. suspended solids;
- e. chemical pollution; and
- f. eutrophication.

Out of the six issues coming out of the first exercise, the three selected ones for Mauritius for the next phase of the exercise are: Modification of ecosystems or ecotones, Shoreline change and Over-exploitation. It is to be noted that these three issues fall under water quality and erosion in the National Environmental Action Plan and are considered as high priority for Mauritius.

2.6 Description of Sites

2.6.1 Grand Baie

Grand Baie is situated in the north west of the island. It extends from Pereybere in the north to Pointe aux Cannoniers in the south (Figure 3). It is bounded inland by the marshy regions and flanked by the sandy strip not exceeding 400m along the coastline. Many of the existing wetlands within the area

have been developed in the past either after having been backfilled or otherwise. The area is generally dry with a population of about 20,000, 13,000 of which are local residents, and the remainder have either secondary houses or are renting guesthouses. It is expected that the resident population will reach 34,000 by the year 2020 with a corresponding increase of the non-resident population to 15,000.

The tourist industry is the major active sector within the region, with employment at different management levels and employees in hotels, restaurants, bungalows, tour operators, boat owners or contractors for carrying tourists in the lagoons or high seas for deep sea fishing, taxis or contract car drivers. The number of fishermen is diminishing gradually and many are involved in side activities to earn a living. The three most important issues at this site are identified as:

- modification of ecosystems or ecotones Issue No. 13;
- over-exploitation Issue No.14; and
- suspended solids (Pollution) Issue No. 7.

2.6.2 Flic en Flac

Flic en Flac is situated in the western district of Black River extending from Wolmar in the south to the Klondike Hotel in the north (Figure 3). Sandy beaches are the most common and typical shoreline within the region, but the northern end presents some exposed basaltic cliffs. The inshore is full of boulders in the northern end but sandy throughout the rest of the region. Behind this, the ridge complex zone runs parallel to the shoreline, stretching over 600m and attaining 5m high in some regions. Much of this dunal ridge complex has been mined for its good quality sand. The foreshore is affected by erosion with cliffs of 1 to 1.5 m. About 150 acres of this deposit has been quarried and the depressed area has been backfilled and subsequently used for construction purposes. This region is presently under hotel and residential development. A permanent spring is located further inland and it is the source of fresh water that flows in front of La Pirogue before draining into the sea behind Sugar Beach hotel. Much of the wetlands of the region have now been reclaimed and during hotel construction (for example the Sofitel Hotel) the region was dotted with numerous small pothole wetlands.

The region is generally dry (750-800 mm rainfall/year) with December and January as the rainiest months of the year. The flora is typical of the western coastline with coastal savannah vegetation and the few woody species such as *Casuarina equisetifolia*. The region has witnessed a considerable amount of development during the past two decades with six major hotels and land development for residential purposes. The three most important issues at this site are identified as:

- shoreline change Issue No. 7;
- over-exploitation Issue No.14; and
- modification of ecosystems or ecotones Issue No. 13.

2.6.3 Belle Mare-Palmar

This eastern part of the island includes some of the most beautiful beaches and is therefore the site of major tourism development with over eight hotels. It extends from the northern tip of Trou D'eau Douce to Poste de Flacq on the north (Figure 3). The region is generally flat and the coastline is composed of sandy beaches and numerous scattered crops of low-lying basalt bedrock. The coastal road demarcates the area developed for tourism and the nearby agricultural lands. Agricultural land is composed of small parcels of land leased to farmers for vegetable growing. A major area of this agricultural zone has also been provided with irrigation facilities. The applied inorganic fertilisers percolate in the sandy soil to reach the lagoon, giving rise to a severe eutrophication problem resulting in the accumulation of a large amount of algae on the beach. There are also a few pockets of wetlands, in particular at Belle Mare.

The reef is within a few hundred metres of the coast and many of the beaches are therefore exposed to the waves. The public beach at Belle Mare is subject to erosion and this is evident by the concave contour of the beach. However, the problem is not so acute as there has been no backshore development. Many of the dunes of this region have been levelled to make way for hotels. The water depth in lagoon is variable but does not exceed 2 m. The shoreline is mostly planted with *Casuarina equisetifolia* trees and the ground covered by trailing vegetation (ground vegetation consisting of lianes mostly, such as *Ipomoea pes Caprae*).

Apart from the village of Belle Mare situated on the coast itself, other residential areas are more inland and include the villages of Mare La Chaux and Quatre Cocos. Many residents from these villages find work in the nearby hotels, whilst others combine part-time fishing with agriculture. The three most important issues at this site are identified as:

- shoreline change Issue No. 23;
- chemical (Pollution) Issue No. 6; and
- over-exploitation Issue No.14.

2.6.4 Riambel-Pomponette

Situated in the south of the island (Figure 3), this region is exposed to the southerly swells and tides have changed the shoreline morphology over the years. In general the land is flat with sandy beaches and a fringing reef at a few hundred metres in the lagoon. The shoreline consists predominantly of sandy beaches and some low-lying basalt platforms. However, the shoreline is eroded over a length of 1500 m with beach cliffs of 1.5-2 m high. The region is flanked by the cobble beach of Riviere des Galets to the West and by the mouth of Riviere Souillac towards the East. The land behind the coastal road consists of the dunal ridge and is mined for its good quality sand resulting in depressions in many areas. These regions have, however, been reclaimed for agriculture and are mostly under cane cultivation.

The main activities of the region are agricultural; sugar cane and vegetable cultivation. A large majority of the residents from the neighbouring villages work elsewhere. Only a minority are involved in marine activities such as fishing. Sand mining has been one of the major activities in the past, practised in the lagoon and on the dunal ridges. The three most important issues at this site are identified as:

- shoreline change Issue No. 23;
- modification of ecosystems or ecotones Issue No. 13; and
- over-exploitation Issue No.14.

2.6.5 Pointe Aux Sables

Pointe aux Sables (Figure 3) is situated towards the southern end of the capital Port Louis, stretching from Grand River North West Bay to La Pointe in the south. The land consists of a low-lying zone adjoining the shoreline and a more elevated area on the hilly side of the region. The shoreline extends over a distance of about 4 km with a fringing reef at approximately 1 km off the coast. The lagoon is shallow and the water reaches only 1m at high tide in certain areas. The lagoon suffers from two major polluting sources; the sewer outfall and the river Grand River North West. The outfall discharges its effluents at a short distance from the lagoon, about 10 m off the reef at a depth of 4-5 m without any diffuser to aid the dispersion of effluents. The river Grand River North West drains agricultural lands and residential areas of the central plateau carrying a large volume of terrigenous material in the lagoon after heavy rainfall.

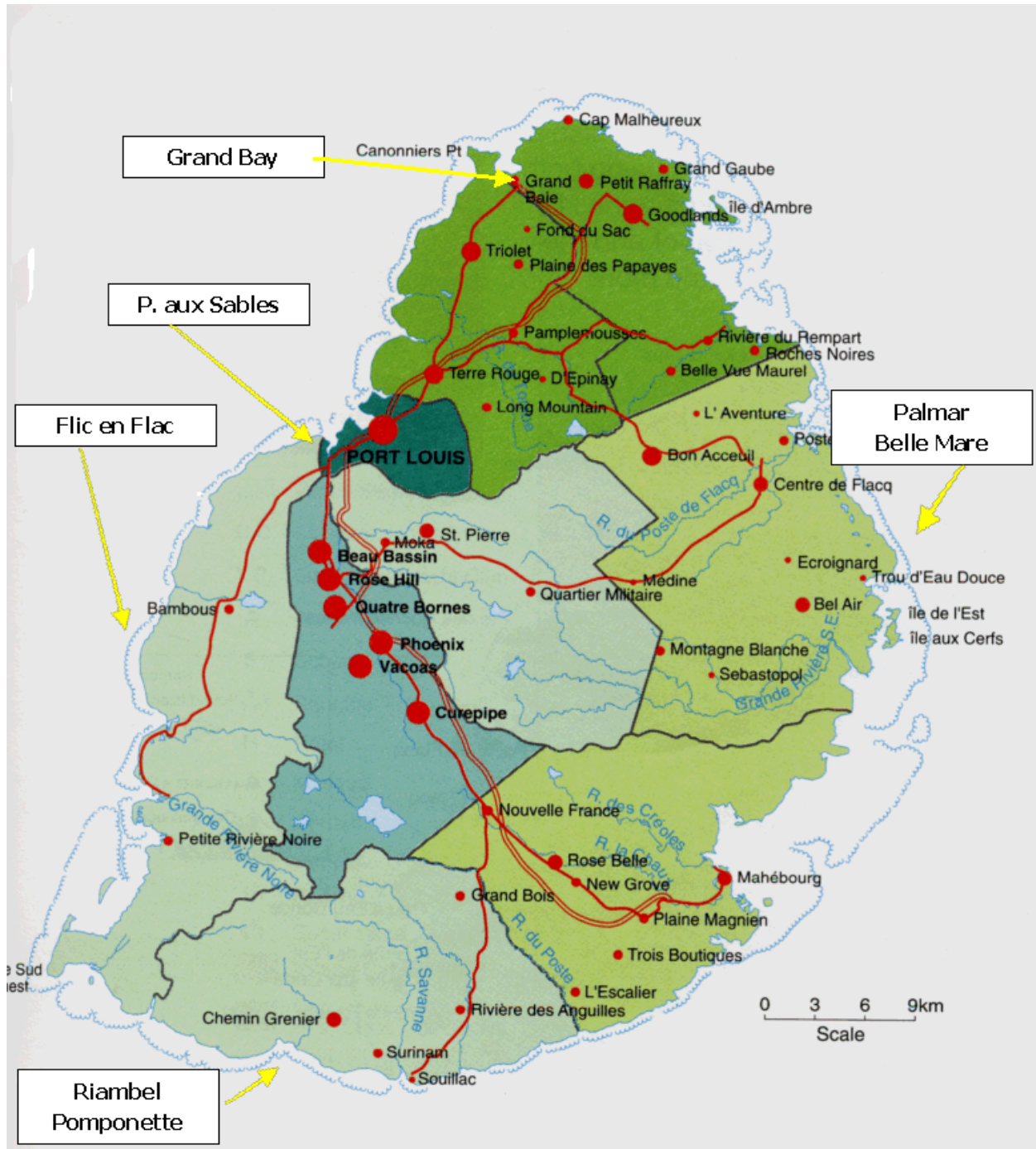


Figure 3. Map of Mauritius Showing the Selected Sites

This coastal village is densely populated and contiguous with the city Port Louis. It is predominantly residential with numerous bungalows on the coast and housing estates inland. The residing population commutes to the city or neighbouring industrial zones of Coromandel and Plaine Lauzun to work. Only a few of the residents earn a living from fishing activities.

The three most important issues at this site are identified as:

- eutrophication (Pollution) Issue No. 5;
- chemical (Pollution) Issue No. 6; and
- suspended solids (Pollution) Issue No. 7.

2.6.6 Rodrigues

Rodrigues (190 40' S, 630 20' E) lies at about 720 km to the North East of Mauritius (Figure 4). It covers an area of 108 km², mostly hilly and rocky and with the highest peak rising to about 398 m. Like Mauritius, it is of volcanic origin and made up of basaltic lavas. The climate is typical of the region and resembles that of Mauritius. The main activities are agriculture (crop production and pasture for livestock), subsistence fishing and the production of handicraft for export. There are still some remaining native forests in the inaccessible mountains and ravines. Rainfall and erosion caused by poor soil management practices have resulted in the formation of steep ravines. About 35% of Rodrigues' area is devoted to the rearing of goats, sheep and cattle. Fishing is also an important activity on the island, practiced both in the lagoons and the offshore coastal waters. The lagoon is nearly three times the size of the island and represents a large area for artisanal fishing. However, the lagoon is seriously affected by siltation and the fishing activity is in decline. The past decade has also seen the development of the tourist industry with a few hotels constructed around the coast.

The major environmental problem in Rodrigues is the impact of human activities on the lagoon. Deforestation has given rise to soil erosion and heavy siltation in the lagoon. Octopus fishermen wade through the shallow waters of the lagoon during the low tide, crushing the corals in their path way and breaking the remaining ones to remove the octopus from their shelter. The three most important issues at this site are identifies as:

- suspended solids (Pollution) Issue No. 7;
- modification of ecosystems or ecotones Issue No. 13; and
- over-exploitation Issue No.14.

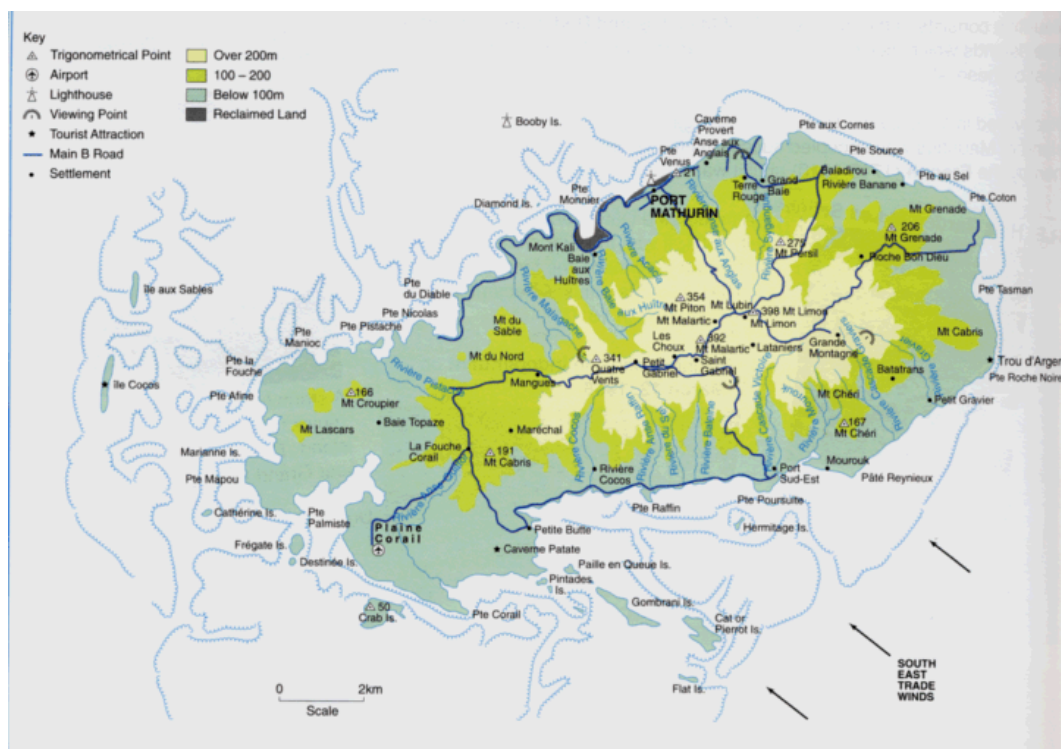


Figure 4. Map of Rodrigues

CHAPTER 3

3. Environmental and Socio-economic Impact Assessment

3.1 Environmental Impact Assessment

The scoping and prioritisation exercise discussed in Chapter 2 led to the identification of three most important issues based on the modified GIWA methodology as recommended for this exercise. In this section the environmental impact and an economic assessment of each of the three issues is presented. In this process the contributing factors and gaps in our knowledge are identified and discussed. Available literature has been used for the analysis, along with relevant expertise to present a more comprehensive picture of the issues. In many cases, particularly for the socio-economic analysis where literature and data are limited, “expert advice” has been predominantly relied upon..

3.1.1 Modification of Ecosystems and Ecotones Issue No. 13

In assessing this issue the biotic and abiotic changes in the lagoon ecosystems have been considered, with the sea grasses, the coral reefs and the shoreline as the main components. The lagoons in Mauritius vary in width from a few metres on some parts of the eastern coast to nearly 1.5 km in the region of Mahebourg. Rodrigues has an even more extensive lagoon area averaging to about three times the island area. The lagoons are bounded by sandy foreshores inland and by fringing reefs towards the sea. In some regions the sandy foreshores are totally absent and basaltic rock outcrops form the shoreline. The lagoons are shallow (1-2 m) but can reach up to 15 m in the region of Mahebourg (Jootun *et al*, 1994). In general the lagoons support a wide diversity of biota, but this biota has been severely affected by coastal developments and anthropological activities within the area. These range from the increasing urbanisation of the coastal areas, the aggressive tourist development, the over utilisation of the biotic and abiotic resources.

3.1.1.1 Destruction/Reduction of Habitats

Sea grass meadows, corals, reefs, and the shoreline offer a wide range of habitats supporting an equally wide range of associated biota. These include various species of fish, crabs, shrimps, crustaceans, echinoderms, holothurians, algae, seaweeds, and marine angiosperms. Any change to these habitats will bear consequent losses to the associated biota. The destruction of corals through coral trampling, fishing malpractices, damages by boats, and natural causes such as coral bleaching affect the quality and availability of these habitats for the residing biota. These effects are visible at Grand Baie, Flic en Flac and Belle Mare. In Flic en Flac, the distribution of corals has altered significantly since it was first mapped (Montaggianni and Faure, 1981). Quantitative studies carried out in 1994 revealed that the cover was below 40% both at Flic en Flac and Wolmar. In Grand Baie, the lagoon floor is littered with coral rubble, mostly caused by boat anchors. With regards to coral bleaching, recent studies (Goorah *et al*, 2000) suggest that 31-39% of live corals in the marine parks of Blue Bay and Balaclava were affected by bleaching. This figure could be higher in regions such as Flic en Flac and Belle Mare. However, Turner *et al* (2000) reported that the mass-bleaching event of 1998 did not seriously affect Mauritius with less than 10% of bleached corals. However, the same report mentioned of the signs of coral degradation due to boat anchors and cyclones.

The clearing of sea grass meadows, also caused by dredging activities, in particular in front of hotels for bathing areas or for ski lanes, impact further the sea floor, causing loss of habitats and floor stability (Ramessur, 1991). Sea grass is known to hold together sediment particles and thus prevent them from being carried by strong currents. Recent studies carried out at Pointe aux Piments towards the southern end of the Grand Baie site indicate that disturbed areas have significantly lower biomass values, higher turbidity, lower biodiversity with only a few rare crabs, and can take four to five years to recover (Choony, 2001).

Likewise sand mining activities affect the physical status of the habitat. Over 800,000 tonnes of sand are removed from the lagoons annually (NEAP, 1999) and the resulting damages of this practice as evidenced at Pomponette-Riambel are two-fold; ecosystems are completely destroyed causing migration and death of associated biota in particular sand dwellers, water currents are changed and sea floor topography modified.

3.1.1.2 Destruction/Reduction of Breeding Grounds

Corals and sea grass meadows are excellent breeding grounds for marine animals such as fish, crabs and amphipods. Damage to these habitats will affect the reproductive cycles of many of these animals and plants with subsequent changes in the whole ecosystem through the disruption of the food chain and the whole food web. This damage can be direct, for example through dredging activities or indirectly through the effects of pollutants. The overall result is that populations are declining and the commercial exploitation of living resources such as fish and octopus are seriously jeopardised.

In Rodrigues numerous lagoons are affected by siltation modifying the sea floor and impacting on the resident biota. The corals and sea grasses are heavily affected. Whole areas are covered with silt deposits and become unproductive. The extent of the damage varies; some bays are completely silted and channels have to be made in order to facilitate the passage of fishing boats. In other areas corals are suffocated by deposits of silt and become unproductive and even the reefs are threatened. The lagoons of Rodrigues are exploited by the coastal community for fish and octopus. Recent studies suggest a decline in octopus and fish catch (Resource Analysis- EDC 1999; Genave, 1997).

3.1.1.3 Deterioration of Water Quality

Amongst the abiotic components of the lagoon ecosystem, the physical and chemical conditions are important parameters governing the health of the system. Any change in these physical (temperature, pH, salinity, DO, etc.) and chemical parameters (NO₃, PO₄, etc.) can have serious implications on biotic components. In Belle Mare high NO₃ levels have been associated with algal proliferation (Government of Mauritius, 1999). There have been reports of fish mortality in Pointe aux Sables (Ministry of Fisheries, 1997), algal coral suffocation in Grand Baie and coral bleaching in Flic en Flac. This nutrient enrichment of lagoon waters results in increased algal growth on the corals, thus affecting their biology (Botte, 2001). Increased sedimentation on the lagoon floor in Rodrigues and also increased suspended solids in Grand Baie (causing deterioration of water quality from enhanced turbidity) result in modification of these respective ecosystems (Resource Analysis-EDC, 1999).

The rise in seawater temperature has been pointed as one of the major causes of coral bleaching. The 1998 mass coral-bleaching event seemed to have caused less damages to the Mauritian corals (Turner et al, 2000). However other factors such as pollutants and sediments can also contribute coral bleaching. The extent to which these contribute to the problem has yet to be determined in Mauritius.

3.1.1.4 Changes in Water Currents

The increase in the number of reef passes (natural and man made) or their widening, have resulted in an increase in the intensity and frequency of waves which impact on the shoreline and lagoon floor. Sand mining activities in the lagoon modifies the currents and affect the stability of the lagoon floor. The erection of sea walls, slipways and jetties cause changes to currents by enhancing long shore drift (Gopaul, 1990; Jootun et al, 1994).

3.1.2 Shoreline Change (Issue No.23)

The coastline of Mauritius has undergone pronounced morphological changes over the years. Evidence of these changes can be found around the island such as the cliffs on the dunal ridge complex, the crenulations of the coastline, the newly abraded rocky surfaces, the inundated coastal roads or the exposed roots of coastal vegetation.

Beach cliffs of 1.5-2.0 m have been noted at Grand Baie and Flic en Flac. The position of the high water line has moved and coastline has receded by 2 m near Flic en Flac public beach (Jootun *et al*, 1994). This is clearly seen by the uprooting of the filao trees from the ridge complex and the retreat of the coastline to the foot of the seawall. The scouring of the ridge has given rise to a rectilinear coastline. Eroded material is carried by long shore currents and deposited elsewhere on the beach thereby altering the beach slope. Erosional scarps are particularly visible in the regions of Flic en Flac, Le Morne, Pomponette-Riambel, Belle Mare and Grand Baie. In some regions the beach line has retreated by at least 10 m over the past ten years. The southern regions are mostly exposed to the constant attacks of high amplitude waves reinforced by southeast trade winds. The impacts of these are further aggravated by the opening of reef gaps onto the fringing reef. The worst sites for erosion are Pomponette and Riambel where a beach retreat of 4 m has been recorded during a period of 3 years. This has produced pronounced beach scarps reaching 2 m and much of the coastal vegetation, particularly the filao trees have had their root systems exposed. At Belle Mare the coastline receded to about 5 m forming scarps of 1.8-2.0 m in 1988 under the influence of tropical cyclones (Prayag *et al*, 1995).

The impacts of shoreline change are:

3.1.2.1 Destruction/Loss of Habitats

The beach varies considerably in terms of the size and nature of deposits, their extent, and slope. The beach width varies from a few metres in the eastern and southern regions to about 25 m in the northern regions. The shoreline provides different habitats for marine and other organisms such as crabs, insects, arachnids, other invertebrates and trailing lianes. These organisms are therefore seriously affected by the destruction or modification of these habitats. This results in the migration of biota to other areas and/or more competition between the sand dwellers for these habitats.

3.1.2.2 Loss of Beach

The wide shoreline provides a recreational zone for tourist and local residents. With an average beach retreat of about 1 m per year (Jootun *et al*, 1994) there has been significant loss of valuable recreational area. In some areas the problem is more acute owing to ill-designed infrastructure such as sea walls, slipways and jetties. In Flic en Flac the vertical sea wall in front of Pearl Beach Hotel is causing wave reflection and the sand at the foot of this wall has been washed away northwards (Prayag *et al*, 1995).

3.1.2.3 Reduction in Beach Protection

Beaches provide protection to the backshore and dunal complexes where most of the hotels are implanted. Changes in the beach profile will have serious impacts on the tourist industry. The linear shape of the dunal ridge running parallel to the coastline, and the steeper downlift and gentler uplift with the vegetation cover provide coastal stability. Once this morphology is altered, disruption of the coastal equilibrium results and beach erosion may occur (Prayag *et al*, 1995). Beaches have then to be reprofiled, protection to beaches more effective, and slipways jetties and groynes have to be redesigned.

3.1.3 Over-Exploitation (Issue No. 14)

In our assessment of this issue we have broadened our understanding of the problem to include the nonliving resources exploited beyond maximum sustainable yield. Owing to the importance of nonliving resources such as the beaches and lagoon waters to the tourist industry we have felt the need to include this extra dimension to our assessment of this issue.

It is evident that over the years the importance of the artisanal fishing industry restricted to lagoon fishing has only dwindled. Both the fish catch and the size of fish have decreased. A similar situation prevails for other marine living resources such as crabs, lobsters, octopus etc.

Impacts are:

3.1.3.1 Decline in Fisheries

Lagoon artisanal fishing has been a traditional activity for coastal communities in Mauritius and Rodrigues. With the ever-increasing demand for marine products and the incentives given to professional fishermen, the industry has not improved over the past decades. In fact there has been a significant drop in catch. In Mauritius the fish catch has dropped from 1597 tonnes in 1987 to 1246 tonnes in 1997.

Table 3. Annual Coastal Fish Catch in Tonnes

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Catch	1362	1597	1479	1544	1637	1568	1775	1583	1663	1443	1616*	1246*

Source: Ministry of Economic Development and Regional Cooperation (1997)

* Source: Ministry of Agriculture, Fisheries and Cooperatives (1999)

Some species (i.e. Octopus) have completely disappeared from the local market as fresh material but is only available frozen, imported from neighbouring countries. The Rodriguan octopus industry has been heavily affected; there has been a considerable decline in catch and size over the past years.

3.1.3.2 Deterioration of Water Quality

The intensive exploitation of the coastline for the construction of hotels, bungalows and houses has placed increasing pressure on the lagoons. The hotel industry has developed considerably during the past decade. In the region of Flic en Flac there are six major hotels and a number of smaller ones operating. The same trend is seen in Grand Baie. Coupled to this, there has also been a massive housing development in these areas, of bungalows, residential house, flats, and various business buildings. In many cases hotels are not fitted with adequate wastewater treatment facilities (especially those hotels with less than 75 rooms) or with less performing water treatment plants. The discharge or percolation/infiltration of wastewater into the lagoons from these areas have resulted in a deterioration of the water quality. Evidence of impacts from wastewater contamination has been recorded at Flic en Flac and Pointe aux Sables. In Flic en Flac black anoxic sands, smelling of hydrogen sulphide are observed at low water mark and have been associated with wastewater (Prayag *et al*, 1995) discharge. At Pointe aux Sables faecal coliform counts are high (Ministry of Fisheries, 2000). In both Belle Mare and Flic en Flac, higher levels of NO₃ and PO₄ have been recorded and associated with proliferation of algal growth (Prayag *et al*, 1995; Botte, 2001).

Table 4. Tourism Statistics from 1990 to 2000

Year	1990	1994	1995	1996	1997	1998	1999	2000
Tourist arrivals ('000)	291.6	400.5	422.5	486.9	536.1	558.2		665.6
Number of hotels	75	90	95	90	87	90	91	93
Number of rooms	4,603	5,888	5,977	6,668	6,800	7267	7903	8000

Source: Central Statistical Office and Ministry of Economic Development and Regional Cooperation

The problem is further aggravated by the increasing demands of the local community for recreational sites. On weekends and public holidays the popular beaches at Flic en Flac, Belle Mare and La Cuvette at the northern end of Grand Baie are packed with people. The marked increase in water sport activities within the lagoons has also contributed to water quality changes such as from engine emissions. This is evidenced by the increased number of ski boats, glass-bottomed boats and other sport facilities like kayaks, pedalos etc.

3.1.3.3 Destruction/Loss of Habitats

Construction of hotels and bungalows has transformed the natural setting of the shoreline. The dunal complexes have been mostly affected, these have had to be levelled off and the surrounding of hotel complexes modified considerably with numerous exotic species of plants introduced. This transformation has modified the existing habitats/ecosystem and consequently affected the existing biota. Dunal complexes offer a variety of habitats for land animals and plants. These native species have been displaced by more aggressive exotic ones. Landscaping has also affected the backshore and foreshores. In many cases beach profiling works have been carried out. These practices were more prevalent before the promulgation of the EPA, which made the EIA license mandatory for all developments.

The increasing human activities in the lagoons coupled with the use of destructive fishing methods have changed the lagoon ecosystem. Coral cover has diminished (through coral trampling, damages by boats, clearance for ski lanes etc) and sea grass beds have been cleared for bathing spaces. All these activities have resulted in changes in the biota; fish catch is on decline while other marine species are proliferating. The reduction of coral cover has been associated with the proliferation of the sea urchins. The problem was so acute in some areas of Flic en Flac that hotels had to resort to manual removal of these sea urchins in front of their premises (Prayag et al, 1995).

In Flic en Flac, Grand Baie and Belle Mare/Palmar regions, hotels have cleared the sea grasses in the lagoon to create bathing areas and ski lanes impacting on the sea floor causing loss of habitats and floor stability (Ramessur, 1991). Recent studies carried out at Pointe aux Piments towards the southern end of the Grand Baie site indicate that dredged areas have significantly lower biomass values, higher turbidity, lower biodiversity with only a few rare crabs, and can take four to five years to recover (Choony, 2001).

3.2 Socio-Economic Assessment

Scoring of Socio-Economic Impact of each Issue.

The unavailability of relevant data for the computation of the socio-economic scores has rendered the exercise quite difficult. In some cases, the expert judgement has been used to come up with approximate values of the m1, m2, and m3 indicators.

M1 Indicator

For regions such as Grand Baie, Flic en Flac, Pointe aux Sables and Rodrigues, the m1 indicator was calculated on the basis of available data as the total mitigation costs divided by GNP Per Capita (PPP\$). Mitigation costs include construction of gabion walls to contain erosion and sewage treatment facilities. Investment in new fishing practices was also considered.

1998 GNP Per Capita (PPP\$) for Mauritius	=	\$ 9,400
Rupees 1998 Exchange Rate to US\$	=	23.98

Lower threshold = $9,400 * 900 = \$ 8,460,000$

Upper threshold = $9,400 * 3,600 = \$ 33,840,000$

M2 Indicator

Given the economic development of the country, the standard of living of the population and the availability of medical facilities, it can be easily indicated that the value range for this indicator will be zero. In addition, the hotspots considered for this exercise are not prone to major outbreaks or cases of illness up to the extent of death. Although figures are available on number of deaths by district, it is not worthwhile to conduct such analysis given the above considerations.

M3 Indicator

Forecast average annual population growth rate 1998-2015 = 0.79 %

Population density source area was estimated given that population density was provided by District and not by Village Council Areas.

3.2.1 Modification of Ecosystems or Ecotones (Issue No.13)

This issue has been addressed by considering both the living and non-living components of the ecosystem. Lagoons support a wide diversity of biota severely affected by coastal developments and anthropological activities within these areas. These range from the increasing urbanisation of the coastal regions, unsustainable tourist development and the over-utilisation of the biotic and abiotic resources.

The socio-economic consequences related to the modification of ecosystems are significant but difficult to assess since there are no relevant data. For this issue, the socio-economic impacts of destruction of breeding grounds for marine animals, changes in water quality and loss of biodiversity will be considered.

3.2.1.1 Destruction/Reduction of Breeding Grounds

The general ambient water quality and health of the ecosystems have major impacts on fish productivity and marine life in general. The destruction or reduction of breeding grounds including sea grass meadows and corals will lead to a decrease in fishery resources and catch. Although such impacts have not been quantified, it is evident that a reduction in fishery resources has adverse socio-economic consequences. The decrease in fish catch has implications on the economy and reduces the ability of the local communities to meet their basic needs. The number of people employed in the fisheries sector will decrease resulting in an increase in the unemployment rate. The total estimated employment in the fisheries sector was 5,500 in 1999 and its contribution to the economy represents about 0.2 % in 1999.

3.2.1.2 Changes in Water Quality

The quality of the lagoon is a major determinant of the recreational value of the site. Any significant change in the lagoon ecosystem for instance, changes in the water quality with regard to sediments affecting the turbidity and water-bathing quality will impact negatively on the recreational value of the site.

A case study on the economic evaluation of water pollution was undertaken in 1998 and the subject site was the Pointe aux Sables lagoon. The Individual Travel Cost Method (ITCM) was used for the impacts of water quality on the recreational value of the lagoon. By observing how visitation rates to the site change as the environmental quality of the site changes, the ITCM provides values for the environmental attribute itself. The ITCM uses the observed behaviour of individuals in travelling to visit the recreation site and the monetary value of time and travel costs incurred are used as a proxy for the value of recreation.

The ITCM showed that the benefits lost due to the negative impact of poor water quality/water pollution was worth about US\$ 122,559. It is important to point out that the value was an underestimation of the real benefits of reducing pollution since it accounted only for the present visitors to the site and the analysis did not include the value to tourists since Pointe aux Sables is considered as a domestic beach. Thus depending on the quality of the sites surveyed, the loss due to changes in water quality will be much higher than the figure of US\$ 122,559 for a site providing higher quality of services and is very much in the tourist area.

The above flows of net benefits could be compared with the cost of an investment aimed at improving the water quality/reducing the pollution of the lagoon. Assuming that the optimal investment in a water treatment plant and that the lifetime investment is 20 years with no maintenance and management costs, then the Net Present Value of the benefits generated by the lagoon in the next 20 years is worth US\$ 1,823,368 (calculated at a discount rate of 3% and US\$ 1,405,742 if the discount rate is 6%). It follows that the recreational benefits alone can justify investments costing up to US\$ 1,823,368 or 1,405,742. Yet the recreational benefits constitute one component of the total benefits that would be generated by reducing pollution in the lagoons. Other important benefits are fisheries, biodiversity and health. Hence more expensive investments could be justified if all the benefits generated by the lagoon were estimated.

3.2.1.3 Loss of Biodiversity

With respect to loss of biodiversity due to modification of ecosystems, no concrete study has been undertaken to evaluate the extent of damage. Biodiversity has high option, existence and bequest values as well as the indirect use value. However, given the absence of any data on the impact of modification of ecosystems on biodiversity and given the difficulties involved in valuing the existence and option values, it is not possible to assess the socio-economic impact of loss of biodiversity.

Besides the above impacts, it is to be noted that the coastal population is very much dependent on the services provided by the lagoon ecosystem i.e. coral reefs and biodiversity for its own food as well as for economic gains, for those involved in the tourist and fishing activities. And any negative impact on the lagoon ecosystem can lead to a reduction in the various sectoral activities and subsequently decreasing the revenues generated by these economic sectors.

Aesthetic Devaluation

In the most severe cases the beach is very eroded and has produced beach scarps of 1-2 m, for example at Riambel and Flic en Flac. Certain remedial steps have been taken to mitigate these impacts. The use of gabions (large rectangular metal wire baskets holding broken basalt rocks) to curtail the negative effects of waves has becoming increasingly popular but the effectiveness of these structures needs to be monitored. Furthermore gabions decrease the aesthetic value of the area, reduce the recreational beach area, prevent easy access to the sea, and add to the cost of maintaining the beaches. In regions such as Wolmar where remedial measures have not been taken the eroded shoreline looks defenceless with the root system of filao trees partially exposed and where the ill-designed seawalls are cracked.

Damages to Infrastructure

The eroded shorelines expose coastal defences and roads to adverse actions of the swells and storm surges. Seawalls have been constructed to protect bungalows and coastal roads built near the shoreline. The vertical seawalls are less resistant than the inclined ones. Slipways crumble down due to the wave action.

3.2.2 Over-Exploitation (Issue No.14)

The socio-economic assessment of this particular issue will include an assessment of the fishery resources and non-living resources such as the beaches and lagoon waters.

3.2.2.1 Over-Exploitation of Fishery Resources

Over-exploitation of fishery resources does occur in most of the lagoons around the island and can be linked with the rapid expansion of the tourist industry and an increase in demand from the local population. The socio-economic consequences of a reduction in fishery resources have been highlighted above (for Issue No.13) and as mentioned, although such impacts have not been quantified, it is evident that a reduction in fishery resources has detrimental socio-economic consequences. The decrease in fishery resources has implications on the economy and reduces the ability of the local communities to meet their basic needs. The number of people employed in the fisheries sector will decrease resulting in an increase in the unemployment rate. The total estimated employment in the fisheries sector was 5,500 in 1999 and its contribution to the economy represents about 0.2 % in 1999.

3.2.2.2 Over-Exploitation of Non-living Resources

The haphazard development of the coastal regions has resulted in undue pressures on the lagoon ecosystem. The deterioration of the water quality of the lagoons can be due to the infiltration of wastewater in the lagoons and the marked increase in water-sport activities. Moreover, the construction of hotel complexes and informal bungalows has transformed the natural setting of the shoreline. This has led to the modification of the existing habitats/ecosystems and consequently affected the existing biota.

The socio-economic assessment of changes in the lagoon water quality has already been undertaken for Issue 13 and the assessment of loss in the recreational value of our lagoons will be same for the issue of over-exploitation of non-living resources.

With respect to loss of biodiversity due to modification of ecosystems, no concrete study has been undertaken to evaluate the extent of damage. Biodiversity has high option, existence and bequest values as well as the indirect use value. However, given the absence of any data on the impact of modification of ecosystems on biodiversity and given the difficulties involved in valuing the existence and option values, it is not possible to assess the socio-economic impact of loss of biodiversity.

3.2.3 Shoreline Change (Issue No.23)

The coastline of Mauritius has undergone profound morphological changes over the years as a result of natural causes and anthropogenic activities. The natural phenomena are tropical cyclones and tidal waves while the anthropogenic activities include the haphazard construction of ill-designed jetties and groynes, removal of sand, increasing infrastructural development and degradation of coral reefs.

The socio-economic assessment of shoreline change implies that all the benefits associated with the coastal zone should be considered. The economic valuation of the shoreline can be undertaken in two ways: (i) total economic benefits associated with activities with a use value (market and non-market values) and; (ii) benefits of preserving the ecosystem (non-use value). These will include assessment of:

- economic benefits of activities (market values) which are dependent on the beach and its environmental resources for instance, earnings from the tourist industry;
- economic benefits (non-market values) of maintaining the coastal zone and the recreational value of the beach for the local residents;

- indirect benefits associated with the preservation of the ecosystems protected by the coastal region, for instance the mangroves;
- benefits associated with other activities which will be affected with shoreline change, for instance the traditional fishing activities, and
- economic benefits associated with coastal zone development, in terms of value of coastal land, commercial and residential buildings.

A matrix of the economic valuation of maintaining the shoreline/coastal zone is given below:

Beneficiaries	Economic Valuation
Hotels	Turnover and capital investment
Tourists	Earnings from the sector
Fishermen	Fish production and value of the land occupied by the fishermen
Coastal population	Cost of coastal land or residential or commercial buildings

3.2.3.1 Economic Benefits Associated with Coastal Zone Development, in Terms of Value of Coastal Land, Commercial and Residential Buildings

The economic valuation of the shoreline of a particular coastal strip in Madagascar (Mouroundave) was undertaken in 1999 in the context of the Indian Ocean Commission Regional Environment Program. The evaluation was carried out to assess the impact of coastal erosion/shoreline change on the value of the coastal land and residential and commercial buildings. We can try to extrapolate the findings of this case study to the coastal regions in Mauritius, bearing in mind the specificities/characteristics of the coastal zone in Mauritius and that in Madagascar.

The evaluation was done using the Hedonic Price Method. The scenario was that the value of the coastal land and the prices of commercial and residential buildings would decrease with shoreline change/coastal erosion. The study considered the impact of coastal erosion in Mouroundave on the price of residential buildings.

The relation between the price of a particular residential building and the distance from the sea was given as below:

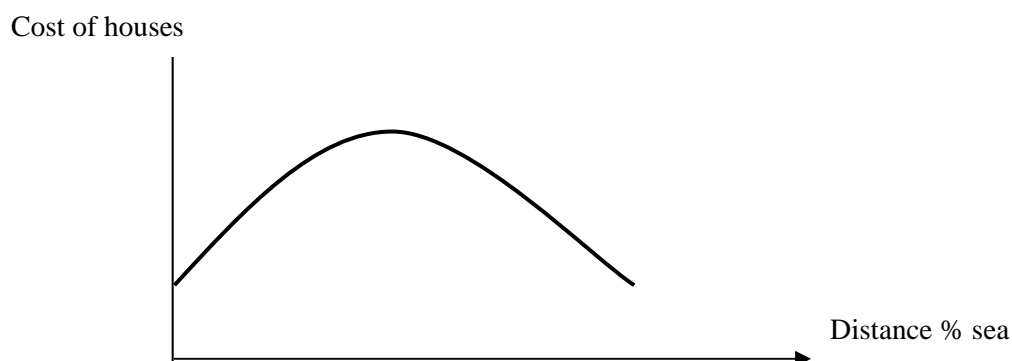


Figure 5. Graphical Representation Between Housing Cost and Distance from Sea

The value of the coastal strip measured by the decrease in the price of residential buildings is shown below:

	Value in FMG	Value in US\$
Individual Consumer Surplus	1.008.000	200
Total Consumer Surplus	5.340.000.000	1.027.000

Considering the extent of development around the coastal zones in Mauritius in terms of hotel development, bungalows, private dwellings, commercial activities and tourist-related activities as well as the very high price of coastal land, the value of the total consumer surplus would have been more significant for Mauritius.

3.2.3.2 Economic Benefits (Non-market Values) of Maintaining the Coastal Zone and the Recreational Value of the Beach for the Local Residents

The shoreline provides a recreational area zone for local and foreign tourists. For Issue No. 13, the recreational value of the beach has been estimated using the Travel Cost Method for the Pointe aux Sables beach. It is worth noting that the recreational value of this particular beach was an underestimation of the real benefits of reducing pollution since it accounted only for the present visitors to the site. The analysis did not include the value to tourists since Pointe aux Sables is considered as a domestic beach. So the recreational value of the beaches in the tourist zones would be very much higher than the figure provided for Pointe aux Sables beach.

3.2.3.3 Economic Benefits of Activities (Market Values) are Dependent on the Beach and its Environmental Resources for Instance, Earnings from the Tourist Industry

During the last decade, the tourism industry has emerged as the fastest growing sector and established itself as the third economic pillar of the Mauritian economy. It is also the largest foreign exchange earner. Gross earnings from the tourism sector for 2000 amounted to around Rs 14,234 million as compared to Rs 13,668 million in 1999. The issue of shoreline change/coastal erosion is of major concern to the tourist sector given the high capital investment in the industry and any subsequent decrease in tourist arrivals might impact negatively on the hotels' turnover and tourist-related activities. The gross earnings from the tourism sector are indicative enough of the importance of the tourism sector in the Mauritian economy.

3.2.3.4 Destruction/Loss of Habitats

The coastal zone shoreline provides different habitat types of marine and other organisms. The bottom of the lagoon contains various plants and animal communities, coral colonies. Mangroves and wetlands play a vital role in the functioning of coastal ecosystems. While mangroves entrap terrigenous sediment that would otherwise be deposited on corals, wetlands provide the essential habitat for many important marine species. The destruction and modification of these habitats, which may occur with shoreline change, seriously affect these ecosystems.

Coastal protection has been undertaken in many ways, for instance the removal of structures that are causing coastal instability and hindering sand movement along the beach. An additional protective measure involves the construction of gabion walls made up of galvanised steel rods, zinc coated with a 0.55mm special PVC coat, which are doubly twisted to give a hexagonal mesh. Gabion structures have been placed at several coastal areas to protect the beach from further erosion and it is estimated that 1 km of gabion structure costs around Rs 2-5 million (US\$ 0.06 – 0.166 million).

CHAPTER 4

4. Causal Chain Analysis

In this section causal chains were developed for the three selected issues. Based on the results of the preliminary assessment of the root causes, the causal chain analysed causes that contribute 10% or more of the issue. Available literature and the advice of relevant experts were used to assess and interpret each causal chain. . The immediate causes and sectoral pressures were treated separately for each issue. The other components of the causal chain analysis such as environmental management and policies, root causes, market responses and the community responses encompass all the three issues and are therefore dealt under the section commonalities.

4.1 Shoreline Change

4.1.1 Immediate Causes and Sectoral Pressures

The causes of shoreline change can be grouped into two main categories; natural causes such as cyclones, storms and tidal surges (which account to 50% of the issue), and anthropogenic causes through the creation/widening of reef passes (15%) and the construction of hard structures on shores (35%). Of the natural causes, cyclonic waves are the most devastating. Beach retreats of 5-10 m have been recorded in certain places after the passage of cyclones (Jootun et al, 1994, Government of Mauritius, 1998). During the cyclone Hollanda (on the 10th of February, 1994) the beach line at Flic en Flac retreated by 2 m and a 1.5 m cliff could be observed along over 500 m stretch. The concave shoreline at the northern end of Flic en Flac at the public beach retreated by 5 m while further north there was accretion of sand in front of Villa Caroline hotel by over 2 m (Prayag et al, 1995).

With regards to shoreline change as they relate to reef passes, the fisheries sector contributes to 70% of the cause (for local consumption only). Reef passes have been made to facilitate access of fishing boats in and out of the lagoons. These passes are also used by pleasure crafts and other small boats, such as those involved in big game fishing and deep sea diving (Gopaul, 1990). At Flic en Flac a reef gap has been deepened in 1991 and this has caused severe erosion on the beach just opposite to the pass orientation (Prayag et al, 1995). Likewise the erosion of the beach towards the north of south of Palmar has been attributed to the widening of the reef pass in that region (Jootun et al, 1994). Protected regions such as the deep sheltered end of Grand Baie are less prone to erosion caused by these wave actions as opposed to the more exposed northern end.

The hard structures referred here are jetties, sea walls, slipways and groynes. A survey dating back to 1996 revealed the presence of over 200 unwarranted or ill-designed jetties/groynes around the island (Prayag et al, 1995). Hotels and private bungalows around the coast have their own jetties. Many of these jetties are not well designed and they interfere with the circulation of water in the lagoons. Similarly sea walls built to delimit properties or mitigate the action of waves are adversely affecting the lagoon and shoreline. In many cases the set back distance has not been respected (Jootun et al, 1994). The compounded effects of the various hard structures inevitably are having long-term consequences on the shoreline and the lagoon itself.

4.2 Over-Exploitation

4.2.1 Immediate Causes and Sectoral Pressures

This issue is addressed to cover both the living and non-living components within the ecosystem. The immediate causes of over-exploitation include decreased level of recruitment (35%), decreased habitat/nursery grounds (30%) and increase demand for coastal recreational activities (35%).

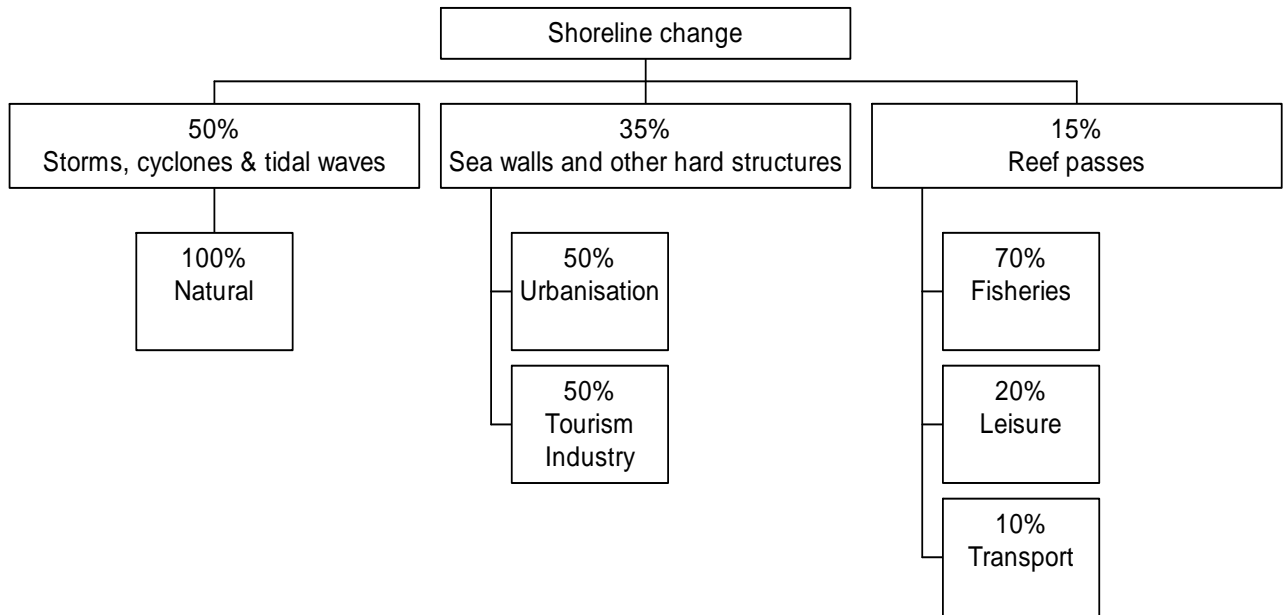


Figure 6. Shoreline Change: Immediate Causes and Sectoral Pressures

It is evident that with a significant movement of the population towards the coast, there would be direct and indirect pressures on the living and non-living resources of these areas. There are increasing demands from the tourist industry and the local population for fish and other marine products. The indiscriminate artisanal fishing practised for decades within the lagoons has brought down fish populations thereby affecting the level of recruitment (Ministry of Fisheries, 1997 & 1998). Both fish catch and fish size caught have gone down (Table 5). Whilst this problem has been alleviated by the promulgation of relevant legislation to control indiscriminate fishing and other fishing malpractices, other sectors affecting recruitment such as urbanisation (20%) agriculture (20%) and tourism industry (20%) have gained importance in contributing to this cause through pollution of the lagoons (Government of Mauritius, 1999b, Government of Mauritius, 1994, Jogarah, 2001).

Table 5. Annual Catch of the Coastal Fishery in Tonnes

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
CATCH	1362	1597	1479	1544	1637	1568	1775	1583	1663	1443	1616*	1246*

Source: Ministry of Economic Development and Regional Cooperation (1997)

* Source: Ministry of Agriculture, Fisheries and Cooperatives (1999)

The coastal regions are not linked to the sewer system and houses are therefore required by law to be equipped with septic tanks to dispose wastewater. But the proximity of these dwellings to the coastline and the porous nature of the sandy soil suggest that there is percolation of wastewater to the lagoon. Similarly hotels of capacity below 75 rooms are not required to install stringent wastewater treatment plants but use septic tanks thus contributing to the pollution of the lagoons. The levels of nutrients such NO₃ and PO₄ are higher in Flic en Flac (Botte, 2001) as are the coliform counts in the Pointe aux Sables region (Ramkhelawon, 1999; Jogarah, 2001; Joomun, 2001). These pollution parameters suggest that the coastal regions are being over-exploited. Another factor contributing to the cause are the increasing water sports and recreational activities in the lagoons. The number of beach visitors is increasing and the popular beaches of Belle Mare, Flic en Flac, Grand Baie are crowded during weekends and public holidays. These people add up the pressure on the lagoons through bathing and

other water sports activities such as snorkelling, diving, water skiing. Such activities cause damages to the habitats like corals and sea grasses and thus affect the biodiversity.

Decreased habitat/nursery grounds are another cause finding its roots within the same sectors mentioned above with a more or less equal share. In most of these cases there is actual physical destruction of the habitat through man made activities within the lagoon for leisure purposes. In spite of the fact that any major development requires an EIA, damage to the habitats still results due to the inadequate follow-up of the conditions of the EIA during the construction stage. Recent studies (Choony, 2001) suggest that the disturbed areas such as dredged sea grass beds have a lower biodiversity and biomass turnover and can take 4-5 years to recover.

Over the past two decades we have witnessed major rapid development in tourist villages such as Grand Baie and Flic en Flac (Sewoobaduth, 1999; Government of Mauritius, 1994; VJ Environment Services, 1995). A similar trend towards an unplanned coastal urbanisation is also evident in Trou D'eau Douce, Grand Gaube. Bungalows, hotels and other infrastructural buildings are coming up within these regions without a proper master plan. The number of tourist coming to Mauritius is increasing every year by an average of 7% and it has passed the figure of 600,000 tourists last year (Table 6). It is therefore from these sectors i.e. urbanisation (35%) and Tourism industry that this demand for coastal recreational activities is being more strongly felt.

Table 6. Tourism Statistics from 1990 to 2000

Year	1990	1994	1995	1996	1997	1998	1999	2000
Tourist arrivals ('000)	291.6	400.5	422.5	486.9	536.1	558.2		665.6
Number of hotels	75	90	95	90	87	90	91	93
Number of rooms	4,603	5,888	5,977	6,668	6,800	7267	7903	8000

(Source: Central Statistical Office and Ministry of Economic Development and Regional Cooperation).

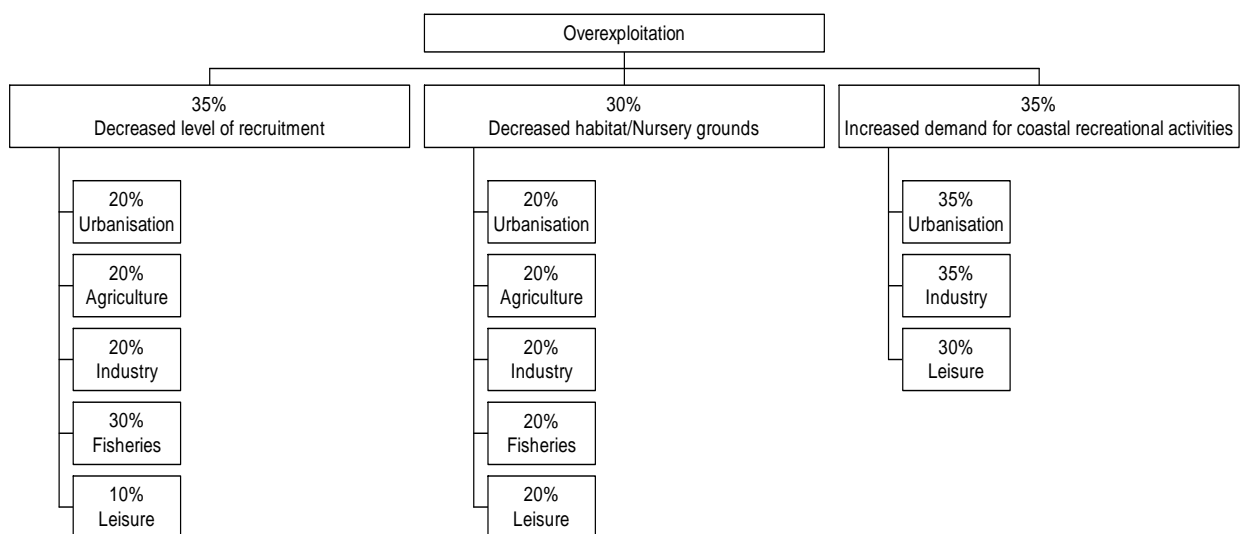


Figure 7. Overexploitation: Immediate Causes and Sectoral Pressures

4.3 Modification of Ecosystems/Ecotones

4.3.1 Immediate Causes and Sectoral Pressures

The immediate causes of modification of ecosystem include land development (35%), changed freshwater and sediment (35%) and partial conversion of ecosystem (30%). Concerning land development, urbanisation and the tourist industry are the most important contributing sectors to this cause. This is evident in tourist areas where there is an increase in the number of hotels and private bungalows. In Grand Baie and Flic en Flac wetlands have been reclaimed for building purposes thereby hindering the natural functions of these lands (Jootun et al, 1994; Prayag et al, 1995; Seewoobaduth, 1998). These developments have been made without due consideration to the necessary accompanying infrastructure such as wastewater disposal systems. Wastewater treatment systems are mandatory for hotels of greater capacity than 70 rooms and new individual residential units should be fitted with septic tanks. In spite of these measures, the water quality of the lagoons has deteriorated as a result of untreated or partially treated wastewater pollution (Bholah, 1993; Ramkhelawon, 1999; Sewoobaduth, 1999; SOGETI-BET, 1995, Soophul, 1997; Jogarah, 2001, Jootun et al, 1997). Wastewater from septic tanks percolates down the porous sandy soil to reach the lagoon causing enrichment of the waters and proliferation of algal species at the expense of other less competitive ones.

The leisure sector contributes about 30% to the cause through beach works such as landscaping and dune levelling or dredging in the lagoons for bathing areas and ski lanes. Hotels and bungalows constructed on the coastline before the promulgation of the EPA and the ensuing EIA were allowed to transform the dunes into levelled areas for their construction and landscaping. In the lagoons, dredging has been commonly practised without due consideration to the corals and sea grass beds. Even with the present set-up of the EIA process, many developments around the coastline have not respected the recommendations in EIA license delivered. It is also a fact that monitoring of the projects during the development stage is the weak point of the present EIA system.

With regard to changed freshwater and sediment, the main problem is the presence of suspended particles in the lagoons, in particular Grand Baie and Ponte aux Sables and the sedimentation of lagoons in Rodrigues (Government of Mauritius, 1994). Whilst on mainland Mauritius the cause is associated with industrial and house hold effluents being discharged in the lagoons particularly at Pointe aux Sables (Ramkhelawon, 1999; Jogarah, 2001; Joomun, 2001), the contributing sector in Rodrigues is mostly agriculture through the sedimentation of soil washed away from agricultural pasture highlands. Some of the bays are completely silted and channels have been constructed to facilitate the movement of boats. The sediment also causes damage to the coral ecosystem thereby impacting on artisanal fishing. The steps taken to alleviate the problem in Rodrigues have not proved to be efficient. Presently there is an aggressive programme of reforestation of the highlands and slopes to curtail this problem in the long term (Resource Analysis-EDC, 1999; Genave, 1997).

The three sectors contributing to the partial conversion of ecosystem are urbanisation (40%), agriculture (30%) and industry (30%). Coastal civil infrastructural works in both newly urbanised areas and hotel complexes account for the pressures stemming from urbanisation and tourist industry. Agriculture contributes through the leaching of nutrients in the lagoon ecosystem and the consequent changes in biota. High NO₃ levels has been associated with algal proliferation in the lagoons of Belle Mare/Palmar with the result that many hotels have had to remove algal deposits from the shoreline on a weekly basis. Also adding to the pressures in the lagoons are the dredging works for bathing areas and ski lanes. These practices destroy whole habitats and cause migration of the biota and disruption of food chains and food webs.

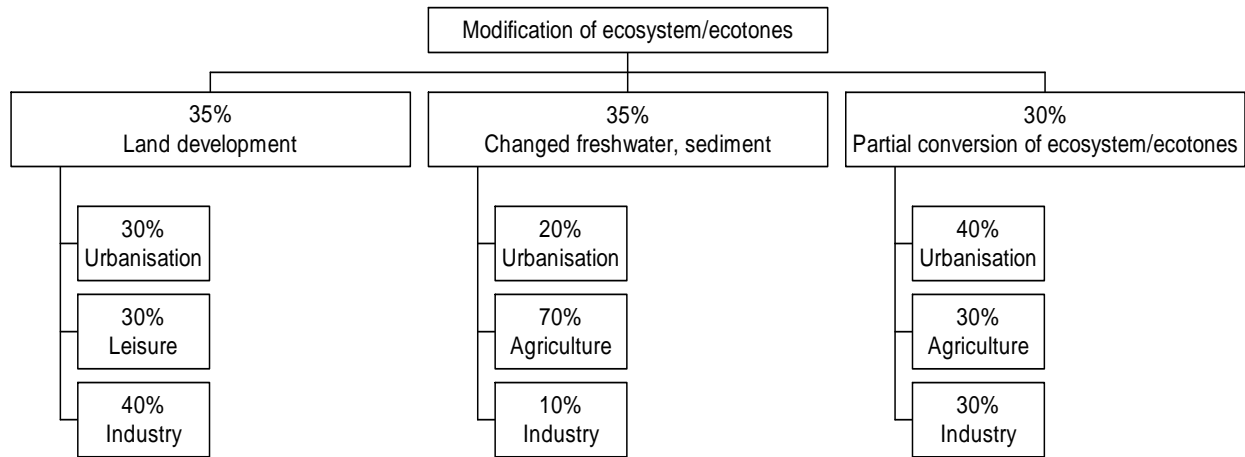


Figure 8. Modifications of Ecosystems: Immediate Causes and Sectoral Pressures

4.4 Commonalities

4.4.1 Immediate Causes and Sectoral Pressures

The two major sectors contributing to the immediate causes of all the three issues are urbanisation and industry (including the tourism industry). Of less importance are the agriculture and leisure sectors. This clearly reflects the trend that Mauritius has taken over the past decades. The rapid industrialisation focused on the light and textile industries whilst the tourist industry has boomed around the coast. There has been a significant increase in the number of hotels, rooms and tourists with a sustained average increase of 7% yearly. Coastal urbanisation is a more recent phenomenon gaining importance with the development in the tourist sector. People migrate to the coast to live closer to their working place in hotels or have come to develop businesses related to the tourism industry. This is coupled to increase in per capita income and the new trend for Mauritians to possess a secondary residence nearer to the coast and also to spend their holidays on the coast. Much of this development has not been accompanied with the necessary infrastructure and relevant environmental regulations.

4.4.2 Root Causes

The root causes for the three issues include social changes, institutional drivers and economic structures, which can be further defined as population increase, increased need for recreational activities, little Government commitment and macro-economic policies.

Population pressure caused by natural population increase, in-migration to the coast and increase in the number of tourists has led to an increase in the demand for land in the coastal regions for residential purposes and for more hotels. This has also led to higher demands for fish and other marine products and lagoonal activities, thereby impacting on the marine ecosystem. (Government of Mauritius, 1999b).

Two explanations can be offered for this migration. Firstly as the tourism industry has concentrated on the coastal regions there are more job opportunities in this sector either directly in the hotels or indirectly running small businesses related to the tourism industry. Secondly many Mauritians prefer to live on the coast and commute to their working places while others have secondary houses on the coast. Also many Mauritians have developed the habit of spending a few days on the coastline for their holidays and thus rent bungalows for this purpose. This boosts up the demand for coastal accommodation and also adds pressure for more recreational activities on the beach and the lagoons.

With the increasing demand for coastal land for residences, bungalows, hotel development and small businesses related to the tourism industry, the highly prized coastal lands have come under even more pressure. Individuals in search for a plot of land are in competition with big conglomerates and investors for this highly valuable resource. In many areas such as Grand Baie, Flic en Flac, land development promoters are fetching higher prices for small plots of land. The macro-economic policies for the development of the tourist industry tends to favour the big investors to boost the tourism sector and the economy and at the same time create more jobs. Government owned coastal lands (pas geometriques) are being leased to hotel promoters and developers at relatively low rates and additional fiscal incentives are given to attract these investors. This has resulted in an increase in the demand for coastal land (resulting in speculations for the prices of these plots). The large hotel development programme is competing with the local population for coastal land and the lagoon ecosystem. The package of incentives given to Hotel Development Certificate Holders include:

- a) payment of a nominal Corporate Tax of 15% during the lifetime of the project instead of the nominal statutory rate of 30%;
- b) dividends received by Shareholders are free from Income Tax in Mauritius for the lifetime of the company;
- c) exemption from payment of customs duty on the importation of an approved list of equipment;
- d) free repatriation of invested capital, profit and dividends; and
- e) terms loans and overdrafts at preferential rates.

Population pressure and low level of education are the main social changes that exert pressure on the ecosystems. The low level of education among fishermen and other users as regards the marine ecosystem has resulted in the destruction of habitats through fishing malpractices and other uncontrolled activities such as sand dredging in the lagoon (Government of Mauritius, 1998, Jootun et al, 1994).

Limited civil society empowerment exerts pressure on the ecosystem due to lack of knowledge on potential environmental problems associated with uncontrolled development in the coastal regions, in particular along the shoreline and inability of civil society to participate in the implementation and enforcement of regulations.

4.4.3 Environmental Management and Sectoral Policies

There are commonalities in the environmental management tools/policies designed to address the issues of over-exploitation, modification of ecosystems or ecotones and shoreline change.

Various organizations are involved in the management of the coastal zone in Mauritius as shown in Table 7.

Table 7. Organisations with Responsibilities Relating to Coastal Resources

Ministry or Department	Mandate
Department of Environment	EIA, environmental quality
Department of Local Government	Shore development, beach cleaning
Ministry of Fisheries and Cooperatives	Fisheries and lagoon ecosystem
Ministry of Home Affairs	Coast guard/police
Ministry of Housing and Lands	Physical planning policy
Ministry of Land Transport, Shipping and Ports	Marine pollution from vessels

Mauritius Marine Authority	Port functions, shipping
Ministry of Tourism and Leisure	Coastal hotels and recreation
Prime Minister's Office	Meteorological services

Source: Ministry of Environment (1999)

The Minister of Environment has specific authorisation for management of the coastal zone under the Environment Protection Act of 1991. Policies for the coastal zone occur under various plans and regulations. Legislation is fragmented and dispersed across a number of different Acts and Regulations, with powers to enforce existing and enact new legislation being conferred on several Ministries and an apparent lack of co-ordination and cooperation between them (Ministry of Environment, 1999). The most important policies are the Environment Protection Acts of 1991, the National Physical Development Plan of 1995 and the Fisheries and Marine Resources Act of 1998.

Land use planning in Mauritius is still governed by the Town and Country Planning Act 1954, since the Town and Country Planning Act 1995 has not yet been passed. The Act sets out land planning regulations. The National Physical Development Plan (NPDP) prepared in 1993, provides a sound basis for integrated land use planning but cannot be used as the necessary legal back up i.e the Town and Country Planning Act of 1995 has yet to be passed.

The Environmental Impact Assessment is a key tool for environmental management under the EPA. However, the effectiveness of the EIA process is reduced by a number of weaknesses in the existing provisions, including the fact that the list of undertakings subject to an EIA is not comprehensive enough to cover all potentially harmful activities. In addition, the procedure for reviewing EIAs and granting EIA licences is lacking in transparency and accountability.

The protection of water resources can be referred to a number of primary and secondary legislations, which include Rivers and Canals Act, Ground Water Act, Waste Water Authority Act, Environment Protection Act and Central Water Authority Act. The body of laws relating to the management of water resources and the control of water pollution are still to be found in separate enactments to a large extent because no consolidating law has yet been proclaimed. A few environmental water standards alone have been prescribed. In addition to the various pieces of legislation, Government has embarked on various sectoral programs to protect the water resources, for instance, the Integrated Pest Management Program and the National Sewerage Program.

The Ministry of Environment has been very active in the recent years in the development of policies, standards and strategies. Apart from the second National Environment Action Plan for the years 2000 to 2009, the Ministry has also developed and issued the following standards and guidelines:

- Standards on Air (Emission and Ambient) - Government Notice (GN). No.105 of 1998 - in force since 1st February 1999);
- Guidelines on Inland Surface Water Quality (GN. No. 188 of 1998);
- Guidelines on Coastal Water Quality (GN. No. 620 of 1999); and
- Guidelines on Irrigation Water Quality (GN. No. 617 of 1999).

During the same period, the following regulations, standards and guidelines have been developed and will be issued soon:

- standards for treated wastewater for use in irrigation;
- standards for non-hazardous wastes;
- standards for hazardous wastes;

- standards for effluent discharge into the ocean;
- standards for effluent discharge onto land, underground and into watercourses not meant for potable water supply;
- industrial effluent discharge permit;
- industrial waste audit regulations; and
- test methods for pollutant analysis.

As regards solid waste, there is no general law dealing exclusively with the collection and disposal of non-hazardous waste. Instead, they are spread out in the statute books, several sections from different enactments, some of which are much more oriented towards penal sanctions and public health considerations than waste minimisation and management as such.

The Fisheries and Marine Resources Act 1998 is the tool used to manage and promote sustainable exploitation of fishery resources, with due regard to environmental concerns. It provides for the better management, conservation and protection of fisheries and marine resources. Provision is also made to control pollutants thrown into the marine environment, for the declaration of Marine Protected Areas, for the regulation and control of fishing activities within the coastal areas and restrict underwater fishing.

As regards coastal zone management, there is need for a more comprehensive approach to coastal zone planning in Mauritius, in the form of an ICZM to address the increasing incidence of coastal problems, resource use conflicts and the understanding of the intricate nature of the coastal environment.

Three organisations closely associated with the enforcement of coastal legislation are the Ministry of Environment's Enforcement Division, the Police through the Coast Guards and the Fisheries Protection Service.

The Ministry of Environment has among its mandate, the protection of the coastal zone. The Enforcement Division has a mobile squad which tracks down offenders. Since 1991, the Ministry has issued a total 15 Prohibition Notices of which 2 cases were against illegal backfilling of wetland at Grand Baie and Pereybere and 1 case against illegal modification of coastline at Blue Bay.

According to Article 12 of the National Coast Guard act of 1988, Coast Guards should prevent any activity that could constitute a threat to the marine zones, including the fauna, flora and coral reefs, and the coastal zones that comprise of the beaches and the shore. Along with the Fisheries Protection Service, they patrol the near shore area in order to discourage and prevent illegal fishing and collection of unauthorised marine organisms.

The Fisheries Protection Service provides a 24-hour service through its 13 Fisheries Posts around the coast. Its main objective is the protection of marine environment through the enforcement of the Fisheries and Marine Resources Act and various other related legislation (Sand Removal Act, the Environment Protection Act and the Pleasure Craft Act) leading to a sustainable exploitation of marine produce at the same time attending to the welfare of fishermen as well as safe guarding the interest of the consumers.

Activities which are punishable by law include illegal removal of sand or any other marine resource, discharge of untreated effluents in the sea, use of explosives or any unlicensed fishing net and catching undersized fish.

The Minister of Environment has recently set up the Environment Police for enforcing regulations. The Ministry of Environment has issued a total 15 prohibition notices to various parties concerning offences against the Environment Protection Act

An Environmental Law Division (ELD) was created at the same time as the ICZM Division in the Ministry of Environment in July 2000. The functions of this legal unit include the drafting of standards, advice to and representation of the Department in court and general legal advice to the Department. However, the unit is presently understaffed and does not have any member with legal qualifications.

In spite of the comprehensive legislation for the protection of the coastal zone, enforcement has not always been very effective due to overlapping of responsibilities and lack of personnel or equipment. Enforcement responsibilities are not always clearly spelt out so that proper deployment of staff becomes difficult. For example, powers of enforcement in respect of marine pollution are spread between the Director of Environment, the Permanent Secretary of the Ministry of Fisheries, the Director of Shipping, and the National Coast Guard. There is no formal mechanism for coordinating the activities of the various organisations involved in coastal zone research. Only in the case of foreign driven projects or externally funded ones, the Ministry of Economic Planning plays a coordinating role between the local and the foreign counterpart. Another major drawback is the fact that research findings are rarely published or made public in any way. Hence important information is lost or forgotten and are thus never used for policy or decision-making.

None of the scientists of the Ministry of Fisheries or the Ministry of Environment has been specifically trained for management of the coastal zone. In spite of the fact that an ICZM Division has been created in the Ministry of Environment, the latter is understaffed and existing staff members are not trained for the specific responsibilities that they are required to shoulder. Due to the shortage of personnel, the Ministry of Environment has found it difficult to release its staff for further training and this gives rise to a spiralling problem.

The general feeling among the staff of the various ministries concerned is that there is a serious lack of appropriate training. Too often, officers are required to take new responsibilities without any form of training the result being a lack of self-confidence.

4.4.4 Community Responses

Community responses to coastal and marine related issues have been restricted to some sporadic manifestations from fisherman associations and local groups with respect to developments in the tourism sector. This low level of community response can be attributed to several factors, the major one being a lack of awareness of environmental issues and non-empowerment of community structures. It is also perceived that, with rapid development and increase in per capita income, Mauritians are more concerned with improving their status than to care common community issues.

4.4.5 Market Responses

The market responses, which overlap across the three issues, are namely, the incentives provided to the tourist industry and the intensification of the fishing activities. The intensive artisanal fishing in many lagoons through the use of illegal fishing gears has resulted in the destruction of many fish breeding grounds and has impacted adversely on the marine ecosystem. Barriers or constraints to further address the issue include the low socio-economic status of the fishing communities and limited access to other employment. Inadequate training facilities to enable transition between artisanal and more technologically advanced semi-industrial fisheries and support facilities are an additional constraint.

Government policy to develop the tourist industry as third growth pillar of the country has resulted in the provision of a package of incentives to the promoters. This has led to extensive development along the coastal regions, resulting in some cases in the modification of the ecosystems, over-exploitation and shoreline change. Land-based (illegal construction of hard structures) and sea-based activities (sport activities) have put addition pressure on the already fragile ecosystem. Constraints to further addressing the issues include inadequate institutional, policy and legislative framework, pressure to

develop the tourist industry as a growth sector and strong pressure for further development of tourism infrastructure.

For decades there has been intensive artisanal fishing in many lagoons through the use of improper fishing gears such as over-sized seine nets, fishing guns and dynamite. This has resulted in the destruction of many fishing breeding grounds and has impacted adversely on the marine biodiversity. However, these environmentally unfriendly practices are nowadays prohibited by law and with the enforcement agencies there is a better control on fishing activities in the lagoons. In addition fishermen's cooperative societies have been set up with a view to providing the fishermen with credit and storage facilities and help them market their products. However, it appears that these societies have failed to meet their main objectives. This can be accounted for by the lack of managerial skills and capacity building and low level of education among the fishermen. It is imperative that these shortcomings be addressed to redress the situation and assure the long-term sustainability of the artisanal fishing industry.

One market response alleviating the pressures of artisanal fishery in the lagoons is the possibility for using Fish Aggregating Devices (FADs). This fishing technique has been recently introduced as a means to encourage the artisanal fishery to move out of the lagoon. The technique has given promising results and there are plans to extend the use of the technique on a larger scale. The involvement of the fishing cooperative societies in such ventures should be encouraged.

Other market responses relieving pressure on the ecosystems include the ban of coral sand extraction, the construction of gabion walls to contain the erosion and the guidelines on coastal water quality (Jootun et al, 1994; Government of Mauritius, 1998 & 1999b). Sand mining activities have been practised in the lagoons for decades and it has been linked to the loss of beaches and biodiversity in several regions. As from 1st October 2001 coral sand mining is banned in Mauritius and the construction industry has now to resort to using of rock sand. It is expected that the ban of coral sand will help curtail down coastal erosion and restore the diversity in the long term. All the stakeholders within the sand mining industry i.e. boat owners, boatman, lorry owners, etc have been given compensation packages as indemnity. The guidelines on coastal water quality will help ensure that there is no excessive level of nutrients. The Government can rely on Ministry of Environment's Enforcement Division and the Police through the Coast Guards to ensure that this ban is respected.

On the other hand, the construction of gabion walls is seen as coastal protection or remedial measures. Although the effectiveness of this type of structure is still debatable, the gabion walls have reduced the extent of coastal erosion on some beaches notably at Pomponette and Flic en Flac.

CHAPTER 5

5. Gaps and Recommendations

5.1 Gaps

a. Systematic monitoring of pollution

In spite of the fact that it is known that pollutants from industry and from agriculture impact on the lagoon environment, there is no systematic study or long-term monitoring being done to determine the extent of such impact

b. Systematic monitoring of shoreline changes

Shoreline modifications as a result of natural processes and anthropogenic activities are clearly visible along the coastline of Mauritius. However, only a few spots have been studied and there is no national long-term strategy for combating erosion.

c. Understanding of natural phenomena and issues

Several causes can be attributed to problems within the lagoon. The extent to which each of these contributes to the problem is not quite clear and this makes policy decisions difficult to adopt. It is only through integrated scientific studies on these that a sound understanding of their contribution to the different issues can be ascertained.

d. Economic evaluation of resources

Food resources are economically assessed. However, the other coastal and marine living and non-living resources are only assessed scientifically; hardly any data exists on the valuation of these resources, thereby there is no appreciation of the true value of the resource.

e. Manpower training

Management of the coastal and marine environment requires a variety of expertise. Within the region, there is a dire shortage of trained personnel to undertake serious studies on these issues. There has been a tendency to seek for assistance from developed countries to help in this matter.

f. Modelling and forecasting programme

Most studies in the coastal environment have been ad hoc and following a crisis. There is little attention regarding long-term studies, modelling and forecasting. This problem is related to the lack of trained manpower and availability of funds. Developing countries tend to give a low priority to such demands.

g. Coherence and coordination between implementing agencies

There are a number of organisations involved in the management of the coastal zone. Very often the responsibilities of these organisations are not clearly defined leading to duplication or overlap of responsibilities.

h. Weaknesses in legislation

The Acts are fragmented, with the relevant provisions being dispersed across a number of different Acts and regulations, often giving rise to jurisdictional overlaps. For example, powers of law making and enforcement are being conferred on a range of different authorities in respect of the same matters:

- much of the Acts are outdated and need to be revised and consolidated; and
- most of the laws are inadequately enforced, mainly due to a lack of resources and capacity in Government departments, a lack of awareness of the laws themselves and overlapping responsibility for enforcement.

5.2 Recommendations

The major sectors associated with the issues are Coastal Urbanisation and Industrial Development. However, information on the contribution of these are scanty and there is a definite need for systematic studies to be carried out to monitor existing development, plan future ones and to formulate and implement mitigating measures. Such an exercise necessitates a proper legal back up and a range of expertise from different fields. It would be desirable that the authorities seriously review all existing legislations, enforcement policies, macro-economic policies (in relation to industrial and tourism development, coastal land development), invest in manpower training in various fields.

It is also recommended that there be a systematic monitoring programme on various issues of pollution, habitat degradation, lagoon water quality, shoreline changes and biodiversity assessment. The adoption of clean technologies by industry and more community participation are also recommended.

The recommendations are here grouped under four different sections namely education, research, legislation and infrastructure. We have preferred this formula rather than strictly making recommendations per issue as many of these recommendations cut across the three issues.

5.2.1 Education

- a) invest in training of relevant fields such as marine ecology, oceanography, socio-economics, environmental management, conservation & town and country planning;
- b) training for fishermen to adopt new technologies and basic conservation; and
- c) encourage community participation through effective education programmes.

5.2.2 Research

- a) undertake systematic long-term studies to monitor pollution in the lagoons;
- b) determine the contribution of different polluting sectors such as industry, agriculture and urbanisation to the pollution of lagoons;
- c) undertake systematic long-term studies to monitor and conserve marine biodiversity;
- d) undertake systematic long-term studies to monitor shoreline changes;
- e) study the effectiveness of remedial and protective measures against wave action;
- f) develop and assess new protective measures against coast line erosion;
- g) socio-economic studies;
- h) carry out economic evaluation of resources; and
- i) develop modelling and forecasting programmes for ecological and socioeconomic issues.

5.2.3 Legislation

- a) review of the current legislations to decrease overlap of responsibilities and assign responsibilities more precisely;
- b) NPDP need to be given a legal status or need to be revised;
- c) enforcement needs to be reinforced and areas of overlap of responsibilities need to be addressed;
- d) coordination between different stakeholders needs to be reinforced; and
- e) the EIA process needs to be rendered more effective by addressing the weaknesses in the existing EIA provisions to allow a better follow up during the implementation phase of projects. In addition, the procedure for reviewing EIAs and granting EIA licences should be more transparent and accountable.

5.2.4 Infrastructure

- a) strict zoning for development is essential after careful examination of environmental issues;
- b) upgrading of existing and development of new waste water treatment plants; and
- c) linking of coastal residential areas to sewer facilities.

5.2.5 Other Policy Measures

- a) encourage industries to adopt clean technologies;
- b) use of economic instruments such as the Polluter Pays Principle, user charges, which will deter pollution practices; and
- c) preparation of the Integrated Coastal Zone Management Plan and ensure its implementation with the provision of the appropriate legal and institutional system;

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ANNEX I

**Identification Sheet:
Hot Spot, Sensitive Areas and/or Overriding Issue**

Hot Spot

- a. Title: Flic en Flac
- b. Region (administrative) and location: Black River District
- c. Surface area / Definition: approx. 8 km²
- d. Transboundary elements - Please identify whether and in what ways the site extends to other country(ies)/region and whether and in what ways adjacent areas influence the site: migration of biota, coastal urbanisation towards the site. Tourist movement towards the site
- e. Relevant [GIWA] issue(s): 4, 5, 6, 2, 13, 14, 16, 20, 23
- f. Context of the site:
 - main human activity(ies) related to the site: tourist and recreational area, residential area, water sports, fishing;
 - natural conditions/phenomenon related to the site: sandy beach, narrow lagoon with fringing reef, sand quarry and marshy region turned into residential area, rapid water circulation; and
 - nature of threats and extent of threats (human and natural): beach erosion, tidal waves, storm surges, over exploitation, over fishing, coral trampling and anchor damages.

If heavy incidence of pollution, list the type of source (point, non-point, diffuse) and pre-identify the exact source(s): *Diffuse-wastewater from residential area, improperly treated wastewater used for irrigation by hotels. Point-untreated effluents from cattle ranch.*

Value of the site:	Local	National	Regional/global
Environmental significance	HIGH	HIGH	LOW
Socio-economic significance	HIGH	HIGH	LOW

List of available data sets:

Bholah, B.Z. *Determination of the role of water quality on algal events in the lagoons of Trou aux Biches & Flic en Flac*. BSc thesis. (Unpublished). University of Mauritius, 1993.

Botte, M.D.M. *Monitoring of coral bleaching at four sites around Mauritius*. BSc Thesis. (Unpublished). University of Mauritius, 2001.

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Hot Spot

- a. Title: Grand Bay
- b. Region (administrative) and location: Pamplemousses District
- c. Surface area / Definition: Approx. 8 km²
- d. Transboundary elements - Please identify whether and in what ways the site extends to other country(ies)/region and whether and in what ways adjacent areas influence the site: Pleasure boat marina, Major tourist attraction centre receiving foreign and local tourists.
- e. Relevant [GIWA] issue(s): 4, 5, 6, 7, 13, 14, 18, 20, 23
- f. Context of the site:
 - main human activity(ies) related to the site: tourism with all grades of hotels, bungalows, water sports, pleasure boat marina, shopping centre, residential area;
 - natural conditions/phenomenon related to the site: sandy beach, hooked lagoon bounded by fringing reef, sea grass meadows, wetlands boundary inland; and
 - nature of threats and extent of threats (human and natural): pollution from household waste water, hotel irrigation waters, boat emissions, over exploited area.

If heavy incidence of pollution, list the type of source (point, non-point, diffuse) and pre-identify the exact source(s): *Diffuse-percolation of household waste water and hotel irrigation water.*

Value of the site:	Local	National	Regional/global
Environmental significance	HIGH	HIGH	LOW
Socio-economic significance	HIGH	HIGH	LOW

List of available data sets:

EIA: Proposed Sewerage Project in the Northern Tourist Zone. VJ Environmental Services, 1995.

Government of Mauritius, 1999a. *Initial national communication under the UN framework convention on climate change*. Mauritius Meteorological Services. 76 pp.

Government of Mauritius, 1998. *A climate change action plan*. Prepared with the assistance of the United States Country Studies Program for climate change.

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Seewoobaduth, J. *Wastewater management in a coastal area*. MSc thesis. University of Mauritius, 1999. 86 pp.

Hot Spot

- a. Title: Rodrigues
- b. Region (administrative) and location: Rodrigues
- c. Surface area / Definition: 108km²
- d. Transboundary elements - Please identify whether and in what ways the site extends to other country(ies)/region and whether and in what ways adjacent areas influence the site: Soil erosion from upland washed down towards lagoons. Increasing tourist visits. Migration of biota
- e. Relevant [GIWA] issue(s): 5, 6, 7,13, 14, 16, 18, 20
- f. Context of the site:
 - main human activity(ies) related to the site: tourism, fishing, agriculture;
 - natural conditions/phenomenon related to the site: lagoon bounded by fringing reef, sandy beaches in some areas, estuaries; and
 - nature of threats and extent of threats (human and natural): soil erosion, siltation of lagoons especially at mouth of rivers, estuaries.

If heavy incidence of pollution, list the type of source (point, non point, diffuse) and pre-identify the exact source(s): *Diffuse-suspended particles, agricultural run off*

Value of the site:	Local	National	Regional/global
Environmental significance	HIGH	HIGH	LOW
Socio-economic significance	HIGH	HIGH	LOW

List of available data sets:

Genave, J.T. Growth, reproductive biology and stock assessment of *Octopus cyanea* off the coast of Rodrigues Island 1997. BSc Thesis (unpublished) University of Mauritius, 1997.

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Resource Analysis- EDC, 1999. Feasibility of desiltation of lagoons in Rodrigues.

Hot Spot

- a. Title: Pointe aux Sables
- b. Region (administrative) and location: Port Louis District
- c. Surface area / Definition: Approx. 6 km²
- d. Transboundary elements - Please identify whether and in what ways the site extends to other country(ies)/region and whether and in what ways adjacent areas influence the site: Proximity to harbour. Receives wastewater from 25,000 inhabitants (to be increased to 200,000) + three industrial zones.
- e. Relevant [GIWA] issue(s)¹: 4, 5, 6, 7,13, 17, 18, 20
- f. Context of the site:
 - main human activity(ies) related to the site: coastal residential area, fishing ;
 - natural conditions/phenomenon related to the site: sandy beach, lagoon bounded by fringing reef, sea grass meadows. Found at extreme end of a polluted estuary; and
 - nature of threats and extent of threats (human and natural): discharge of municipal and industrial waste water affecting biodiversity and water quality.

If heavy incidence of pollution, list the type of source (point, non-point, diffuse) and pre-identify the exact source(s): Point-municipal and industrial wastewater. Diffuse-percolation of household waste

Value of the site:	Local	National	Regional/global
Environmental significance	HIGH	HIGH	LOW
Socio-economic significance	HIGH	HIGH	LOW

List of available data sets:

Jogarah, K. *The eutrophication status and macro-algal production at Pointe aux Sables, Trou aux Biches and Poste Lafayette*. BSc Thesis. (Unpublished). University of Mauritius, 2001.

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SOGETI-BET, 1995. *Appui a la gestion des ressources en eau et a la preservation de leur qualite. Iere partie: Le recif de pointe aux Sables: Impact de l'emissaire urbano-industriel*.

Hot Spot

- a. Title: Palmar/Belle Mare
- b. Region (administrative) and location: Flacq District
- c. Surface area / Definition: Approx. 8 km²
- d. Transboundary elements - Please identify whether and in what ways the site extends to other country(ies)/region and whether and in what ways adjacent areas influence the site: Movement of agricultural run-offs into the site. Local and foreign tourist movement towards the site
- e. Relevant [GIWA] issue(s): 5, 6,13, 14, 16, 20, 23
- f. Context of the site:
 - main human activity(ies) related to the site: tourism, recreational area, fishing, large number of small-scale vegetable exploitations;
 - natural conditions/phenomenon related to the site: sandy beach, lagoon bounded by fringing reef, sea grass meadows, sand dunes; and
 - nature of threats and extent of threats (human and natural): beach erosion, tidal waves, storm surges, agricultural run offs.

If heavy incidence of pollution, list the type of source (point, non point, diffuse) and pre-identify the exact source(s): Diffuse-agricultural runoffs, improperly treated hotel effluents used for irrigation.

Value of the site:	Local	National	Regional/global
Environmental significance	HIGH	HIGH	LOW
Socio-economic significance	HIGH	HIGH	LOW

List of available data sets:

Botte, M.D.M. *Monitoring of coral bleaching at four sites around Mauritius*. BSc Thesis. (Unpublished). University of Mauritius, 2001.

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Jootun, L., Gungaparsad, D., Ragoonaden, S., Dunpath, K. and Ujodha. *National report on the state of coastal erosion in Mauritius*, 1994.

Hot Spot

- a. Title: Riambel/Pomponette
- b. Region (administrative) and location: Savanne District
- c. Surface area / Definition: Approx. 6 km²
- d. Transboundarity elements - Please identify whether and in what ways the site extends to other country(ies)/region and whether and in what ways adjacent areas influence the site: Lagoonal sand mining and sand quarry on dunes.
- e. Relevant [GIWA] issue(s): 6,13, 14, 16, 20,23
- f. Context of the site:
 - main human activity(ies) related to the site: coastal residential and recreational area, sand mining, fishing;
 - natural conditions/phenomenon related to the site: sandy beach, lagoon bounded by fringing reef; and
 - nature of threats and extent of threats (human and natural): beach retreat, tidal waves, storm surges, over exploitation at sand quarry, agricultural run-off.

If heavy incidence of pollution, list the type of source (point, non point, diffuse) and pre-identify the exact source(s): Diffuse- from agriculture

Value of the site:	Local	National	Regional/global
Environmental significance	HIGH	HIGH	LOW
Socio-economic significance	HIGH	HIGH	LOW

List of available data sets:

Government of Mauritius, 1999a. *Initial national communication under the UN framework convention on climate change*. Mauritius Meteorological Services. 76 pp.

Government of Mauritius, 1998. *A climate change action plan*. Prepared with the assistance of the United States Country Studies Program for climate change.

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Jootun, L., Gungaparsad, D., Ragoonaden, S., Dunpath, K. and Ujodha. *National report on the state of coastal erosion in Mauritius*, 1994.

ANNEX II

Causal Chain Summary Table 1 for Characterisation

Summary Table for Immediate Causes
Country: Mauritius

1	2	3	4	5
Issue	Immediate Cause	Indicator	Further characteristics	Link to sectors and %
Shoreline Change	Reef Passes 15%	Change in current pattern, Erosion of shoreline, Beach retreat, Sand dune levelling, Formation of Beach cliffs, Trees uprooting, destruction of coastal reinforcements and structures (Jootun, L., Gungaparsad, D., Ragoonaden, S., Dunputh, K., & Ujodha, 1994).	Long shore drift along the coast causing changes in sand deposits. Average of 1 m/yr beach retreat recorded at several places along the coast. Beach cliffs of 1 to 2 m formed. Beach retreat of 5 to 10 m recorded in certain places after cyclones. Vegetation uprooted mostly Filao trees	Leisure 10%, Fisheries 70%, Transport 20%
	Storms, Cyclones & Tidal waves 40%			Natural 100%
	Seawalls and other hard structures 25%			Urbanisation 50%, Industry 50%

Summary table for Sectoral Pressures
Country: Mauritius
Issue: Shoreline change

	1	2	3	4	5	7	8	9
Immediate Cause	Sectoral Pressures: Resource Use activity	Further characteristics	Indicator	Sectoral Pressures: Resource Use practice	Further characteristics	Indicator	Critical Incidence of "environmentally-friendly" practice	Link to root causes and responses
Reef Passes 15%	Leisure 20%	Mauritius recognised as a deep-sea diving and big game fishing resort	Number of visiting divers and international big game competitions	Pass used by pleasure crafts for access to open sea	Reef passes used by pleasure crafts, deep sea diving operators and recreational fishing by tourists	Number of trips of pleasure crafts through reef passes. Number of divers	Creation/widening of reef passes necessitate an EIA.	Increase in erosion in newly created reef pass areas has created new awareness among policy makers
	Fisheries 70%	Fishermen being encouraged to fish outside the lagoon around open sea FADS	Number of fishing boats around FADS	Pass used by fishing boats for access to open sea	Reef passes used by professional fishermen for access to FADS	Number of trips of fishing boats through reef passes. Number of FADS	Creation/widening of reef passes necessitate an EIA	Increase in erosion in newly created reef pass areas has created new awareness among policy makers
	Transport 10%	Conservation projects and ecotourism on outer islets increase traffic through passes	Number of service boats	Pass used by service boats	Reef used for access to outer islets	Number of trips of service boats through reef passes	Creation/widening of reef passes necessitate an EIA	Increase in erosion in newly created reef pass areas has created new awareness among policy makers
Storms, Cyclones & Tidal waves 40%	Natural 100%	High surges, swells during cyclone	More pronounced erosion during cyclones				Placement of gabions in eroded areas	Gabions placed in order to mitigate effects of cyclones & surges on shoreline

	1	2	3	4	5	7	8	9
Immediate Cause	Sectoral Pressures: Resource Use activity	Further characteristics	Indicator	Sectoral Pressures: Resource Use practice	Further characteristics	Indicator	Critical Incidence of "environmentally-friendly" practice	Link to root causes and responses
Seawalls and other hard structures 25%	Urbanisation 50%	Bungalows, roads and related infrastructure constructed close to shoreline	Extent of seawalls along the shoreline	Sea wall constructed to delimit private property and strengthening of coastal roads	Seawalls not properly designed and affect the water circulation and currents. Set-back distance not rigorously observed	Seawalls damage and breakdown. Erosion more pronounced in seawall & jetty areas. High water mark closer to built areas.	Jetties redesigned to allow free water flow. New EIA regulations for enforcement of setback distance, seawall construction, jetties and other coastal development	Policy to mitigate adverse effects of seawalls and jetties
	Industry 50%	Tourism	Number of solid jetties	Solid jetties constructed by hotels in the past for docking of pleasure crafts. Solid walls constructed to retain substrate	Jetties and walls not properly designed and affect the water circulation and currents. Set-back distance not rigorously observed			

Summary Table for Root Causes
Country: Mauritius
Issue: Shoreline Change

Social Changes	Characteristics	Indicator	Links to resource use changes and responses	Institutional drivers	Characteristics	Indicator	Links to resource use changes and responses	Economic structure	Characteristics	Indicator	Links to resource use changes and responses
Population pressure	Natural population increase	Overall country population increases at 1% per year. A more pronounced increase in population for the coastal zones	Increased demand for coastal land	Little government commitment	Little empowerment of local authorities	Absence of appropriate legislation (Town and Country Planning Act dates as far back as 1954)	Haphazard development along the coastal zones	Development model and macro-economic policies	Government policy to make the tourist sector as a growth sector	Incentives given to the tourist industry	Increased demand for coastal land
	In-migration to the coast		Evidence of coastal erosion where there has been illegal construction of jetties or other hard structures		Lack of a national physical development plan	Non-implementation of the National Physical Development Plan	Pressure on all government sectoral policies		Tourism Development Master Plan (2001)	Increased number of hotels	Large hotel development programme
	Increase in the number of tourists		Pressure on all government sectoral policies							Increased number of informal accommodation	Pressure on all government sectoral policies

Population pressure (cont'd)								Little private sector commitment	Mitigating measures to protect the shoreline	Investment in mitigating measures	Dredging of the lagoon to accommodate ski-lanes, thereby impacting on the coastal ecosystems
									Conformity to existing regulations (EIA)	Approved EIAs	

Please highlight the cause and particular characteristics which carry more weight in driving a lower level cause (sectoral resource use or response)

Summary table for Responses

Country: Mauritius
Issue: Shoreline Change

1. Environmental Management = policy or tool(s) designed to address environmental problems

					Reasons/causes for ineffective use and/or outcome of the tool or policy			
Environmental Management Policy or Tool	Nature of the Tool and/or Policy in Use (Government)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	Effectiveness of the Tool and/or Policy to Protecting the Environment? (-4 to +4)	Inconsistent/ Inappropriate Law Developed	Inadequate Implementation of the Policy and Tool	Gaps in the Monitoring or Availability of Data	Ineffective Enforcement
					<i>Please describe carefully each of the causes, giving as much evidence as possible. Each of these could become the subject of an intervention (see possible generic options below)</i>			
Land use changes	1954 Town and Country Planning Act; National Physical Development Plan	Link to control land use planning in the coastal zones and on the island		-4	Outdated legislation (the Town and Country Planning Act dates as far back as 1954); lack of Government commitment to review the legislation	Lack of Government commitment to implementation; conflicts with other policies/lack of intersectoral co-operation		
Major project decision making	Integrated Coastal Zone Management Plan; EIA	Link to control development in the coastal zones		-2	Lack of coherent integrated policy making	Conflicts with other policies		Lack of resources; lack of enforcement powers
Fisheries regulation	Environment Protection Act 1991	Control sand mining activities		-2	Allowed sand mining in restricted areas	This activity had adverse effects on ecosystems		Inadequate control on actual amount of sand removed

Suggested Generic Options for Causes of Ineffectiveness in Environmental Management

(Please describe more specifically and feasible, as relevant)

(List extracted from GIWA Governance section)

<p>Inconsistent/ Inappropriate Law Developed</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Poor awareness of problems and solutions Deficient policy planning (e.g. lack of env. strategy) Conflicts with other policies/lack of intersectoral cooperation Low value attached to env. in government (e.g. low status for MOE) NGOs ineffective (e.g. through lack of capacity or cooperation or recognition) Lack of coherent integrated policy making Not in national interest to develop governance</p>	<p>Gaps in the Monitoring or Availability of Data</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Poor awareness of problems and solutions No policy for systematic data collection on relevant issues Lack of intersectoral cooperation (e.g. between govt department or agencies or international bodies) Other: explain</p>
<p>Inadequate Implementation of the Policy and Tool</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Lack of government commitment to implementation Conflicts with other policies / lack of intersectoral cooperation Other: explain</p>	<p>Ineffective Enforcement</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Poor awareness of problems and solutions Lack of enforcement powers (e.g. low penalties or no powers to enforce) Ineffective legal system (e.g. legal system slow or lacking understanding of env. matters) Lack of available monitoring data Other / explain (e.g. absence of regulatory authority)</p>

2. Sectoral policy = those which indirectly increases the pressure

	Nature of the Tool and/or Policy in Use (Government)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	How Does it Actually Increase Pressure on the Issue?	Reasons/Causes for the Implementation of this Policy or Tool?	Please Describe Carefully Each of the Causes, Giving as Much Evidence as Possible. Each of these Could Become the Subject of an Intervention (see possible generic options below)
Urbanisation	1954 Town and Country Planning Act; National Physical Development Plan. 1991 Environment Protection Act. Integrated Coastal Zone Management Plan; EIA	These acts regulate and control use of coastal land		National Physical Development Plan (NPDP) has not been given legal status and used only as guideline. EIA not followed up and conditions not always respected during implementation phase	The NPDP was designed to control development in a systematic manner but is not strictly enforced because it does not have a legal status. EIA has been an instrument to monitor development in an environmentally sound manner, but in not respected due to lack of follow-up during the construction stage	
Fisheries	Environment Protection Act 1991	Control sand mining activities in lagoons		Allow sand mining in selected lagoons	Sand mining is regulated by the EPA of 1991. However, for social reasons, sand mining was allowed in selected areas. New regulations enforced in Aug 2001 will make sand mining illegal as from October 2001	
Tourism	1954 Town and Country Planning Act; National Physical Development Plan. 1991 Environment Protection Act. Integrated Coastal Zone Management Plan; EIA	These acts regulate and control use of coastal land		National Physical Development Plan has not been given legal status and used only as guideline. EIA not followed up and conditions not always respected during implementation phase	The NPDP was designed to control development in a systematic manner but is not strictly enforced because it does not have a legal status. EIA has been an instrument to monitor development in an environmentally sound manner, but in not respected due to lack of follow-up during the construction stage	

Options of Causes for Implementation of this Policy or Tool

<p>Reasons for sectoral policy developed which directly contribute to the issue</p>	<p>High priority for development of sector to combat poverty High priority for development of sector to meet population growth needs Low value attached to env. in government (e.g. low status for MOE) Lack of transparency Poor awareness of problems and solutions Deficient policy planning (e.g. lack of env strategy) Lack of intersectoral cooperation Abuse of influence (e.g. corruption) NGOs ineffective (e.g. through lack of capacity or cooperation or recognition) Lack of coherent integrated policy making Other: specify</p>
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3. Community Responses: describe the initiative from community or social groups which may alleviate pressure on the issue or further contribute and increase the pressure

Nature of the Initiative in Use (Where, Who, Scope, etc.)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	How Does it Actually Alleviate and/or Increase Pressure on the Issue?	Barriers or Constraints to Further Addressing the Issue

4. Market Responses

Nature of the Initiative in Use (Where, Who, Scope, etc.)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	How Does it Actually Alleviate and/or Increase Pressure on the Issue?	Barriers or Constraints to Further Addressing the Issue
Incentives to the tourist industry (for e.g. lease of Pas Géométriques")	Pressure on coastal land and lagoon/marine resources through development of shore side sites and sea-sports activities		Development of shore side sites and sea-based activities have led to poor water quality, beach erosion and loss of biological diversity in the sea and coast. Whilst some beach erosion is natural, it is exacerbated by hard structures on the beach such as sea walls and jetties, which restrict the natural movement of sand.	Inadequate institutional, policy and legislative framework, for instance the loopholes in the EIA; pressure to develop the tourist industry as a growth sector; inadequate knowledge on the complex interactions between sea and land interface; strong pressure for further development of tourism infrastructure
Ban on extraction of coral sand for construction purposes	Pressure on the marine biodiversity and beach erosion. About 800,000 tonnes of sand are mined annually and sand mining has been linked to loss of beach in many coastal areas		Sand extraction has led to damage to the beaches leading to beach erosion. Biological impacts are also noticeable through loss of habitats and changing currents. The ban of coral sand will help avoid all these negative impacts some ecological impacts	lack of enforcement capacity; redeployment of sand extractors in other economic activities is very difficult; high level of compensations have to be paid
Construction of gabion walls	Coastal protection or remediation measure		The protection works, which include construction of gabion walls help retain sand, which would have been washed away. Gabion walls thus prevent further coastal erosion	The effectiveness of the gabion walls is still debatable. Gabion walls cannot be used as a protection measure on all beaches

ANNEX III**Causal Chain Summary Table 2 for Characterisation****Summary Table for Immediate Causes
Country: Mauritius**

1	2	3	4	5
Issue	Immediate Cause	Indicator	Further characteristics	Link to sectors and %
Over-exploitation				
	Decreased level of recruitment 30%	Fisheries catch (Fisheries Annual Report 1997,98)(Resource Analysis-EDC (1999). Genave, J.T. (1997).	Decrease in catch both quantity and size	Urbanisation 20% Agriculture 20% Industry 20% Leisure 10% Fisheries 30%
	Decreased habitat/nursery grounds 25%	Reduction in Seagrass/coral cover (Ramessur, T. 1991)(Jootun, L., Gungaparsad, D., Ragoonaden, S., Dunpath, K., and Ujodha 1994). .	Clearance of sea grass beds for bathing area, Coral destruction for ski lanes, Coral trampling and damages by fishermen and boat anchors	Urbanisation 20% Agriculture 20% Industry 20% Leisure20% Fisheries20%
	Increase in demand for Coastal Recreational activities 30%	Number of tourists, hotels, bungalows and other amenities on the coast. Land prices (NEAP, 1999) (CSO, 1999)	Direct and indirect pressures from expanding tourism activities and recreational activities from permanent and transient residents	Urbanisation 35% Industry 35% Leisure 30%

Summary Table for Sectoral Pressures
Country: Mauritius
Issue: Over exploitation

1	2	3	4	5	6	7	8
Sectoral Pressures: Resource Use Activity	Further Characteristics	Indicator	Sectoral Pressures: Resource Use Practice	Further Characteristics	Indicator	Critical Incidence of "Environmentally-Friendly" Practice	Link to Root Causes and Responses
Urbanisation 20%	Increased output from coastal residential areas	Increase in coastal population	Non-point sources of pollution from residential areas. Absence of sewage system	Partially treated or untreated wastewater from residential areas affecting habitats.	Water quality	Encouraging use of septic tanks. Implantation of sewage network along coast	Improvement of water quality will ensure a healthy life cycle and increased recruitment
Agriculture 20%	Small scale vegetable plot very close to shoreline	Number of plots and number of small scale growers	Excessive use of fertilisers and pesticides in coastal vegetable plots	Agricultural runoffs pollution affecting fish reproductive cycles	Low fish catch in affected areas. Algal blooms causing oxygen crash	Monitoring of water quality and utilisation of encouragement of organic manuring	High demand for agricultural products. Stakeholders' pressure
Industry 20%	High demand for fish products from tourism industry	Increase in hotel rooms and tourist arrivals	Indiscriminate fishing	A lot of the catch go to the hotels	Fish catch comprising of minimum legally acceptable size being caught	Phasing out of large nets through a government buy-back policy. Banning of blasting and underwater guns	Government policy to give incentives to fish outside the lagoon
Leisure 10%	Water sports and bathing	Number of pleasure crafts and daily coastal visitors	Trampling of and damages to habitats	Damages to habitats by amateur fishermen and pleasure crafts, indiscriminate fishing by amateur fishermen	Damages more pronounced in areas where these activities are practised	Sensitisation campaigns. Policy to diversity leisure activities and movement to inland leisure	Mitigate negative effects
Fisheries 30%	Lagoon and seine fishing	Number of lagoon fishermen & fish catch	Recruitment over-fishing	Fish caught closer to acceptable size limit	Fish size	Fisheries and Marine Resources Act dictates minimum fish size and fishing season. Closed season for fishing to allow reproduction &	More strict enforcement

1	2	3	4	5	6	7	8
Sectoral Pressures: Resource Use Activity	Further Characteristics	Indicator	Sectoral Pressures: Resource Use Practice	Further Characteristics	Indicator	Critical Incidence of "Environmentally-Friendly" Practice	Link to Root Causes and Responses
						recruitment	
Urbanisation 20%	Physical destruction of habitat	Area of natural floor cover	Coastal development practices	Dredging, sand mining, construction and other beach works	Number of coastal works	All coastal works require an EIA	Closer monitoring of coastal works
Agriculture 20%	Small scale vegetable plot very close to shoreline	Number of plots and number of small scale growers	Agricultural runoffs pollution affecting habitats.	Fish habitat suffocated by excessive algal cover	Coral death by suffocation by algae	Monitoring of water quality and utilisation of encouragement of organic manuring	High demand for agricultural products. Stakeholders' pressure
Industry 20%	Sugar, Textile, Tourism and construction industry	Industrial growth rate	Discharge of wastewater. Dredging, sand mining. Hotels with <70 rooms are not forced to have wastewater treatment plant. Wastewater used for irrigation by hotels	Partially treated or untreated wastewater in lagoon	Water quality (various parameters), effluents from industrial zones, Tonnage of coral sand	Banning of coral sand mining. Setting up of effluent standards	Government encouraging further development of hotel industry
Leisure 20%	Water sports and bathing	Number of pleasure crafts and daily coastal visitors	Trampling of and damages to habitats	Damages to habitats by amateur fishermen and pleasure crafts, indiscriminate fishing by amateur fishermen	Damages more pronounced in areas where these activities are practised	Sensitisation campaigns	Policy to diversify leisure activities and movement to inland leisure

1	2	3	4	5	6	7	8
Sectoral Pressures: Resource Use Activity	Further Characteristics	Indicator	Sectoral Pressures: Resource Use Practice	Further Characteristics	Indicator	Critical Incidence of "Environmentally-Friendly" Practice	Link to Root Causes and Responses
Fisheries 20%	Seine fishing and use of other active gear	Number of licensed nets	Fishing malpractices	Degradation/destruction of the habitats	Coral cover, sea grass beds cover	Buy back policy for large nets. Encouraging of outer lagoon fishing. FADS.	Increased demand for fish products
Urbanisation 35%	Greater demand from inland population for coastal residences	Number of coastal secondary residences and coastal infrastructure.	Construction of individual bungalows	Increased pressure on coastal resources	Number of bungalows and other residences	Need for building permit for residential buildings	Response to constructions not meeting required norms
Industry 35%	Greater demand from tourists for coastal hotels	Number of coastal hotels	Construction of different categories of hotels to cater for this demand	Increased pressure on coastal resources	Number of hotels	Need for EIA, treatment plant, set-back distance, height limitation	Preventive measures to prevent ecological damage
Leisure 30%	Beach and water sports	Number of pleasure crafts and daily coastal visitors	Increasing population looking for beach and lagoon recreational activities	Transient population consisting of tourists and week-end visitors add to the existing local population	No of visitors	Policy to diversity leisure activities and movement to inland leisure	Mitigate negative effects

Summary Table for Root Causes
Country: Mauritius
Issue: Overexploitation

Social Changes	Characteristics	Indicator	Links to Resource Use Changes and Responses	Institutional Drivers	Characteristics	Indicator	Links to Resource Use Changes and Responses	Economic Structure	Characteristics	Indicator	Links to Resource Use Changes and Responses
Population pressure	Natural population increase	Overall country population increases at 1% per year. A more pronounced increase in population for the coastal areas	Increased demand for fishery resources; increased demand for lagoonal and beach activities	Little Government Commitment	Little empowerment of local authorities	Absence of appropriate legislation (the Town and Country Planning Act dates as far back as 1954)	Haphazard development along the coastal zones	Development Model and Macro-economic Policies	Government policy to make the tourist sector as a growth sector	Incentives given to the tourist sector	Increased demand for coastal land
		In-migration	Increase in the number of secondary residences and hotel development		Lack of a national physical development plan	Non-implementation of the National Physical Development plan	Over-exploitation of the coastal and marine resources		Preparation of a tourism development master plan (2001)	Increase in the number of informal accommodation and hotels	Large hotel development programme
	Foreign tourists	Increase in the number of foreign tourists	Pressure on all government sectoral policies				Pressure on all government sectoral policies				Pressure on all government sectoral policies
Increased need for recreational activities	Beach activities; water sports	Time spent on sea/beach activities	Increased demand for beach and sea activities								

Social Changes	Characteristics	Indicator	Links to Resource Use Changes and Responses	Institutional Drivers	Characteristics	Indicator	Links to Resource Use Changes and Responses	Economic Structure	Characteristics	Indicator	Links to Resource Use Changes and Responses
		Affluence and time spent on public beaches	Increase in demand for informal accommodation								
			Haphazard development of the coastal zone								

Please highlight the cause and particular characteristics which carry more weight in driving a lower level cause (sectoral resource use or response)

Summary Table for Responses
Country: Mauritius
Issue: Overexploitation

1. Environmental Management = policy or tool(s) designed to address environmental problems

					Reasons/causes for ineffective use and/or outcome of the tool or policy			
Environmental Management Policy or Tool	Nature of the Tool and/or Policy in Use (Government)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	Effectiveness of the Tool and/or Policy to Protecting the Environment? (-4 to +4)	Inconsistent/ Inappropriate Law Developed	Inadequate Implementation of the Policy and Tool	Gaps in the Monitoring or Availability of Data	Ineffective Enforcement
					<i>Please describe carefully each of the causes, giving as much evidence as possible. Each of these could become the subject of an intervention (see possible generic options below)</i>			
Water pollution	Central Water Authority Act; Environment Protection Act, Ground Water Act; Waste Water Authority Act; Integrated Pest Management Programme; National Sewerage Master Programme; Guidelines on Coastal Water Quality and Sugar Industry Effluents Standards	Link to control of pesticide use and fertilisers; link to control of sugar industry effluents; link to control of sewage; link to control of water bathing quality		-1	No consolidating law for water pollution has been proclaimed and only a few environmental water standards have been prescribed. Some of the Acts are outdated.	Lack of resources (technical staff, equipment, financial); Lack of Government commitment to implementation; lack of intersectoral cooperation - overlapping of responsibilities	No policy for systematic data collection on relevant issues; lack of resources (lack of staff and equipment)	Lack of resources (staff and equipment); lack of enforcement powers; lack of available monitoring data; unclear institutional responsibilities
Solid wastes	Public Health Act; Local Government Act and the Environment Protection Act; National Solid Waste Management Programme	Link to control of indiscriminate dumping of solid and hazardous wastes		-2	No general law dealing exclusively with the collection and disposal of solid wastes.	Lack of Government commitment to implementation		

1. Environmental Management = policy or tool(s) designed to address environmental problems

1. Environmental Management = policy or tool(s) designed to address environmental problems								
					Reasons/causes for ineffective use and/or outcome of the tool or policy			
Environmental Management Policy or Tool	Nature of the Tool and/or Policy in Use (Government)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	Effectiveness of the Tool and/or Policy to Protecting the Environment? (-4 to +4)	Inconsistent/ Inappropriate Law Developed	Inadequate Implementation of the Policy and Tool	Gaps in the Monitoring or Availability of Data	Ineffective Enforcement
Land use changes	Town and Country Planning Act; National Physical Development Plan	Link to control land use planning in the coastal zones and on the island		-4	Outdated legislation (the Town and Country Planning Act dates as far back as 1954); lack of Government commitment to review the legislation	Lack of government commitment to implementation; conflicts with other policies/lack of intersectoral cooperation	No policy for systematic data collection on relevant issues; lack of resources (lack of staff and equipment)	
Major project decision making	Integrated Coastal Zone Management Plan; EIA	Link to control development in the coastal zones		-2	Lack of coherent integrated policy making; the list of undertakings subject to EIA is not comprehensive enough to cover all potentially harmful activities; procedure for reviewing EIAs and granting EIA licences is lacking in transparency and accountability	Conflicts with other policies		Lack of resources; lack of enforcement powers
Fisheries regulation	Fisheries Act (1998)	Link to control the exploitation of fisheries and marine resources		-1	Lack of resources (e.g. lack of staff and equipment)	Lack of resources; lack of enforcement powers		

Suggested Generic Options for Causes of Ineffectiveness in Environmental Management

(Please describe more specifically, as relevant and feasible)

(List extracted from GIWA Governance section)

<p>Inconsistent/ Inappropriate law developed</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Poor awareness of problems and solutions Deficient policy planning (e.g. lack of env. strategy) Conflicts with other policies / lack of intersectoral cooperation Low value attached to env. in government (e.g. low status for MOE) NGOs ineffective (e.g. through lack of capacity or cooperation or recognition) Lack of coherent integrated policy making Not in national interest to develop governance</p>	<p>Gaps in the monitoring or availability of data</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Poor awareness of problems and solutions No policy for systematic data collection on relevant issues Lack of intersectoral cooperation (e.g. between govt department or agencies or international bodies) Other: explain</p>
<p>Inadequate implementation of the policy and tool</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Lack of government commitment to implementation Conflicts with other policies / lack of intersectoral cooperation Other: explain</p>	<p>Ineffective enforcement</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Poor awareness of problems and solutions Lack of enforcement powers (e.g. low penalties or no powers to enforce) Ineffective legal system (e.g. legal system slow or lacking understanding of env. matters) Lack of available monitoring data Other / explain (e.g. absence of regulatory authority)</p>

2. Sectoral policy = those which indirectly increases the pressure

	Nature of the Tool and/or Policy in Use (Government)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	How Does it Actually Increase Pressure on the Issue?	Reasons/Causes for the Implementation of this Policy or Tool?	Please describe carefully each of the causes, giving as much evidence as possible. Each of these could become the subject of an intervention (see possible generic options below)
Urbanisation	Environment Protection Act; Waste Water Authority Act; National Sewerage Master Programme; Public Health Act; Local Government Act; National Solid Waste Management Programme; Town and Country Planning Act; National Physical Development Plan	These acts empower authorities to exert control on the following: sewage and waste water disposal, water bathing quality, land use	Convention on Biological Diversity. Nairobi Convention	National Physical Development Plan (NPDP) has not been given legal status and used only as guideline. EIA not followed up and conditions not always respected during implementation phase. Lack of enforcement powers	The NPDP was designed to control development in a systematic manner but is not strictly enforced because it does not have a legal status. EIA has been an instrument to monitor development in an environmentally sound manner, but in not respected due to lack of follow-up during the construction stage	
Agriculture	Ground Water Act; Integrated Pest Management Programme; Guidelines on Coastal Water Quality and Sugar Industry Effluents Standard; Public Health Act; Environment Protection Act; National Physical Development Plan	Provide for the control of pesticide, fertiliser and land uses	Convention on Biological Diversity. Nairobi Convention	National Physical Development Plan (NPDP) as not been given legal status and used only as guideline. Lack of enforcement	Legislation was enforced to protect ground water, enhance food safety and protect coastal waters from contamination. The NPDP was designed to control development in a systematic manner but is not strictly enforced because it does not have a legal status. EIA has been an instrument to monitor development in an environmentally sound manner. However, several of these laws are not being scrupulously respected and enforced.	
Fisheries	Environment Protection Act, Fisheries and Marine Resources Act	Control of water quality, fishing practices and activities	Convention on Biological Diversity. Nairobi Convention	Lack of enforcement	Fisheries & Marine Resources Act provides protection against overexploitation, regulates fishing practices. There are, however, sporadic cases on non-compliance.	

	Nature of the Tool and/or Policy in Use (Government)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	How Does it Actually Increase Pressure on the Issue?	Reasons/Causes for the Implementation of this Policy or Tool?	Please describe carefully each of the causes, giving as much evidence as possible. Each of these could become the subject of an intervention (see possible generic options below)
	Central Water Authority Act; Environment Protection Act, Ground Water Act; Waste Water Authority Act; National Sewerage Master Programme; Guidelines on Coastal Water Quality and Sugar Industry Effluents Standard; Public Health Act; Local Government Act and the Environment Protection Act; National Solid Waste Management Programme; Town and Country Planning Act; National Physical Development Plan	Provide for the control of sewage and waste water disposal, control of industrial effluents, control of water bathing quality, control of indiscriminate dumping of hazardous wastes, control of land use	Convention on Biological Diversity. Nairobi Convention	National Physical Development Plan (NPDP) has not been given legal status and used only as guideline. EIA not followed up and conditions not always respected during implementation phase. Lack of enforcement	Legislation was enforced to control development and protect ground water & coastal waters. The NPDP was designed to control development in a systematic manner but is not strictly enforced because it does not have a legal status. EIA has been an instrument to monitor development in an environmentally sound manner. However, several of these laws are not being scrupulously respected and enforced.	
Tourism	Central Water Authority Act; Environment Protection Act, Ground Water Act; Waste Water Authority Act; Integrated Pest Management Programme; National Sewerage Master Programme; Guidelines on Coastal Water Quality and Sugar Industry Effluents Standard; Public Health Act; Local Government Act and the Environment Protection Act; National Solid Waste Management Programme; Town and Country Planning Act; National Physical Development Plan	Control of sewage and waste water disposal, water bathing quality and land use	Convention on Biological Diversity. Nairobi Convention	National Physical Development Plan (NPDP) has not been given legal status and used only as guideline. EIA not followed up and conditions not always respected during implementation phase. Lack of enforcement	The Town and Country Planning Act and the NPDP were designed to control development in a systematic manner but the NPDP is not strictly enforced because it does not have a legal status. EIA has been an instrument to monitor development in an environmentally sound manner, but in not respected due to lack of follow-up during the construction stage. The other Acts control water pollution in the lagoon. However, legislation is not fully effective in combating pollution e.g. wastewater used for irrigation is not fully treated.	

Options of Causes for Implementation of this Policy or Tool

Reasons for Sectoral Policy Developed which Directly Contribute to the Issue	High priority for development of sector to combat poverty High priority for development of sector to meet population growth needs Low value attached to env. in government (e.g. low status for MOE) Lack of transparency Poor awareness of problems and solutions Deficient policy planning (e.g. lack of env. strategy) Lack of intersectoral cooperation Abuse of influence (e.g. corruption) NGOs ineffective (e.g. through lack of capacity or cooperation or recognition) Lack of coherent integrated policy making Other: specify
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3. Community Responses: Describe the Initiative from Community or Social Groups that may Alleviate Pressure on the Issue or Further Contribute and Increase the Pressure

Nature of the Initiative in Use (Where, Who, Scope, etc.)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	How Does it Actually Alleviate and/or Increase Pressure on the Issue?	Barriers or Constraints to Further Addressing the Issue
Fisheries Association/cooperatives	Registration of fishermen. Respect fishing season and use only the allowed gears. Decrease their dependency on lagoon fishing.	Convention of Biological Diversity	Rational exploitation of lagoon fishing.	Incentives to embark on other fishing territories
Agricultural associations	Use fertilisers and pesticides on coastal lands. Encourage the use of green manure		Pollutants affect water quality and biota. Green manure environmentally friendly	Commitment of the agricultural community towards rational use of fertilisers and pesticides.
Mauritius Marine conservation Society	Conservation of biodiversity. Monitoring of lagoons and reefs	Convention of Biological Diversity	Sensitisation of the stakeholders on relevant issues	Sensitisation programmes to be more outreaching

4. Market Responses

Nature of the initiative in use (where, who, scope, etc.)	Link to sectoral pressure and/or immediate cause	Link to international agreement, programme or policy	How does it actually alleviate and/or increase pressure on the issue?	Barriers or constraints to further addressing the issue
Intensified fishing activities along the coast	Fishing mal-practices with the use of small mesh-size nets		The intensified fishing activities and the use of destructive fishing gears have resulted in over-fishing and degradation of the coastal ecosystems, and adversely impacting on productivity and biodiversity	Inadequate training facilities to enable transition between artisanal and more technologically advanced semi-industrialised fisheries; Existing soft loan arrangements inadequate to develop large investment semi-industrial fisheries and support facilities; low socio-economic status of fishing communities and limited access to other employment; resource use conflicts
Setting up of fisheries cooperatives	By grouping themselves into co-operatives fishermen can be provided with storage facilities, marketing services and credit facilities		Optimise fish catch which eventually leads to over-exploitation of the fishery resources	Poor management skills; no appropriate "encadrement", i.e. no training opportunities and technical advice
Incentives to the tourist industry (for e.g. lease of Pas Géométriques")	Pressure on coastal land and lagoon/marine resources through development of shore side sites and sea-sports activities		Development of shore side sites and sea-based activities have led to poor water quality, beach erosion and loss of biological diversity in the sea and coast	Inadequate institutional, policy and legislative framework; pressure to develop the tourist industry as a growth sector; inadequate knowledge on the complex interactions between sea and land interface; strong pressure for further development of tourism infrastructure
Provision of Fish Aggregating Devices (FADs) to fishermen	To prevent over-exploitation of the lagoon fisheries.		FADs provide a means to encourage the artisanal fishery to move out of the lagoon and take steps to reduce its operation within.	High FAD loss; Cost of FADS not met by fishery; catches seasonal; Distant FADS require large boats; excessive effort around existing near shore FADs assessable to fishermen

ANNEX IV

Causal Chain Summary Table 3 for Characterisation

Summary Table for Immediate Causes

Country: Mauritius

1	2	3	4	5
Issue	Immediate Cause	Indicator	Further characteristics	Link to Sectors and %
Modification of ecosystem or ecotones	Land development 30%	Fisheries catch (Fisheries Annual Report 1997,98)(Resource Analysis-EDC (1999). Genave J T. (1997). Number of hotels increased from 75 (1990) to 91 (1999) (CSO, 2000)	Decrease in catch both quantity and size. Hotel rooms increased from 4,603 (1990) to 7903 (1999) (CSO, 2000) Tourist increase from 291,600 (1990) to 558,200 (1999) (CSO, 2000)	Urbanisation 30% Industry 40% Leisure30%
	Changed freshwater and sediment 30%	Reduction in Seagrass/coral cover (Ramessur, T. 1991) (Jootun, L., Gungaparsad, D., Ragoonaden, S., Dunpath, K., and Ujodha 1994). Siltation (Resource Analysis- EDC, 1999).	Clearance of sea grass beds for bathing area, Coral destruction for ski lanes, Coral trampling and damages by fishermen and boat anchors. Turbidity (Resource Analysis- EDC, 1999). Sediment thickness (Resource Analysis- EDC, 1999).	Urbanisation 20% Agriculture 70% Industry 10%
	Partial conversion of ecosystem/ecotones 20%	Number of tourists, hotels, bungalows and other amenities on the coast. Land prices (NEAP, 1999)(CSO, 1999)	Direct and indirect pressures from expanding tourism activities and recreational activities from permanent and transient residents. Tourist increase from 291,600 (1990) to 558,200 (1999) (CSO, 2000)	Urbanisation 40% Agriculture 30% Industry 30%

Summary Table for Sectoral Pressures
Country: Mauritius
Issue: Modification of Ecosystems or Ecotones

	1	2	3	4	5	6	7	8
Immediate Cause	Sectoral Pressures: Resource Use Activity	Further Characteristics	Indicator	Sectoral Pressures: Resource Use Practice	Further Characteristics	Indicator	Critical Incidence of "Environmentally-Friendly" Practice	Link to Root Causes and Responses
Land development 30%	Urbanisation 30%	Population growth accompanied by rise in construction rate	Number of buildings and inhabitants	Increase in waste production	Limited waste treatment. Limited sewer network	Number of household connected to sewer system. Number of treatment plants	Upgrading of existing wastewater treatment plant and extension of sewer network	Water quality affects ecosystem
	Industry 40%	Various types of industries: Sugar, textile, tourism	Number of industries	Dumping of wastes directly into water bodies & sewer system	Limited waste treatment.	Various pollutants	Enforcement of new regulations for industries. Monitoring of wastes produced. Clean production technology	Water quality affects ecosystem. Industry adopting cleaner technologies
	Leisure 30%	Coastal development for recreational activities	Extent of coastal area developed.	Levelling of sand dunes, landscaping, dredging.	Upgrading of public beaches	Extent of coastal area developed for leisure	All coastal land development requires an EIA. Aesthetic values considered.	Affects habitats. Not perceived negatively as it benefits local population
Changed freshwater and sediment 30%	Urbanisation 20%	Households connected to sewer system + pollutants from coastal non-point sources leaching into the lagoon	Number of household connected to sewer system. Coastal bungalows without a septic tank	Partially treated wastewater being discharged into the lagoon	Suspended solids. Nutrients. Turbidity	Water quality (various parameters)	Upgrading of existing wastewater treatment plant and extension of sewer network. Use of septic tank required in coastal areas	Water quality affects ecosystem
	Agriculture 70%	Soil wash-away from agricultural lands	Water turbidity	Cattle over-grazing. Agricultural land left bare after harvest. Deforestation in Rodrigues	Exposed soil washed into water courses and ultimately into the lagoon	Sediment thickness, turbidity, coral suffocation and death	Terracing and contour plantation in Rodrigues. Reforestation.	Siltation causes suffocation of biota and modifies ecosystem

	1	2	3	4	5	6	7	8
Immediate Cause	Sectoral Pressures: Resource Use Activity	Further Characteristics	Indicator	Sectoral Pressures: Resource Use Practice	Further Characteristics	Indicator	Critical Incidence of "Environmentally- Friendly" Practice	Link to Root Causes and Responses
	Industry 10%	Industrial effluents discharged into lagoon directly or through sewer system	Number of industries connected to sewer system.	Partially treated industrial wastewater being discharged into the lagoon	Suspended solids. Turbidity	Water quality (various parameters)	Upgrading of existing wastewater treatment plant and extension of sewer network. Regulations for discharge of industrial effluents into water bodies	Water quality affects ecosystem
Partial conversion of ecosystem/ecotones 20%	Urbanisation 40%	Coastal civil works	Coastal road length, backfilling extent.	Dredging, sand dune levelling. Sea grass removal. Beach works	Works carried out for apparent aesthetic reasons	Extent of habitat destruction	EIA required by law for any development	Breeding grounds and habitat affected by coastal works
	Agriculture 30%	Proximity of coastal agricultural plots	No of plots	Overuse of fertilisers	Leaching of nutrients into the lagoon ecosystem	Eutrophication. Algal blooms. Increase in nutrient level.	Use of green manure	Eutrophication causes change in biota composition
	Industry 30%	Infrastructural development	Extent of development	Dredging, sand dune levelling. Sea grass removal. Beach works	Works carried out for apparent aesthetic reasons	Extent of habitat destruction	EIA required by law for any development	Breeding grounds and habitat affected by coastal works

Summary Table for Root Causes
Country: Mauritius
Issue: Modification of Ecosystems or Ecotones

Social Changes	Characteristics	Indicator	Links to resource use changes and responses	Institutional drivers	Characteristics	Indicator	Links to resource use changes and responses	Economic structure	Characteristics	Indicator	Links to resource use changes and responses	
Population pressure	Natural population increase	Overall country population increases at 1% per year. A more pronounced increase in population for coastal zones	Increased demand for fishery resources and lagoonal activities	Limited Civil Society Empowerment	Sensitisation campaigns on marine ecosystems	Number of fishermen grouped in cooperatives	Poor knowledge of the ecosystem which impact thereon	Macro-Economic Policies	Government Policy to develop the tourist sector	Fiscal and other Incentives given to the Tourist Sector	Increased demand for land in the coastal regions	
	In-migration to the coast		Phasing out of coral sand extraction		Pressure groups/ cooperatives	Number of participants in sensitisation campaigns	Setting up of training school and fishermen training school		Preparation of a Master Plan for the Development of the Tourist Industry	Increase in the number of hotel complexes and informal accommodation for the foreign tourists	Large hotel Development Programme	
			Regulations for fishing practices								Pressure on all Government sectoral policies	
Low level of education	Sensitisation on marine ecosystems	Number of trained fishermen	Destruction of habitats									
	Fishing malpractices	Number of illegal fishing equipment/ gears	Regulations for fishing practices									

Please highlight the cause and particular characteristics, which carry more weight in driving a lower level cause (sectoral resource use or response)

Summary Table for Responses
Country: Mauritius
Issue: Modification of Ecosystems or Ecotones

1. Environmental Management = Policy or Tool(s) Designed to Address Environmental Problems

Environmental Management Policy or Tool	Nature of the Tool and/or Policy in Use (Government)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	Effectiveness of the Tool and/or Policy to Protecting the Environment? (-4 to +4)	Reasons/Causes for Ineffective Use and/or Outcome of the Tool or Policy			
					Inconsistent/ Inappropriate Law Developed	Inadequate Implementation of the Policy and Tool	Gaps in the Monitoring or Availability of Data	Ineffective Enforcement
					<i>Please describe carefully each of the causes, giving as much evidence as possible. Each of these could become the subject of an intervention (see possible generic options below)</i>			
Water pollution	Ground Water Act; Central Water Authority Act; Waste Water Authority Act and the Environment Protection Act; Integrated Pest Management Programme; Sugar Industry Effluents Standards; National Sewerage Master Programme; Guidelines on Coastal Water Quality	Link to control of pesticide use and fertilisers; link to control of sugar industry effluents; link to control of sewage; link to control of water bathing quality		-1	No consolidating law for water pollution has yet been proclaimed. Most of the existing pieces have to be reviewed	Lack of resources (technical staff, equipment, financial); Lack of Government commitment to implementation; lack of intersectoral cooperation - overlapping of responsibilities	No policy for systematic data collection on relevant issues; lack of resources (lack of staff and equipment)	Lack of resources (staff and equipment); lack of enforcement powers; lack of available monitoring data; unclear institutional responsibilities

1. Environmental Management = Policy or Tool(s) Designed to Address Environmental Problems

Environmental Management Policy or Tool	Nature of the Tool and/or Policy in Use (Government)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	Effectiveness of the Tool and/or Policy to Protecting the Environment? (-4 to +4)	Reasons/Causes for Ineffective Use and/or Outcome of the Tool or Policy			
					Inconsistent/ Inappropriate Law Developed	Inadequate Implementation of the Policy and Tool	Gaps in the Monitoring or Availability of Data	Ineffective Enforcement
Land use changes	Town and Country Planning Act; National Physical Development Plan	Link to control land use planning in the coastal zones and on the island		-4	Outdated legislation (the Town and Country Planning Act dates as far back as 1954); lack of Government commitment to review the legislation	Lack of government commitment to implementation; conflicts with other policies/lack of intersectoral cooperation	No policy for systematic data collection on relevant issues	
Major project decision making	Environment Protection Act; Integrated Coastal Zone Management Plan; EIA	Link to control development in the coastal zones		-2	The EIA process needs to be reviewed since the procedure for reviewing EIAs and granting EIA licences is lacking in transparency and accountability; lack of coherent integrated policy making	Conflicts with other policies		Lack of resources; lack of enforcement powers
Fisheries regulation	Fisheries Act (1998)	Link to control the exploitation of fisheries and marine resources		1	Lack of resources (staff and equipment)	Lack of resources; lack of enforcement powers		

Suggested Generic Options for Causes of Ineffectiveness in Environmental Management (please describe more specifically, as relevant and feasible)

(List extracted from GIWA Governance section)

<p>Inconsistent/inappropriate law developed</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Poor awareness of problems and solutions Deficient policy planning (e.g. lack of env. strategy) Conflicts with other policies / lack of intersectoral cooperation Low value attached to env. in government (e.g. low status for MOE) NGOs ineffective (e.g. through lack of capacity or cooperation or recognition) Lack of coherent integrated policy making Not in national interest to develop governance</p>	<p>Gaps in the monitoring or availability of data</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Poor awareness of problems and solutions No policy for systematic data collection on relevant issues Lack of intersectoral cooperation (e.g. between govt department or agencies or international bodies)</p>
<p>Inadequate implementation of the policy and tool</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Lack of government commitment to implementation Conflicts with other policies / lack of intersectoral cooperation Other: explain</p>	<p>Ineffective enforcement</p>	<p>Scientific/technical capacity (e.g. in staff expertise or staff training) Lack of resources (e.g. lack of staff or equipment) Abuse of influence (e.g. corruption) Lack of transparency (e.g. in the operation of the agency) Poor awareness of problems and solutions Lack of enforcement powers (e.g. low penalties or no powers to enforce) Ineffective legal system (e.g. legal system slow or lacking understanding of env. matters) Other / explain (e.g. absence of regulatory authority)</p>

2. Sectoral Policy = Those Which Indirectly Increases the Pressure

	Nature of the Tool and/or Policy in Use (Government)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	How Does it Actually Increase Pressure on the Issue?	Reasons/Causes for the Implementation of this Policy or Tool?	Please Describe Carefully Each of the Causes, Giving as Much Evidence as Possible. Each of these Could Become the Subject of an Intervention (see possible generic options below)
Urbanisation	Ground Water Act; Central Water Authority Act; Waste Water Authority Act and the Environment Protection Act; National Sewerage Master Programme; Guidelines on Coastal Water Quality. Town and Country planning Act.	Provide for the control of land use and development, sewage, waste water disposal and water bathing quality	Convention of biological Diversity. Nairobi Convention	National Physical Development Plan (NPDP) has not been given legal status and used only as guideline. EIA not followed up and conditions not always respected during implementation phase. Lack of enforcement powers		These regulations provide an array of tools to protect the lagoon ecosystem especially with regard to pollution and damages resulting from coastal urbanisation. However, because of the absence of a continuous long term monitoring and lack of enforcement, the abiotic and biotic components of the ecosystem are affected thus resulting in its degradation.
Agriculture	Ground Water Act; Central Water Authority Act; Environment Protection Act; Integrated Pest Management Programme; Sugar Industry Effluents Standards; Guidelines on Coastal Water Quality	Exert control on the following: use of pesticides and fertilisers, sugar industry effluents and water bathing quality	Convention of biological Diversity. Nairobi Convention	National Physical Development Plan (NPDP) has not been given legal status and used only as guideline. EIA not followed up and conditions not always respected during implementation phase. Lack of enforcement powers		The NPDP was designed to control development in a systematic manner but is not strictly enforced because it does not have a legal status. Even in its present form the NPDP allows for development of agriculture in close proximity to the shoreline which impacts negatively on the lagoon. Enactments are used to control the pesticide and fertiliser use. However, cases of non-compliance are rampant because of the difficulty of actually monitoring fertiliser and pesticide application rates.

	Nature of the Tool and/or Policy in Use (Government)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	How Does it Actually Increase Pressure on the Issue?	Reasons/Causes for the Implementation of this Policy or Tool?	Please Describe Carefully Each of the Causes, Giving as Much Evidence as Possible. Each of these Could Become the Subject of an Intervention (see possible generic options below)
Fisheries	Fisheries and Marine Act (1998)	Control fishing activities and practices	Convention of biological Diversity. Nairobi Convention	Lack of enforcement	Fisheries & Marine Resources Act provides protection against overexploitation, regulates fishing practices. There is however some environmentally unfriendly practices e.g. coral damages through trampling, anchoring etc.	
Industry	Ground Water Act; Central Water Authority Act; Waste Water Authority Act and the Environment Protection Act; National Sewerage Master Programme; Guidelines on Coastal Water Quality	Exert control on pesticide and fertilisers uses, on sugar industry effluents, water bathing quality and land use and development	Convention of biological Diversity. Nairobi Convention	National Physical Development Plan (NPDP) has not been given legal status and used only as guideline. EIA not followed up and conditions not always respected during implementation phase. Lack of enforcement powers	These regulations provide an array of tools to protect the lagoon ecosystem especially with regard to pollution and damages resulting from industry. However, because of the absence of a continuous long term monitoring and lack of enforcement, the abiotic and biotic components of the ecosystem are affected thus resulting in its degradation. The NPDP was designed to control development in a systematic manner but is not strictly enforced because it does not have a legal status. EIA has been an instrument to monitor development in an environmentally sound manner, but in not respected due to lack of follow-up during the construction stage	
Tourism	Ground Water Act; Central Water Authority Act; Waste Water Authority Act and the Environment Protection Act; Integrated Pest Management Programme; Sugar Industry Effluents Standards; National Sewerage Master Programme; Guidelines on Coastal Water Quality	Provide for the control of the following: land use and development, sewage and waste water disposal and water bathing quality	Convention of biological Diversity. Nairobi Convention	National Physical Development Plan (NPDP) has not been given legal status and used only as guideline. EIA not followed up and conditions not always respected during implementation phase. Lack of enforcement powers	These regulations provide an array of tools to protect the lagoon ecosystem especially with regard to pollution and damages resulting from development. EIA has been an instrument to monitor development in an environmentally sound manner, but in not respected due to lack of follow-up during the construction stage. However, because of the absence of a continuous long term monitoring and lack of enforcement, the abiotic and biotic components of the ecosystem are affected thus resulting in its degradation. The NPDP was designed to control development in a systematic manner but is not strictly enforced because it does not have a legal status.	

Options of Causes for Implementation of this Policy or Tool

Reasons for Sectoral policy developed which directly contribute to the issue	High priority for development of sector to combat poverty High priority for development of sector to meet population growth needs Low value attached to env. in government (e.g. low status for MOE) Lack of transparency Poor awareness of problems and solutions Deficient policy planning (e.g. lack of env. strategy) Lack of intersectoral cooperation Abuse of influence (e.g. corruption) NGOs ineffective (e.g. through lack of capacity or cooperation or recognition) Lack of coherent integrated policy making Other: specify
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3. Community Responses: Describe the Initiative from Community or Social Groups that may Alleviate Pressure on the Issue or Further Contribute and Increase the Pressure

Nature of the Initiative in Use (Where, Who, Scope, etc.)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	How Does it Actually Alleviate and/or Increase Pressure on the Issue?	Barriers or Constraints to Further Addressing the Issue
Fishermen Association protest against drop in fish catch	Express concern about developments in lagoons	Convention of Biological diversity	Watch dog against environmentally unfriendly activities	An economically vulnerable group active sporadically. Low level of education specially on ecological fields.
NGOs and pressure groups protest against unplanned development and abuse	Conservation of marine biodiversity	Convention of Biological diversity	Carries out regular monitoring of biota and also active in education and sensitisation on marine conservation issues	Sensitisation programmes should target larger groups. Interaction with stakeholders
Grouping of lagoon fishermen to embark on new fishing techniques e.g. high-sea fishing	Less fishing activity in the lagoon	Convention of Biological diversity. Nairobi Convention	Ease down the fishing pressure on the lagoon stocks	Financial incentives. Such ventures are costly and risky. Reluctance of fishermen to embark on new technologies. Bad day allowance has a counter effect to such initiatives

4. Market Responses

Nature of the Initiative in Use (Where, Who, Scope, etc.)	Link to Sectoral Pressure and/or Immediate Cause	Link to International Agreement, Programme or Policy	How Does it Actually Alleviate and/or Increase Pressure on the Issue?	Barriers or Constraints to Further Addressing the Issue
Intensification of agricultural production	A shift towards production of fruits, vegetables and flowers; a changing pattern of sugar production and some shift to organically grown fertiliser		The increasing use of pesticides is associated with the shift towards fruit, vegetables and flowers; On the other hand, consumption of fertilisers has declined. With the changing pattern of sugar production and some shift to organically grown fertiliser, there may be a decrease in the use of fertiliser.	The high demand for fruits, vegetables and flowers is contributing to the shift in agricultural production. Pesticides do not carry a subsidy. Fertiliser is controlled, resulting in a small Government subsidy of about 5 %
Intensified fishing activities along the coast	Fishing mal-practices with the use of small mesh-size nets		The intensified fishing activities and the use of destructive fishing gears have resulted in over-fishing and degradation of the coastal ecosystems, and adversely impacting on productivity and biodiversity	Inadequate training facilities to enable transition between artisanal and more technologically advanced semi-industrialised fisheries; Existing soft loan arrangements inadequate to develop large investment semi-industrial fisheries and support facilities; low socio- economic status of fishing communities and limited access to other employment; resource use conflicts
Setting up of fisheries cooperatives	By grouping themselves into co- operatives fishermen can be provided with storage facilities, marketing services and credit facilities		Optimise fish catch, which eventually leads to over-exploitation of the fishery resources	Poor management skills; no appropriate "encadrement", i.e. no training opportunities and technical advice
Incentives to the tourist industry (for e.g. lease of Pas Géométriques")	Pressure on coastal land and lagoon/marine resources through development of shore side sites and sea-sports activities		Development of shore side sites and sea-based activities have led to poor water quality, beach erosion and loss of biological diversity in the sea and coast.	Inadequate institutional, policy and legislative framework; pressure to develop the tourist industry as a growth sector; inadequate knowledge on the complex interactions between sea and land interface; strong pressure for further development of tourism infrastructure

Guidelines on coastal water quality	High level of nutrients close to discharges of waste water and built up areas of the coast		Monitoring of lagoon water quality to avoid any contamination which may occur due to high level of nutrients	Lack of enforcement power; lack of financial resources and technical capacity
Ban on extraction of coral sand for construction purposes	Pressure on the marine biodiversity and beach erosion		Sand extraction has led to damage to the beaches leading to beach erosion. Biological impacts are also noticeable through loss of habitats and changing currents. The ban of coral sand will help avoid all these negative impacts some ecological impacts	Lack of enforcement capacity; redeployment of sand extractors in other economic activities is very difficult; high level of compensations have to be paid