

Chapter 2. Forest and Terrestrial Biodiversity of Mauritius

2.1 Overview of Biodiversity

Mauritius has an area of 1,865 km², of which 30% is considered forested. The area of good quality native forest, (i.e. that with more than 50% native plant cover, Page & d'Argent 1997), is estimated to cover less than 2% of the island (NEAP 1999, MWF unpublished, Fig.2.1). The rest consists of plantation forestry, deer-ranches or highly degraded vegetation invaded by alien plant and animal species. As a result Mauritian biodiversity is amongst the most threatened in the world.

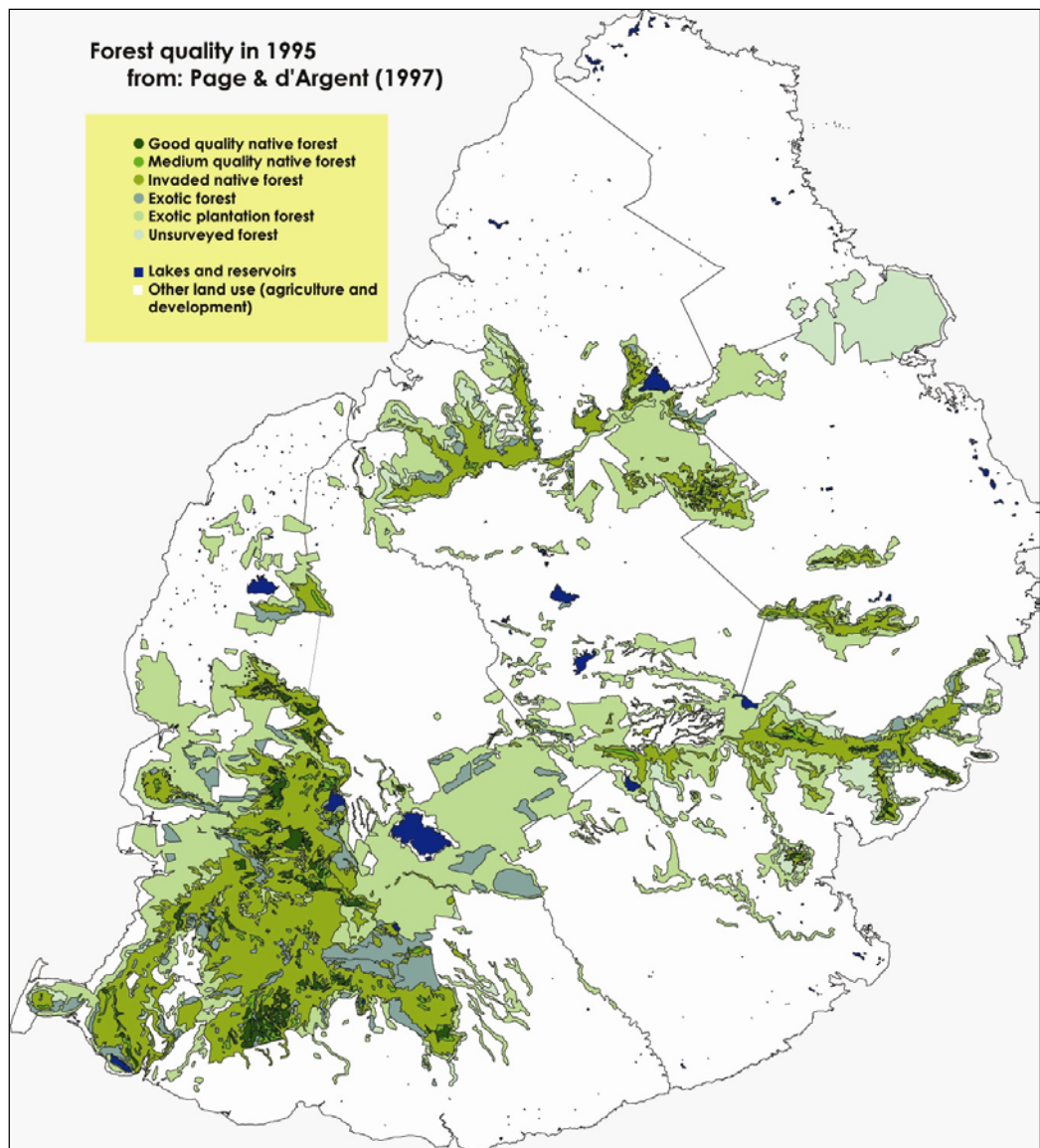


Figure 2.1 Forest cover in Mauritius (Page and d'Argent, 1997)

Fifteen vegetation types have been classified (Vaughan & Wiehe 1937), varying

in species composition and structure, and ranging from coastal sand dune vegetation to cloud forest. Remnants of some vegetation types are concentrated in the Black River Gorges National Park in the south west, the Bambous Mountain Range in the south east and the Moka-Port Louis Ranges in the North West. There are also some isolated mountains which are important e.g. Corps de Garde, Trois Mamelles and Le Morne Brabant, and several offshore islands with remnants of coastal and mainland diversity.

Table 2.1: Native diversity of selected groups in Mauritius, with respective total number of extinctions. Numbers in brackets indicate the number of endemic species.

	Number of native species	% species endemic	Number of extinct species	Number of extant species
Angiosperms ¹	671 (311)	46%	77 (42)	594 (269)
Mammals ²	5 (2)	40%	2 (1)	3 (1)
Birds ²	30 (24)	80%	18 (15)	12 (9)
Reptiles ²	17 (16)	94%	5 (5)	12 (11)
Butterflies ³	37 (5)	14%	4 (1)	33 (4)
Snails ⁴	125 (81)	65%	43 (36)	82 (45)

1. Page & D' Argent, 1997; 2. Cheke, A. S. & Hume, J. P. *in press*; 3. Williams, 1989; 4. Griffiths & Florens *in prep*.

2.1.1 Flora

There are 671 species of indigenous flowering plant recorded in Mauritius, of which 311 are endemic (Mauritius has eight endemic plant genera), and 150 are endemic to the Mascarene Archipelago (Page & d'Argent, 1997; Strahm, 1994). 77 of these indigenous species are classified as extinct. Of the extant flowering plant species, about 35% are already classified as threatened as per IUCN criteria (Bachraz & Tezoo, 1997).

The most recent study of lower plants estimates that there are 207 taxa consisting of 89 genera of mosses and 59 genera of hepatics (Tixier & Gueho, 1997). There are about 200 species, subspecies and varieties of pteridophytes, of which 13 species are endemic, and 40 are extinct (Bachraz, 2000).

2.1.2 Fauna

24 of the 52 native species of forest vertebrate that were known to have occurred on Mauritius and adjacent islets are now extinct, including the Dodo (*Raphus cucullatus*), a giant parrot (*Lophopsittacus mauritianus*) and two species of giant tortoise (*Cylindropsis* spp.). Many of the extant species are threatened.

Mammals – The only native mammals are bats. Of the three species of fruit bat (*Pteropus niger*, *P. subniger* and *P. rodricensis*) known to have occurred, only one (the Mauritian fruit bat *P. niger*) remains and is still locally common. *P. subniger* is extinct. *P. rodricensis* still occurs on Rodrigues. There are two native insectivorous bat species (*Taphosus mauritianus* & *Mormopterus acetabulosus*) that are also found on Reunion and mainland Africa (IUCN, 2003).

Birds - Twelve species of land bird have so far escaped extinction (Table 2.1). Of these,

nine are threatened according to the IUCN Red List (2003). Species recovery programmes have saved three of these species from probable extinction:

The Mauritius Kestrel (*Falco punctatus*) was once the rarest falcon in the world due to DDT poisoning with only four birds known in 1974. The kestrel population is now estimated to be 800 birds.

The Echo Parakeet (*Psittacula eques echo*) is the last surviving parrot in the Mascarenes. It was considered the rarest parrot in the world, with only about 12 individuals known in 1987 due to nest predation by invasive species and habitat loss. An intensive captive breeding and release programme, supplementary feeding, provision and monitoring of predator-proof nest boxes, and predator control have increased the population to about 270 birds (Malham, 2005).

The Pink Pigeon (*Columba mayeri*) now numbers around 400 birds, compared to a population of c25 birds in the 1970s. There are now five managed populations, four in the Black River Gorges National Park and one population on Ile aux Aigrettes.

Of the remaining forest bird species, the Mauritius grey white eye (*Zosterops mauritianus*) is common, the Mascarene cave swiftlet (*Collocalia francica*) and the Mascarene Swallow (*Phedina borbonica*) are fairly common, while all the others are threatened. A recovery programme was initiated in 2003 to establish a population of the Mauritius Fody (*Foudia rubra*) on Ile aux Aigrettes (a rat-free islet). There are now about 50 birds on the island, and individuals began to breed in 2004.

None of the other species (Mauritius Cuckoo shrike (*Coracina typica*), Mauritius black bulbul (*Hypsipetes olivaceus*), Mauritius olive white eye (*Zosterops chloronothos*), or Mascarene paradise flycatcher (*Terpsiphone bourbonensis* subsp. *desolata*) receive any active management.

Reptiles - Of the 17 native reptile species, only 12 remain, 11 of which are endemic (Table 2.1). Seven of these are restricted to the northern offshore islets. These include five species found only on Round Island; the keel scaled boa (*Casarea dussumieri*), Telfair's skink (*Leiolopisma telfairii*), Gunther's gecko (*Phelsuma guentheri*) and a night gecko (*Nactus durrelli*). The burrowing boa (*Bolyeria multicarinata*) was last seen in 1975 and may already be extinct.

Invertebrates - Of the invertebrate fauna, only butterflies and land snails have been well studied. There are 39 native species of butterfly, of which five are endemic, and 125 known native species of land snail of which 43 are already extinct (Table 2.1).

2.1.3. The forest estate and protected areas

30% of Mauritius is forested consisting of exotic plantation, deer-ranching land and natural forest most of which is badly degraded. 47% of the forested land in Mauritius is state owned (Table 2.2).

State land - Plantations

Exotic plantations cover 11,816 ha. The most common species are *Pinus elliottii*

and *P. taeda*, (65 %), *Eucalyptus tereticornis* (16 %) and *Cryptomeria japonica* (13 %). In 2003, it was decided that half of the plantation area would be set aside for protection of ecosystem services (water catchments, soil protection etc.).

State land - Pas Géométriques

The *Pas Géométriques* forms a narrow belt of state-owned land all around the coast. This is 81.21 m (250 French feet) in width, although there are several cases where the width is less than this, or it does not exist at all. Much of the *Pas Géométriques* is leased for campments (seaside holiday homes) and hotels. Beaches occupy a fairly large area around the island, but a substantial portion, especially in the south, are leased to adjacent estates. Other areas have been granted long-term leases for grazing and tree planting in place of land that has been forcibly acquired from private estates.

There are 635 ha of forest on the *Pas Géométriques* managed by the Forestry Service. This includes exotic plantations (mostly filao - *Casuarina equisetifolia*), lands leased for grazing and tree planting, as well as un-plantable or “to be planted” lands.

State land - Protected areas

The mainland has one National Park, seven Nature Reserves and two Reserves covering an area of 7,246 ha. 16 of the 49 offshore islets are protected due to their conservation importance, seven as Nature Reserves, eight as National Parks and one as an Ancient Monument (Table 2.3).

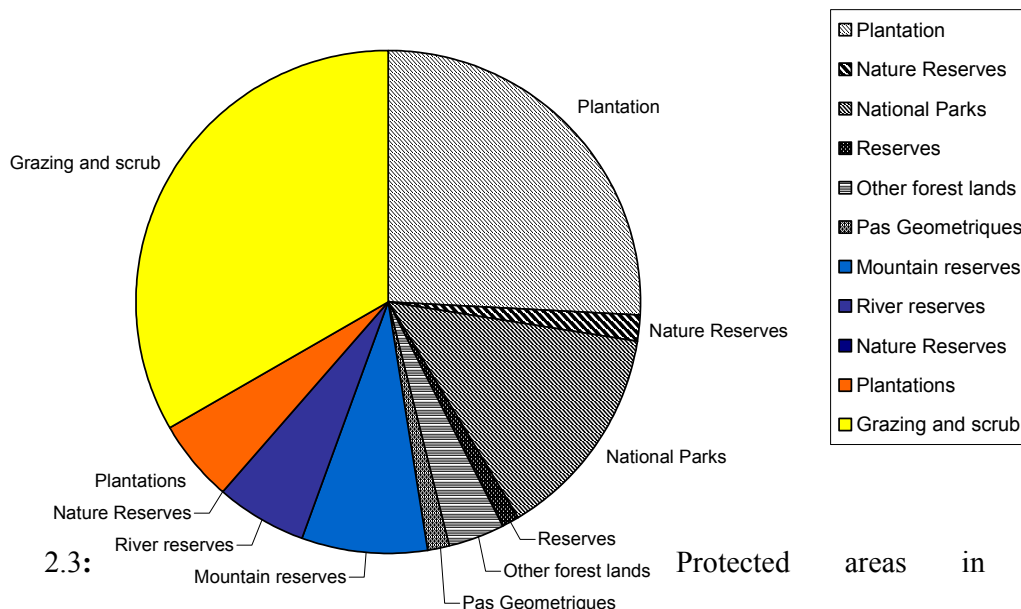
Mainland Nature Reserves are managed by the Forestry Services, while the National Parks and Conservation Service oversee the National Parks and most offshore islet Nature Reserves. Ile aux Aigrettes Nature Reserve is leased for conservation management to the Mauritian Wildlife Foundation.

Table 2.2: The area of different types of forest in Mauritius

Type of forest	Area (ha)
State	22,200
Plantations	11,816
Nature Reserves	799
<i>Mainland</i>	200
<i>Islets</i>	599
National Park	6,708
<i>Black River Gorges National Park</i>	6,574
<i>Islet National Parks</i>	134
Bras D'eau and Poste La Fayette Reserves	472
Unplanted, protective or to be planted	1,770
Pas Geometriques	635
<i>Plantations</i>	226
<i>Leased for grazing and tree planting</i>	230
<i>Unplanted, protective or to be planted</i>	179
Private (including leased land)	25,000
Reserves	6,553
<i>Mountain reserves</i>	3,800
<i>River reserves</i>	2,740
<i>Nature Reserves</i>	13
Plantations	2,600
Forest lands, incl. scrub, grazing lands (estimate)	15,847
TOTAL	47,200

*Updated from Forestry Service, Ministry of Agro-Industries and Fisheries (2004).

Figure 2.2: Area and land use of state (black shading) and private (coloured shading) lands



Table

2.3:

Protected areas in

Mauritius with respective areas under active management.

AREA	AREA (HA)	AREA MANAGED (HA)*	AREA	AREA (HA)	AREA MANAGED (HA)*
Mainland – National Parks	6,574.00	39	Offshore islets - National Parks	134.38	0
<i>Black River Gorges</i>	<i>6,574.00</i>		<i>Pigeon Rock</i>	<i>0.63</i>	
Mainland – Nature Reserves	200.26	4.44	<i>Ile D'Ambre</i>	<i>128.00</i>	
<i>Perrier</i>	<i>1.44</i>	<i>1.44</i>	<i>Rocher des Oiseaux</i>	<i>0.10</i>	
<i>Les Mares</i>	<i>5.10</i>	<i>1.00</i>	<i>Ile aux Fous</i>	<i>0.30</i>	
<i>Gouly Pere</i>	<i>10.95</i>	<i>1.00</i>	<i>Ile aux Vacoas</i>	<i>1.36</i>	
<i>Cabinet</i>	<i>17.73</i>		<i>Ile aux Fouquets</i>	<i>2.49</i>	
<i>Bois Sec</i>	<i>5.91</i>		<i>Ilot Flamants</i>	<i>0.80</i>	
<i>Le Pouce</i>	<i>68.80</i>		<i>Ile aux Oiseaux</i>	<i>0.70</i>	
<i>Corps de Garde</i>	<i>90.33</i>	<i>1.00</i>	Offshore islets – Nature Reserves	598.62	194.8
Mainland - Reserves	497.00	25.00	<i>Round Island</i>	<i>168.84</i>	<i>168.84</i>
<i>Mare Sarcelles</i>	<i>20.00</i>		<i>Ile aux Serpents</i>	<i>31.66</i>	
<i>Bras d'Eau</i>	<i>452.00</i>		<i>Flat Island</i>	<i>253.00</i>	<i>1.00</i>
<i>Rivulet Terre Rouge Bird Sanctuary</i>	<i>25.00</i>				
Mainland – Private Reserves	13.00	5	<i>Gabriel Island</i>	<i>42.20</i>	
<i>Mondrain</i>	<i>5.00</i>	<i>5.00</i>	<i>Gunner's Quoin</i>	<i>75.98</i>	
<i>Emile Series</i>	<i>8.00</i>		<i>Ilot Mariannes</i>	<i>1.98</i>	
			<i>Ile aux Aigrettes</i>	<i>24.96</i>	<i>24.96</i>
			Offshore islets - Ancient Monument	2.19	0
			<i>Ile de la Passe</i>	<i>2.19</i>	
TOTAL – Mainland				7284.26	73.44
TOTAL – Offshore islets				735.19	194.8
GRAND TOTAL				8019.45	268.24

*Active management entails regular weeding of invasive alien plant species and restoration planting of native species. Trapping and poisoning of exotic animals is carried out on a small scale in some of these areas.

a) Mainland Protected Areas

The Black River Gorges National Park in the south west of Mauritius was proclaimed in 1994 and covers an area of 6,574 ha. The Park harbours many different forest vegetation types, ranging from dry lowland forest near to the west coast, to heath and mossy forest at high altitudes. It is home to all of the endemic birds of Mauritius, and many rare plant species. Although much of the forest is very degraded, areas of good quality vegetation remain. The National Park contains a visitor centre, an information centre and four field research stations. The mainland Nature Reserves and Reserves that

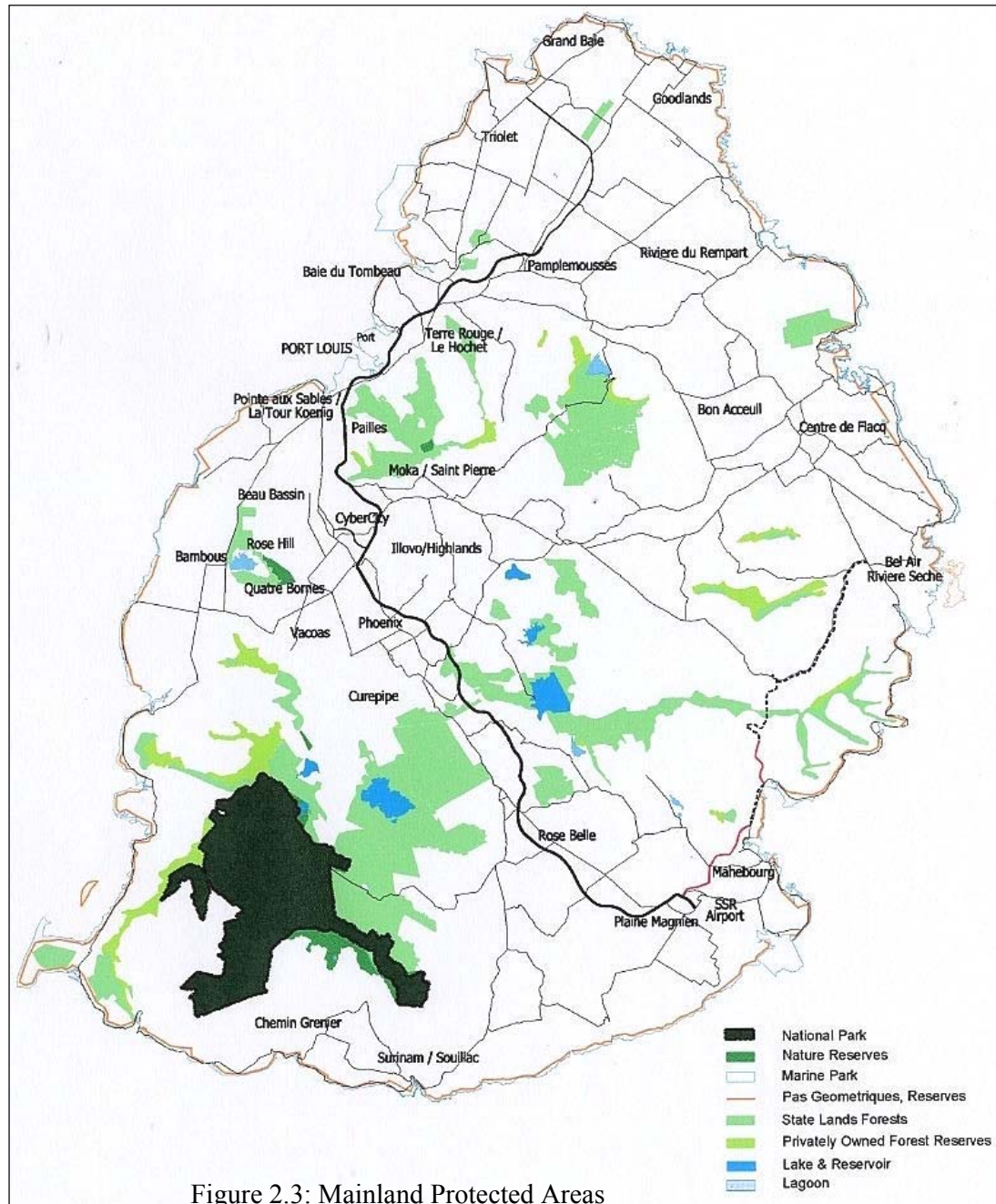


Figure 2.3: Mainland Protected Areas

fall outside of the National Park, provide legal protection to some important areas of

plant biodiversity, in particular Corps de Garde, Le Pouce and Mare Sarcelles.

b) Offshore islets

The 16 protected islets harbour species, and habitats that have almost disappeared from the mainland. For example, seven of the remaining twelve species of reptile are restricted to islets, the last remaining areas of coastal ebony forest and palm-rich forest are found on Ile aux Aigrettes, and Round Island respectively and many of the northern islands have important seabird colonies.



Figure 2.4: The protected offshore islets of Mauritius

Round Island is of exceptional biological importance because it is the largest area free of

introduced mammals and reptiles in the Mascarenes. It supports the last remnants of the palm rich forest once characteristic of the northern plains of Mauritius. It is home to at least ten threatened native plant species and possibly eight species of native reptiles including six that are endangered - five of which are now restricted to Round island. The island is also an important seabird breeding ground most notably for the rare Round Island petrel (*Pterodroma arminjoniana*).

Serpent Island is an important seabird colony. This otherwise barren rock is home to the sooty tern (*Sterna fuscata*), brown noddy (*Anous stolidus*), lesser noddy (*Anous tenuirostris*), and a tarantula that has yet to be described scientifically.

Flat Island, Ilôt Gabriel & Pigeon Rock lie to the north of Mauritius. Pigeon Rock is a volcanic plug, rising vertically out of the sea and is home to a seabird colony. Ilot Gabriel is a small island with coastal sand dune vegetation including the only known wild population of Baume de l'Ile Plate (*Psiadia arguta*). Flat Island is separated from Ilot Gabriel by a narrow lagoon and is the largest of the northern islets (253ha). In spite of its degraded nature, the islet is home to several species of reptile including the night gecko (*Nactus coindemirensis*) and the last refuge of the orange tailed skink (*Gongylomorphus* sp.). It harbours a seabird colony and has remnant populations of some plant species that once formed part of the palm-rich forest.

Although the palm-rich forest that used to cover Gunner's Quoin is much degraded, the island is important for several native species, including *Gagnebina pterocarpa* (Acacia indigène), *Lomatophyllum tomentorii* (mazambroun marron), *Dicliptera falcata* and *Cynanchum scopulosum*. The island is also used by seabirds for breeding and has an important population of *Nactus coindemirensis*.

Ile aux Aigrettes has the best-preserved native vegetation cover of all the corraline islands and contains the last remaining patch of ebony-rich forest. The island is also a refuge for many rare plants, such as *Gastonia mauritiana* (bois de boeuf), *Diospyros egrettarum* (bois d'èbène) and *Sideroxylon boutonianum* (bois fer). The island's vegetation has been restored over the last ten years, and now only requires periodic weeding. One population of pink pigeons and Mauritius fody have been established on the island.

The three islets Ile aux Vacoas, Ile aux Mariannes & Ile de la Passe are important historically due to their strategic position in defending the bay of Mahebourg, and the remaining buildings and ruins represent an important cultural heritage. Ile de la Passe has

been declared as Historical Monument and is under the management of the Ministry of Arts and Culture. The islets also contain some remnants of natural coastal vegetation, and Ile aux Mariannes is rich in insect life (AGRER 2004).

c) Private land

It is estimated that 25,000 ha of forested land are privately owned, or leased to private landowners. Much of this forest is managed for deer hunting with clearings for pasture. These forests are of high conservation importance because they include habitat types and gene pools not represented in state land protected areas.

Some of the private land is classified as Mountain Reserve or River Reserve and receives legal protection. Mountain Reserves occupy the upper third of mountains. River Reserves vary in width from 3 to 16 m on each side, depending the size of the river. Deforestation is not permitted in these reserves but enforcement is poor.

There is little active conservation management of privately-owned forests apart from one private reserve on the land of Medine Sugar Estate comprising 5 hectares and managed by the Royal Society of Arts and Sciences of Mauritius. There are also some innovative forest restoration projects being initiated by Bioculture Ltd. (Mauritius), and several private landowners are developing nature-based tourism on their land.

2.2 Consumptive and non-consumptive resource use

There is very little use of native forest resources because there is so little forest left and the components are in general very rare.

Creation and protection of forest resources

It is estimated that MRU 200 million is spent annually by the country as a whole, in addition to external funding, on the conservation of forests and terrestrial biodiversity.

Timber exploitation

In 2004 6,858 m³ of timber and poles were produced from state forestlands. There was also some extraction of waste wood, in the form of privet (*Ligustrum robustum* var. *walkeri*) and goyave de Chine (*Psidium cattleianum*) stakes. In 1995 the amount of wood used for cooking purposes was equivalent to 81,000 tons of petroleum products, meeting about 10.2% of local needs. By 2000 less than 5 % of fuel consumption was through firewood.

Deer ranching

The introduced rusa deer from Java (*Cervus timorensis*) is mainly reared on

extensive farms and estates for hunting purposes. The national herd is estimated to number about 70,000 heads. In 2004, 12,000 heads, representing 480 tonnes of carcass, were shot during the hunting season (1 June to 30 September). This was valued at MRU 53 million. (Mauritius Deer Farming Cooperative Society Ltd, 2005). The meat is exclusively for the local market.

Export of monkeys

Introduced long-tailed macaques (*Macaca fascicularis*) are highly invasive and have deleterious effects on both native flora and fauna. Monkeys are caught from the wild or bred in captivity and exported to laboratories and biomedical research institutions, mainly in Europe and America. In line with the CITES Convention, a voluntary annual export quota of 8000 wild-caught *Macaca fascicularis* has been fixed by the Ministry of Agro-Industry & Fisheries (MOAIF) to four companies. In addition, captive-bred monkeys are also exported. A contribution of 50 US\$ per head exported is credited into the National Parks and Conservation Fund (NPCF). This was increased to 70 USD in July 2004. Table 2.5 indicates the contribution to NPCF from 1995-2004. The trade provides an important incentive to control the pest in the wild and at the same time support various biodiversity conservation programmes.

Table 2.5: Number of monkeys exported from 1995 to 2004 and respective contribution to the National Park and Conservation Fund.

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Number of animals	5,410	6,084	5,998	5,578	7,263	7,870	7,050	5,731	7,740	7,621
Contribution to NPCF (million Rs.)	8.1	9.1	9.0	8.4	10.9	11.8	10.6	8.6	11.6	11.4

Wild fruit collection

Many introduced fruit tree species have naturalised, or become invasive in the forests of Mauritius e.g. *P. cattleianum* (goyave de Chine). This fruit is available for about four months of the year and guava picking is a popular Mauritian pastime. Fruit are also collected for sale but there are no reliable figures as to its economic significance.

Nature-based tourism

Guided visits on quad bikes or jeeps to admire the scenery and introduced animals, or canoeing trips down rivers, and abseiling down waterfalls are amongst the activities available.

One of the ecotourism destinations in Mauritius is the Nature Reserve of Ile aux Aigrettes. Proceeds from guided tours of the island are used for its restoration. 8,000

tourists visited the island in 2004.

Palm hearts

The endemic palmiste blanc (*Dictyosperma album* var. *album*) is cultivated in plantations on marginal lands for their cabbage. This local trade is estimated to be worth 20 million rupees MRU (Govinden, 2004). Although in the past the cabbages were exported (mainly to Reunion), this trade has stopped, as local demand from hotels and restaurants is greater than the supply. There is little harvesting of wild palms as the species are rare and hard to find in the wild.

Traditional use

A few families have earned their living for generations from the sale of traditional remedies using native species collected from the forest. However, this is a dying trade and much traditional knowledge passed down orally is being lost. In addition several of the plant species used are critically endangered, sometimes due to over harvesting.

A scientific survey funded by the European Union and carried out under the aegis of the Indian Ocean Commission estimated that there are about 100 native plant species with medicinal properties in Mauritius and Rodrigues in addition to 500 introduced species (Gurib-Fakim *et al.*, 1994-2000). Other species have been found to contain active ingredients for herbicides and pesticides (Dulloo, 1995).

Vacoas leaves (*Pandanus utilis*) are used by two communities for making baskets, mats and hats. Forest resources that are exploited illegally include ferns and orchids. The current market value of ferns is around MRU 150 per plant (NEAP, 1999). Data on the number of species collected and their potential value are not available.

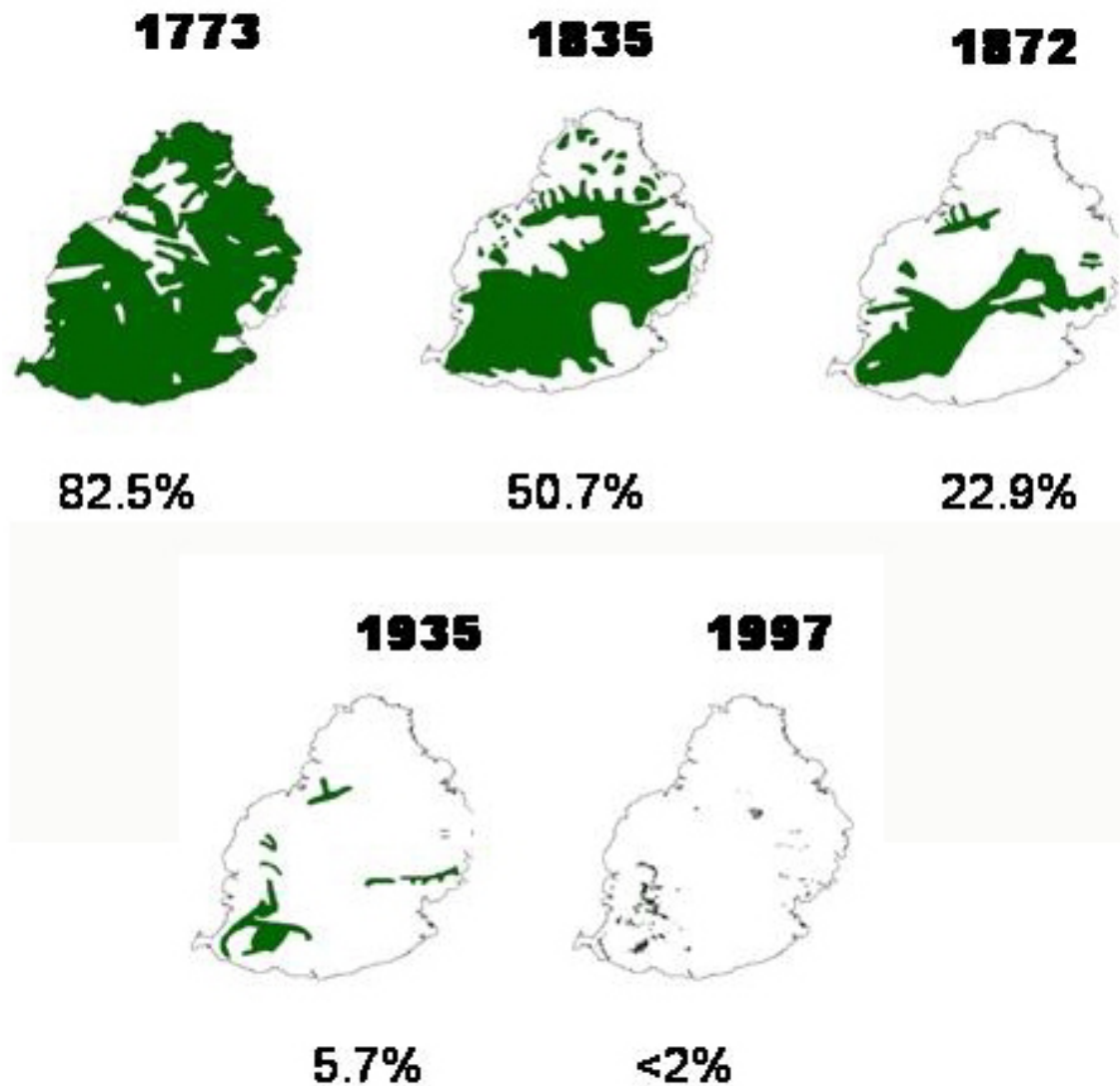
2.3 Causes of Biodiversity Loss

2.3.1 Loss of habitat

Forest clearance for agriculture and settlement began with the colonisation of the island in 1638 although selective logging for ebony (*Diospyros tessellaria*) started in 1598. Most of the forest cover had been lost by 1935, and the last major project of forest clearance occurred in the 1970s following a World Bank Funded scheme to replace native upland forest with plantation forestry based on pine (Figure 2.5). Despite these losses, habitat destruction and fragmentation continues to this day. There is a gradual conversion of forest to enlarge pasture areas for deer grazing. Development projects also

pose serious threats. A proposed road project that would have resulted in the loss of 9 ha of forest, the possible extinction of 2 species of plant and disturbance to one of the most important areas for the Mauritius kestrel (Ministry of Environment & NDU, 2004), was stopped recently after 1.5 years of pressure from conservation stakeholders and the general public.

Figure 2.5 Forest cover loss since colonisation (MWF unpublished)



2.3.2 Invasive alien species

Invasive alien species pose the most serious current threat to the remaining terrestrial biodiversity. At least 21 introduced species of mammal, reptile and mollusc are naturalised, more than 1,675 plant species have been introduced of which at least 20 plant species have been identified as particularly aggressive invaders (Mauremootoo *et al.*, 2003). Animals such as the rusa deer (*C. timorensis*), introduced in 1639, browse native shrubs, saplings and seedlings. Feral pigs (*Sus scrofa*), introduced in 1606, disturb the soil, disperse seeds of alien plants and have negative effects on native plant regeneration. Pig predation was also probably partly responsible for the extinction of several ground-nesting endemic species such as the dodo and the giant tortoises. They may also affect ground-dwelling invertebrates. Javanese macaques (*Macaca fascicularis*), introduced at the turn of the seventeenth century, damage unripe native fruits and eat the eggs and chicks of native birds (Carter and Bright, 2002). Rats (*Rattus rattus* and *R. norvegicus*), also predate on eggs and chicks (Safford and Jones 1998), reptiles and invertebrates and are notable seed predators (Cuddihy and Stone, 1990).

Predation by a range of alien species appears to pose a very serious threat to the survival of endemic snails, which are often taken by rats, toads and tenrecs (*Tenrec ecaudatus*) and the carnivorous rosy wolfsnail (*Euglandina rosea*) (Griffiths *et al.*, 1993).

A diverse suite of invasive alien weeds is threatening all the remaining native forests. The worst species include goyave de Chine (*Psidium cattleianum*) and privet (*Ligustrum robustum* subsp. *walkeri*). A recent arrival is liane cerf (*Hiptage benghalensis*), an aggressive invader of lowland dry forests. These species, and many more, out-compete native plants for space, light and nutrients and quickly come to dominate the forests throughout the island.

2.3.3 Hunting and harvesting

Direct exploitation of certain species has pushed them towards extinction. The Dutch colonised Mauritius for its ebony (*Diospyros tessellaria*), which was highly prized. Several other species were also exploited for their wood. Most species of Mauritian palms were exploited for their edible hearts and are all now highly threatened (Maunder *et al.*, 2002). The four endemic species of giant tortoise (two species each on Mauritius and Rodrigues) are all extinct having been exploited for their meat (Cheke, 1987a).

Direct exploitation of most native species has now largely ceased although certain plant species are still being taken from the wild for handicraft and medicinal purposes (Prosper, 1998), and endemic reptiles are occasionally caught for the international pet trade. Small quantities of endemic hardwoods are also still being exploited in certain areas.

2.3.4 Pests and Diseases

Very little information exists on the impact of insect pests and diseases on Mauritian biodiversity, but it is likely that their effect on ecosystem degradation has been under-estimated.

Insect introductions to Mauritius accelerated considerably in the late 20th century in line with increased international traffic (Williams and Ganeshan, 2001). Of the 22 significant pests to have entered Mauritius, fourteen arrived after 1975. No reliable information exists on the effect of such pest species on native biodiversity.

Pink pigeons (*Columba mayeri*) are known to be very prone to three serious pathogens: *Trichomonas*, a protozoan transmitted directly or via contaminated food or drinking water; *Leucocytozoon marchouxi* a protozoan transmitted by blackfly (Simuliids); and avian pox, a virus spread by contact, contaminated surfaces or insect vectors notably mosquitoes. Psittacine beak and feather disease is causing a problem for the recovery programme of the echo parakeet. It was first reported in 2004-2005, and has prevented intensive hand rearing for the 2005-2006 season.

2.4 Management of Biodiversity

2.4.1 Identification and monitoring (Article 7 CBD)

a) Identification.

Genetic level - There have been long-term studies at the genetic level of reptilian and avian species. Genetic studies of some native plant genera have also been carried out (*Coffea*, *Helichrysum*, *Psiadia*, *Gaertnera*, etc).

Species level - At the species level, some groups have been studied including angiosperms, ferns, terrestrial vertebrates and snails (Table 2.1). Forest surveys are

carried out regularly to help improve knowledge of the distribution of plant species, focusing in particular on locating individuals of critically rare plants. Several 'extinct' species have been rediscovered in the last decade, and the distribution of many species has been widened. The forest quality maps of Mauritius (Page & d'Argent, 1997) have been digitized, and GPS positions are collected for all rare plants.

The University of Mauritius has begun to study the micro fungi in native forest and has conducted a census of about 300 species, many of which are first records for Mauritius (pers. comm. R. Dullymamode).

A Darwin Initiative Grant (2003-2007) was awarded to the University of Plymouth and MWF to provide training to Mauritians in taxonomy and baseline research on insect species distribution and abundance.

Ecosystem level - Forest classifications were established by Vaughan & Wiehe (1937). Page & d'Argent (1997) classified forest quality and many studies have looked at the distribution of individual plant species (e.g. Strahm, 1994). Species distribution and composition of different associations are known by historical collections and by flora and fauna surveys over the last 30 years.

A detailed ecological survey has been carried out on Round Island every 7 years since 1975 (Bullock & North 1975, 1982; North & Bullock 1986, 1994).

b) Monitoring

A Darwin Initiative project grant to set up "An Information System for Biodiversity and Conservation Management in Mauritius" developed databases for threatened bird species and plant nursery management. Both are in use.

There is regular and detailed monitoring of four mainland bird species (Mauritius kestrel, Mauritius pink pigeon, Echo parakeet, Mauritius fody). Population estimates are carried out for four seabird species on Round Island. Five reptile species, three on Round Island and two on Flat Island, are also monitored to provide baseline information for future translocations.

All of the threatened plant species (c300) are monitored to some extent to aid in species recovery programmes. A database for threatened plants in line with IUCN criteria is being established.

Other species are monitored over the short term for higher degree projects (e.g Orange tailed skink (Ross, 2004), Telfair's skink (Pernetta, 2004).

Long-term monitoring systems have been put in place by the Ministry of Environment and NDU under the Environment Information System Project including monitoring the proportion of native species of birds and higher plants that are threatened.

2.4.2 In-situ conservation management (Article 8 CBD)

a) Mainland

In-situ conservation (or habitat restoration) involves control of invasive plants and animals. In the National Park, active management takes place in Conservation Management Areas (CMAs). These fenced and weeded plots of forest cover 39 hectares, five forest types, and range in size from 0.34 to 18 ha. The management involves the initial and maintenance weeding of invasive alien plants and fencing against deer and feral pigs. Where CMAs have been used for establishment of populations of pink pigeons and echo parakeets trapping of feral cats, mongooses and rats is also carried out. This network contains 57% of all native species (Strahm, 1992), but the small size of the protected areas may not allow the populations to be self-sustaining or representative. It is a recognized national policy that the area of forest being actively managed must be increased (NEAP, 1999; NSSSP, 2003-2007). This is being realized through establishment of new areas, and extension of existing CMAs. Three areas are already fenced (totaling 19 hectares), and one of these (4.9ha) will be weeded in 2005.

4.4ha of the Nature Reserve network is actively managed in a similar way to the CMAs. This area is spread over four reserves. The private nature reserve of Mondrain (5ha) is also under active management.

The weeding of two privately managed forests, each of 40 hectares has been started. These two areas are not fenced, and restoration involves the use of herbicides to control invasive plant species.

A programme of micromanagement has also begun in the National Park. Weeding is carried out around individuals of critically endangered plant species. The plants will be monitored to maximize seed collection for ex-situ species recovery.

b) Islets

Rats were removed from Ile aux Aigrettes, Flat Island, Pigeon Rock, Ilot Gabriel and Gunner's Quoin between 1995 & 1998 (Bell & Bell 1996, 1999).

Ile aux Aigrettes has now been to a large extent restored by the Mauritian Wildlife Foundation (MWF). Grants from the Global Environment Facility (1996-2000), enabled MWF to eradicate the rats and initiate full-scale restoration of the island's vegetation. A grant from the IUCN Sir Peter Scott Fund (2004-2005) is allowing the rest of the island to be weeded. Following this, only periodic maintenance weeding should be necessary.

Intense restoration of Round Island by MWF (in collaboration with the Government) with GEF funding began in 2000. The establishment of a field station on the island has allowed permanent presence, and active restoration to re-establish the palm-rich forest is taking place. Monitoring of birds and reptiles (the latter for future translocation projects) also takes place. There is a strict quarantine system to prevent rats, reptiles and weeds reaching the island.

NPCS has started some trials on Flat Island to establish methods for restoring this highly degraded island.

A 2001 Task Force on islets assessed the causes and extent of islet degradation and proposed remedial measures for their restoration and protection. An Islets National Park Strategic Plan has been produced for 16 islets of conservation importance (AGRER, 2004). Eight islets were proclaimed as Islet National Parks in 2004 (Section 2.1.4).

c) Alien species

UNDP/GEF-SGP funded the 'Development of predator-exclusion area for conservation of upland forest' (2001-2004), which involved the design and trial of a predator-exclusion fence by a consultant from New Zealand to determine if this technology could be of use in Mauritius. The grant also provided for the design of quarantine posters for the airport to inform people of the importance of not bringing invasive species into the country.

An Invasive Alien Species committee was created in 2003 in order to advise sectors on issues relating to invasive alien species. A grant of 1 million MRU has been allocated under the EIP2 to establish a national strategy and action plan on invasive alien species for Mauritius.

2.4.3 Ex-situ conservation (Article 9 CBD)

a) Propagation of endangered plant species ex-situ for reintroduction in-situ

Over 80% of the flowering plants of Mauritius are threatened, and 103 of these species are known from less than 50 individuals in the wild. To date, NPCS and Forestry Services have successfully propagated c40 of the species with less than 50 individuals in the wild.

There are five nurseries that only propagate native species (two Government, two for MWF, and one private). These nurseries concentrate on propagation of critically endangered species for species recovery programmes and also mass-produce native plants for restoration projects.

For many rare species, seed is not readily available and propagation involves techniques such as grafting and tissue culture.

In an attempt to save not only species but also the genetic diversity of the rarest plants species, a field gene bank has also been set up in the uplands in a collaborative project between the NPCS and the MWF. Targeting 20 species with less than 50 individuals in the wild, capturing all genetic diversity of these species by taking cuttings or seed from each known wild individual, and developing a duplicate collection. A field genebank for coastal plants is about to be established in Bras d'Eau Reserve.

The 'Mauritian Rare Fern project' in collaboration with the Royal Botanic Gardens (Edinburgh) has set up a fern propagation facility at the NPCS nursery. This includes a fern tunnel and a mist propagation unit. Some 50 species of ferns are being propagated at present.

Ex situ collections of Mauritian flora are held at Conservatoire de Brest (France), Royal Botanic Gardens, Kew (UK), and Edinburgh Botanic Gardens (UK).

b) Species recovery programmes for critically endangered bird species

Captive breeding programmes were established by the Durrell Wildlife Conservation Trust (Jersey) in 1976 to save the Mauritius pink pigeon, Mauritius kestrel and Echo parakeet from extinction. All three programmes have been successful, and populations of each of the three species have been re-established in the wild. In-situ management is still required for these species through provision of predator-proof nest boxes, predator control and supplementary feeding. This is carried out by MWF.

A population of the Mauritius fody, based on hand-reared birds, has also been established on the predator-free island of Ile aux Aigrettes.

2.4.4 Sustainable use of components of biological diversity (Article 10 CBD)

a) Biodiversity and tourism

The 2002 Tourism Development Plan considers biodiversity and tourism development through the protection of conservation areas, mountain areas, nature reserves and nature parks. The National Development Strategy (2003) also incorporates strategies to protect the natural environment. Tourism Action Area Plans, Tourism Zones and ‘campement’ sites have been earmarked so that development is confined to designated zones.

2.4.5 Research & training (Article 12 CBD)

a) Research

The University of Mauritius has carried out inventories of all medicinal plants through an Indian Ocean Commission Project (Inventory and Study of the Medicinal and Aromatic Plants of the States of the Indian Ocean). A computerized database on these plants now exists at the University.

The Mauritius Research Council (MRC) has funded several projects, submitted by the University of Mauritius. The aims are to validate traditional data and to test for the biological activity of indigenous/endemic plant extracts.

Biodiversity research by students for higher degrees is encouraged and supported. e.g. the effect of weeding IAS on native plant regeneration, the effect of introduced animals on native birds, detailed population and ecological studies of pink pigeons, Mauritius fody and Echo parakeet etc...

b) Training

The University of Mauritius degree in biology now incorporates four modules related to Ecology.

Five Mauritian students have received training at M.Sc. level in ecology and conservation in overseas Universities over the last 5 years.

Several PhD and Masters students are also being trained in the field of phytochemistry and ethnobotany at the University of Mauritius. Close collaboration

exists with many universities overseas and in the region.

2.4.6 Public education and awareness (Article 13 CBD)

Public education and awareness forms an integral part of the routine activities carried out by government and NGOs. Schools can request talks on forest biodiversity and guided tours of the forest. Plants are also available for an endemic corner in school grounds. Poster exhibitions, brochures, films and newspaper articles are produced regularly. A campaign of awareness against invasive species has been started with the launching of quarantine posters at the airport, and production of posters about IAS for schools. There are visitors' centres in the National Park, on Ile aux Aigrettes, at Mont Vert and at Bras d'Eau to inform the public about nature conservation.

Gurib-Fakim (2003, 2004 and 2005) has produced several T.V. programmes with the Mauritius College of the Air and books to address the issue of Public Education and awareness.

2.4.7 Impact assessment & minimizing adverse impacts (Article 14 CBD)

The Environment Protection Act (2002) specifies that an EIA is required for conversion of forest land to other land use and clearing and development in environmentally sensitive areas such as water catchments, mountain slopes, islets and wetlands.

National programmes and initiatives are usually set up, monitored and evaluated through national consultations and inter-ministerial committees where the relevant authorities and interested and affected stakeholders take care of the biodiversity issues. The policies are also usually mediated such that NGOs and the public can comment if the project is having adverse impacts on biodiversity.

2.4.8 Exchange of information (Article 17 CBD)

Mauritius received a grant in 1997 to develop a clearinghouse mechanism for biodiversity. The project is ongoing.

2.4.9 Financial resources (Article 20 CBD)

In addition to international and regional funds for biodiversity conservation, national funding mechanisms include:

- ☐ The National Parks and Conservation Fund, established under the Wildlife & National Park Act (1993). Contributions from exportation of monkeys, export and

import permits under CITES and native plant sales go into this fund for biodiversity conservation. Any project that falls under the remit of the Director of NPCS can receive funding. The projects can involve other stakeholders, but NPCS must be the lead agency.

- ☐ The National Environment Fund supports environmental projects and is accessible to any stakeholder.
- ☐ The Mauritius Research Council provides grants through five schemes on nine themes including biodiversity.

2.5 Legislation, policy and institutional framework

2.5.1 Legislation

Mauritius is signatory to 18 international treaties and conventions on the environment and was the first signatory country of the 1992 Rio Convention on Biodiversity. In addition, there are four national laws of relevance to terrestrial biodiversity conservation:

The Environment Protection Act (1999 and 2002)

This Act established the Ministry of Environment (MoE) as the body responsible for overall coordination of environmental management. Under the EPA five ministries are assigned the role of enforcement for implementation of environmental policies. The Act covers all aspects relating to EIA procedures.

The Forest and Reserves Act (1983, amended 2003)

This is the principal legislation governing the management of forests resources and designates the power to declare national forests, nature reserves, mountain reserves, river reserves and road reserves. Sixteen Nature Reserves have been selected (two of which now form part of the National Park, and 4 are in Rodrigues) for the purpose of maintaining vegetation cover and the provision of ecosystem services. The Act provides protection for designated areas of state land but is inadequate to safeguard against the loss of privately owned areas with rich biodiversity resources, as penalties are too weak to be an adequate deterrent.

The Wildlife and National Parks Act (1993)

This is the principal legislation for the protection of flora and fauna, with the Wildlife Regulations of 1998 giving effect to the CITES Convention in Mauritian law. In 1996, the National Parks and Reserves Regulations were made under the Act, laying down rules regarding activities on reserved land. The Act and its regulations are

currently being revised to make them fully compliant with the provisions of CITES. The opportunity is also being taken to increase legal protection of native biodiversity at national level.

The Plant Act (1976)

This Act is currently under revision to the Plant Protection Bill. A Black List of the worst invasive weeds to be prevented entry into Mauritius has been proposed to help protect native biodiversity.

2.5.2 Policy

Various documents lay down policy regarding conservation of terrestrial biodiversity including:

White Paper for a National Conservation Strategy (1985)

The NCS defines the major objectives for the conservation of natural resources but has been outdated and superseded by Mauritius' commitments under the CBD and the National Environmental Action Plan.

The National Environmental Action Plan for the next decade (1999)

The NEAP contains a programme on terrestrial biodiversity, with a strategic goal to 'ensure that native Mauritian biodiversity survives, flourishes and retains its genetic diversity and potential for evolutionary development'. The strategy focuses on rationalizing and strengthening the political, institutional, legislative and financial foundation by

- i) bringing management of all protected areas under the portfolio responsibility of NPCS;
- ii) increasing the capacity of NPCS to prioritise, plan, co-ordinate and report;
- iii) maximizing the role of NGOs to undertake specific projects;
- iv) increasing involvement of the private sector and the public in conservation activities; and
- v) identifying options to fund management activities.

National Development Strategy (2004)

The NDS includes the designation of a network of Environmentally Sensitive Areas to reinforce a 'general presumption' against development in these areas using the precautionary approach. The network includes coastal features, wetlands, mountain areas and other areas of high biodiversity (both private and state owned). A proposed network is given, although base line information is still being compiled (under EIP II projects).

The Non-Sugar Sector Strategic Plan (2003-2007)

The NSSSP is a sustained programme for agricultural diversification and includes the goal ‘to reverse the present tendency towards degradation of biodiversity, safeguard and manage in a sustainable manner the biotic wealth of the country, and arouse public awareness on the value and importance of biodiversity’.

Islets National Park Strategic Plan (2004)

The Plan covers 16 islets of conservation importance. Draft management plans for 9 of these islets were completed in 2004. The plans have been gazetted.

2.5.3 Institutional framework

The National Parks and Conservation Service (Ministry of Agro-Industry & Fisheries)

The NPCS is responsible for the Black River Gorges National Park, Islet National Parks and the Ramsar site at Terre Rouge. The Service was officially established on 9 May 1994 under Section 8 of the Wildlife and National Park Act 1993. The budget for 2005-2006 was 16.3 million rupees. It employs 86 staff and is headed by a Director who is responsible for monitoring all issues related to the conservation of terrestrial flora and fauna in Mauritius and provision of advice to the executive.

At present the NPCS has an equipped native plant propagation centre, a captive breeding centre, 4 field research stations, a shade house, information centres at Pétrin and Black River, a fernery and a green house at Curepipe. The Service runs various conservation programmes such as management of offshore islets, management of Conservation Management Areas, control of pests, management of wetlands and awareness raising.

Much of the active forest restoration and conservation is contracted out due to lack of staff. The National Parks and Conservation Fund (section 2.4.9) finances the work.

The Forestry Service (Ministry of Agro-Industry & Fisheries)

The Forestry Service, headed by the Conservator of Forests, has a staff of 1037 and a budget of 157 million MRU for 2005-2006. It is responsible for 15,300 ha of forest and an additional 1,938 ha of ‘native’ forest designated as mountain and river reserves for the protection of ecosystem services. The main activities of the Service are shifting

from timber production to soil, water and biodiversity protection. The Service is also responsible for 200 ha of Nature Reserves, although only 4.4 ha are actively managed. Some 25,000 indigenous plants, including several critically endangered native species, have been successfully propagated and reintroduced into Nature Reserves.

The Service also carries out awareness raising through a visitor centre, nature walks, school programmes and production of native plants for public places.

Ministry of Environment & National Development Unit

The Ministry of Environment is the national focal point for the CBD, UNCCD and UNFCCC. In practice CBD-related activities are implemented by the NPC. The vision of the MoE is to provide a better environment and quality of life for the present and future generations. The Ministry has sections specializing in information and education, pollution control, integrated coastal zone management, policy and planning, environmental law and environmental assessment. The National Environment Commission (chaired by the Prime Minister) functions to steer the work of the Ministry by setting national goals and objectives for the protection of the environment.

Mauritian Wildlife Foundation (NGO)

The largest terrestrial biodiversity NGO, it was created in 1984 to help save critically threatened birds from extinction. There are 54 full time Mauritian staff, 10 expatriates, and up to 16 volunteers. MWF is actively involved in islet restoration, ecotourism on Ile aux Aigrettes, species recovery management for rare birds, forest surveys, rare plant propagation, and public education and awareness. It also works with the private sector. The MWF has earned international renown for its pioneering work with endangered bird species.

Mauritius Herbarium (MSIRI).

Since 1960 the Mauritius Herbarium has been housed at the Mauritius Sugar Industry Research Institute and comprises some 25,000 sheet-mounted specimens and associated collections. It also houses a unique assemblage of publications, manuscripts, original sketches, paintings and maps. The Mauritius Herbarium is a regional herbarium dedicated to collection from the Mascarene Islands, and from islets including Agalega, St Brandon, the Chagos Archipelago and some other countries. The research for the publication of a modern regional flora, Flore des Mascareignes, is nearing completion with the main financial assistance from the European Union. The Mauritius Herbarium has a small living collection of native plants and also carries out research on ecology and conservation of native species. It has a staff of one technical officer and one technical

assistant

University of Mauritius.

Research is carried out through the University on ecological processes and the effectiveness of conservation management. The University also runs several courses containing modules on ecology and conservation at under and post-graduate levels. There is one lecturer specialising in terrestrial ecology. Modules like the Economic use of plants, biotechnology etc. are also being addressed.

2.6 Summary of gaps and existing needs

1. Limited area under protection and inadequate active conservation management of native ecosystems;
2. No strategy for invasive alien species (IAS) control;
3. Lack of training of Mauritians, limited human capacity at all levels;
4. Inadequate protection for biodiversity, especially on private land;
5. Incomplete inventory;
6. Habitat fragmentation;
7. Limited inter-institutional communication and collaboration;
8. Limited research or monitoring to support adaptive management;
9. Limited awareness of the population at large;
10. Limited development of conservation as a profitable venture;
11. Commitment to conservation not necessarily a priority for government.

Chapter 3. Freshwater, Coastal and Marine Biodiversity

3.1 Overview of the Freshwater, Coastal and Marine Biodiversity of Mauritius

The Republic of Mauritius has an Exclusive Economic Zone (EEZ) of 1.9 million km². The coastline of Mauritius is 322 km long and largely encircled by coral reefs that enclose a lagoon of 243 km² (MoE, 2005). The climate is subtropical with a cyclonic season that starts in November and ends in May. The wind predominates from the southeast and the water temperature of the ocean varies between 22 and 28°C. The tide variation is weak - about 0.7 m during the spring tide.

Mauritius is surrounded by 49 offshore islets and has two groups of outer islands, Agalega and St Brandon. Agalega consists of two sandy cays covering c21 km² surrounded by 100 km² of coral reef. St Brandon Shoals has 55 low-lying islets and sand cays covering c3 km² within a 100 km long coral reef system (Figure 3.1). Mauritius has an extremely rich coastal zone of wetlands and mangroves, lagoon coral and fringing coral reefs.

The freshwater biodiversity of Mauritius is contained within some 90 rivers and streams (Map of Mauritius and Rodrigues Y682 (DOS 529) of 1983), several man-made reservoirs, natural lakes and marshy areas.

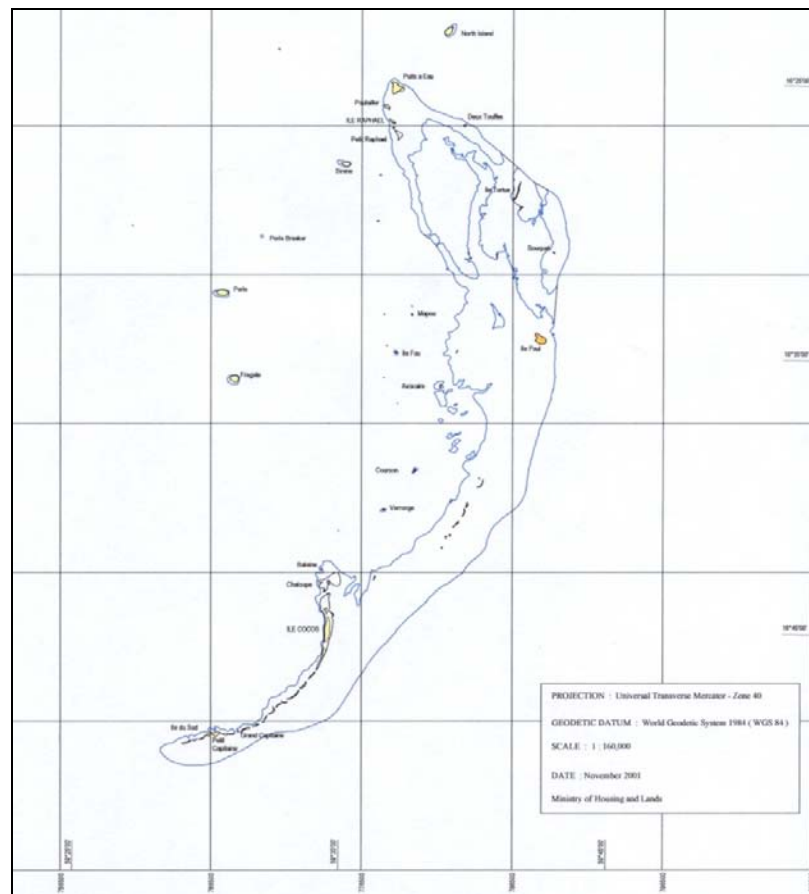


Figure 3.1 St Brandon Shoals

3.1.1 Fauna and Flora

Coastal & Marine

Mauritius has a diverse marine environment with five reef types: Fringing Reefs, Patch Reefs, Atolls, Reef flats and Barrier reefs. A total 159 species of scleractinian corals have so far been recorded (Pillay *et al.*, 2002). Out of 340 species of fish that have been identified (Terashima *et al.*, 2001), 42 within the lagoon area are of economic importance. Five species of Penaeid shrimps (*Penaeus monodon*, *P. latisulcatus*, *P. canaliculatus*, *P. indicus* and *Metapenaeus monoceros*) as well as two species found in deeper water have been identified. Other invertebrates include octopus, mussels, oysters (the endemic *Crassostrea cuculata*), barnacles and clams.

The effect of over-fishing of *Lethrinids* is apparent on the fringing reefs of Mauritius with a population explosion of sea urchins (*Diadema* and *Echinometra* spp). Several species of sea stars and echinoderms are reported in the Mauritian waters. The coral grazing Crown of Thorns Starfish (*Acanthaster planci*) is occasionally sighted on the fringing reefs.

Mauritius has a rich algal flora. Over 160 genera of marine algae have so far been identified from the coastal waters. Records on the marine flora date back to 1875 and the Mauritius Herbarium has a collection of more than three hundred marine algae.

Sea cows, once common in the lagoons of Mauritius are extinct, and marine turtles are rarely seen due intense hunting pressure. Turtles still use St Brandon Shoals and Agalega for nesting. Seventeen marine mammal species have been recorded in Mauritian waters – mostly during their migration to and Antarctica for calving. Some dolphins are resident in Mauritian waters.

Of the outer islets, the marine ecosystem around St. Brandon is still virtually ecologically intact with abundant large reef fish, corals and sea creatures. St. Brandon is an important seabird site with eight species breeding (Newlands, 1975). Seabird numbers appear to be in decline due to poaching and introduced rats. Nesting sea turtles though still common are in decline (Swinnerton *et al.*, 1996).

Wetlands

There are 44 recognised coastal wetlands in Mauritius (ICZM subcommittee unpublished report, 2005).

Two species of mangrove, *Rhizophora mucronata* and *Bruguiera gymnorrhiza*, grow around Mauritius. Over the years the extent of mangrove cover around the island has decreased significantly through cutting for firewood, construction and to enable boat passage. Recently large-scale replanting programmes have reversed this trend.

There are important mudflats for migratory birds at river estuaries. Around 1,200 birds of 16 species visit the most important wetland at Terre Rouge Estuary (RTREBS) each year. (Bird survey count 1997, NPCS unpublished).

Freshwater

The freshwater vertebrate fauna of Mauritius is low in diversity and endemism. A survey carried out using electro-fishing in eight of the major rivers found 18 species of fish, of which 5 are introduced and the rest native. The same survey found ten species of macrocrustaceans belonging to two families; the Atyidae (six *Caridina* spp. and one *Atyoida* sp.) and the Palaemonidae (two *Macrobrachium* spp. and one *Palaemon* sp.). Three of these species are endemic to Mauritius (ARDA, 2003). Of 18 freshwater and one brackish water snail recorded (Griffiths & Florens in prep), only 10 are native, and perhaps one of these endemic. There has been no systematic survey of freshwater macro-invertebrates in Mauritius.

3.1.2 Protected Areas

Marine Protected Areas

The Fisheries and Marine Resources Act 1998, enables the designation of Marine Parks, Fishing Reserves and Marine Reserves. Two marine parks at Blue Bay (353 ha) and Balaclava (485 ha) were proclaimed in 1997 as National Parks under section 11 (1) of the Wildlife and National Parks Act 1993. Both were declared Marine Protected Areas (MPAs) and designated as Marine Parks in June 2000 under the Fisheries and Marine Resources Act 1998. The Balaclava Marine Park is as yet unmanaged.

Six Fishing Reserves were also proclaimed in June 2000 to protect and conserve marine habitats that are nursery grounds for juvenile fish (Figure 3.2)

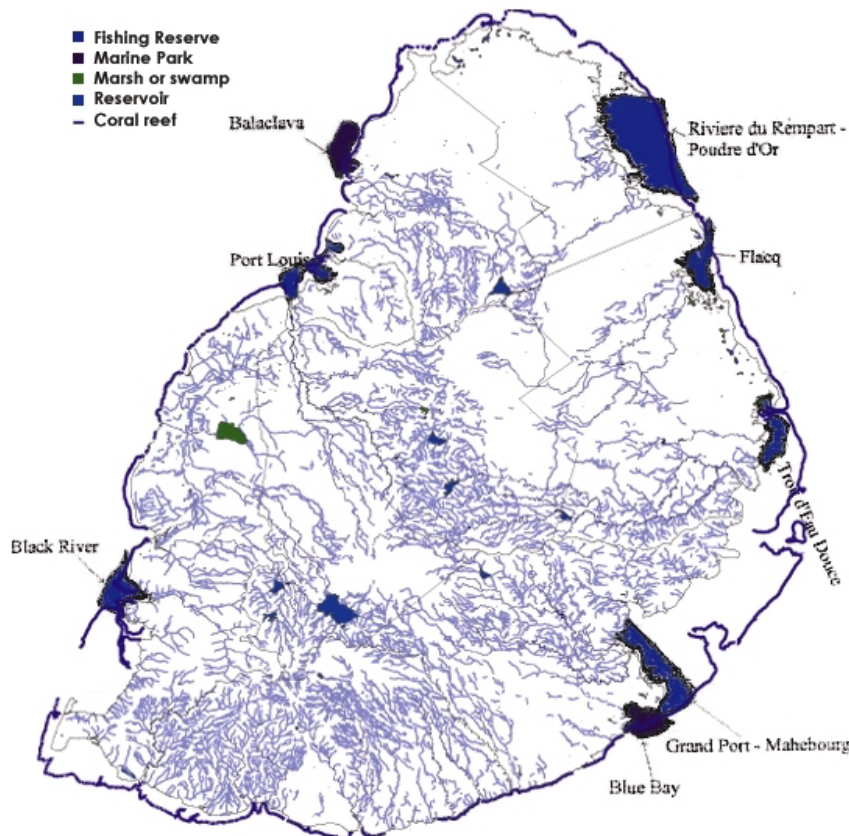


Fig. 3.2: Marine Protected Areas (Source: Fisheries Division).

Wetlands

The wetland at Rivulet Terre Rouge Estuary Bird Sanctuary (RTREBS) was declared a Ramsar Site in 2001. The wetland covers 26ha of mud flats and muddy sands. The estuary has abundant marine life, and forms a refuge and important feeding ground for migratory birds. Mare Sarcelles (20ha) at Bras D'Eau, has been declared a Reserve under the Wildlife and National Parks Act (1993).

Freshwater

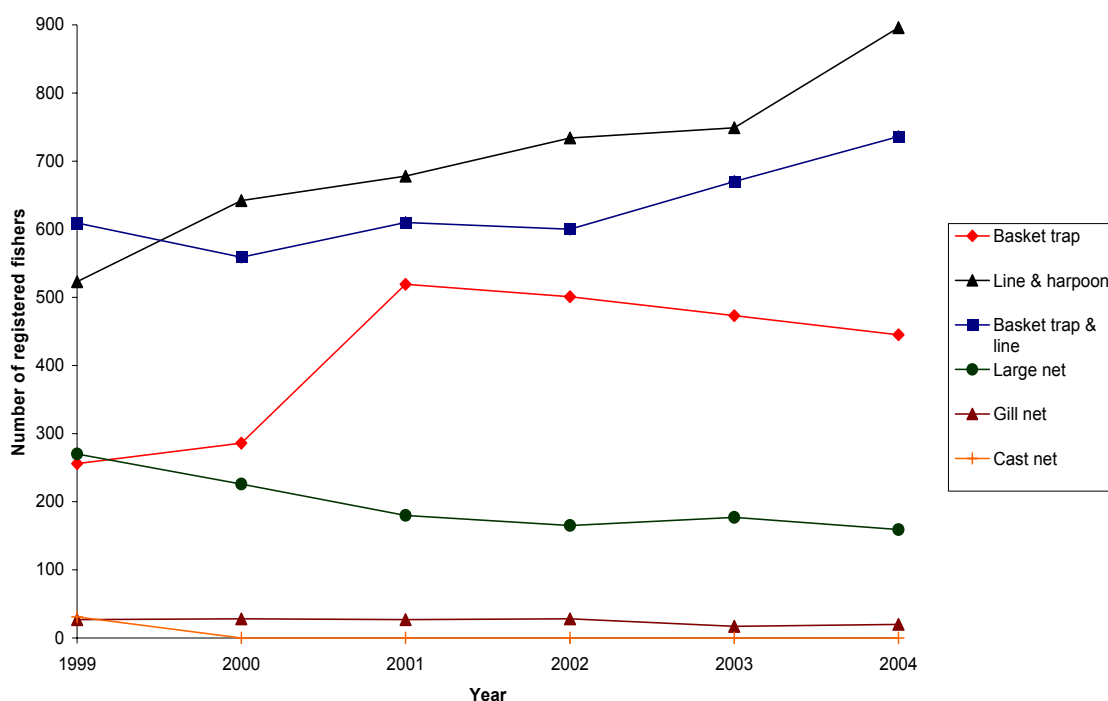
There are no areas of freshwater protected for biodiversity.

3.2 Use of Freshwater, Coastal and Marine Biodiversity

Coastal and Marine

Marine biodiversity is a valuable resource, generating income through tourism and fisheries, and is the focus of much of Mauritian leisure time. It is the source of direct and indirect employment for c45, 000 people (CSO, 2005). Lagoon fisheries account for 1% of GDP and provide a livelihood for 2,256 registered fishermen (Fisheries Division 2003) Fishing exports accounted for USD 139 million in 2003 (MoE & NDU, 2005).

Figure 3.3: Number of active fishermen by gear-type (Source: Fisheries Division)



Fishery resources are found in the lagoon and off-lagoon areas of Mauritius, Rodrigues, Agalega, St Brandon, the banks along the Mauritius-Seychelles ridge stretching from St Brandon to Saya de Malha, and the Chagos Archipelago, as well as in the open sea tuna fisheries. The total area of the fishery grounds is c52,000 km². The total fish production in fresh weight equivalent stood at 11,003 tonnes in 2004, compared to 12,116 tons in 1999 (Fisheries Division). The *per capita* consumption of fish in Mauritius is given in Table 3.1

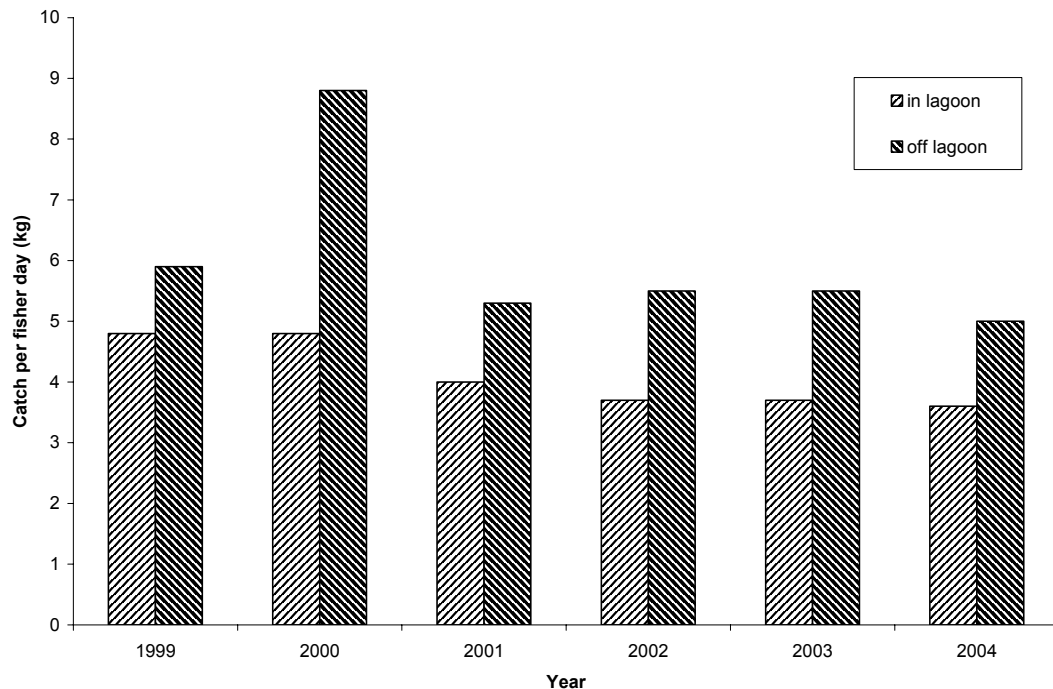
Table 3.1 Per capita consumption of fish (Fisheries Division)

Year	1999	2000	2001	2002	2003	2004
Quantity (kg)	20.6	23.3	19.9	20.0	18.7	19.8

There are five different classifications of fishery: artisanal, banks, pelagic, aquaculture and sport.

The Artisanal fishery includes in-lagoon and off-lagoon fishing for about 42 fish and 7 crustacean species. The catch from the artisanal fishery is marketed as fresh fish. The artisanal fishery of Agalega is exploited at a subsistence level. The Maximum Sustainable Yield (MSY) for the artisanal fishery has been estimated at 1,700 tonnes and the annual catch for 2004 was 1,043 tonnes (Fisheries Division).

Figure 3.4: Catch, fisher days and catch per fisher day in lagoon and off-lagoon (Source: Fisheries Division)



The Banks fishery is carried out in the shallow waters of the Saya de Malha, Nazareth, Albatross and Chagos banks. The catch is sold as frozen fish, with most fish coming from Saya de Malha (76%) and Nazareth (15%) (Table 3.2). About 90% of the catch consists of *Lethrinus* spp. such as Dame Berri, Caya and Capitaine (Fisheries Division). The annual catch for the year 2004 was 2,679 tonnes.

Table 3.2: Annual catch (tonnes) of frozen fish by bank (Source: Fisheries Division)

Year	No. of vessels	Saya de Malha	Nazareth	St. Brandon	Chagos	Albatross	Total catch
1999	13	2,107	1,121	341	127	226	3,922
2000	12	2,099	1,080	267	312	141	3,899
2001	11	1,283	1,366	332	228	202	3,411
2002	10	2,090	918	0	223	55	3,286
2003	9	2,354	468	0	235	37	3,094
2004	8	1,686	855	0	117	21	2,679

Table 3.3: Fishing effort and catch from the banks for 2004 (Fisheries Division)

Bank	Catch (t)	Fishing days	Bad weath er days	Effort (Fisher days)	Catch per fisher day (kg)	% Total catch
Saya de Malha	1,686	474	183	23,729	71	62.9
Nazareth	855	206	65	10,154	84.2	31.9
Chagos	117	34	26	1,761	66.4	4.4
Albatross	21	11	2	541	39.9	0.8
Total	2,679	725	276	36,185	74.0	100

The Pelagic Fishery consisting of tuna (*Thunnus* spp.), skip jack (*Katsuwonus pelamis*) and other species (including swordfish, bill fish and shark) is exploited on an industrial scale. This is the most abundant fishery source in the EEZ of Mauritius. Canned tuna corresponds to more than 90% of fish exports— in 2004 33,625 tonnes were exported, and 1,236 tonnes were sold locally (Fisheries Division, 2005).

A joint public-private sector initiative to develop Mauritius as a seafood hub has been initiated. The hub aims to be an efficient and attractive environment for the supply of value-adding processes and services. (Fisheries Division, 2005).

Aquaculture has a long history Mauritius. Fish, crabs and oysters (including introduced species) are collected and placed in coastal ponds enclosed by stone walls (barachois). Fingerlings are collected from the open sea and are released in the "barachois" for growing after which they are harvested. There are about 13 "barachois" in Mauritius. However, at present many are not in use.

A major private aquaculture project began in 2002, farming an introduced

species, red drum (*Sciaenops ocellatus*) in floating cages. In 2004, this enterprise produced 330.8 tonnes of fish for local consumption and export (Fisheries Division).

The Sports Fishery is an important tourism activity. Professional anglers come to Mauritius for blue and black marlins, sail fishes and pelagic tuna. It is estimated that the industry produces c650 tonnes of fish per year (Fisheries Division estimate, 1988).

Recreation

Foreign tourists and locals exploit the marine and coastal ecosystem for recreational purposes, with tourism being one of the most vibrant industries in the Mauritian economy (Table 3.4). Tourists enjoy the beaches, water sports, sport fishing, dolphin watching, snorkelling and diving. For example, in 2004 109,000 people visited the Blue Bay Marine Park (Fisheries Division). The success of the industry is directly linked to the quality of the lagoon, its biodiversity and ecosystem services. There are plans to develop the outer islets of Agalega and St Brandon for tourism (Ministry of Shipping, Rodrigues and Outer Islets, 2004).

Table 3.4: Number of tourists and money spent (Source: CSO, 2003)

Year	2000	2003	2004
Number of tourist arrivals	656,500	712,000	718,900
Tourist receipts (million Rupees)	14,234	19,415	23,448

Freshwater

Fishing for introduced species such as *Tilapia* is a popular activity, especially in the reservoirs. Fishing for camaron and chevrettes still occurs for local use, and has resulted in the rarity of this macro-crustacea. There is some freshwater aquaculture – 16 tonnes of the introduced *Macrobrachium rosenbergi* were produced in 2004.

The demand for water for agricultural and municipal use is high and places pressure on river systems. In addition to extraction, the rivers receive pollution from industry and agriculture (NEAP, 1999).

Waterfalls and several rivers are popular tourist attractions used for nature-based tours through canoe trips and abseiling down cliffs. Water-based ceremonies are an integral part of the Hindu religion and the riverbanks and lakes in many areas have been developed to allow ceremonies to take place.

3.3 Causes of biodiversity loss

Unsustainable use of resources

Lagoon fishing currently exceeds sustainable levels of exploitation (MoE & NDU, 2005) with the size of fish and the total catch decreasing despite increased effort. Anchors, traps and boat poles are damaging corals. Corals and shells are protected and their removal prohibited without permit. Local species are still found on the market however. Turtle hunting is prohibited by law (Fisheries and Marine Resources Act, 1998).

Development:

Land-based human activities, including construction, pollution from sewage and agriculture and unsustainable use of coastal resources are having considerable impacts on the coastal zone, especially in terms of lagoon water quality (NDS, 2003). Much of this is a result of pressure for tourism and residential development, particularly in the north of the island. At present the development of infrastructure associated with tourism is not well coordinated. Non-compliance with established guidelines also occurs. A review of the existing planning norms focusing on development density, height of complexes and compulsory architectural designs is considered a priority.

Environmentally sensitive areas are being degraded or lost mainly due to construction for housing or tourist accommodation. Areas of particular concern are wetlands, including marshes and mangroves. Most of the wetlands at Grand Baie, Pereybere, Baie du Tombeau, and Flic en Flac have been reclaimed for hotel and residential development. The Ministry of Environment estimates that 20% of wetlands have been filled in the northern tourist zone of Mauritius and 50% in Flic on Flac.

Beach erosion

Whilst some beach erosion is natural, it is exacerbated by hard structures on the beach, such as sea walls and recreation jetties, which restrict the natural movement of sand. Many of these structures do not conform to existing planning guidelines. For example, the appropriate setback for hard structures has varied between 15m (NPDP, 1994) and 30 metres (EPA 2002) from the high water mark. A 1997 MOE survey of public beaches identified seven critical sites of beach erosion covering 5,300 m. A further study was commissioned in 2002 on coastal erosion, and the final report was submitted in 2003 by Baird and Associates. Its recommendations are being implemented.

Sand mining

Though now banned the former practice of sand mining in the lagoon has had negative impacts on the marine environment through destruction of habitats and the siltation of corals. Sand mining has also been linked to coastal erosion.

Pollution

In many coastal locations and some established settlements such as Grand Baie, rapid development of housing and commerce has outstripped the rate at which local authorities have been able to provide environmental services and community facilities, especially sewage systems. For example effluent is released through four short sea outfalls directly into the sea in the Port Louis region.

Industrial effluents and agricultural run off are issues of concern, causing degradation of water quality that can lead to eutrophication and algal blooms. At some locations on the eastern coast, high nutrient levels, from heavy use of inorganic fertilisers, have resulted in the growth of the nuisance algae (*Ulva* sp.) that can cover inshore corals and be washed ashore causing odour and aesthetic problems.

It is likely that pollution is the major cause of biodiversity loss for freshwater systems. Agricultural chemicals and discharge from textile industries are two key sources of pollution. (Seelarbokus, 1990; Geddedu, 1998).

Invasive alien species

IAS threaten biodiversity in all the aquatic zones. Ballast water from ships is a potential source of invasive marine species, but otherwise little is known about the IAS situation in marine systems. Many introduced species have been recorded in freshwater systems, including the western mosquito fish (*Gambusia affinis*) renowned for its damaging effect on freshwater fauna, the Nile perch (*Tilapia* sp), and the golden apple snail (*Pomacea bridgesi*). The water hyacinth (*Eichornia crassipes*), and many other waterweeds are also present, and river banks tend to be highly invaded by alien species (Page & d'Argent 1997).

Shell extraction

While the extraction of shells and corals from the lagoon is illegal, the importation of shells and corals into Mauritius is permitted (32,570 units were imported in 2004 from Madagascar and Philippines). As a consequence it is likely that there is still a high incidence of illegal collection of corals from the lagoon in Mauritius. There is some local artisanal trade, although much of the jewellery is also imported.

Improper beach management

Proper beach management has not yet been optimised in Mauritius. The use of prime beach areas for parking, cooking and an increasing number of commercial activities, has deprived these zones of much of their appeal. The cleaning up of beaches and a move towards professional beach management is required.

Climate change

Climate change is a major concern to Mauritius as an island state. Coral bleaching was observed in late February 1998, which coincided with the abnormally high temperatures and heavy rainfall. Bleaching was studied within the Balaclava and Blue Bay Marine Parks and the results that 39% and 31% of the live corals had been affected in the two parks respectively. Mauritius suffered further sporadic bleaching in 2003 and 2004. Surveys at four sites recorded bleaching levels between 16 and 85%.

3.4 Management of Biodiversity

This section deals almost exclusively with coastal and marine (including wetland) biodiversity as there is no management of freshwater systems for biodiversity.

3.4.1. Identification and monitoring (Article 7 CBD)

a) Identification

Species level

The Marine Oceanography Institute (MOI) is developing a taxon-based biogeographic database of marine organisms of Mauritian maritime zone. It will store literature based on taxonomic and geographical data for species reported from Mauritian Waters. The end product will be made available online and on CD-ROM.

Ecosystem level

The Albion Fisheries Research Centre (AFRC) has recently prepared thematic maps of the coastal area around Mauritius and Rodrigues. These maps depict the different coastal habitat up to the reef and will be used for monitoring changes in the coastline and habitats.

A preliminary survey has been carried out to identify all the coastal wetlands of Mauritius (ICZM, MoE). NPCS is in the process of recruiting a consultancy team to carry out a comprehensive survey of all wetlands.

b) Monitoring

The AFRC monitors coral at 12 selected sites around Mauritius. Since the early nineties observations on coral spawning, growth and recruitment have been carried out between October and December.

A long-term monitoring programme has been established for the Blue-Bay and Balaclava Marine Parks. Data is collected on coral, benthos and fish populations. Physical, chemical and bacteriological properties of water are also monitored.

3.4.2 In-situ conservation management (Article 8 CBD)

a) Wetlands

A mangrove propagation programme was initiated in 1995. The public has been sensitised to the importance of mangroves and is being urged to protect them. To date 17 sites with a total area of about 12.8 ha have been re-established.

The Ministry of Environment commissioned a study in 2002 to advise and recommend remedial measures for the protection of the wetlands in the Grand Bay area. An Implementation Committee has been set up to follow up on the recommendations. The study has earmarked all the wetlands that need protection and actions are being initiated to declare these sites as reserves. NPCS, in collaboration with the Fisheries division, has submitted documents to Ramsar Bureau to proclaim a second site, Blue Bay Marine Park, as a Ramsar site. The NPCS is working to fulfill national obligations under the Ramsar Convention. A National Ramsar Committee has been formed and a wetlands bill drafted.

b) Invasive Alien Species

There is no active management against aquatic alien species although stakeholders from the aquatic sectors are represented on the National Invasive Alien Species Committee. A task force on the Monitoring of Ballast Water, consisting of representatives from various institutions, has been established. There is an urgent need to undertake a baseline survey to identify exotic marine species.

3.4.3 Sustainable use of components of biological diversity (Article 10 CBD)

a) Artisanal fishery

Since 1996 management measures have been taken to relieve the fishing pressure in the lagoon. These include:

- A buy-back policy for large nets and gill nets, and compensation of fishermen who relinquish their net licences.
- A closed season of five months for net fishing (October to February).
- A control on the number and type of nets in the fishery.
- A minimum size for harvest of oysters; crustaceans in the berried state are prohibited for capture.
- Placement of 21 Fish Aggregating Devices (FADs) 1.67-12.3 nautical miles outside the lagoon.
- Training of fishers in modern off-lagoon fishing techniques with a stipend of 250 rupees per day.
- Soft loan facilities for cooperatives to purchase equipment for off-lagoon fishing.

Efforts are being made to restock the lagoon with experimental seed productions for the mangrove crab (*Scylla serrata*), giant tiger prawn (*Penaeus monodon*), and the gueule pavée (*Rhabdosargus sarba*) while culture of berri rouge (*Oreochromis* sp.) and crayfish (*Cherax quadricarinatus*) are on-going.

b) Banks fishery

Statistics collected over the years indicate that fish size has decreased. Entry to the fishery has subsequently been limited with only nine vessels licensed to operate in 2003.

c) Pelagic fishery

Studies are being carried out in collaboration with IOTC to estimate the stock size.

d) Aquaculture

The Ministry of Fisheries five-year plan sets out to rehabilitate unused barachois for projects that combine fish farming with public leisure and eco-tourism.

e) Outer islets

The marine environment of the outer Islets of St. Brandon and Agalega is relatively undisturbed. The islands were once important nesting sites for the green turtle *Chelonia mydas* and the Hawksbill turtle, *Eretmochelys imbricata*. These species were declared protected in 1983.

- A project to place permanent mooring sites in the ocean to prevent anchor damage to coral reefs is carried out by the NGOs Reef Mauritius and the Mauritian Marine Conservation Society (MMCS).

3.4.4 Incentive measures (Article 11 CBD)

A bad weather allowance to registered fishers has proved controversial and is considered a perverse incentive by encouraging people to become registered fishers, and thus increasing the pressure on the lagoon fish stocks. Research and work is required to develop a structured system of incentives that foster the conservation and sustainable use of biodiversity.

3.4.5 Research & training (Article 12 CBD)

Coral reef monitoring

An IOC funded project (2003-2005) collected regional data on coral reefs. The programme included training of more than 25 people (from government and NGOs) in monitoring techniques, data processing and logistical support (including equipment and dive training). The data is used in the Global Coral Reef Monitoring Network.

Aquaculture

Research is being undertaken by AFRC for the development of aquaculture, especially seed and fingerling production of species used for restocking the lagoon.

Continental Shelf Project

The MOI has been entrusted with the task of formulating the claim for the extended continental shelf for Mauritius. This claim must be submitted to the UN Commission on Limits of the Continental Shelf by 2009.

Bioprospecting in Mauritian Waters

This project aims to assess the biological properties of certain classes of marine organisms.

3.4.6 Public education and awareness (Article 13 CBD)

Wetlands

NPCS celebrates the World Wetland Day every year in February with a series of activities to sensitise school children and the public on the importance of wetlands. An NGO was recently awarded a small grant from Ramsar to carry out a project related to public awareness and training of wetland leaders.

Fisheries

AFRC produces regular publications and there is an annual open day to the sensitise public on the fisheries sector. There are two dedicated education officers who give talks to visitors at AFRC and Blue Bay Marine Park and visit schools and hotels. There is also a sensitisation campaign for fishermen. Some NGOs are involved in awareness-raising activities e.g. CEDREFI carried out a 2 year project to sensitise villagers of the importance of a sustainable way of living; EcoSud carries out awareness raising in schools in the Mahebourg area; Reef Mauritius and MMCS produce posters, games and leaflets, and carry out sensitisation in key areas (e.g. dolphin watching at Tamarin).

3.4.7 Impact assessment & minimizing adverse impacts (Article 14 CBD)

Pollution

1.2-1.4 billion MRU have been invested since 2000 in a sewage masterplan. This includes wastewater projects, including tertiary level treatment, a long sea outfall and the cessation of use of the short outfalls at Pointe aux Sables and Bain des Dames.

Erosion

The Ministry of Environment commissioned a study in 2002 on coastal erosion around Mauritius. The final report was submitted in 2003 by Baird and Associates. A committee has been set up to implement the recommendations made by the consultants.

Public beaches

A Beach Authority has been established (2002) to provide for the management and control of the public beaches.

Development

The Ministry of Environment has commissioned a technical report for the preparation of a strategic EIA to identify potential sites for marinas, ski lanes and bathing areas. The final report is expected by the end of 2005.

3.4.8 Access to genetic resources (Article 15 CBD)

Any requests for material are sent to the Ministry of Fisheries. They must be fully justified and are sent to the Prime Minister's Office for approval.

3.4.9 Exchange of information (Article 17 CBD)

The Ministry of Fisheries has a detailed website which lists all publications. The Ministry also produces annual and research reports. Information on fisheries is used in the National Environment Indicator System.

3.4.10 Technical & scientific cooperation (Article 18 CBD)

The Ministry of Fisheries has received significant technical and scientific cooperation from the Government of Japan to finance the construction of facilities including: ARFC, a marine conservation centre, a fishing port at Trou Fanfaron and a marine shrimp culture station. Technical assistance and exchange programmes have been provided through the Japan International Cooperation Agency (JICA) and the Overseas Fisheries Cooperation Foundation has implemented an outer lagoon fisheries development programme. More recently, five experts have been attached to the AFRC for five years in a 'Coastal Fisheries Resources and Environment Conservation Project'. There is also an exchange programme with India to provide observers on vessels through the Indian Ocean Tuna Commission (IOTC).

3.4.11 Financial resources (Article 20 CBD)

A Marine Park Fund is being set up by the Ministry of Fisheries, which will consist of revenue from donations and permits. The money will be used for conservation within the Marine Parks.

The National Parks and Conservation Fund can also support biodiversity conservation projects relating to wetlands.

3.5 Legislation, Policy and Institutional Framework.

3.5.1 Legislation

Legislation is fragmented and dispersed across a number of different acts and regulations, with powers conferred to several ministerial portfolios resulting in an apparent lack of co-ordination and co-operation between them. The existing legislations are also inconsistent in several respects. Where possible legislation needs to be strengthened and harmonised in order to provide adequate protection. The main acts relevant to marine, coastal and freshwater biodiversity protection include:

Environment Protection Act (EPA), 2002

The Environment Protection Act (2002) specifies that an EIA is required for land clearing and development in environmentally sensitive areas such as water catchments, mountain slopes, islets, and wetlands.

The Act provides for the creation of an Integrated Coastal Zone Management Unit within the Ministry of Environment to coordinate the various actors. A multi-stakeholder ICZM Committee was set up in 2003. The Act vests powers in the Minister to make regulations for the prevention of pollution in the coastal and maritime zones, this mandate however is yet to be used to any substantial degree, and decisions for individual items are largely taken independently by the agencies concerned.

Mauritius Oceanography Institute Act, 1999

The Mauritius Oceanography Institute (MOI) was established under the MOI Act (Act No. 24 of 1999) to rationalise and co-ordinate research and development activities related to Oceanography. The MOI monitors the marine environment around Mauritius, Rodrigues and the Outer Islands, and advises the Government on appropriate policies and strategies for the management of resources under its jurisdiction.

Wildlife and National Parks Act 1993, the National Parks and Reserve Regulations of 1996, and the Wildlife Regulations of 1998

The Act specifies that camarons (*Macrobrachium lar*) less than 8.5cm and berried females cannot be caught or sold, and that camarons and shrimps cannot be fished for with explosives, poisons or using artificial light. It also specifies that unless the watercourse is on private land, a permit is required for fishing.

The Fisheries and Marine Resources Act 1998 & MPA regulations 2001

The Act provides for the management, conservation and protection of fisheries and marine resources, and the protection of marine ecosystems. In addition to providing for general enforcement and compliance measures, it also deals with protection of the aquatic ecosystem against pollution, exploitation of mangroves and construction activities. The Act also enables proclamation of marine protected areas in Mauritian

waters. The Regulations include specifying associated land areas for the MPA, setting up of an MPA Fund and conservation measures.

National Coast Guard Act, 1988

The National Coast Guard has the responsibility for enforcement of any law relating to the protection of maritime zones. In addition, they have the powers to prevent any activity which is likely to constitute a threat to maritime zones including pollution.

Maritime Zones Act, 1997 (amended 2005)

This provides for the Prime Minister to make regulations for the preservation and protection of the marine environment and the prevention and control of marine pollution.

Central Water Authority Act (1981)

This act, lays down the responsibilities of the CWA. These include the study and formulation of policy in relation to the control and use of water resources including the protection of wildlife, afforestation and control of soil erosion, disposal of industrial waste, abatement and prevention of water pollution. The CWA also has the power to stock rivers and watercourses with fish undertake measures for the prevention of diseases and discontinue supply of water of any consumer that discharges polluted water.

River, Reserves and Canals Act (1863)

This act specifies actions, buildings and livestock activities that are prohibited within a given distance from the water body as they can cause water pollution.

Public Health Act (1925)

This act empowers the authority to remove any nuisance that pollutes a water body.

3.5.2 Policy

The present institutional, policy and legislative framework for managing the coastal zone is fragmented. The 1991 *State of the Environment Report* recommended that the control, custody and management of a coastal zone should be vested in one authority. However, as yet there is no government body with overall responsibility for the coastal zone and many Ministries and organisations have inter-related responsibilities.

The main policies for controlling development of coastal zone are the NDS (2003) and NEAP (1999). According to the NDS, the coastal area is the most sensitive environmental area given its vulnerability to irreversible damage and the importance of this zone for the Mauritian economy.

An Integrated Coastal Zone Management Unit (ICZM unit) has been established under the EPA (2002) within the MoE. Its role is to develop appropriate policy and legislation for coastal resources and identify research priorities.

The tourism policy for the Government of Mauritius is to promote high class tourism, in line with a development strategy which is focused on quality at all operational levels. The *Vision 2020* tourism strategic plan anticipates a continued growth in net tourist receipts, although with a restriction on the extent of tourism development, and therefore on the numbers of arrivals. A ceiling of 700,000 visitors per year and 9,000

hotel rooms was proposed in the Tourism Carrying Capacity study commissioned by the Ministry of Tourism (KPMG, 1998). However this limit has been reached and the Government has already expressed its intention to further develop the industry in the near future. As a powerhouse of economic growth, tourism takes on an added dimension in the medium and long-term national policy and development framework of the island.

3.5.3 Institutional framework

The following governmental institutions are involved in coastal, marine and freshwater issues:

<i>Institution</i>	<i>Responsibility</i>
Department of Environment	EIA, environmental quality
Ministry of Agro-Industry & Fisheries	Fisheries and lagoon eco-system
Department of Local Government	Shore development, beaches
Ministry of Housing and Lands	Physical planning policy
Ministry of Land Transport, Shipping and Ports	Marine pollution from vessels
Mauritius Ports Authority	Port functions, shipping
Ministry of Tourism and Leisure	Coastal hotels and recreation
Prime Minister's Office	Meteorological services, National Coast guard/police
Beach Authority	Shore development and beach management
Central Water Authority, Ministry of Public Utilities	Freshwater distribution
Water Resources Unit, Ministry of Public Utilities	Assessment of freshwater resources
Waste Water Authority; Ministry of Public Utilities	Wastewater management
Outer Islands Development Corporation	Outer islands management

The Division of Fisheries is the enforcement agency for waters, under the Environment Protection Act (2002) and has two sections:

- *The Albion Fisheries Research Centre (AFRC)* has a staff of about 60. There are eight technical divisions: Coastal Zone Management, Marine Parks, Fisheries Management, Fisheries Planning, Marine Science, Fisheries Research, Aquaculture and Fisheries Training Extension and Development.
- *The Protection Service* is responsible for the enforcement of the Fisheries Act and regulations and has a staff of about 230. Protection personnel work with the National Coast Guard at sea to carry out enforcement.

Mauritius Oceanography Institute (MOI) and National Oceanographic Data Centre (NODC)

These agencies have an important role in managing data on the coastal zone. MOI carries out scientific research on oceanic processes and facilitates sustainable use of resources. It is the hub of regional collaboration and global cooperation for the Indian Ocean Studies, and the National Coordinating body for oceanographic activities in the country.

Non-Governmental Organisations

There are a large number of non-governmental organisations specifically focused on the coastal zone, many of which are associated with diving. The Mauritius Marine Conservation Society (MMCS), the Mauritius Scuba Diving Association (MSDA), the

Mauritius Underwater Group (MUG) and Reef Mauritius continue to sink ships to form artificial reefs, set up permanent mooring sites and have organised an underwater film festival to raise awareness of the value of the coastal zone. The NGO Grand Baie Watch works to improve the environment of the important tourist resort of Grand Baie.

3.6 Identification of Gaps and Existing Needs

Review of the existing documentation and consultations with stakeholders have identified a number of priority concerns. There is a need for holistic management of the coastal zone so as to optimise the balance of socioeconomic and environmental benefits. Key issues associated with the coastal zone include:

- Control of shoreline development
- Management of beaches
- Waste and pollution management
- Soil and agrochemical management
- Control of lagoon usage
- EIA as a tool for mitigating adverse effects of development
- Strengthening resource stewardship
- Protection of waters around offshore islets
- Increased monitoring of ecosystem health

Management is currently constrained by:

Lack of Data

Data are inadequate and difficult to access. There is a general lack of information on fresh water biodiversity. A comprehensive survey is required to enable the conservation and sustainable use of freshwater biodiversity.

There is inadequate information on marine resources in the EEZ and information on IAS is lacking.

Lack of Consistent Guidelines

Planning guidelines and procedures for the coastal zone do not successfully harmonise the built environment with the natural environment. In some cases existing guidelines are contradictory.

Public awareness and sensitization

Public education and sensitization of school children, local communities and decision makers needs to be an on-going process. Stakeholder interaction needs to be enhanced to enable their contribution towards biodiversity conservation.

Protected areas

The existing protected areas are not representative of marine habitats or large enough to enable sustainable use.

Ecotourism

The ecotourism component of the tourism sector remains small and under exploited. There is a need to further develop ecotourism as a means of advancing the conservation and sustainable use of biodiversity. A Code of Ethics and a National Environment Pledge should be elaborated and marketed for a countrywide adoption to ensure tourism developments are established and maintained sustainably.

Chapter 4. Agricultural Biodiversity, Biotechnology & Biosafety

4.1 Overview of the Agricultural Sector

Crops and animals have been introduced to Mauritius since the first settlements

in the seventeenth century. Many of the current crops grown and animals reared have thus formed the basis of agriculture for a long time and it is these varieties and breeds, which are seen as constituting the agricultural biodiversity of Mauritius. One species from the native flora is exploited (*Dictyosperma album*), and there are three members of one genus that has yielded economically important crops elsewhere (*Coffea* sp.).

It is still unknown how many local cultivars and varieties of crops, fruit, vegetables and breeds of livestock there are in Mauritius. Today's agriculture depends increasingly on new introduced varieties of crops to increase yields per unit area and quality of produce (e.g. the Crop Research Department of AREU introduced 325 varieties of 22 crops in 2004 (AREU 2005)). Consequently local types and related traditional knowledge are being lost. Crop conservation relies on efficient and well-maintained seed and genebank programmes.

Up until the 1970's the Mauritian economy was predominantly agricultural and based on sugar cane production. Since the 1980's there has been an increase in industrialization and economic diversification. The agricultural sector's contribution to GDP has declined from 23% in 1970 to 6.2% in 2004 with sugar cane, tea and tobacco contributing 66% of this total, food crops 20%, and livestock and poultry 10% (Central Statistical Office 2004).

46% of the island is under agricultural cultivation, of which 82% is sugar cane (CSO 2004). Mauritius is normally self-sufficient in vegetables but not fruit (NDS 2003), and imports some potatoes, onions, garlic and maize and all of its wheat and rice (NSSSP 2003). There is some export of tropical fruits, notably litchis and pineapples. Mauritius is self-sufficient in chicken meat and eggs although 80% of the ingredients for feed is imported. Most other meat is imported -for example 90% of beef and 40% of goat meat consumed comes from abroad (Mauritius Meat Authority, 2003).

4.2 Plant genetic resources

Sugar cane

The cultivated *Saccharum* species, *S. officinarum*, *S. sinense*, *S. barberi*, and the wild *Saccharum* species *S. spontaneum*, *S. robustum* as well as associated genera, *Erianthus*, *Miscanthus*, *Narenga*, *Sclerostachya* constitute the basic genetic resources of sugar cane. The history of the introduction of sugar cane dates back to the colonisation of Mauritius, but it was during British rule that many varieties were introduced and later there were more systematic introductions by the Chamber of Agriculture (Ramdoyal & Domaingue, 1995). The varietal situation witnessed a major change towards the turn of the twentieth century and the advent of interspecific hybridization. When the Agricultural Department was established in 1913, variety introduction from abroad was further promoted. The Sugar Research Station established in 1930 continued to introduce commercial hybrids and wild species and to carry out breeding activities. With the creation of the Mauritius Sugar Industry Research Institute (MSIRI) in 1953, breeding work was intensified and a dynamic varietal exchange policy was maintained. New varieties are regularly developed to meet the requirements of the sugar industry.

Maize

Maize (*Zea mays*) was an economically important crop at the beginning of the

French colonization in the 18th century. There were subsequent periodic introductions from several sources including America, Europe and Africa. Introductions were restricted when quarantine laws were enacted in 1940, and it was then that farmers started selecting on the basis of their own taste and requirements. By saving seeds from one generation to the next, farmers created a number of ecotypes suited to their production systems. The preference for these ecotypes was more accentuated in Rodrigues, where farmers continue to cultivate modern versions in the form of composites. In Mauritius maize is no longer grown to a significant extent.

Vegetables

The number of local crop varieties, races and cultivars is still unknown. Local varieties of 35 crop species are still used regularly (PRDO, Div. Horticulture 2005). These include 'local red' bean, 'yard long' asparagus bean (*Vigna unguiculata* cv *sesquipedalis*), local red onion (*Allium* spp.), tomato 'var. quatre carres'; groundnut 'var. cabri'; garlic 'var. local'; cucumber 'var. local white', local cauliflower and pumpkin 'var. local'.

Other crops (root, tuber and fruit)

Many old cultivars of cassava (*Manihot esculenta*) and sweet potato (*Ipomoea batatas*) still exist as they were important staple foods as recently as the Second World War.

The pineapple (*Ananas comosus*) is an important export commodity. 437 tonnes were exported in 2003, with a value of MRU15.9 million. Litchi (*Litchi chinensis*) was introduced in the early 19th century from China, and has been grown extensively for local consumption and as a commercial crop. 150 tonnes of litchi were exported in 2004, mostly to Europe (223 tonnes were exported in 2005). There are three cultivars in Mauritius, one of which constitutes 98% of the commercial business. Between 1989 and 1992 eleven new varieties were introduced to develop high yielding varieties. Many of the 62 mango cultivars (*Mangifera indica*) are grown extensively for local consumption. There are 18 cultivars of banana (*Musa* sp.) and many local varieties of citrus.

In addition some species that yield fruit or vegetables are grown in backyards e.g. *Ziziphus mauritiana* (maçon or Indian jujube), *Elaeocarpus serratus* (Ceylon olive or sweet olive), *Artocarpus heterophyllus* (jack fruit) *Artocarpus altilis* (bread fruit). Others have become naturalised or even invasive in Mauritius including *Psidium cattleianum* (goyave de chine) and *Syzygium jambos* (jamrosa).

Wild relatives of food crops

The native flora contains one species that is exploited (*Dictyosperma album*) and three members of one genus (*Coffea* spp.) that has yielded economically important crops elsewhere. Two of these *Coffea* species (*Coffea macrocarpa* and *C. myrtifolia*) are endemic to Mauritius, while the third, *C. mauritiana*, is also found in Réunion. These species are known to be naturally caffeine-free and could thus be of great importance in developing low caffeine cultivars (Dulloo, 1998).

The endemic palmiste blanc (*Dictyosperma album* var. *album*) is cultivated in plantations on marginal lands for its palm cabbage. This local trade is estimated to be worth 20 million rupees (Govinden, 2004). In the past the cabbages were exported, but

the trade has stopped as local demand from hotels and restaurants is greater than the supply.

Although they are not native, several wild relatives of important crops have become naturalised in Mauritius. These include tomato (*Lycopersicon esculentum* var *tallerelli*), pigeon pea (*Cajanus cajan*), potato (*Solanum commersoni*), *Solanum torvum* (white flowers) and *Solanum indicum* (violet flowers).

An interesting species, lentille créole (*Vigna glabreus*), is believed to be unique. It was found in the Pamplémousses Garden and is extensively used in the development of fusarium-wilt resistant beans. Seeds are stored in the *Vigna* collection at Gembloux, Université Agricole, Belgium.

Mauritius has a lot of lesser known and under-utilized crops to which value needs to be added and their utilization encouraged (Gurib-Fakim, 2005).

Forestry

Commercial forestry relies on introduced tree species. This is dealt with in the section on terrestrial and forest biodiversity.

Medicinal plants

These are discussed in the section on terrestrial and forest biodiversity.

4.3 Animal genetic resources

All farm animal genetic resources were introduced to Mauritius during the period of colonisation. The 'local' breeds found in Mauritius originate from these introductions. However indiscriminate crossing of exotic breeds with local breeds has led to the genetic erosion of this resource.

Cattle

The Creole breed of cattle is a medium sized cow, characterized by its white colour, an absence of hump and lack of horns. The breed originated from Northern Europe and most probably came through France if not from France. According to Bennie (1956), it is possible that this breed was introduced in the eighteenth century while the first introductions of cattle date back to 1511. New germplasm in the form of live animals has been introduced over time, namely the Jersey, Friesian, Sahiwal, Ongole, Boran and Brahman breeds. Presently artificial insemination is carried out using imported semen from the Friesian breed. In 2001 there were 8,690 cattle in Mauritius, of which 273 were the Creole breed. (AREU 2003)

Goats

There were some 21,450 goats in Mauritius in 2001 (AREU, 2003), the majority belonging to the local breed – the Barbari. This is a mixture of different breeds that were introduced over time. As recently as 1980's and 1990's several breeds such as the Jamna Pari, the Anglo-Nubian and the Boer were imported to try and boost the goat sector. These introductions have not been successful although the Boer still exists in its pure state due to its recent introduction.

Sheep

The local breed has been heavily diluted by introductions of breeds such as the Dorper, Black Head Persian, Romanov, Vendeen, Causse du Lot and the Blanc du Massif Central.

Pigs

In 2001 there were some 12,100 pigs (AREU, 2003) comprising Large White and landrace breeds. A few farmers still possess the local breed - the mongoose pig- although exotic breeds have almost completely displaced it due to their higher productivity.

Poultry

The local chicken still exists in rural areas. The commercial production of poultry meat and eggs relies on imported breeds suited for intensive production.

Ducks

Manille and Peking ducks are still found in rural areas.

Apiculture

In 2000 Mauritius produced 35 tonnes of honey and imported 103 tonnes (NSSP, 2003).

4.4 Ex-situ conservation

4.4.1 Plant genetic resources

Separate *ex situ* programmes exist for the different agricultural crops.

Sugar cane

The MSIRI holds a collection of clones, which have either directly or indirectly contributed to produce varieties that increase productivity. Details of this collection are shown in Table 4.1. It should be noted that these clones are conserved exclusively by vegetative means.

Maize: MSIRI used to hold forty-one accessions of ecotypes (2001). These were transferred to PGR Unit at Curepipe which now holds twenty-eight accessions in the seed bank.

Vegetables: Seeds have been collected and stored in a seed genebank since 1985 through collaboration between the MoA and IPGRI, and latterly the SPGRC. To date there are 381 accessions in the collection (pers comm. PRDO Horticulture, 2005), stored at Curepipe with a replicate collection at the SPGRC, Zambia (Table 4.2). This compares to 220 accessions in 1985. Characterisation and multiplication of these accessions has yet to begin.

Table 4.1: Status of *Saccharum* germplasm and allied genera in the MSIRI collection
(Source: K. Ramdoyal, 2005)

Species	Number of accessions
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<i>S.officinarum</i>	151
<i>S.spontaneum</i> ¹	30
<i>S.robustum</i>	9
<i>S.sinense</i>	6
<i>S.barberi</i>	1
<i>Eranthus</i> sect <i>Ripidium</i>	21
<i>Saccharum</i> hybrids ²	429
<i>Erianthus</i> hybrids	3
<i>Miscanthus</i> hybrids	2
Commercial hybrids	
Mauritian	800
Foreign	710
Others ³	38
TOTAL	2200

¹ An additional 40 clones are available in quarantine; ² Early generation nobilisation, F1, BC1, BC2; ³ Advanced generation backcrosses

Table 4.2: List of Accessions at the Seed Gene Bank, Curepipe

Scientific name	Common name	No. of Accessions (2005)
<i>Abelmoschus esculentus</i>	Okra	28
<i>Allium cepa</i>	Onion	18
<i>Amaranthus</i> spp.	Greens	8
<i>Anettum spp</i>	Annett (wild)	1
<i>Arachis hypogea</i>	Ground nut	6
<i>Benincasa hispida</i>	Wax gourd	1
<i>Brassica oleracea</i>	Cabbage	2
<i>Brassica oleracea</i> var. <i>oleracea</i>	Cauliflower	9
<i>Brassica</i> spp.	Greens	10
<i>Cajanus cajan</i>	Pigeon Pea	2
<i>Capsicum</i> spp	Chilli pepper	39
<i>Carica papaya</i>	Pawpaw	2
<i>Cavanalia gladiata</i>	Sword bean	1
<i>Citrillus lanatus</i>	Watermelon	7
<i>Coriandrum sativum</i>	Coriander	3
<i>Cucumis melo</i>	Melon	1
<i>Cucumis sativus</i>	Cucumber	23
<i>Cucurbita maxima</i>	Butternut	1
<i>Cucurbita maxima</i>	Pumpkin	11
<i>Cucurbita pepo</i> var 3	Squash	1
<i>Daucus carota</i>	Carrot	3
<i>Glycine max</i>	Soya bean	3
<i>Lablab purpureas</i>	Hyacinth bean	1
<i>Lactuca sativa</i>	Lettuce	7
<i>Lagenaria siceraria</i>	Bottle gourd	18

<i>Luffa acutangula</i>	Ridge gourd	11
<i>Lycopersicum esculentum</i>	Tomato	23
<i>Momordica charantia</i>	Bitter gourd	6
<i>Morinda citrifolia</i>	Noni	2
<i>Moringa oleifera</i>	Drum stick	1
<i>Nicotiana tabaccum</i>	Tobacco	3
<i>Petroelinum crispum</i>	Parsley	2
<i>Phaseolus spp</i>	Beans	34
<i>Pisum sativum</i>	Pea	1
<i>Raphanus sativus</i>	Radish	5
<i>Ricinus communis</i>	Castor (wild)	2
<i>Solanum nigrum</i>	Nightshade	5
<i>Solanum spp.</i>	Aubergine	33
<i>Tetragonia tetragonioides</i>	Spinach	1
<i>Tricosanthes cucumerina</i>	Snakegourd	4
<i>Vicia faba</i>	Faba bean	1
<i>Vigna mungo</i>	Mung bean	5
<i>Vigna unguiculata</i>	Cowpea	7
<i>Zea mays</i>	Maize	28
<i>Ipomoea obscura</i>	Liane lastic	1
TOTAL		381

Other crops - Roots, tubers and fruits:

Roots, tubers and fruits are kept in field genebanks. The PGR unit (Division of Horticulture) has two ex-situ field genebanks, one in the dry zone (Roches Brunes) and one in the humid zone (Nouvelle Decouverte), There is also a collection at AREU. For several crops, such as mango, all of the old varieties are represented in the collection, for some the collection is still being established, and for one species (cassava) the collection set up containing 18 local varieties has been lost, and is being rebuilt. The *ex situ* coffee collection has also been removed. The accessions at these stations are given in Table 4.3

Table 4.3: List of Accessions of roots, tubers and fruit. (updated 2005 Horticulture Division and AREU)

Scientific Name	Common Name	Location of collection	Number of Accessions in 2005 (in
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			brackets 1995)
<i>Allium cepa</i>	Chives	Nouvelle Decouverte PGRC	1
<i>Allium sativum</i>	Garlic	AREU	31
		Nouvelle Decouverte PGRC	37
<i>Amorphophallus campanulatus</i>	elephant yam	Nouvelle Decouverte PGRC	2
<i>Ananas comosus</i>	Pineapple	AREU	5 (3)
<i>Ananas bracteatus</i>	wild pineapple	Nouvelle Decouverte PGRC	1
<i>Bactris gasipaes</i>	peach palm	Nouvelle Decouverte PGRC	1*
		Curepipe E.S	1
		Richelieu E.S	1*
<i>Canna edulis</i>	arrow root	Nouvelle Decouverte PGRC	1
<i>Colosia esculenta</i>	songe	AREU	5
<i>Colocasia esculenta</i> var. <i>antiquorum</i>	Taro(arouille cari)	Nouvelle Decouverte PGRC	1
<i>Colocasia esculenta</i> var. <i>antiquorum</i>		AREU	3
<i>Colocasia esculenta</i> var. <i>esculenta</i>	Taro(arouille violette)	Nouvelle Decouverte PGRC	1
<i>Colocasia esculenta</i> var. <i>esculenta</i>		AREU	2
<i>Curcuma amada</i>	mango ginger	Nouvelle Decouverte PGRC	1
<i>Dioscorea</i> spp.	Igname	Nouvelle Decouverte PGRC	3
<i>Fragaria ananassa</i>	Strawberry	Nouvelle Decouverte PGRC	3
		AREU	6
<i>Ipomea batatas</i>	sweet potato	Nouvelle Decouverte PGRC	58*
		AREU	6 (39)
<i>Litchi chinensis</i>	Litchi	AREU	14 (3)
<i>Mangifera indica</i>	Mango	AREU	40 (62)
<i>Manihot esculenta</i>	Cassava	Nouvelle Decouverte PGRC	4
		AREU	3 (18)
<i>Musa</i> sp.	Banana	AREU	40(8)
Palm		AREU	10
		Nouvelle Decouverte PGRC	17
<i>Psidium guajava</i>	Guava	AREU	6
<i>Sechium edule</i>	chou chou	Nouvelle Decouverte PGRC	3
<i>Zingiber officinale</i>	ginger	AREU	2
		Nouvelle Decouverte PGRC	2
		corn flour	Nouvelle Decouverte PGRC
<i>Cocos nucifera</i>	Coconut	AREU	2
<i>Coffea</i> sp.	Coffee	AREU	0 (13)

* Accessions contain duplicates

4.4.2 Animal genetic resources:

Under a project funded by SADC 'Management of farm animal genetic resources in the SADC region (1999-2003) a census of cattle, goats, pigs and sheep was carried out. However, the local breed was only considered separately for cattle. The survey recorded 273 créole cows (AREU 2003).

The only germplasm conservation that is carried out for animals has been the creation of a nucleus of Creole cattle at Curepipe Livestock Research Station.

4.5 Sustainable farming practises

Market gardening in Mauritius is heavily dependent on pesticides and fertilisers. Sugar-cane production relies on integrated pest management for pest control, but requires intensive use of fertilizers (500-700 kg per hectare). In 2004 Mauritius used 61,000 tonnes of fertiliser (Central Statistical Office, 2004).

Potential negative environmental impacts of the sustained use of agrochemicals include water pollution, loss of freshwater biological diversity, declining soil fertility and falling crop yields. At present little is known about the link between the concentration of agrochemicals in hydrological, estuarine and marine environments and on-going agricultural practices (CBD First National Report, 2000). There is also little awareness or monitoring of the impact on the health of employees and the general public (ERM, 1999; NDS 2003). Strict controls over the use of these chemicals near sensitive areas (residential areas, schools etc) should be established. (NDS, 2003).

Projects aimed at developing a more environmentally sustainable agriculture include:

Organic farming

At present organic farming is not carried out commercially and a regulatory framework pertaining to organic farming needs to be developed in order to meet stringent regulations. Research is being carried out by both AREU and the Agricultural Services (MoA) on the applicability of organic farming to a wide range of cultivated crops. Two recent experiments with cauliflower and cucumber indicate that both crops produce good yields using compost and organic pesticides (Agronomy Division, Agricultural Services 2005).

The trial production of organic sugar by three sugar estates for a niche market in Europe amounted to 649 tonnes in 1995. By 2003 only 50 tonnes were exported, and production has now stopped.

Organic fertilizer by composting

With the support of the University of Mauritius (UoM), and the UNDP GEF-SGP, an aggressive campaign of composting was launched following the successful implementation of a pilot/ demonstration compost plant in Belle Mare. Means to convert municipal waste into organic materials are also being explored – a tender has been launched to carry out a feasibility study for a National Composting Plant (Ministry of Local Government 2005).

Biological control - Several trials of biological control are ongoing. These include:

- ☐ Cyprus aphids (*Cinera cupressivora*) using the parasite *Panesia juniperorum* imported from the Kenya Forest Research Institute.
- ☐ *Aleurodicus dispersus* (spiraling white fly), first recorded in Mauritius in July 2000 and a source of severe problems on ornamentals and fruit trees. A predator *Nephaspis bicolor*, from the Republic of Trinidad and Tobago has been released

in both Mauritius and Rodrigues to control the insect.

- ☐ The rhinoceros beetle (*Oryctes rhinoceros*) using the virus *Baculovirus oryctes*. The virus has become firmly established since 1970 and keeps the insect in check.

Fruit flies pose an economic problem for fruit production. Bait Application Techniques (BAT) and Male Annihilation Technique (MAT) have been adopted to control fruit flies. A sterile insect technique is also used for the control of both fruit flies and melon flies. The success of these projects is not known.

4.6 Traditional knowledge, access and benefit sharing

With the increased use of modern agriculture and adoption of novel improved varieties, traditional genetic resources are in rapid decline along with the associated traditional knowledge. Traditional knowledge represents centuries of accumulated experiences and skills of farmers who often sustained yields under adverse farming conditions. This knowledge is as important to conserve as the varieties themselves.

So far no inventory of traditional knowledge within the farming community has been documented and immediate steps should be initiated to gather and preserve traditional knowledge before it is lost forever.

4.7 Ongoing strategies and activities towards conserving agricultural diversity

Ongoing activities in this sector include:

- ☐ Monitoring of viability of accessions in the crop seed gene bank.
- ☐ Establishment of field gene banks for fruit species and tuber crops.
- ☐ Maintenance, management and evaluation of sugar cane accessions in the field;
- ☐ Collaboration and training through SADC Plant Genetic Resources Centre. To date 3 Mauritians have received funding for M.Sc. programme, 11 have received a certificate in Plant Genetic Resources.
- ☐ SADC project for the management of farm animal genetic resources.
- ☐ Characterisation of Creole cattle and creation of a nucleus population at Curepipe.
- ☐ Compilation of literature review on Farm Animal Genetic Resources in Mauritius.
- ☐ Characterization of the local goats.

4.8 Biotechnology in Mauritius

Biotechnology has many traditional applications in agriculture and has been applied in Mauritius for a number of years in the processing of dairy products, in brewing and in the transformation of sugarcane co-products for the production of alcohol and animal feed. The application of modern biotechnological tools began to take on importance in the late 1980s in the agricultural sector.

The application of biotechnology to crop breeding is being increasingly emphasized. For apart from sugarcane, where genome mapping, marker-assisted selection and genetic transformation are being developed, it is expected that in the next

decade biotechnology will be integrated into the classical plant breeding programme to enhance the production of new cultivars. The introduction of new traits, for disease and drought resistance, for nitrogen fixing, and for the production of bioplastics in sugarcane are being contemplated. These techniques may also be applied to other crops such as potato for the production of pest and virus resistant clones.

In the last decade Mauritius has become more involved in new biotechnologies and now has several institutions devoted to agricultural research. The leading institute is the MSIRI, with trained scientists and specialised laboratories. Since the early 1990s it has focused on three main research areas - marker-assisted selection, molecular diagnostic tools and genetic engineering for improving sugarcane cultivars with new traits. The University of Mauritius has a Research and Development (R&D) programme in biotechnology and provides training in this field to undergraduate and postgraduate students. There is a strong government will to promote biotechnology. In the Non-Sugar Sector Strategic Plan (2003-2007), the government proposed to set up a National Biotechnology Institute at the cost of MRU 360 Million. A Memorandum of Understanding in Biotechnology was signed between India and Mauritius in 2002 to allow exchange of personnel between the two countries.

Research in biotechnology in the non-sugar sector is predominantly Government funded. Sugarcane biotechnology is mainly financed by a cess (or tax) on sugar produced. International funding by the European Union (EU) has partly contributed to the setting up of the FARC tissue culture laboratory, but inadequate funding is a major constraint towards the progress of many of the existing laboratories. In 1997 the overall funds allocated to biotechnology in the country was estimated to be less than MRU 12 million.

Most of the research activities in biotechnology have been in the agricultural sector with a comprehensive programme in the sugar sector, which includes projects in plant tissue culture, molecular diagnostics, genetic transformation, and molecular mapping for breeding purposes.

Tissue culture

Plant tissue culture is of particular interest because it requires low biotechnological techniques. In 2004, six plant tissue culture laboratories were operational on the island. Some of the laboratories carry out multiplication of imported starter cultures using commercial protocols, while others are involved in all steps required for propagating tissue cultured plants. Plants propagated include ornamentals (orchids, anthurium, carnation, syngonium, caladium, gerbera, chrysanthemum, begonia, roses), fruits (banana, pineapple, strawberry), vegetable crops (asparagus, potato, ginger) and sugarcane varieties.

The laboratories have a potential *in vitro* annual production capacity of over 1.5 million plantlets. *In vitro* culture is also being used to eliminate diseases from sugarcane cultivars infected with pathogens of viral and bacterial origin (Parmessur *et al.*, 2002).

Diagnostics

For the diagnosis of plant, animal and human diseases, molecular techniques

based on serological tests using monoclonal and recombinant antibodies, and nucleic acid sequence-based techniques, are being applied. These new techniques provide a higher sensitivity, specificity and accuracy and thus enhance diagnosis of diseases. These techniques are also proving to be useful for the study of genetic variability amongst strains of pathogens present in Mauritius. In the veterinary sector, a small volume of vaccines against Newcastle disease and Fowl pox are produced using imported seed vaccines.

Genome mapping

Molecular techniques are being applied to plant breeding as an aid to conventional methods. Research in molecular mapping and genetic transformation was initiated in 1994 to improve the sugarcane crop. A molecular genetic map for a local commercial sugarcane cultivar has been produced using AFLP and microsatellite markers and markers linked to the yellow spot disease resistance gene have been identified (Aljanabi *et al.*, 2005). The aim is also to identify molecular markers for resistance to yellow spot and leaf scald diseases, sucrose content and other agronomic traits.

Collaborative links of the MSIRI to various foreign institutions as a member of the International Consortium for Sugarcane Biotechnology (ICSB), has allowed the Mauritian sugar industry to benefit from the results of several biotechnology projects being undertaken in well-known research centres abroad.

Genetic transformation

Research in the field of genetic transformation was initiated in Mauritius in 1995. In May 1999, the MSIRI produced its first transgenic sugarcane plants. Scientists at the MSIRI introduced the *bar* gene that confers resistance to the herbicide Basta® into the embryogenic callus of two commercial sugar cane varieties. The transgenic plants have been multiplied *in vitro* for further testing, and evaluated under glasshouse conditions. Field-testing will only be carried out after appropriate legislation governing biosafety is enacted.

Environmental management

The use of biotechnology for the treatment of wastewater is being investigated at the University of Mauritius.

4.9 Legislation, policy and institutional framework

4.9.1 Legislation:

The Genetically Modified Organisms Act (2004)

This law provides for measures ‘to regulate the responsible planning, development, use, marketing and application of genetically modified organisms’ in the food and agricultural sector. It also ensures that all activities involving the use of GMOs and products thereof are carried out in such a way to limit damage to the environment and risk to human health. Only part of this Act has been enacted, namely entry, transit and labelling of GMOs.

A National Biosafety Committee has been set up under the Act to advise on all aspects concerning the importation, exportation, transit, development, research, production and use of GMOs.

The Environment Protection Act (2002)

Part A of the First Schedule of the Act stipulates that the development, production, release, use, marketing and application of GMOs warrant an EIA Licence.

The Plant Genetic Resources and Plant Breeder's Right Bill (in development)

The object of this bill is to provide for the protection of plant breeder's rights on new varieties.

Memorandum of Agreement for the supply of biological material

A Memorandum of Agreement for the supply of biological material by the Government of Mauritius is in place. This agreement is in accord with the CBD and specifies that the property remains with Mauritius and that use is for non-commercial purposes only. A new agreement must be signed for commercial use, specifying that any benefits will be shared with the Government of Mauritius.

4.9.2 Policy

- ☐ The Non-Sugar Sector Strategic Plan (2003-2007) – a sustained programme for agricultural diversification includes a policy on plant genetic resources. The policy includes establishing a legal and institutional framework to address Plant Genetic Resources and GMOs, consolidation of germplasm collections by increasing facilities and training staff, promotion of long-term conservation of PGR, establishment of an information system, evaluation of genetic drift in local varieties, and development of relevant research programmes.
- ☐ National Biosafety Framework (1999) An Institutional Biosafety Committee was constituted at the MSIRI in 1996 to review all projects regarding GM technology. In 1999, with the assistance of UNEP/GEF, National Biosafety Guidelines for the 'Safe Development and Introduction of Genetically Modified Organisms in Mauritius' were prepared (Dookun *et al.*, 1999).

4.9.3 Institutional framework

Some of the institutions that are actively involved with Agricultural Biodiversity at the national level are:

- ☐ PGR Unit of the MoA (*ex situ* conservation of food crop, fruit, root and tuber genetic resources);
- ☐ Mauritius Sugar Industry Research Institute (Conservation and utilization of sugar cane and potato);
- ☐ University of Mauritius provides training in biodiversity and sustainable agriculture for students studying Agriculture at degree level. There is also a crop museum which is maintained at the University farm;
- ☐ Agricultural Services including the Veterinary Service, Animal Production Division of the MoA;

- ☐ Agricultural Research and Extension Unit (AREU);
- ☐ Mauritius Chamber of Agriculture (MCA);
- ☐ Farmers Service Centre;
- ☐ Food and Agricultural Research Council (FARC).

Research in biotechnology is carried out in several centres in Mauritius namely:

- ☐ Agricultural Services - Ministry of Agriculture, Food Technology & Natural Resources
- ☐ Food and Agricultural Research Council (FARC)
- ☐ Agricultural Research and Extension Unit (AREU)
- ☐ University of Mauritius
- ☐ Mauritius Sugar Industry Research Institute (MSIRI)
- ☐ Private firms

The Faculty of Agriculture at the University of Mauritius has run B.Sc. (Hons.) Food & Agricultural Biotechnology in the past and at present is running a B.Sc. (Hons.) in Agricultural Biotechnology (24 students in 2005) and M.Sc. in Plant Biotechnology (10 students in 2005). Other biotech related programmes at the University include M.Sc. in Bioinformatics and a M.Sc. in cell & molecular biology. There is also a Certificate/Diploma in Biotechnology for Small and Medium Enterprises, and a number of MPhil/PhD students working on Biotech projects. Recently 2 PhDs and 1 MPhil in Plant Biotechnology have been awarded, and there are at present 7 students doing their MPhil/PhD in Plant Biotechnology at the Faculty of Agriculture.

4.10 Identification of Gaps and Existing Needs

The consultations undertaken for the NBSAP have revealed a number of shortcomings, gaps and issues:

Institutional framework and integrated policy

At present there is no coordination body for activities in the agricultural biodiversity sector and genetic resources available in the country. The inadequate coordination of activities can lead to inefficient use of resources, duplication of work, and restricted information flow among others.

Biological data

Data on farm animal genetic resources has yet to be collected. In the crops sector data on ecotypes of varieties of crops and under-utilised species is not available. The lack of basic biological data will hinder the formulation of conservation policies.

Conservation activities

The MSIRI has an on-going programme for the exchange, conservation, evaluation, characterisation and utilisation of sugar cane germplasm for breeding purposes. For other crops, the characterisation of accessions in the genebank, the regeneration and multiplication of accessions, the management of genebank accessions, and the establishment of field genebank are not being undertaken due to lack of equipment, shortage of land and facilities available to the PGR Unit. In the livestock sector, there have not been any conservation activities except for the fact that a nucleus of Creole cattle is being kept at Curepipe Livestock Research Station (AREU) since

2000.

Shortage of personnel in specialized fields

Many activities concerning agricultural biodiversity are very specific and therefore require trained personnel to tackle specific duties. At present such personnel are limited.

Public awareness and sensitisation

Conservation and utilisation programmes require the cooperation and support of the public but activities on public awareness are practically non-existent in this sector. In particular there has been little public education and consultation with regard to the handling, transfer and use of GMOs.

Legal framework

Complete enactment of the bills in progress needs to be carried out, as well as development of new bills in line with international obligations.

In order to develop a CBD-compliant discipline of biotechnology several constraints need to be overcome.

Lack of appropriate and modern laboratories

A number of institutions do not have adequate infrastructures to carry out high-tech biotechnology projects.

Poor development of biosafety guidelines

Biosafety standards and procedures as identified in the National Biosafety Guidelines must be implemented in the various institutions. So far only one institution, the MSIRI, has prepared its Institutional Biosafety Guidelines and set up its Institutional Biosafety Committee to review all projects in relation to the development of Genetically Modified Organisms (GMOs).

Trained personnel

There is a need for more qualified personnel in biotechnology as it is a specialized field. The National Biotechnology Committee has already identified training as a major issue towards the development and implementation of biotechnology projects in the country.