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Chapter 2

MANGROVE CONSERVATION IN TRINIDAD AND TOBAGO, WEST INDIES

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ABSTRACT

Located at the southernmost end of the Caribbean island chain on the continental shelf of South America, Trinidad and Tobago are continental islands (4,828 km^2 and 300 km^2 in area respectively), which were separated from the South American mainland in recent historical times. As a consequence, their flora and fauna are relicts of the South American biota, with minor variation, and are rich in biodiversity. Trinidad and Tobago's mangroves fall within the Amazon-Orinoco-Maranhão mangrove complex in the Orinoco bioregion. Mangrove forests are found on all coasts of Trinidad particularly the Atlantic and Gulf and Paria coasts, while in Tobago, mangroves are mainly concentrated in the southwest end of the island. Current estimates of mangrove coverage are 91.46 km^2 in Trinidad and 2.23 km^2 in Tobago. Estuarine mangroves are the dominant type, but there also are lagoonal and coastal fringe.

Mangrove forests in Trinidad and Tobago have been negatively impacted by land conversion to accommodate population growth, thereby increasing urbanization, industrialization and tourism in coastal areas, and the associated catchments. The remaining systems are threatened by proposed coastal development, pollution from land–based sources and coastal erosion. They are also projected to be adversely affected by sea-level rise especially where they are constrained on the landward side by built development or where they are starved of sediment. Attempts have been made to protect certain mangrove forests by gazetting parts of the Prohibited Areas and Wildlife Sanctuaries through national legislation. Subsequently, Trinidad and Tobago acceded to the RAMSAR Convention in 1993, and three sites were designated Wetlands of International Importance (Ramsar Sites). In 2001, a National Policy and Programmes on Wetlands Conservation for Trinidad and Tobago was adopted which includes the concept of "no net loss of wetlands and values and functions on publicly owned lands and

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waters". But has the rate of mangrove loss decreased or has ecosystem health improved through these interventions? This chapter assesses the effectiveness of these and other conservation strategies by examining both 'protected forests' in Caroni and Nariva (Trinidad) and the Bon Accord Lagoon (Tobago) and 'non-protected forests' in Godineau, Point Lisas and Los Blanquizales (Trinidad) and Kilgwyn (Tobago). Based on the assessment, this chapter provides recommendations of cost effective management interventions on mangrove conservation

Keywords: Mangrove forest, conservation strategies, management intervention, protected areas

INTRODUCTION

Mangroves are not a single genetic group but represent genetic adaptation of a large variety of plant families to a particular environment [1, 2]. Most of the true mangrove species occur in the Indo-Pacific region where plants are believed to have acquired the mangrove habitat and evolved the physiological and morphological adaptations to brackish water about 100 to 80 million years ago [3]. Through radiate dispersal during the Pliocene Epoch, mangroves were dispersed throughout most of the tropics. Mangroves crossed through the still open Atlantic Ocean to the Caribbean by the early Eocene (55-50 million years) also jumping the then flooded Panama isthmus to the Pacific coast of the Americas [3]. From the original Indo-Pacific pool, eight species belonging to five genera presently constitute the mangrove flora in the Caribbean. They are *Rhizophora mangle* (L.), *R. racemosa* (G.F.W. Meyer), *R. harrisonii* (Leechman), *Avicennia germinans* (L.) Stearn, *A. schaueriana* (Stapf & Leechman), *Laguncularia racemosa* (L.) Gaernt, *Conocarpus erectus* and *Acrostichum aureum* (L.) [4].

Mangrove coverage in the Insular Caribbean was estimated at about 785 km^2 [4], and although there have been attempts to protect these forests by implementing coastal management and planning programs, and declaring some of them Wetlands of International Importance under the Ramsar Convention, there is still a net loss [4,5]. Impacts include:- landfill and solid waste dumping; vegetation clearing for timber and/or charcoal production; reclamation for agriculture, marina, hotels and harbours; hydrological alteration, particularly by roadways, or flood diversion schemes; and pollution by factory and domestic effluent.

Global climate change and attendant sea level rise is expected to exacerbate loss and degradation of mangrove forests and loss or decline of their associated species [6]. The Caribbean has experienced an average mean relative sea-level rise of 1 mm $year^{-1}$ during the 20^{th} century, although there is extensive local variation. Sea-level is projected to rise between 0.18 – 0.59 m by 2099 [7]. Small island developing states have limited capacity to adapt to relative sea level rise, including accommodating landward migration of mangroves and other coastal ecosystems. This is a result of their small land mass, high population densities and growth rates, poorly developed infrastructure, and susceptibility to damage from natural disasters [8].

Loss of these ecosystems translates to degradation and loss of their ecosystem services, consequently jeopardising the potential health and well-being of individuals and local communities [6]. Reduced mangrove area will result in increase damage to shorelines from

coastal hazards such as erosion, flooding, and storm waves and surges thereby increasing threat to human safety. It will diminish coastal water quality, reduce biodiversity, eliminate fish and crustacean nursery habitat and adversely affect adjacent coastal habitats [9, 10, 11]. Furthermore, mangrove destruction can release large quantities of stored carbon and exacerbate global warming trends [12, 13, 14].

TRINIDAD AND TOBAGO

The Republic of Trinidad and Tobago is an archipelagic state situated in the southernmost end of the Caribbean island chain between 10° 02'-10° 50'N latitude and 60° 55'-61° 56'W longitude (Figure 1). It comprises two main islands and many small peripheral/outer islands that together encompass 5,128 km^2. Trinidad, which is the oldest settled island in the anglophone Caribbean, lies on the South American continental shelf and once formed part of South America. Its vegetation is similar to that of northeastern South America. Tobago was formed by obduction at the edge of this shelf [15]. Its flora has an Antillean influence but is more closely related to that of South America [16]. The country is less exposed to tropical storms and hurricanes than most of the other Caribbean nations because of its southerly location, and has a tropical climate with two distinct seasons [17]. The marine ecosystems of the twin-island states are influenced by discharge from South American Rivers, mainly the Orinoco River.

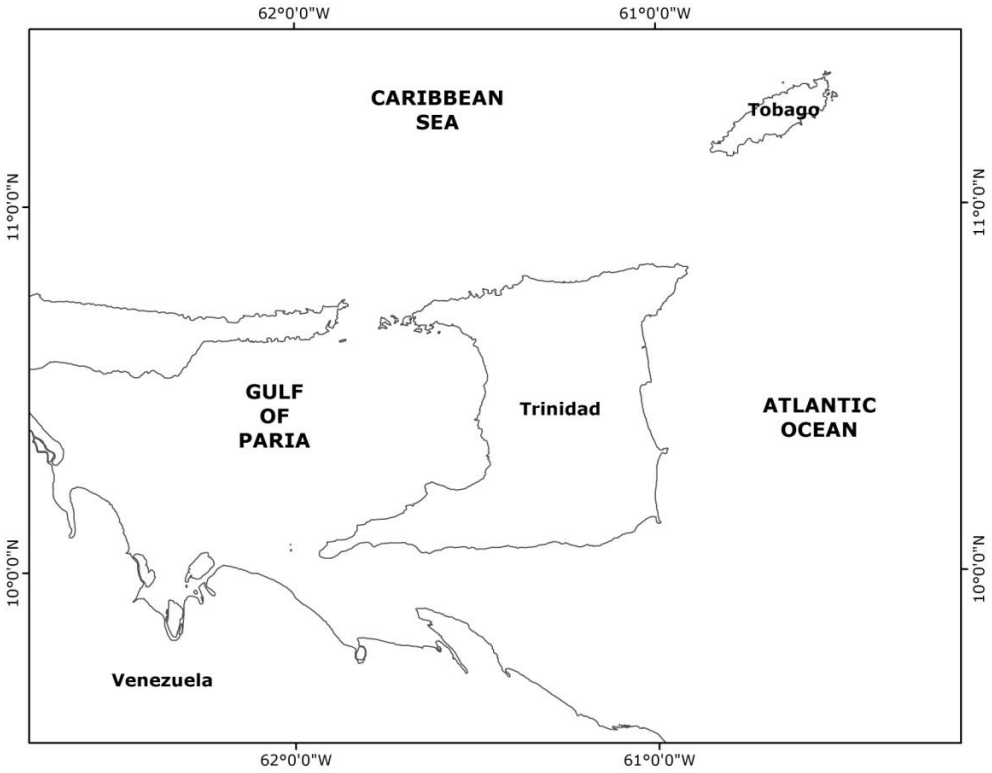

Figure 1. Location of Trinidad and Tobago.

Mangrove forests in Trinidad and Tobago fall within the Amazon-Orinoco-Maranhão mangrove complex in the Orinoco bioregion [18]. They are found on all coasts of Trinidad particularly the Atlantic, Gulf and Paria coasts, while in Tobago, mangroves are mainly concentrated in the southwest end of the island.

Current estimates of mangrove coverage are 91.46 km^2 in Trinidad and 2.23 km^2 in Tobago. All eight mangrove species recorded in the Caribbean are found in Trinidad, while four species (*R. mangle, A. germinans, L. racemosa and C. erectus*) are found in Tobago. Mangrove forests have been identified and classified according to six community types based on forest appearance, geological nature and flow of water through the system [19]. In Trinidad and Tobago, the mangrove forests are generally riverine/ estuarine, fringe or basin systems [20].

The citizens of Trinidad and Tobago have always depended on the marine and coastal environment for economic, social, nutritional and cultural well-being. Approximately 70% of the population and 80% of economic activities are concentrated along the coast and the economy is supported by activities in the coastal and marine environment ranging from oil and gas to fisheries to tourism. Most of the country's current and proposed developments are situated along the coast, which puts pressure on the already degraded ecosystems caused by land-based pollution, land-use changes, habitat loss, coastal erosion and over-exploitation.

Major alterations to mangrove forests in Trinidad were recorded as far back as 1787, when a major river through the city of Port of Spain was diverted and mangroves were reclaimed for the city's expansion [21]. Since then mangrove forests have been reclaimed for the construction of roads, sewage ponds, landfills, for agriculture and to provide land for high density housing, recreational and port facilities. In 1979, 5 km^2 ha of mangroves were reclaimed for the construction of the Point Lisas Industrial Park and deep-water port. In Tobago, mangroves were reclaimed to facilitate government buildings, hotel development and for the expansion of the international airport.

Management of mangrove forests in Trinidad and Tobago falls under the ambit of the Forestry Division and there have been some interventions by the State to arrest degradation and decline. Parts of wetlands were declared Prohibited Areas and Wildlife Sanctuaries under the Forests Act Chap 66:01 of 1915.

In 1993, Trinidad and Tobago acceded to the International Convention on Wetlands (Ramsar Convention) whereby Nariva Swamp was designated a Wetlands of International Importance. Caroni Swamp and Buccoo Reef / Bon Accord Lagoon were later designated Ramsar Sites in 2005. In addition, in 2001, a National Policy and Programmes on Wetland Conservation for Trinidad and Tobago was adopted which includes the concept of "no net loss of wetlands and values and functions on publicly owned lands and waters".

Although the government has signalled its intention to conserve wetlands through its policies, the question remains as to whether the strategies used have been effective. This chapter assesses the effectiveness of these conservation strategies by examining the state of mangrove communities in both 'protected forests' in Caroni and Nariva in Trinidad and the Bon Accord Lagoon in Tobago; and 'non-protected forests' in Godineau, Point Lisas and Los Blanquizales (Trinidad) and Kilgwyn (Tobago) (Figures 2a and 2b). Based on the assessment, recommendations are provided for cost effective management interventions.

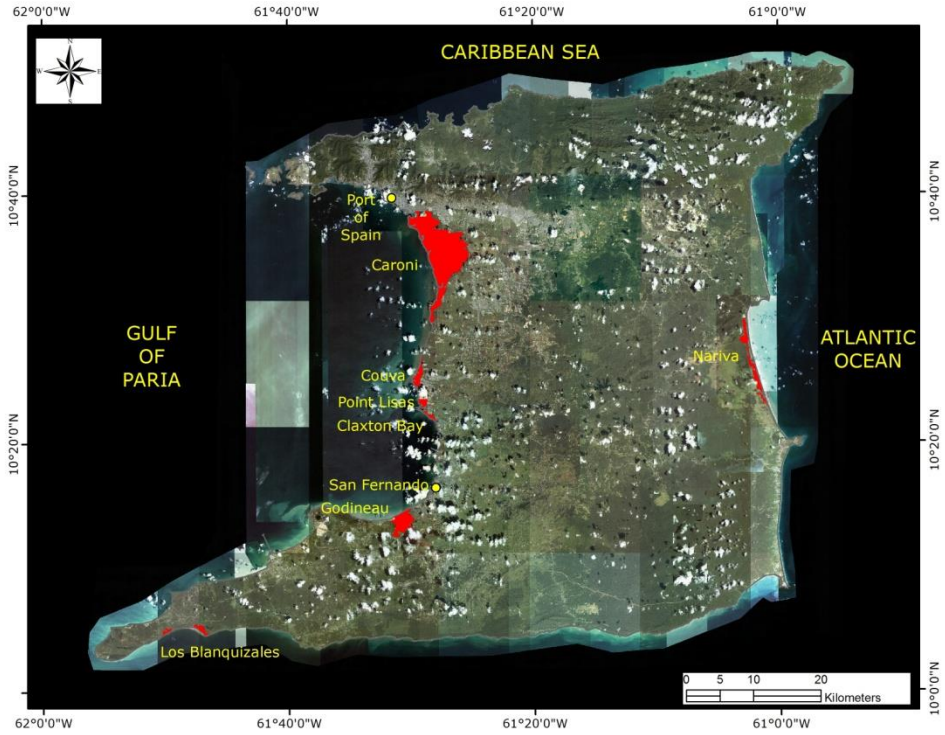

Figure 2a. Map showing selected mangrove forests in Trinidad.

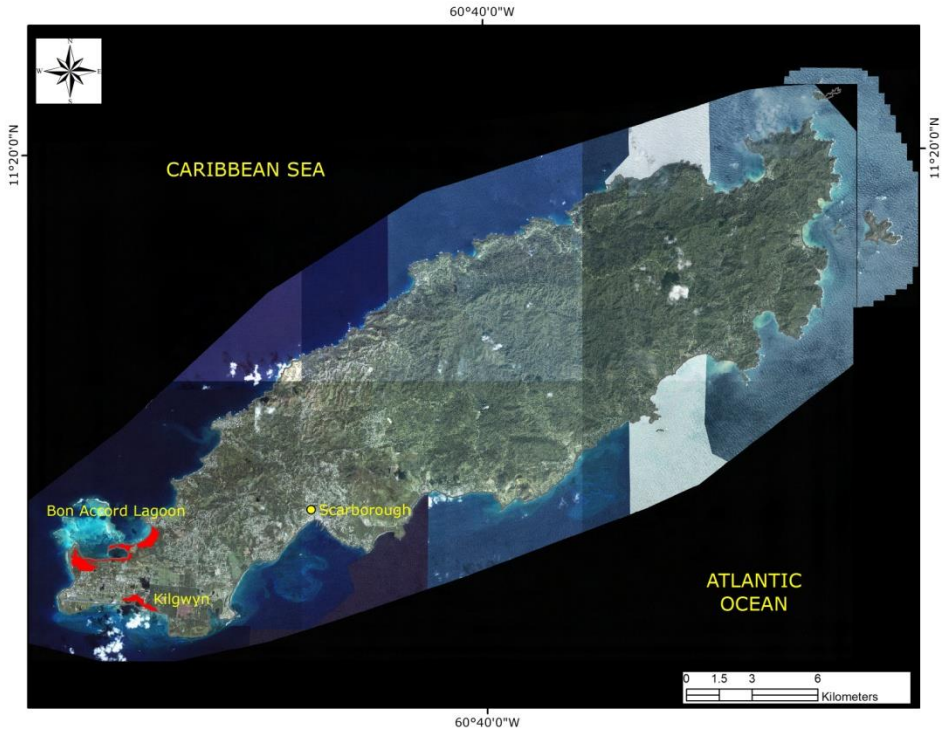

Figure 2b. Map showing selected mangrove forests in Tobago.

AREAS OF PROTECTED MANGROVES

Caroni Swamp, Trinidad

Caroni Swamp is the largest estuarine mangrove forest in Trinidad; occupying approximately 21.7 km of the Gulf of Paria coastline and covering an estimated 52.6 km^2 (Figures 2a). The mangrove forest comprises the eight mangrove species recorded in Trinidad, and is a mixed system. *R. mangle* is the dominant species, with a few small stands of *R. racemosa* and *R. harrisonii*. The more landward areas are dominated by *A. germinans*, with isolated patches of *A. schaueriana* (Stapf & Leechman). *L. racemosa* is ubiquitous, but nowhere common [22]. The eastern borders of Caroni Swamp are occupied by saline marshes, dominated by sedges (Cyperaceae) in association with grasses (Graminaea and Poaceae) and the fern *A. aureum* which grades into rice fields [23]. Extensive mudflats are found on the seaward side. The swamp is important economically for oyster and fish harvesting, hunting and ecotourism, particularly bird watching.

A wide variety of aquatic, estuarine invertebrates are present in Caroni Swamp, including commercially important resource organisms such as the mangrove oysters (*Crassostrea rhizophorae and Isognomon alatus)*, mussels (*Mytella guyanensis & M. falcata)*, clams (*Phacoides pectinatus)*, black conch (*Melongena melongena)*, and shrimp (*Penaeus* spp.) [24]. Some 190 species of birds have been reported in the wetland inclusive of 20 endangered species. Species found in the swamp that are included under CITES Appendices include: scarlet ibis (*Eudocimus ruber*), comb duck (*Sarkidiornis melanotos*), snail kite (*Rostrhamus sociabilis)*, great black hawk (*Buteogallus urubitinga*), common black hawk *(Buteogallus anthracinus)*, long-winged harrier (*Circus buffoni)*, yellow–headed caracara (*Milvago chimachima)*, aplomado falcon (*Falco femoralis*), pigeon hawk *(Falco columbarium)*, and sparrow hawk (*Falco sparverius*).

Caroni Swamp has a long history of significant anthropogenic alterations. From as early as the 1920s the Cipriani Reclamation Scheme was implemented to facilitate rice cultivation. The scheme involved hydrological adjustments to the swamp - embankments were built, channels were cut, and two tide exclusion sluices were constructed [24]. By 1942, a relatively large portion of the Caroni Swamp was covered with freshwater marsh vegetation and agriculture; primarily rice fields. The Reclamation Scheme was officially abandoned in 1954 by which time the canals and embankments were already in a state of disrepair [24]. This problem, along with further flood protection works, which began in the 1950s, and the construction of the Caroni Arena Dam resulted in an overall reduction of freshwater inflow into the Caroni Swamp. Highways were also constructed and this impeded the flow of the rivers into the wetland.

These hydrological changes eventually led to saltier conditions in the eastern marshes, eastward of the N-S embankment and colonization by mangroves. Beyond, the 1950's there were major land cover changes. The mangrove forest on the northern side of the Caroni River was reclaimed for the construction of a solid waste landfill, sewage treatment ponds, and unplanned housing. Built development expanded along the fringes of the wetland and while agriculture land reverted to marshes, marshlands were overgrown by mangroves.

In 65 years (1942-2007), mangrove coverage in the swamp increased by 11.1 km^2 while marshland decreased by 5.2 km^2 and agriculture decreased by 3.9km^2. Built development

increased by 8.3 km^2 between 1942 and 2007 [25]. Generally, natural wetland communities (mangrove, marshes and open water/pond) increased between 1942 and 2003, as agriculture lands reverted to marsh and mangroves colonized new areas – the mudflats and deposited dredged spoilt. However, between 2003 and 2007, natural wetland coverage declined by about 3.5km^2 as built development and agriculture lands increased [25].

The Caroni River Basin, the hydrometric area that encompasses the Caroni Swamp, also experienced extensive land-use/land cover changes within the past few decades and this had serious consequences for the Caroni Swamp; the receiving environment for the land-based runoff. In addition to saltwater penetration, Caroni Swamp receives sediment-laden water polluted with sewage, wastewater from industry and agriculture run-off [26, 27]. This has affected the quality of the habitat, and shellfish that are harvested in the swamp. Fish kills and mangrove dieback seem to be a regular occurrence [24, 28]. Frequent hydrological work to mitigate flooding in the associated catchment have negatively impacted the wetland, since channels are widened and dredged, mangrove trees are removed, and the dredged spoilt placed on the bank inhibits the natural flushing of the system, resulting in hyper-saline conditions.

Management

Portions of Caroni Swamp have been delimited protected areas for just under eight decades. The Caroni Swamp Forest Reserve (28.3 km^2) was proclaimed in 1936 and in 1953, a further 1.4 km^2 was designated a Wildlife Sanctuary for breeding Scarlet Ibis; the national bird of Trinidad and Tobago. Fishing, oyster collecting and hunting had been permitted in all areas except the Wildlife Sanctuary. In 1987, the major part of Caroni Swamp, south of the Blue River, was declared a Prohibited Area (Forests Act, Chap 66:01). This meant that all fishing, oyster collecting and other extractive activities (including cutting mangrove bark, stakes, poles) became illegal and, with the exception of licensed tour guides, local communities were no longer permitted to use the resources of Caroni Swamp. Although these interventions were made, poaching of scarlet ibises and harvesting of oysters still continue.

Scarlet Ibises (*Eudocimus ruber*) roosting in Caroni Swamp, Trinidad (Photo by A. Lum Kong).

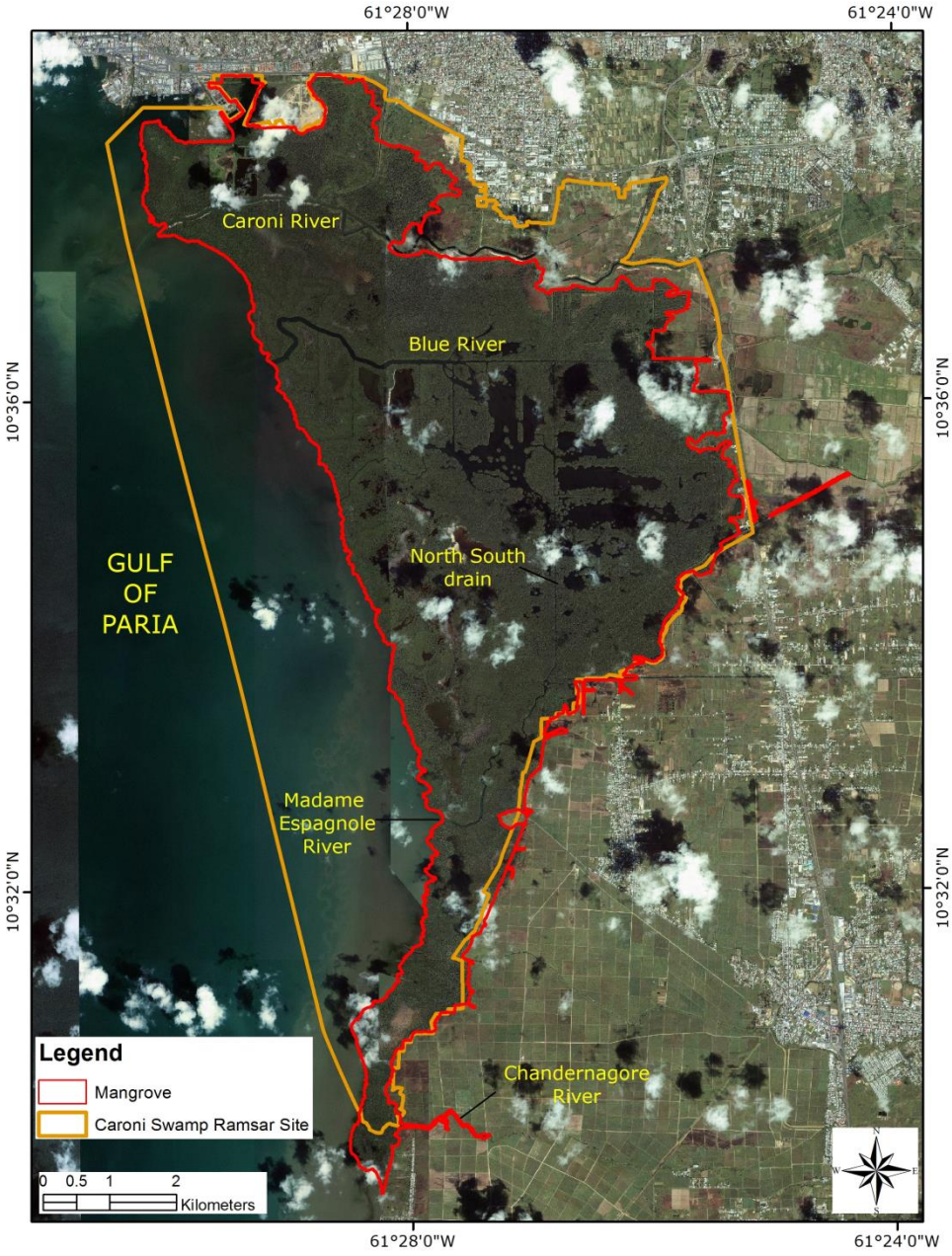

Figure 3. Map of Caroni Swamp Ramsar Site showing the delineated mangrove forest.

In 2005, Caroni Swamp was designated a Wetland of International Importance under the Ramsar Convention (Figure 3). This designation was expected to bring much needed and renewed conservation impetus to the swamp, yet between 2003 and 2007, built development within the wetland doubled and no attention has been placed on preserving the marshlands. There are privately owned lands within the Ramsar Site and development of these lands continue to negatively impact the wetland, especially along the Highway. The Forestry Division has responsibility for managing the Caroni Swamp and while they provide game

wardens to patrol the swamp to discourage poaching, there is no comprehensive management plan for the conservation and restoration of this wetland.

Nariva Swamp, Trinidad

Nariva Swamp is the largest wetland (approximately 113.4 km^2), as well as the largest freshwater swamp system in Trinidad and Tobago. The swamp is found along the Atlantic coast of Trinidad (Figure 2a) and is an ecologically diverse system with an association of mangroves, freshwater marsh, freshwater swamp forest, palm forest and small sections of upland forest interspersed within its boundary (Figure 4).

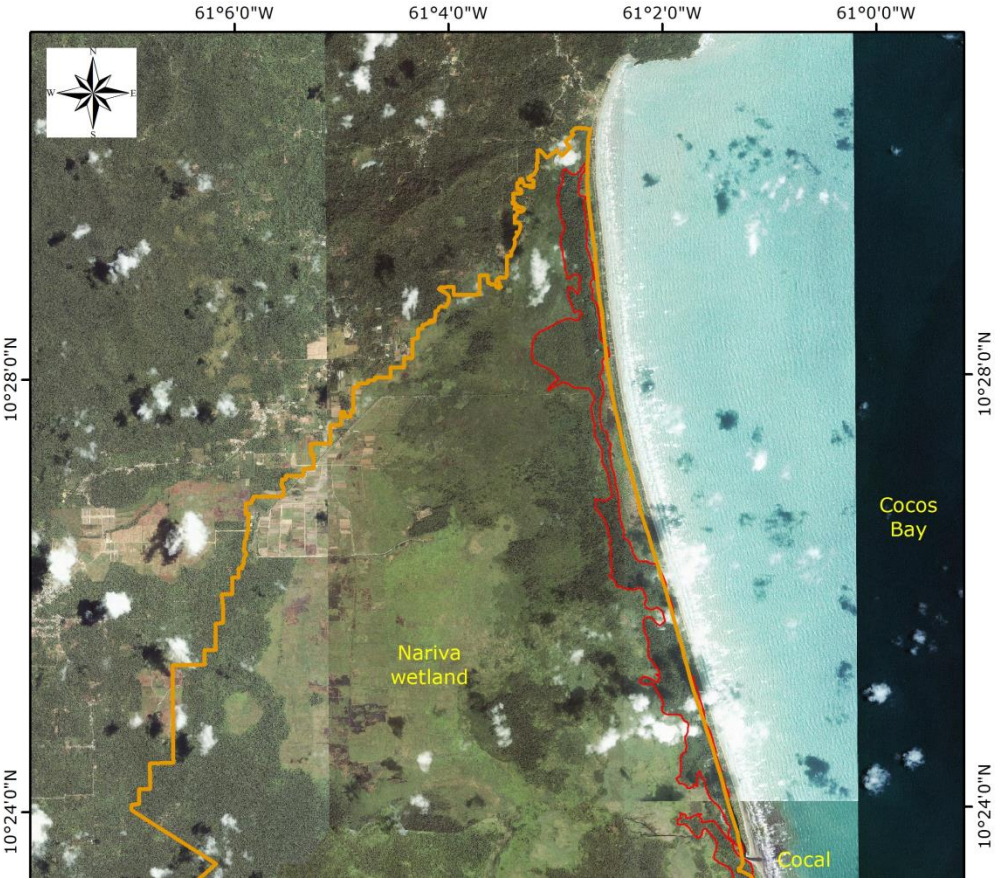

Figure 4. Map of Nariva Swamp Ramsar Site showing the delineated mangrove forest.

As a result of the diversity of ecotype, floral and faunal diversity are high, making it a unique wetlands in the Caribbean. A total of 319 macro-plant species distributed into four wetland types and 15 communities have been reported for Nariva Swamp, in addition to 614 species of fauna [29]; inclusive of vulnerable and critically endangered species according to the IUCN Red List.

Nariva Swamp consists of a series of north-south running ridges with depressions between; thought to have been formed as beach ridges and lagoons during successive stages in the retreat of the sea from the area during marine regression which began ca. 6000 to 5000 years ago. The Cocal represents the present beach barrier, with a narrow lagoon trapped behind it to the west [29]. The lagoon is colonised by mangroves, while the depressions between the ridges have been occupied by herbaceous vegetation (Figure 4). The mangrove forest in Nariva is approximately 5.8 km^2, representing 5 % of the entire wetland. It is a mixed estuarine/ basin system on the eastern side of the wetland with seven of the eight mangrove species reported in Trinidad. The forest is mixed, with red mangrove (*R. mangle*) being dominant, black mangrove being abundant and white mangrove common. *A. aureum* is found growing amongst the brackish marsh while *C. erectus* is found among the littoral woodlands near the coast.

Management

Although Nariva Swamp was protected under Forestry and Wildlife legislation, the wetland experienced severe ecological changes in the 1980s as a large area was used for illegal rice farming. Between 1986 and 1995, 13 illegal rice farmers were found occupying some 9.5 km^2 of swamp land. These large-scale rice farmers altered the hydrology of the wetland by cutting canals for drainage and for irrigation purposes. This hydrological alteration resulted in salt water intruding further inland, affecting freshwater marsh and palm communities. In 1993, after relentless lobbying by environmental non-governmental organizations and the Forestry Division, Nariva Swamp was declared a Wetland of International Importance under the Ramsar Convention, and shortly afterward the large scale rice farming was stopped. A number of initiatives were undertaken by the Government to demonstrate its commitment to the Convention, including a request to include the Nariva Swamp in the Montreux Record and to initiate a Ramsar Advisory Mission. Arising out of the Advisory Mission was a series of recommendations aimed at reversing degenerative trends and improving the management of the wetland [30]. These recommendations included: undertaking an environmental impact assessment (EIA) of heavily impacted areas; development of a management plan for the area; and commissioning a hydrological and aquatic vegetation restoration program.

The EIA and the management plan were completed in 1998 and 1999 respectively. In 1999, a restoration initiative for Nariva Swamp was commissioned but it was decided that before any extensive restoration work could be effectively undertaken, a historical analysis of the land use/land cover changes using GIS and remote sensing technology was needed. In 2003, a historical change detection analysis was conducted [31]. In this study mangrove forest was classed together with freshwater swamp, wood and palms as swamp forest. The study showed a decrease in swamp forest from 1942 to 1969 and a slight increase in 1994; by the 1980's mangroves had started to progress into marsh areas on the eastern edges [31]. Bacon (1993) estimated the mangrove forest in Nariva Swamp to be approximately 2.8km^2; this is less than half of the 5.8 km^2 reported in 2007 estimates [32]. The mangrove community in Nariva Swamp has expanded and this may be due to the hydrological alteration that resulted in salt water intruding further inland, and/or sea level rise.

The 1999 restoration initiative outlined two major programs; a hydrology and aquatic vegetation restoration program of heavily impacted areas, and a fire-fighting program. These programs are currently being implemented by the Forestry Division. In 2006, Nariva Swamp

was also declared an Environmentally Sensitive Area (ESA) under the Environmentally Sensitive Areas Rules, 2001 of Section 26 (e) and 41 of the Environmental Management Act, 2000. This Act seeks to award protection to certain areas of Trinidad and Tobago that contain threatened and remarkable representations of this country's biodiversity.

In 2011, the Environmental Management Authority (EMA) in conjunction with the University of the West Indies (UWI), the Forestry Division, and Community-based Organisations (CBOs) in the area commenced the Nariva Swamp Restoration, Carbon Sequestration, and Livelihoods Project. The objective of the Project was to restore forest cover in the Nariva Swamp, maximising the capacity of this cover for carbon sequestration and wildlife habitat while creating sustainable livelihood opportunities for neighbouring communities. Activities under the project included: reforestation of degraded areas; tending and fire suppression in replanted areas; seedling production; communications, education and public awareness (CEPA); and research into Carbon sequestration by indigenous tropical tree species. Another significant management objective was to build capacity and knowledge of stakeholders for the long-term management of the Nariva Swamp.

The Project has successfully completed the reforestation of 0.026 km^2 of land and approximately 0.05 km^2 have been identified for replanting. This Project engaged 11 CBOs in the neighboring communities and has provided training in land preparation and planting, nursery operation, seedling production and health and safety operations. The government agencies involved are working in tandem with the project CBOs in providing continuous institutional strengthening. These developing CBOs have thus increased their levels of communication and operational efficiency while providing opportunities for employment and sustainable development. Although game wardens and foresters patrol this wetland, wildlife poaching and fire still remains a problem.

Bon Accord Lagoon, Tobago

The mangrove forest in Bon Accord Lagoon covers 0.91 km^2 inclusive of open water lagoons, and is the largest such forest in Tobago. Located on the leeward coast of southwest Tobago (Figure 2b), it is a fringed mangrove forest contiguous with a seagrass community and coral reef (Figure 5). *R. mangle* dominates the intertidal zone, while *L. racemosa*, *C. erectus* and a few *A. germinans* are found in the drier landward side. The lower intertidal zone of the forest is subjected to tidal flushing twice a day. There is no direct riverine inflow into the swamp but two drains carry land-based runoff through the mangroves into the main lagoon. Landward of the mangrove forest is a brackish marsh community dominated by sedges (*Eleocharis sp*).

Bon Accord Lagoon mangrove forest supports a variety of animal species. The mangroves not only supply organic matter, but its structural complexity provides a wide range of habitats for both resident and migrant species, with a range of feeding habits. Detrital feeders in the mangrove include crabs such as *Uca spp*., *Cardisoma guanhumi*, *Ucides cordatus* and *Aratus pisonni*, and the Coffee snail, *Melampus coffeus*. The bivalves *Isognomon alatus*, *I. radiatus*, the mussel *Brachidontes sp*., the barnacles *Balanus sp*. and sponge colonize the prop roots. A number of reef fish and invertebrates use the lagoon as an alternative habitat (33). Twenty-five fish species were caught in faunal surveys using trammel and gill nets set in the Bon Accord Lagoon near the mangrove, while many more species were

observed among the prop roots but were not caught in the nets. The most abundant species were the grunts, snappers and seabream. Most of the species caught and observed in the Bon Accord Lagoon mangrove were also found on coral reefs [33].

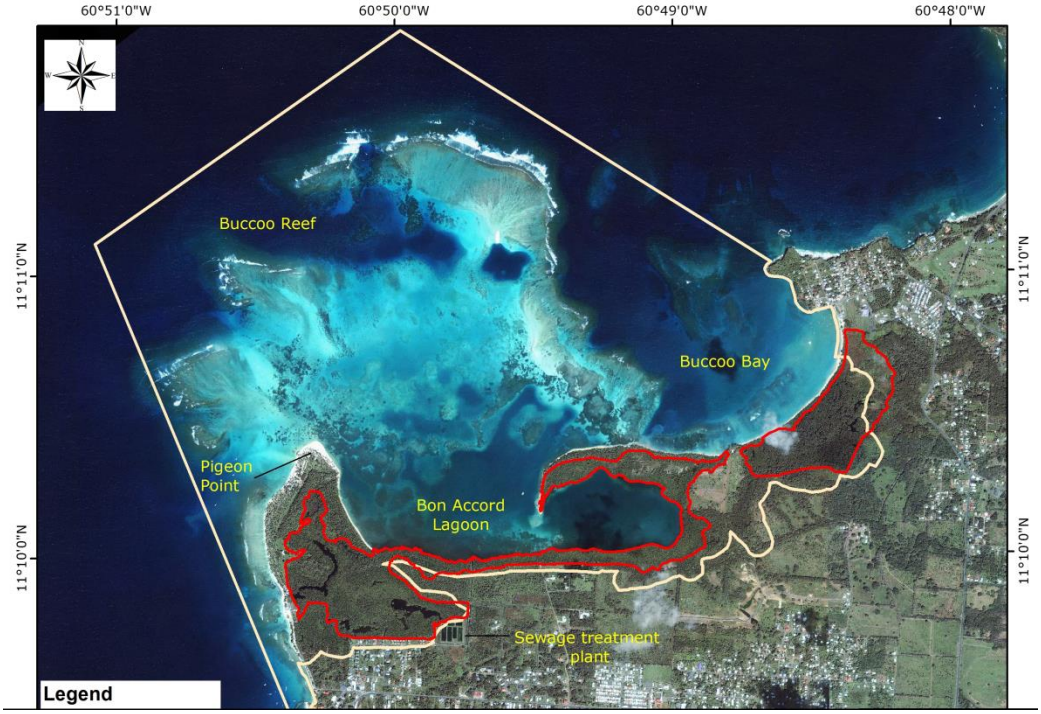

Figure 5. Map of Buccoo Reef/ Bon Accord Lagoon Ramsar Site showing the delineated mangrove forest.

Since the 1970s major developmental issues have surrounded this ecosystem, as there has been rapid infrastructural development in southwest Tobago to accommodate the tourism sector and housing [34].

Bon Accord Lagoon mangrove forest has been impacted by reclamation for built development, hydrological alterations and pollution [35, 36]. The Bon Accord Lagoon sewage treatment facility was constructed in the 1970s with an effluent drain that flowed through the mangrove forest into the lagoon. This drain was a conduit for salt water coming further inland during high tide, and mangroves were able to colonize areas where they were not previously found. Within the past three years, the white, black and buttonwood mangroves landward of the intertidal red mangrove fringe, and west and east of the sewage effluent drain were removed for housing and resort development. Housing construction continues to encroach upon the mangrove fringe.

Management

Bon Accord Lagoon mangrove forest together with the adjoining Buccoo Reef was designated a restricted area under the Marine Areas (Restricted Area) Order in 1973 using the Marine Area (Preservation & Enhancement) Act of 1970. The protected area extends “thence along the highwater mark and including the mangrove forest bordering the Bon Accord

Lagoon and its environment". This ecosystem complex remains the only designated Marine Protected Area (MPA) in the country.

In 1994, a management plan was formulated for this MPA by the Institute of Marine Affairs, and accepted by the Tobago House of Assembly (THA)[1], the local governing body in Tobago. The plan, however, did not address impacts that emanated from outside the boundary of the park such as land-based pollution, and was never fully implemented. In 2005, the Buccoo / Bon Accord Lagoon MPA was designated a Wetland of International Importance under the Ramsar Convention because of its rich biological diversity and the fact that it was habitat for threatened and endangered species.

It was hoped that by having it declared a Ramsar Site, the MPA would receive the much needed management interventions to arrest degradation but this, thus far, has not been realised. Although environmental non-government organisations have attempted to implement projects to improve the health of the ecosystems, they remain degraded.

AREAS OF UNPROTECTED MANGROVES

Godineau Swamp/ Oropuche Lagoon, Trinidad

Godineau Swamp is the second largest wetland system on the Gulf of Paria coast of Trinidad - after Caroni Swamp - covering approximately 31.7 km^2 (Figure 2a). The main plant communities within the wetland are tidal marshes and mangrove forest [37]. Tidal marshes cover approximately 17.5 km^2 and include brackish and freshwater communities. Brackish marsh are located lower down the estuary and are dominated by sedges *(Eleocharis mutata, Cyperus articulates)* and grasses *(Panicum grande, Paspalum fasciculatum)* while freshwater marsh are located upstream.

Godineau mangrove forest covers 7.4 km^2 and is dominated by *R. mangle* intermixed with *A. germinans, A. schauerana* and *L. racemosa* [32]. Thin stands of *A. schauerana* occupy the banks of the Oropuche River. Other land cover classes within the wetland are agriculture, terrestrial forest and urban development (Figure 6). Twenty-nine [29] species of fish belonging to 19 families, 24 species of aquatic invertebrates and 133 bird species have been reported in this wetland [21, 38]. The mangrove oyster (*Crassostrea rhizophorae*) is commercially harvested.

Godineau mangrove forest has not changed significantly in total extent since 1969, although its health has been negatively impacted in parts by land-based pollution, frequent oil spills and hydrological alterations [39]. From the 1977 topographic map, mangrove coverage was estimated at 7.2 km^2 while from 1980 and 1994 aerial photographs it was estimated at 7.1 km^2 and 7.2 km^2 respectively. From field surveys conducted in 2002, it is evident that mangroves were cleared to provide roads and embankments for oil activities. These roads and embankments have interrupted the hydrological flow affecting the tidal flushing within the wetlands. Periodic dredging of water courses to alleviate flooding upstream have also negatively impacted the wetlands, as embankments interrupt tidal flushing. Mangroves on the seaward side of this wetland are expected to be cleared for the construction of a new highway.

[1] The THA is an elected body of persons which affords Tobago some measure of autonomy, devolved from the central government of Trinidad and Tobago.

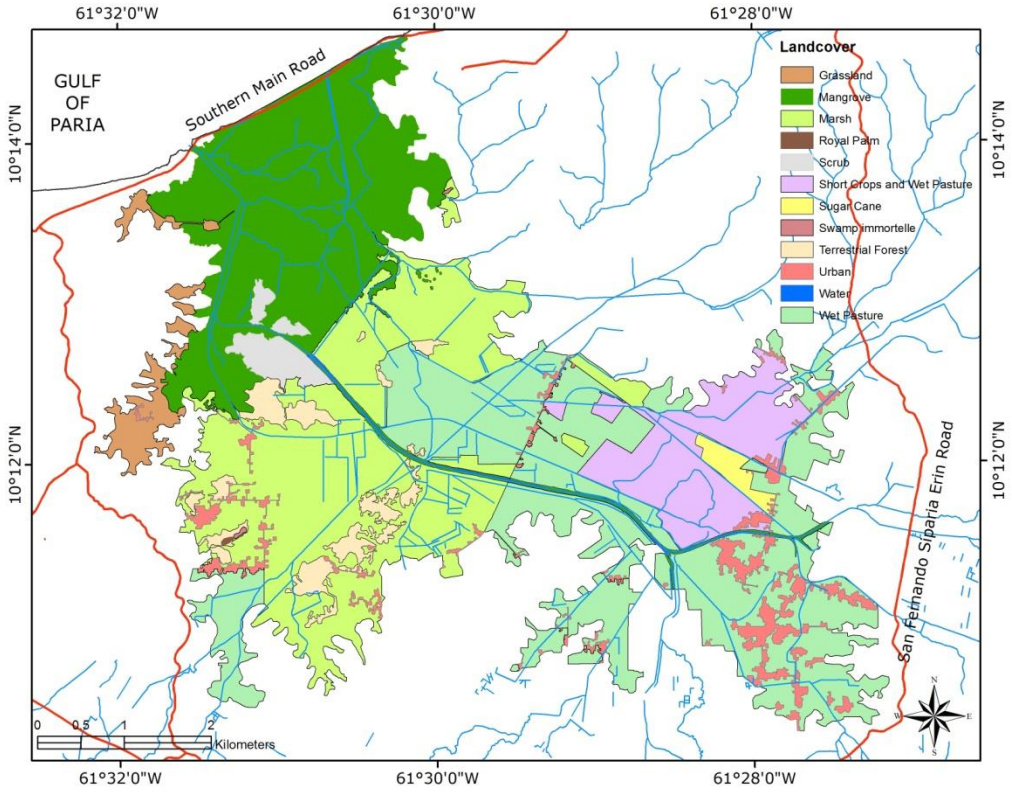

Figure 6. Map of Godineau Swamp/ Oropouche Lagoon, Trinidad.

Fishermen sailing through a channel in Godineau Swamp, Trinidad (Photo by J. Gomez).

Godineau Swamp/ Oropuche Lagoon has a long history of human occupation and activity. Several archaeological sites have been discovered in this wetland, and the artifacts found revealed an Amerindian (Saladiod group) presence thousands of years ago [40]. These indigenous people were known to have occupied hilltop locations and engaged in hunting, fishing, farming and pottery making. In describing the area in 1881, de Verteuil (2000) identified the Swamp as "an inexhaustible source of malaria". In 1852, a two-mile long road, which included a "fine iron structure" across the Godineau River, was laid closely parallel to the sea shore.

Agriculture has been an important activity in the wetland. Rice cultivation began in the early 1890s and by the 1920s, Oropuche became the most important rice growing area in Trinidad, sometimes at the expense of mangroves. Between 1962 and 1969, 1.9 km^2 of mangrove forest was cleared for the establishment of rice paddies through a system of embankments and sluice gates. However, water control devices subsequently failed and the scheme had to be abandoned because of saltwater intrusion. This cleared mangrove area was transformed into a brackish marsh community that is currently used as a feeding ground by a number of water birds. Still, in the late 1960s, over 14 km^2 of the Oropuche wetland was under rice cultivation and rice remained an important crop until the early 1990s when cultivation ceased owing to a combination of environmental factors and Government policies. Cocoa was also cultivated and Oropuche had become an important cocoa area by 1915 [40].

Godineau Swamp has also had oil activities since the early part of the twentieth century. To facilitate operations, oil companies laid over 320 km of roads in South Trinidad [41]. The oil rights over the Oropuche Lagoon concession were held by the British Controlled Oilfields company. The Oropuche Lagoon concession covered more than 16.2 km^2 in the area known as Mosquito Creek, on the northwest end of the swamp. Before exploration could begin, the company planned to drain the Lagoon at an estimated cost of £80,000. They considered that even if the ensuing oil explorations were unsuccessful, the value of the reclaimed land would be over twice the capital value of the company. They had just raised the money when a world-wide depression affecting oil exploration set in during 1919-20 [41]. However, the Trinidad Lands and Reclamation Ltd. was formed in 1920 with £100,000 capital and was to receive a 10% royalty on all crude oil won from the drained area. Cipriani and Company of Port of Spain was contracted to drain the lagoon and the work was finally completed in 1924. The work included raising/elevating the road across the seaward side of the lagoon to stop the sea flowing into the lagoon except at the highest of tides. A dredger was used to cut several 40 feet wide drainage channels and since that time the recurrent flooding of the area has been minimized even in the worst of rainy seasons [41].

A geological survey of the reclaimed area was conducted and well sites selected. The first well, drilled in 1923 within 200 yards (180 m) of the San Francique Road eventually produced 80,000 barrels of oil, but was the only success. The second well, close to the Southern Main Road and about 50 yards from the coast and the Godineau River, as well as six others, were abandoned as dry holes. At the time, as far as oil exploration was concerned, the costly drainage scheme was a failure, though a technical success. Maintenance of the reclamation was taken over by the Government in 1925. By the end of 1982, the area had produced over 6 million barrels of oil from 128 wells – the depths ranging from several 100s to 4000 feet [41].

To protect oil facilities upstream from salt water, the Trinidad Bank, the Trinidad Sluice and the St. John Sluice were constructed in 1924. These constructions and the work to drain

the lagoon were very significant changes to the hydrological regime of the swamp. In an attempt to further improve drainage in the lagoon, thereby making more lands available for agriculture, the Food and Agriculture Organization of the United Nations (1957) recommended the construction of a central drain. By 1962, a drain was cut in the lower catchment area. This drain did not solve the flooding problem and allowed salt water to penetrate further inland [42].

Today, traditional uses, such as fishing, recreation, housing and religious activities, continue in swamp and its environs. Eco-tours are also conducted. Recreational/Boating, picnic and religious facilities have been constructed to aid some of these traditional uses. The range of activities in the Godineau swamp imply a range of stakeholders including residents, farmers, fishers, non-government organizations, community-based groups and a multitude of State agencies. Most activities, however, remain unmanaged and largely unregulated.

Point Lisas, Trinidad

The hub of the country's petrochemical activities is located along the central west coast of Trinidad at the Point Lisas Industrial Estate (Figure 2a). Point Lisas Industrial Estate occupies 12 km^2 of reclaimed mangrove forest and former sugar plantation. The once continuous wetland in this area has now been fragmented into the Couva River/ Carli Bay mangrove forest, the Lisas Bay forest and the North Claxton Bay mangrove forest (Figure 7).

Mangroves in Point Lisas, Trinidad.

i. Couva River/ Carli Bay

This mangrove forest is an estuarine/ fringe system approximately 3.0 km^2 located at the mouth of the Couva River and fringing Carli Bay (Figure 7). Red mangrove is dominant along the seaward border, while black mangrove and to a lesser extent, white mangrove occupies the area furthest from the sea. This mangrove forest is fronted by extensive mudflats, which were exposed during ebb tide and is being colonised by red mangrove seedlings. A number of birds species have been reported in this area including adult and juvenile scarlet ibises, herons, plovers and sandpipers. This mangrove forest is utilised by hunters and crab catchers.

Figure 7. Map of the mangrove forests in Point Lisas, Trinidad.

In 2007, approximately 0.4 km^2 of black and white mangroves had died north of Couva River, but has since regenerated. The cause of this dieback was not determined. Prior to this, in 2003, mangrove die-off was recorded in the same general area and this was due to diseases/infestation, but by 2005 there was some regeneration. In 1998, mangrove die-off was reported south of the Couva River and the cause of this die-off was believed to be hot water being released from a nearby industrial installation. This system later regenerated after the situation was rectified. This forest seems to undergo a frequent cycle of die-off and re-growth.

The Couva / Carli Bay mangrove system is also impacted by reclamation and river diversion. In 1979, 5 km^2 of mangrove from the Couva to Claxton Bay area were reclaimed for the construction of the Point Lisas Industrial Park and a deep-water port (21). In addition, mangrove and marsh were lost through cutting and dredging of the new river channel and dumping of dredge spoil when the Couva River was diverted.

Bacon (1993) reported this system to be 1.7 km^2 however; the 2007 estimate of 3.0 km^2 shows a 1.3 km^2 increase in mangrove coverage [32]. It appears that while the landward edge of this system is being encroached upon by industrial development and impacted by pollution from the Couva River, the system seems to be extending seaward upon extensive mudflats.

ii. Lisas Bay

This is a broad fringe of mangroves approximately 1.4 km^2 located in the southern side of Lisas Bay (Figure 7). The forest is dominated by red mangroves with the occasional white and black mangroves associated with sedges and grass. Bacon (1993) reported this system to be approximately 0.3 km^2 and stated that the size at that time represented a significant loss of wetlands as a result of land reclamation for the Point Lisas Industrial Estates and port construction. Alleng (1997) indicated that in the reclaimed area there was a pond which was used as a resting ground for a large number of seabirds. The reclaimed area is now being colonized by mangroves and grasses. Just south of the main Lisas Bay wetland, a thin fringe of scrubby black mangrove less than 5m in height can be found on the periphery of the turning basin for the port. This mangrove stand is approximately 0.14 km^2. No faunal species were observed in this mangrove during field surveys in 2009 as the water within the turning basin was hot; way above the ambient water temperature of 29°C.

iii. North Claxton Bay

North Claxton Bay mangrove forest forms the southern sector of the once continuous mangrove fringe seaward of the Point Lisas Industrial Estate (Figure 7). This mangrove fringe is approximately 0.9 km^2. The northern section is dominated by shrubby black mangroves interspersed with a few white mangrove trees. Towards the centre of the mangrove system there was a large area of dead mangroves which has now resulted in an open water area. Bordering this open water area on the landward side are numerous short black mangroves. Seaward of the pond is a narrow sand bar 15 m wide with short white and black mangroves (≈3 m in height), grasses (*Panicum spp.*, *Paspalum spp*), and *Sesuvium portulascastrum*. At the southern end, large red mangroves fringe the coast. These trees have a well established prop root faunal community. Mangrove oyster (*Crassostrea rhizophorae*), barnacle (*Balanus spp.*) and Periwinkle snail (*Littorina angulifera*) are abundant on the roots.

The North Claxton Bay mangrove forest was initially impacted in 1979 when part of it was reclaimed for the Point Lisas Industrial Estates [21]. Again in the latter part of the 1990s the mangroves were impacted by reclamation activities.

Red mangroves in North Claxton Bay.

An island was constructed in the bay, and mangroves were planted to replace mangroves that were lost through reclamation. The island was contained by a silk screen which was eventually dislodged, and it eroded. The remnants of the constructed island comprise three small islands; the largest being 0.05 km^2. These small islands are now colonized by short white mangrove trees and grasses and are used by a number of seabirds. Extensive mudflats are found in North Claxton Bay and toward the southern side *Thalassia* beds were recorded [43].

North Claxton Bay mangrove is impacted in the north side by encroachment from the Point Lisas Industrial Estate and on the eastern edge by illegal housing. This mangrove area is also threatened by proposed port development and industrialization. The bay is utilized by fishers who harvest green mussels, shrimp and fish.

Los Blanquizales, Trinidad

Los Blanquizales wetland is located in a relatively undeveloped part of South Trinidad (Figure 2a) and comprises marshland, palm forest and mangrove forest. The mangrove forest is a mixed basin/ fringe system with large red, white, black and buttonwood mangroves. On the coast the mangrove is associated with coastal thicket. Landward of the mangroves are large communities of mangrove fern (*A aureum*), marsh, palm forest and terrestrial forest.

The most recent estimates place the size of the wetland at approximately 9.1 km^2 with mangrove forest accounting for about 2.5 km^2 (28%) [32]. In 1997, Alleng reported that this wetland was 10.9 km^2 and that part of it was converted to rice fields (35). However, there were no signs of rice cultivation during field surveys in 2009. Ramcharan et al., (1982) provided vegetation maps for the wetland and indicated that large tracts of mangroves were

destroyed along this coast by erosion [21]. There is still evidence of erosion occurring in this area especially on the western side.

Most of the Los Blanquizales wetland is remote and inaccessible by road. There are a few roads in the area and these roads lead to oil facilities and houses. There is minor agriculture landward of the mangrove forest. The major impact on the mangrove forest at Los Blanquizales has been and still remains coastal erosion. There have been concerns that this erosion may be associated with land subsidence since oil exploration and extraction activities have been occurring in this part of the country for more than 50 years.

Kilgwyn Bay, Tobago

Kilgwyn Bay is located on the windward coast of Southwestern Tobago (Figure 2b). It extends from La Guira Bay in the south to Canoe Bay in the east-northeast (Figure 8). In 1980, it was proposed as a Scientific Reserve, as the area represented the only remaining example of littoral forest on the island [44]. This bay is colonized by extensive seagrass beds, and protected by a fringing coral reef. Within Kilgwyn Bay there are two mangrove areas: - Kilgwyn Swamp and Friendship Swamp. Kilgwyn Swamp is a basin mangrove forest surrounding a shallow lagoon behind a beach barrier (Figure 8).

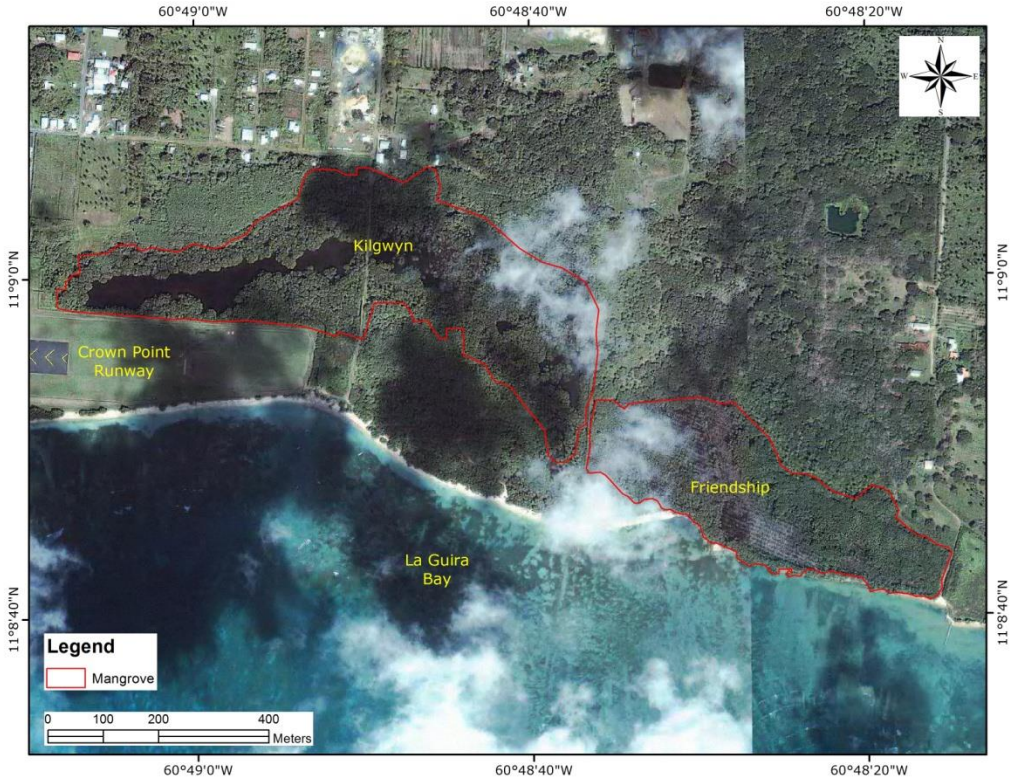

Figure 8. Map of the mangrove forests in Kilgwyn Bay, Tobago.

The mangrove forest including the lagoon is estimated at 0.34 km^2 and is dominated by *L. racemosa*. *R. mangle* forms a narrow fringe along the periphery of the lagoon while *L. racemosa* is more abundant and widely distributed. In 1990, only a thin fringe of mangrove was left around the west, northwest and southwest boundaries of the lagoon since most of the western part had been cleared for the extension of the international airport [46]. The lagoon is connected to the sea by an ephemeral canal, and the mangrove forest and lagoon have been divided into two sections by a road leading to the beach. A concrete culvert under the road connects the two sections. In 1986, Kilgwyn Swamp was estimated to be 0.12 km^2 [45] and described as a permanent brackish lagoon with fringing mangrove swamps, separated from the sea by a sand bar.

Friendship mangrove forest is east of Kilgwyn and is a basin forest estimated at 0.12 km^2 (Figure 8). This mangrove forest is found behind a beach berm approximately 7 m wide. It is dominated by *L. racemosa*, with fewer *A. germinans* and *R. mangle* found along the berm. Friendship wetland is not flooded by tides. The water within the basin is impounded; there are no channels/outlets to the sea. A relatively large area of mangrove die-off was reported in the centre of this system in 2007 but by 2008 there was evidence of re-growth as numerous seedlings and saplings were found in the dead area. Kilgwyn and Friendship mangrove areas are hydrologically connected, and may have been a contiguous system that was impacted by the construction of a channel and sand mining activities. Attempts were made to drain the eastern part of the swamp, as there was evidence of channels traversing this area and an old pump station on the coast [46]. From 1994 (1:12,500) aerial photographs, Kilgwyn swamp was estimated at 0.08 km^2 while Friendship Swamp was estimated at 0.05km^2 [47]. These estimates however, are much smaller than the 2007 estimates.

Aerial view of the mangroves in Kilgwyn Bay, Tobago.

The beach vegetation between Friendship and Kilgwyn Swamps comprises tree species such as Machineel (*Hippomane mancinella*), buttonwood (*Conocarpus erectus*), seagrape (*Coccoloba uvifera*), and Seaside Mahoe (*Hibiscus tiliaceus, Thespesia populnea*), and grass species such as *Ipomoea pre capres*, *Wedelia tribolata*, *Sporobolus sp.*, *Paspalum spp.*, *Panicum spp.* This area of coast has been affected by sand mining, resulting in the formation of small ponds that are colonized by sedges (*Eleocharis spp*, *Cyperus spp*, and *Fimbristylis spp*).

LEGISLATIVE AND POLICY ENVIRONMENT FOR MANGROVE MANAGEMENT

Currently, the most common strategy in Trinidad and Tobago employed to conserve mangrove forests and/or their constituents is by designating them protected areas with restricted access. Four varying forms of protected mangrove areas exist in the country:

- **Game Sanctuary** through the Conservation of Wildlife Act Chapter 67:01 (Act 16 0f 1958). This was done for parts of Nariva and Caroni swamps.
- **Prohibited Area** through the Forests (Prohibited Areas) Order which is subsidiary legislation to the Forests Act Chapter. 66:01 (1995). This was done for parts of Nariva and Caroni swamps.
- **Restricted Area** through the Marine Areas (Restricted Areas) Order which is subsidiary legislation of the Marine (Preservation and Enhancement) Act Chapter 37:01 (Act 1 of 1970). This was done for the mangrove system bordering the Bon Accord lagoon in Tobago.
- **Environmentally Sensitive Area** through the Environmentally Sensitive Areas (ESA) Rules (2001) which is subsidiary legislation to the Environmental Management Act (2000). The Nariva Swamp Managed Resource Protected Area was designated under the ESA Rules in 2006.

Game Sanctuaries in Trinidad and Tobago are more concerned with protecting fauna within their boundaries and offer no specific protection to mangroves themselves or restrictions to access except when hunting. However, where portions of Caroni and Nariva were designated Game Sanctuaries, they were subsequently given an additional Prohibited Area designation which seeks to restrict access and also makes it an offence to cut or damage flora associated with the mangrove ecosystem. Therefore, especially through the latter, these regions were brought more in line with ecosystem based conservation approaches. The Restricted Area in Tobago, which includes Bon Accord Lagoon mangroves, also attempts to limit access and provide specific protection for both flora and fauna. With respect to the ESA Rules, they allow designation across the range of IUCN Protected Areas categories[2]. In Nariva Swamp, the Managed Resource Protected Area designation allows practices that encourage "sustainable use and management to ensure long term protection and maintenance

[2] http://www.iucn.org/about/work/programmes/gpap_home/gpap_quality/gpap_pacategories/

of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs" (ESA Rules, 2001, p. 105)

In both Trinidad and Tobago, however, having an area of mangrove forest designated as protected has not effectively stemmed destruction or degradation of those particular mangrove ecosystems. In many cases outdated legislation does not provide sufficient disincentives, in the form of fines and penalties, to deter illegal activities in protected areas. Apart from this, and perhaps more importantly, the institutions tasked with managing protected areas lack capacity to adequately perform their duties. Thus, essential components required in the successful administration of protected areas, such as regular patrols to enhance enforcement and prosecution, are lacking. In Trinidad, the Forestry Division, which responsible for managing areas of protected mangroves, is understaffed and under-resourced. The same can be said for the THA's Department of Marine Resources and Fisheries which is responsible for managing the Buccoo Reef Marine Protected Area and the mangrove forests that it contains.

As alluded to earlier, it was hoped that the accession of Trinidad and Tobago to the Ramsar Convention on 21st April 1993 would result in more resources being directed towards fulfilling the commitments involving wetland conservation. Although the country now has three sites designated as Wetlands of International Importance, with a total surface area of 159.2 km^2, Ramsar has not proven to be the conservation "silver bullet". Without national legislation to give effect to fulfilling the obligations of the international convention, it holds little weight. An illustrative case is the reversal of a decision taken in 2002 by Trinidad and Tobago's Environmental Management Authority (EMA) to refuse granting a Certificate of Environmental Clearance (CEC) to an international oil exploration company, Talisman Petroleum Ltd., to carry out works in Nariva, based on the fact that it was designated a Ramsar site. The CEC was requested by the company to conduct 3 Dimensional seismic surveys in areas of the swamp. The decision to refuse the CEC was overturned by the country's Environmental Commission because there was no Act of Parliament applying provisions of the Ramsar Convention to Nariva Swamp specifically. Thus, the terms of Ramsar could not be enforced locally. As a result the CEC was eventually granted to Talisman Petroleum, albeit with the imposition of strict rules regarding the company's conduct in the wetland. The ESA Rules, which became law after this ruling, are now meant to give effect to the Ramsar Convention and other similar multilateral environmental agreements. However, to date, Nariva Swamp is the only Ramsar site to be designated an ESA.

The most recent National Protected Areas Policy of Trinidad and Tobago (2011), seeks to treat with some of the observed shortcomings in protected area management in the country. It proposes the establishment of a new institutional arrangement – a Forest and Protected Areas Management Authority. This Authority is envisaged to be less bureaucratic and more politically and financially independent than the Forestry Division. The policy also recommends a suite of provisions intended to boost the human, technical and financial capacity of this Authority and thus its effectiveness. Combined with this are recommendations for revised/new legislative arrangements that would provide a framework for better achieving conservation objectives. In addition, the policy proposes mechanisms, such as incentives and voluntary compliance, for sustainable use and management of private lands which have been identified as sensitive or critical areas and encourages more participatory and community based processes for protected area management.

Indeed the importance of encouraging and institutionalizing community based natural resource management of mangroves cannot be overstated. In Trinidad and Tobago, surrounding communities do exhibit dependence on mangrove forests. Although degrees of dependence vary among areas of mangroves, communities and even community constituents the recognition that conservation of mangroves cannot take place without the support and input of these communities is increasingly coming to the fore. The preservationist approach to conservation that seeks to prevent humans from accessing resources within the confines of protected areas is giving way to conservation that is more cognizant of human needs with sustainable resource use being the focus alongside ecosystem based management.

Given the resource constraints of the bodies tasked with managing protected areas in Trinidad and Tobago, the many long established and intimate mangrove-community interactions that already exist in the country and the stated need to conserve wider areas of mangrove nationally, community based conservation is perhaps the more feasible option. While strict protected areas that, *inter alia*, restrict access to human populations and their activities do have their place, they should be now be made the exception rather than the rule. Community based conservation approaches are now increasingly being employed in Nariva Swamp with some degree of success. More initiatives employing these approaches should be undertaken in unprotected areas of mangroves and wetlands around the country and steps should be taken to ground these arrangements legislatively.

In keeping with the commitment stated in the 2001 National Programme and Policy for Conservation of Wetlands regarding the objective of "no net loss of wetlands and their values and function, on publicly-owned lands and waters" it is also important to synchronise and regulate the activities of private enterprises and governmental ministries, agencies and departments when they have the potential to impact wetlands on state lands. Several situations have been highlighted, which post date this "no net loss" recommendation, where wetland habitat was degraded or destroyed through, for example, agricultural schemes, road construction and oil and gas extraction initiatives. On most occasions the established policy was flaunted as loss was not adequately compensated for. Where wetland loss takes place it is important that requisite rehabilitation or replanting is conducted elsewhere that equates to no net loss of wetlands and their services. At present no proper mechanism exists for co-ordinating and guiding the activities of private and public enterprises operating in the coastal zone to ensure that their activities are in line with national policy prescriptions. Development and implementation of an Integrated Coastal Zone Management (ICZM) Policy will go some way in filling this identified gap.

ICZM will also have additional benefits as it relates to mangrove conservation. It will lead to a more ecosystem based approach to management by confronting, *inter alia*, pollution issues emanating from the hydrometric areas that encompass, and which therefore affect, the respective wetlands. ICZM is also concerned with instituting climate change mitigation and adaptation measures throughout the process. Therefore it will seek to treat with vulnerability and boost resilience of mangrove ecosystems, thereby minimising habitat loss due to climate change induced coastal erosion. In 2012, the Government of Trinidad and Tobago appointed a Multi-sectoral Steering Committee tasked with formulating an ICZM Framework Policy, Strategies and Action Plan for the country.

The last issue that needs to be tackled in policy that relates to the conservation of mangroves and their ecosystem services is the creation of a clearly defined set of rules, in terms of setback distances, when proposals for development in close proximity to wetlands

are received by the bodies responsible. The Town and Country Planning Act Chapter 35:01 (1977) does call for special provisions to be made in planning proposals as it relates to preservation or protection of the environment. However, something more concrete is advisable. In several wetlands, conduits now exist that allow salt water to intrude further inland than in the past. This, along with sea level rise, is leading to the landward migration of mangrove assemblages in many areas of the country and the consequent loss of freshwater wetlands. However, infrastructural development for housing and roads at the very edge of mangroves, is leading to coastal squeeze as migrating mangroves are blocked from advancing landward. For conservation purposes, as well as avoidance of the potential hazards - health and otherwise - that may be associated with living in close proximity to mangroves; it is prudent to establish definitive rules that govern planning in these areas. These rules should try, as far as possible, to be cognizant of the need for uninhibited avenues for natural adaptation of mangrove assemblages to environmental change.

CONCLUSION

From the observed trends it is evident that challenges exist with regard to effectively achieving mangrove, and indeed wetland conservation in Trinidad and Tobago. The existing laws and institutional arrangements are inadequate for carrying out its intentions, as the rate of mangrove degradation and/or loss has not decreased since their implementation. This is so in both protected and unprotected mangrove forests. In areas where legislated protection regimes have long existed for mangroves, maintaining ecosystem integrity has been problematic due to institutional and resource inadequacies, as well as failure to manage impacts that emanate from outside the protected areas. In other areas, where there is no protective area designation, these inadequacies coupled with a myriad of unmitigated anthropogenic impacts make the conservation problem even more difficult to address. Lastly, even in less populated, more remote areas of the country where competing land uses and human influences on mangrove ecosystems are not as pronounced e.g. Los Blanquizales on the Southern coast of Trinidad, coastal erosion, be it through natural phenomena or changes due to climate change, also hinders preservation of mangroves.

There is a definite need for an ecosystem-based approach to management that addresses impacts emanating from outside wetlands, such as land–based pollution, to negative impacts within the boundaries of wetlands. As an island state, this requires integrated management across the watershed to ocean continuum. River basins in Trinidad and Tobago are comparatively small and thus there is a short lag time from when basin development activities occur to coastal responses. Also needed is a shift away from a sectoral approach to management of mangroves. Currently, there are plethoras of Acts that make provisions for direct and indirect regulation of habitats and natural resources, while several agencies have concurrent responsibility for managing aspects of the natural environment. This sectoral approach has resulted in poor coordination and limited enforcement of policies and laws.

The development of an Integrated Coastal Zone Management (ICZM) Policy Framework will support ecosystem-based management, and provide a platform for coordination and integration of activities across space, agencies, organizations, and jurisdictions thereby capitalizing on human, technical, and financial resources and avoiding unnecessary

redundancies and wastage. ICZM will also promote co-management, where stakeholders share aspects of governance with the state, and community participation is an essential part of the management process.

To give effect to a co-management approach, laws will have to be enacted or amended. The implementation of an effective public education and awareness programme that targets specifically the varied stakeholder groups would be imperative. Stakeholders would more likely participate in the management process if they feel empowered, and increasing knowledge level is an avenue of empowerment. All new management approaches would be based on sound science, which suggests an increased role for the scientific community. Apart from a revolutionized management framework, more pointedly, if effective mangrove conservation is to take place, clearly defined rules with regards to building set back and development in and near to areas of mangroves would be required. Finally, the need to adapt to impending climate change impacts by building resilience of mangrove forests would be critical.

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