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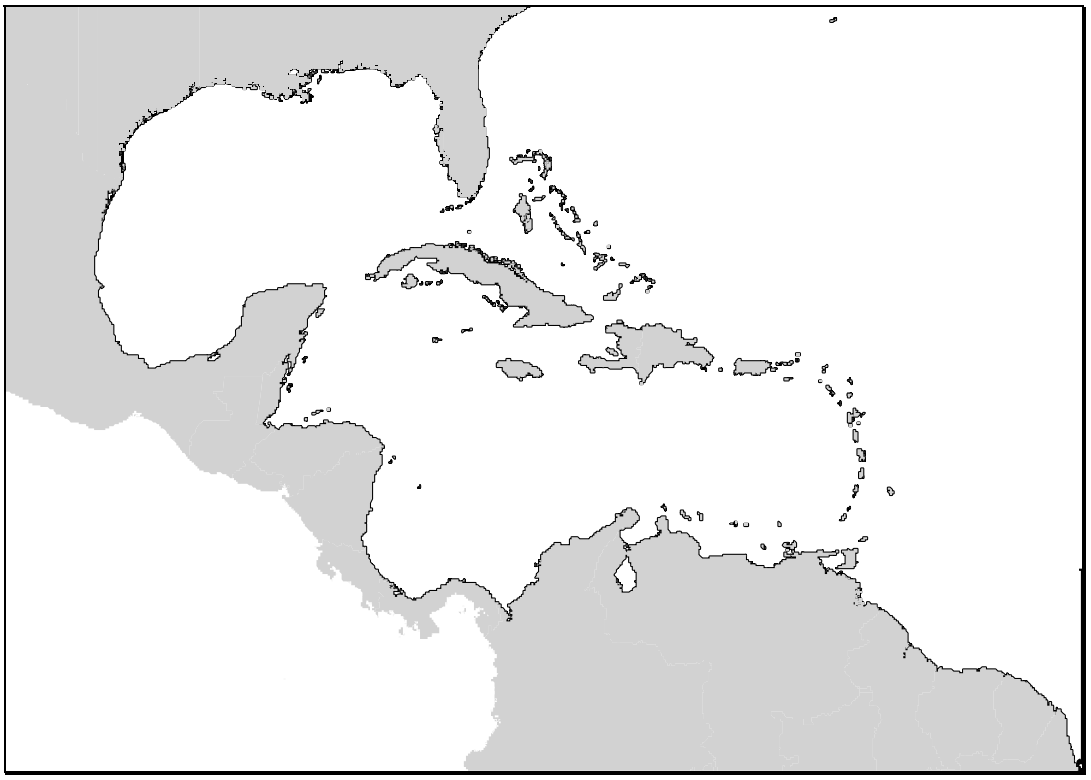
EVALUATION OF THE COASTAL AND MARINE RESOURCES OF THE ATLANTIC COAST OF GUATEMALA



Prepared in cooperation with:

Program of Ecology, Fisheries and Oceanography
Of the Gulf of Mexico

CEP Technical Report No. 34

1995

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EVALUATION OF THE COASTAL AND MARINE RESOURCES OF THE ATLANTIC COAST OF GUATEMALA

Alejandro Yañez-Arancibia

David Zárate Lomelí

Angel Terán Cuevas

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I. Background

Tourism is primarily associated with the cultural and archaeological richness of the country and to a lesser extent with its coastal areas (the Pacific in particular). At present, tourism is the number two foreign exchange earner of the country. During 1987-1991 alone, tourism earnings reached 774.7 million dollars (INGUAT, 1992). For this reason, the stimulation and diversification of tourism is an important part of the socio-economic policies defined by the Government of the Republic of Guatemala for the 1991-1996 period.

To this end, the Guatemalan Institute of Tourism (INGUAT) designed a plan of action for developing the tourism sector known as the National Plan for Developing Sustainable Tourism. Within this framework, and considering that the Atlantic Coast possess great tourism potential, the Guatemalan Institute of Tourism (INGUAT) decided to prepare an integrated management plan for this coastal area.

As part of the studies undertaken in the Atlantic Coast of Guatemala which were aimed at evaluating existing natural resources, other components were considered i.e. fisheries; evaluation of the eco-tourism potential and the preparation and implementation of a programme on environmental education and public awareness.

Figures 2-7, 10, 11, 12, 15 and 16 of this document are adapted from the original satellite imagery.

II. Objectives

- Evaluation of the potential and extent of the mangroves and sea grass beds, as well as the causes and degree of environmental degradation of these ecosystems;

- Evaluation of the extent and potential of the sea grass beds in the "Golfete", Punta de Manabique, Graciosa Bay and English Canal lakes;

- Preliminary evaluation of the condition and potential of primary fishery resources; and

- Provide recommendations for the preparation of the integrated management plan;

III. Methodology

1. Definition of the Study Area

The study area has been defined taking into account ecological, geographical and administrative criteria.

2. Environmental Features

This phase of the study involved the definition and description of the main environmental features of the study area, considering, water and hydro-dynamics, geomorphology, populated areas, etc. From the analysis of a satellite imagery and field verification, the types, potential and location of mangroves and sea-grass beds have been evaluated providing information on the structure and functioning of the ecosystem. To fully define the study area, certain socio-economic aspects of the region, such as productive activities, coastal infrastructure and services, etc., were also considered.

Satellite imagery analysis considering geo-reference, spectra, numerical pre-classification and final classification was undertaken utilizing an image from Landsat T of March 17, 1993, Path 19, Row 49.

Geo-reference

A transfer of information from the satellite photograph to maps prepared by the Military Institute of Geography (MIG) was performed in order to determine soil use, types of vegetation and coverage. A geo-reference of the satellite photograph was also undertaken.

Spectral Analysis

Based of the spectral resolution of the Landsat-T photograph in the visible range, reflective infrared and thermal infrared, the spectral analysis considered 7 bands. The analysis permitted the identification of the types of vegetation and actual land use.

Numerical Pre-classification

The results of the spectral analysis allowed for an initial pre-classification of the image based on 7 selected spectral bands.

Final Classification

Based on the pre-classification and field validation, the classification of land use and type of vegetation type was undertaken. Also, the degree of perturbation was evaluated and the coverage for each classified unit was determined.

3. Environmental Analysis

The objective of this phase was to identify and evaluate the principal causes of degradation in the mangroves and sea grass beds.

4. Definition of Management Guidelines

Based on the environmental analysis and considering the ecological, socio-economic, and legal aspects, the management guidelines for the preservation of the marine and coastal areas and its natural resources have been defined.

IV. Analysis

1. Definition of the Area of Study

The study area is shown in **Figure 1** and considers the coastal plain up to the 20 metres height isobase and the marine component down to the 10 metres isobath. This definition is based on the geographical characteristics, geomorphology, hydrology, tides, winds, water dynamics and freshwater influence in the area.

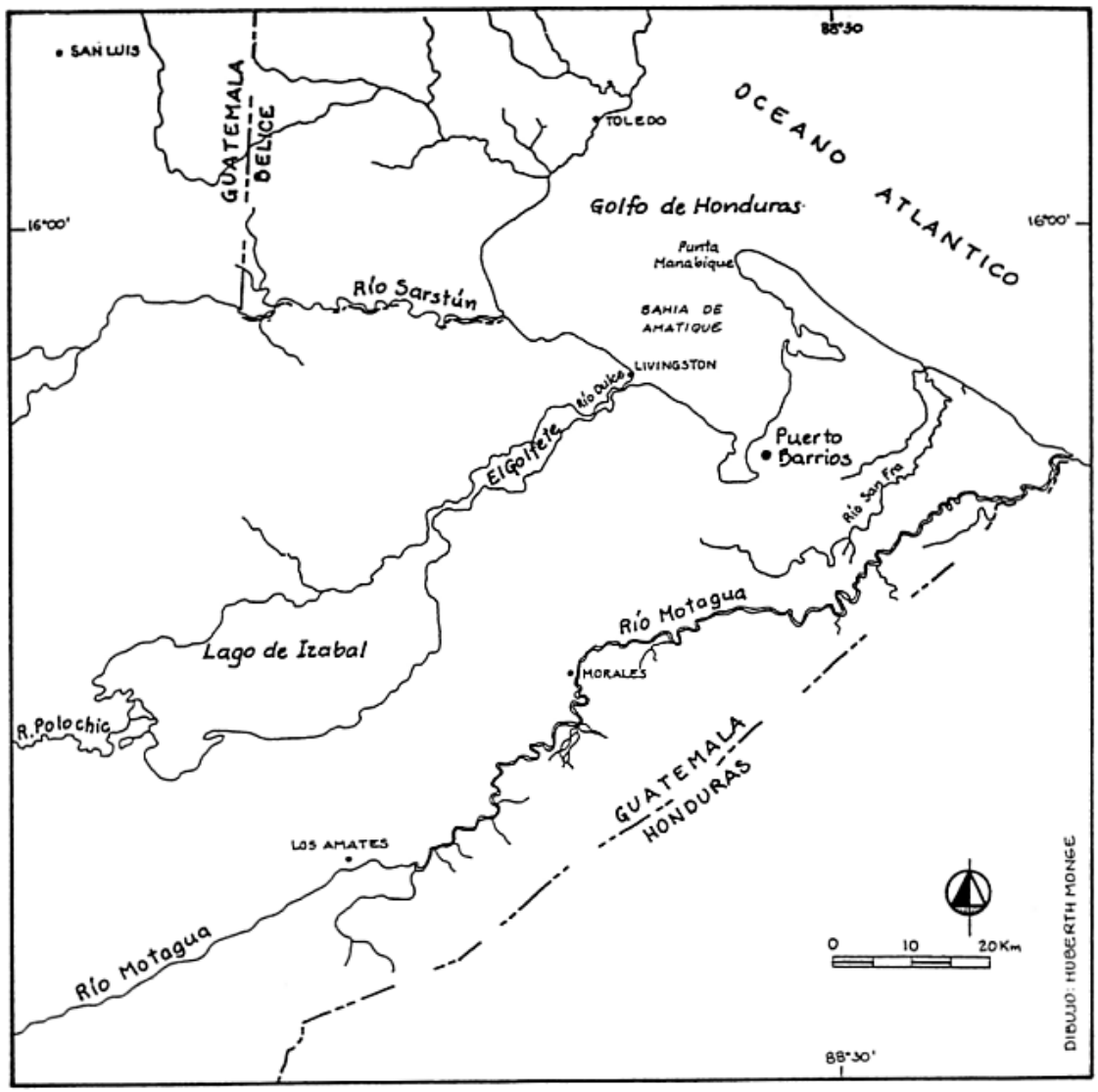


Figure 1. Area of Study. Atlantic Coast of Guatemala

2. Environmental Features

The Atlantic coast of Guatemala is located in the Gulf of Honduras and includes a semi-enclosed bay of 140.6 Km long - the Bahia de Amatique. This bay forms a complex ecosystem of coastal lagoons, swamps and marshes, influenced by tides, riverine systems (Rio Dulce - El Golfete), and canals connecting protected waters and the adjacent continental platform. A brief analysis of the main environmental features of the area is provided below:

3. Physiography

According to Gonzalez et al. (1990), Morena et al. (1993) and Godínez (1993), there are 4 distinct regions or physiographic units in the area (**Fig.2**):

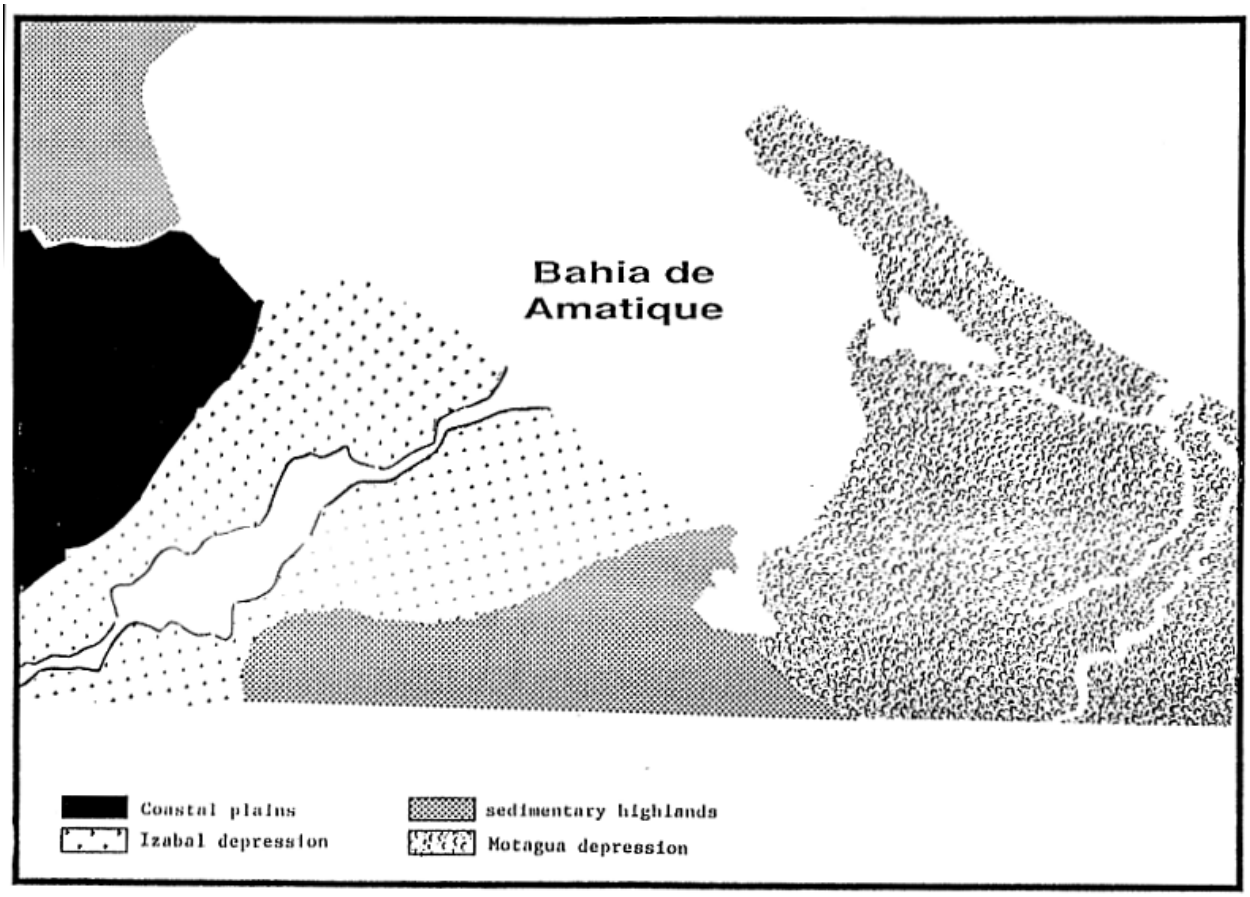


Figure 2. Physiography of the Atlantic Coast of Guatemala.

(a) Coastal Plain of the Caribbean

This region belongs to the lower Sarstún river basin. It is part of a plain formed by alluvial material from the Quaternary Era presenting numerous marshy areas. There are also a number of islets located off the coast and connected to coralline formations.

(b) Izabal Depression

This is a depression that does not exceed 100 metres above sea level between the Sarstún River and the foothills of the Mico Mountains. The Rio Dulce-El Golfete system is an outstanding geographical feature, connected to the Izabal Lake. Generally, the region is marked by poor drainage with soils typical of flooded areas. It also presents inner lagoons particularly in the "El Golfete" region.

(c) Sedimentary Highlands

This is a small region south of Bahía de Amatique located in the foothills of the Mico Mountains. This region is known for the Karst scenery as it is uneven and marked by folds, faults under erosion processes.

The soils in this region have poor drainage and are not well developed (CIEGEPLAN, 1993).

(d) The Motagua Depression

A large part of the study area is found in this region. It is a wide flood plain (from 0 to 40 mts above sea level) formed by alluvial material from the Quaternary Era. The physiography is marked by well developed fossilized dry streams. There are also tidal canals and salty marshes. The sedimentary deposits transported by the Montagua River form a large sandy barrier in a SE-NW direction called Punta de Manabique (CIEGEPLAN, 1993 and Moreno et al. (1993).

4. Climate

Following the classification of Koeppen, the climate of the study area falls within the Rainy-Warm type "A", subtype Awi presenting two distinct climatic periods: A rainy season from June to September with the highest levels of rainfall and humidity or together with a reduction in wind speed and temperature rise. The dry season goes from October to May and it is marked by a reduction in temperature and rainfall (CIESEG, 1993).

There is an isothermic period throughout the year with variations of less than $5^{o}C$. The average annual temperature varies from $26.9^{o}C$ in the region of the Golfete to $25.5^{o}C$ in Puerto Barrios. The dominant winds are the Trade Winds blowing in a NNE direction and with annual average velocities of 10.2 Km/h (CIESEG, 1993). The annual average rainfall is 3000 mm with relative humidity of 80% (INSIVUMEH, 1990; Godínez, 1993).

5. Hydrology

According to the hydrological pattern of the country, the study area is found in the Atlantic Versant and forms 3 basins, the Motagua; Sarstún and Río Dulce River Basin and the Izabal-Rio Dulce Sub-Basin. The main features of these basins (**Fig. 3**) are described below:

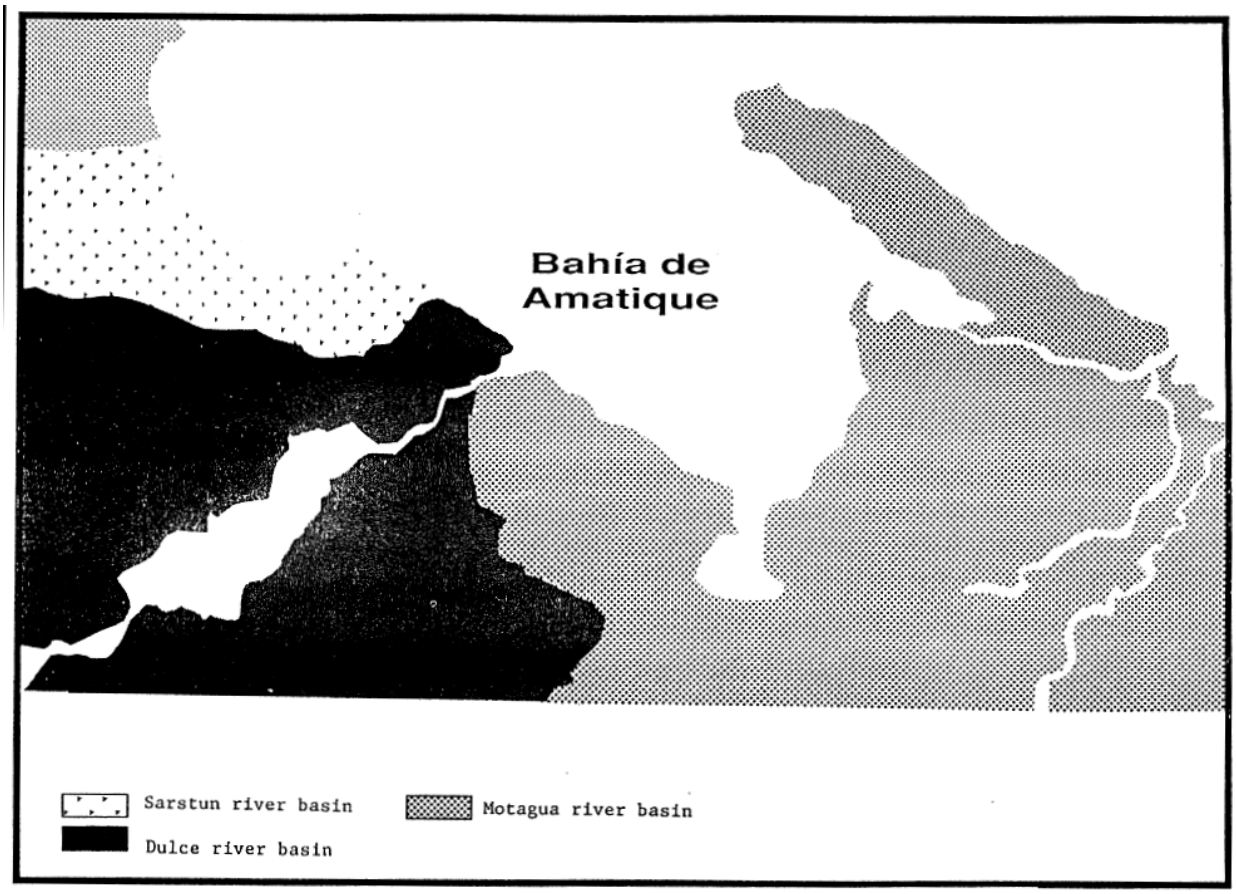


Figure 3. Hydrological basin of the Atlantic Coast of Guatemala.

- ***Motagua River Basin***

This is a drainage system forming a valley within the Meredon and Espiritu Santo Mountain Ranges to the SE of Bahía de Amatique and the Minas Mountain Range; the Mico and Cerro San Gil Mountains are located South of the Bay. The lower basin is marked by the formation of a wide flood plain and the presence of well developed or abandoned meanders (Bastarrachea, 1985).

The Motagua River is the main system draining into the basin. This river and its tributary, the San Francisco River, empty directly into the Caribbean Sea in a wide area covered by highly developed mangroves and tropical rain forests, both are of great ecological and aesthetic value presenting endangered species such as the tapir, jaguar, spider monkey and gigantic ant eater. Another important hydrological feature in the basin is the Piteros River which runs parallel to

the Motagua River and forms the plain of inundation of the Punta de Manabique region. This river empties into the Caribbean sea through a mouth that opens seasonally. In the most distal part of this river bed, the Canal de los Ingleses is connected with La Graciosa Bay. This region is covered with mangroves and tropical rain forests rich in epiphytes. The fauna include numerous species of migratory birds such as the "pico de espatula", "pico de zapato" and soldier heron (CIESEG, 1993).

- ***Rio Sarstún Basin***

The Sarstún basin lies between the Santa Cruz Mountain Range and the Sarstún River, which marks the political boundary between Belize and Guatemala. The Sarstún River (140 Km long) forms meanders and a flood plain on its journey to Bahía de Amatique. As a result of the river's heavy sedimentary load there is an area of sediment accumulation by the river mouth which is moderated by the movement of tidal waves, coastal currents and wind action (CIESEG, 1993).

- ***Río Dulce Basin (Izabal-Río Dulce Lower Basin)***

The lower basin and Lake Izabal drainage converges with that of the Río Dulce and it is carried towards the Bahía de Amatique. On its journey towards the Bay, Río Dulce is divided in three regions or sections: a) a canal 10.5 Km long which links Lake Izabal with the Golfete and the Juan Vicente, Seja and Ciénaga Rivers;

b) a widening area of the middle section of the river forming the El Golfete lagoon with a surface area of 5855.9 has. The western shore of the lagoon presents a flooding area located between Chocón-Machaca and Chiquimulilla, and four islands called Cuatro Cayos, Cayo Julio, Cayo Grande and Cayo Palomo; and c) a canal which links the Golfete with Bahía de Amatique (CIESEG, 1993).

6. Soils

According to the classification system of Simmons, et al. (1959), there are 5 soil types in the study area : Inca, Chacalate, Chocón, Alluvials and Manabique. Following is an analysis of the primary characteristics of these soils (Gonzalez et al., 1990; CIESEG, 1993):

- ***Inca Soils (In)***

These soils are found all over the flood plain of the Motagua River and were formed by the continuous alluvial deposits of the river. They have poor drainage, are grayish brown in colour, are exposed to flooding a major part of the year which creates a serious restriction for their use for agricultural purposes. The productivity in this type of soil is low to medium and requires intensive management practices.

- ***Chocón Soils (Chc)***

These soils are found on the banks of the Sarstún River and the Golfete, as well as on the coast of Bahía de Amatique. They are formed by marine deposits being dark brown to grey in colour,

flat, of medium texture with moderate internal drainage. These features make them suitable for some agricultural activities such as corn and bean farming with the possible limited mechanization. The productivity of these soils could be high under moderate to intensive management practices. Despite the suitability of the soils for agriculture in the Golfete region, the presence of dense forests makes this region unsuitable for this activity.

- ***Chacalate Soils (Cha)***

Chacalate soils are found in the lower Motagua valley, part of the Merendón Mountain Range and the Mico Mountains in slopes exceding 50%. These soils are originally formed from limestone, very dark brown in colour and present with good drainage.

The soils found on the banks of the Río Dulce and Río Sarstún are good for agriculture with some limitations. However, due to the presence of dense vegetation it renders the terrain incompatible with agricultural activity.

- ***Alluvial Soils (AS)***

These soils which are found in both banks of the Bay of Santo Tomas were formed from alluvial deposits carried by rivers, or as result of the variation in the lakes water level and have already been widely utilized, making the addition of fertilizers a normal practice. The western bank contains arable land within some limitations, while the soils of the eastern coast are not productive due to the poor drainage and under-development. The AS soils are currently being cultivated by extensive practices presenting areas of secondary vegetation of graminaceous in abandoned lands.

- ***Manabique Soils***

These are found throughout the Manabique Peninsula, and are formed from alluvial deposits of the Quaternary Era. The drainage is good, clay-sandy texture, dark brown color and it is likely that fertilizers will have to be applied for agriculture.

7. Biomes:

According to the Holdridge system (Cruz, 1976) and CIESEG (1993), two main biomes are found in the study area.

- ***Very Wet Subtropical Warm-Forest bmh-S (c)***

This is found in the Sarstún River region. The rainfall and average annual temperature in this type of forest lyes between 1587-2066 mm and 21-25^{o}C, respectively. There is a large diversity of flowering plants associated to this type of soil and amount of rainfall. Typical vegetation includes:

Orbignya cohune (Corozo), *Terminalia amazonia* (Canxan naranjo), *Brosimun alicastrum* (Ramón blanco), *Lonchocarpus spp.* (Manchiche or palo gusano), *Virola spp.* (Palo sangre),

Cecropia spp. (Guarumo), *Ceiba petandra* (Ceiba), *Vochysia hondurensis* (San Juan) and *Pinus caribaea* (Pino del petén) (CIEGEPLAN, 1993; Moreno et al., 1993).

- ***Very Wet Tropical Forest bmh-T***

This type of forest is found over the entire study area, occupying the coastal plains of the Golfete and Punta de Manabique. The annual rainfall in this region is 3,600 mm annually and the mean annual temperature, 27^{o}C.

The vegetation species common to this type of forest are: *Acacia cookii* (Subín), *Cordia gerascanthus* (white laurel), *Zanthoxylum belicense* (Lagarto), *Crudia spp.*, *Podocarpus spp.* (Cipresillo), *Brasiloxylon excelsa* (chestnut) CIEGEPLAN, 1993; Moreno et al., 1993).

8. Mangrove Forest:

- ***Identification of Species***

Based on in situ surveys and the analysis of information it was determined that there are four species of mangroves growing in the region: *Rhizophora mangle* (red mangrove), *Avicennia germinans* (black mangrove), *Laguncularia racemosa* (white mangrove) and *Conocarpus erectus* (button mangrove), *R. mangle* being the dominant species.

- ***Coverage***

This analysis was performed based on the analysis of satellite imagery, aerial photographs and field studies. **Figures 4 to 7** show the mangrove areas in the following regions: Rio Sarstún-Livingston, Livingston-Punta de Palma, Río Dulce-El Golfete River, Port Barrios and Punta de Manabique, respectively. The total mangrove area covers 707.6 ha. A total of 91.9 km of mangrove growth are present along the shores.

9. Structure and Distribution of Mangrove Forests

Mangroves do not appear along the entire length of the coast. The types of soil and topography limit their distribution as the major part of the coast presents altitudes exceeding the average sea level. Soils are of karstic nature and are under-developed. Both features are not well suited for mangrove development.

There are mangrove forests along river basins, flood plains of the Sarstún River as well as in the deltas and flood plains formed by the San Martin, Tapon Creek, Cocoli and Quehueche Rivers (between Punta San Juan and Livingston); the total surface area covers approximately 189.9 ha.(**Fig.4**)

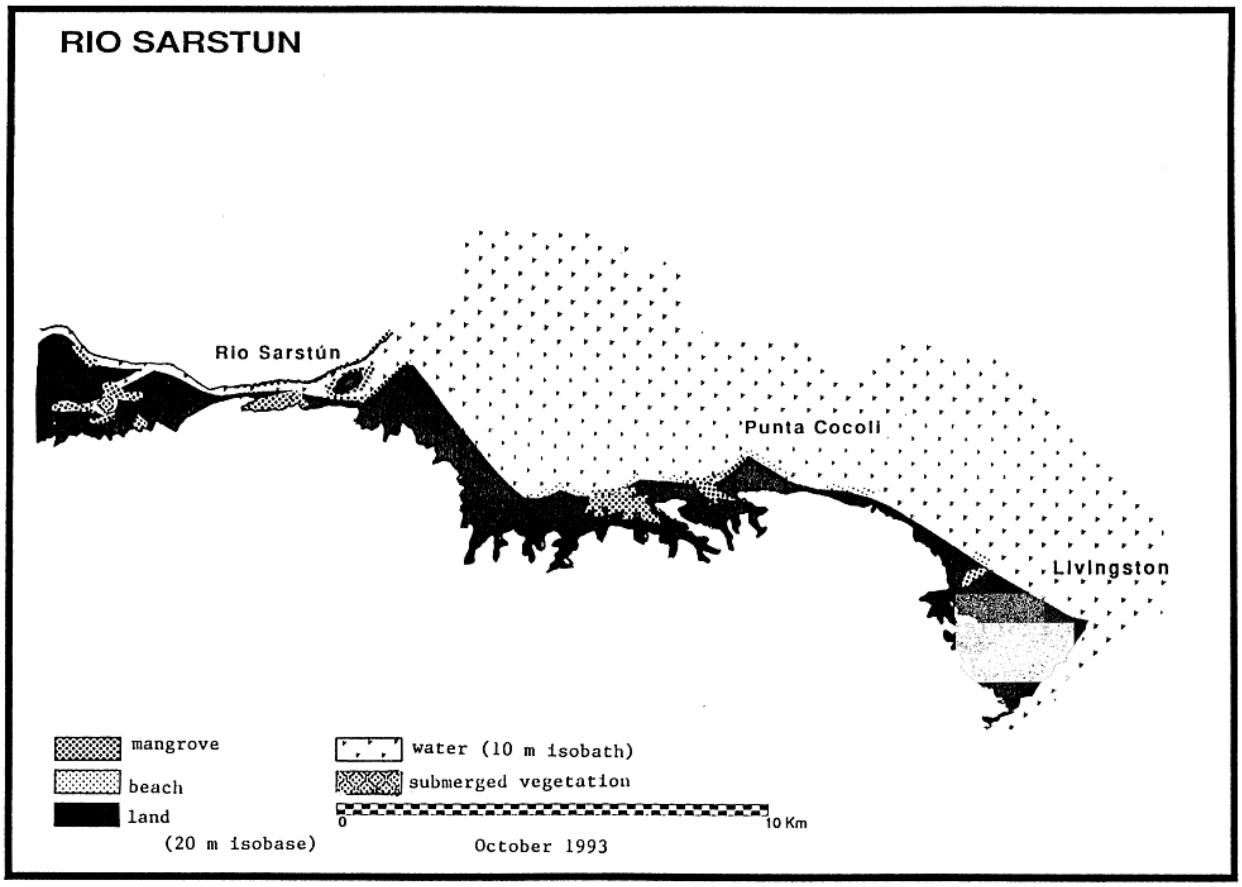


Figure 4. Mangrove and submerged vegetation coverage. Sarstun region.

In the river banks and delta of the Chocón-Machacas River, mangroves are also growing as in the Tamejá River (in the Golfete region). The area covered by these forests is about 269.6 ha. (**Fig. 5**)

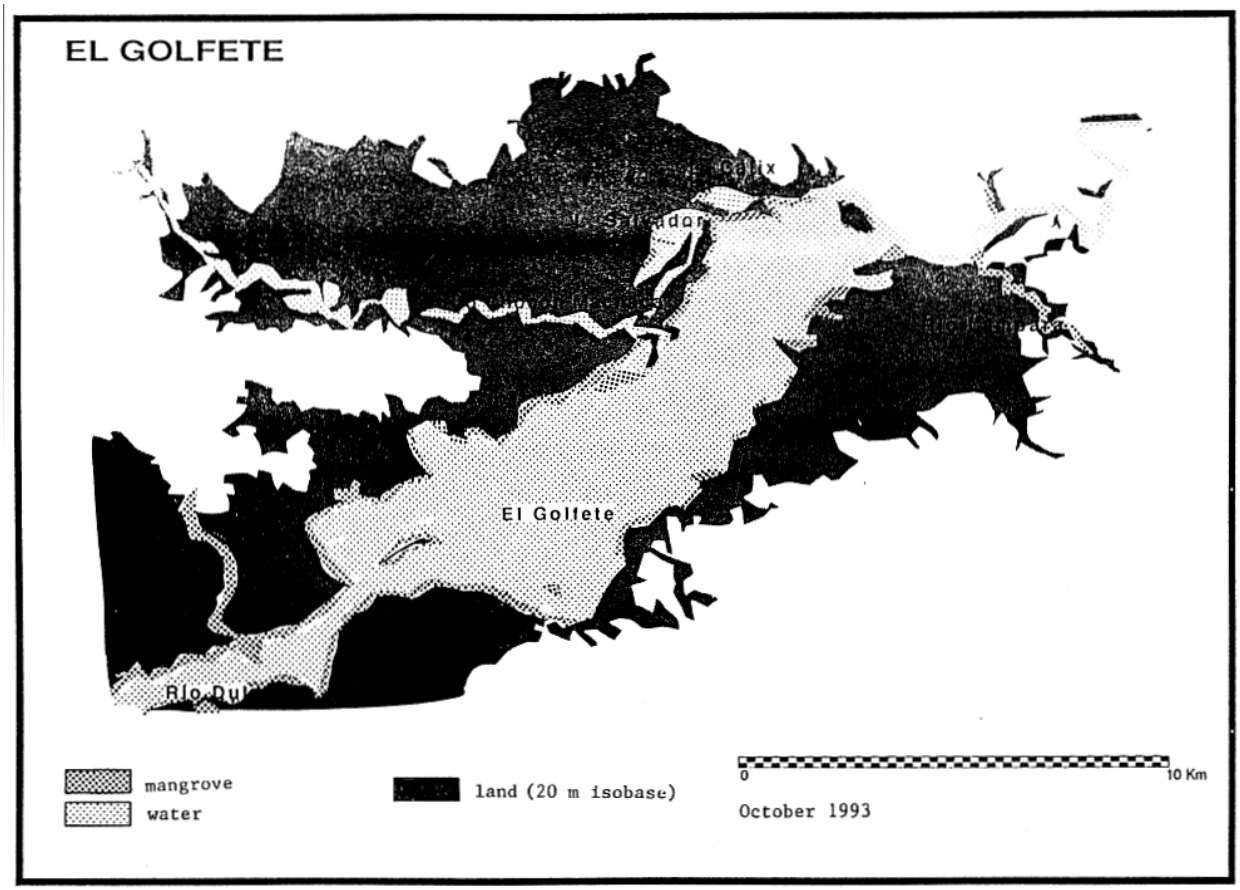


Figure 5. Mangrove and submerged vegetation coverage. El Golfete region.

The Bay of Santo Tomás of Castilla presents mangrove clusters and the San Carlos, Las Pavas and Romana Rivers also have growths along the banks. The total surface area covered by the mangroves in this region is about 24 ha. (**Fig. 6**), including riverine and basin types of forests.

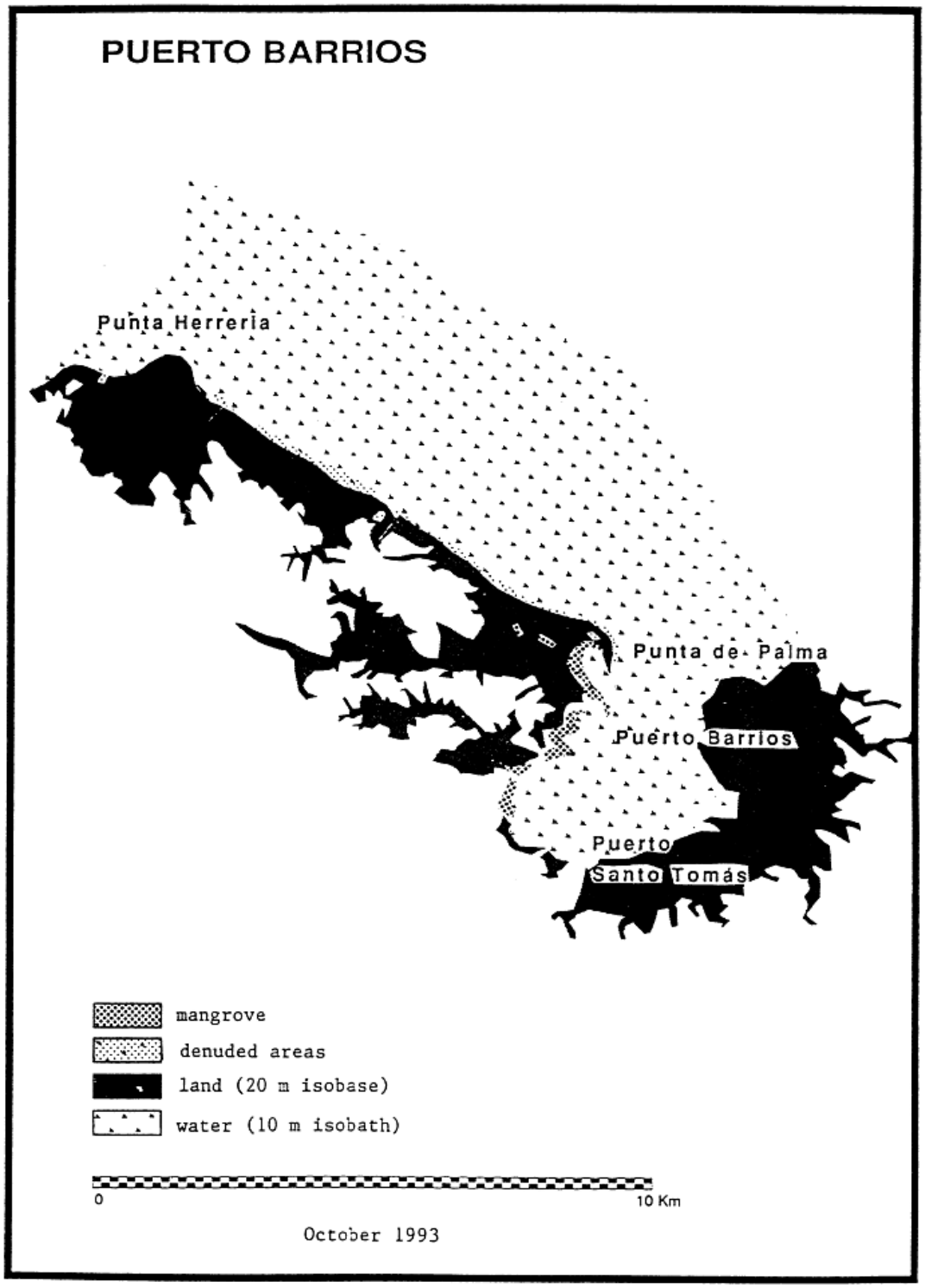


Figure 6. Mangrove and submerged vegetation coverage. Puerto Barrios region.

Between Pichilingo Point and Punta de Manabique (including La Graciosa Bay) up to the mouth of the San Francisco River, there are mangroves growing along the river bank. The total surface is about is about 224.1 ha. **(Fig. 7)**

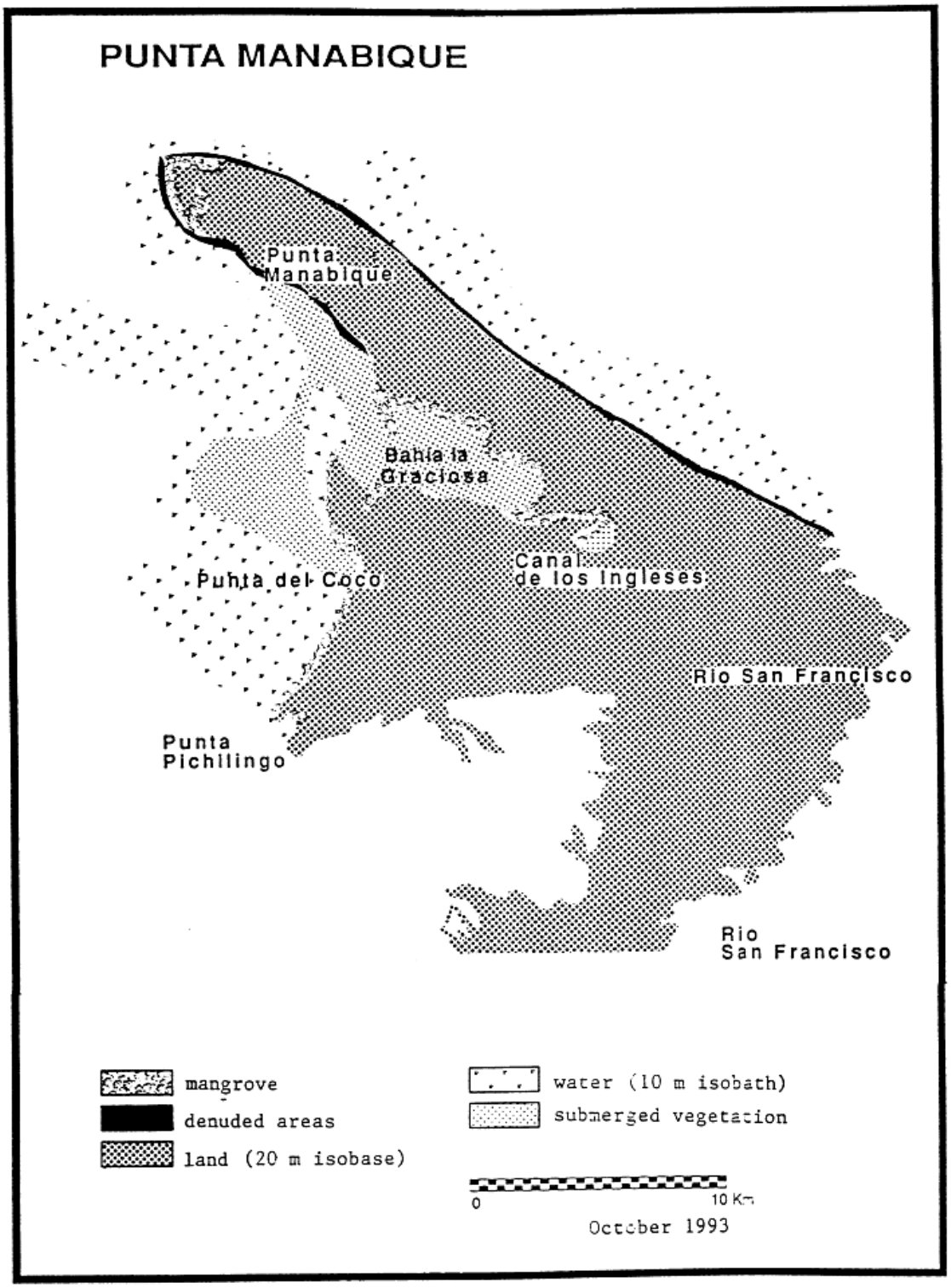


Figure 7. Mangrove and submerged vegetation coverage. Punta Manabique region.

In order to characterize the mangrove forests in the study area, and following Cintron and Shaeffer-Novelli, (1983-1984) and Schaeffer-Novelli and Cintron (1986), four sample sites were chosen (**Fig.8**) and the following parameters were selected: diameter at breast height (dbh), area at base, density, relative density, relative frequency, relative predominance and value. Also the index of complexity developed by Holdridge (1971) was calculated. The technique selected for sampling was the centred point (Cottam and Curtis, 1956). Results are given in **Table 1**.

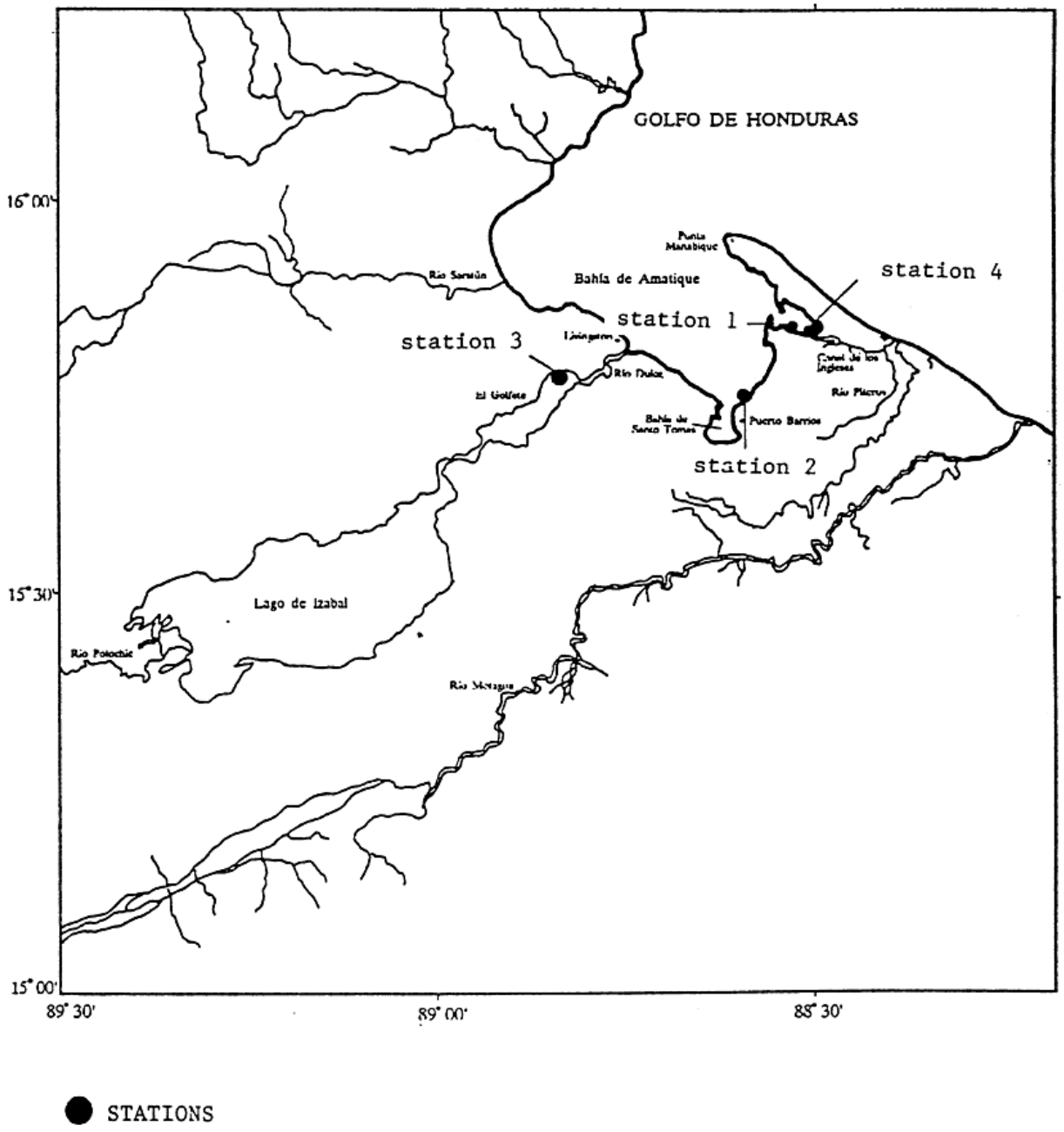


Figure 8. Stations for the mangrove studies.

The mangrove growth that predominates in Bahía de Amatique could be considered as a border type (**Stations 1 and 4**), presenting low density (25-29 trees per 0.1 ha) and 11.6 to 23.87 m. tall. The dominant species, *R mangle A. germinans* occurs sporadically. Forests show low complexity and have small basal area (1.31 to 1.72 m2/0.01 ha).

Table 1. Structural comparisons of mangrove forests in the sampling stations*

Location	Density (0.1 ha)	Base Area (m2/0.01 ha)	Average Height (m)	Relative Frequency (%)	Relative Density	Relative Occurrence	Vale	Complexity Index
Station 1 R. mangle	26	1.31	11.06	100	100	100	300	0.38
Station 2 R. mangle, A. germinans	12 3	0.51 0.39	11.9 24	66.7 33.3	81.3	56.8	204.8	0.48
Station 3 R. mangle	42	1.71	11.69	100	100	100	1.001	0.87
Station 4 R. mangle	29	1.79	23.87	100	100	100	100	1.19

Mangroves nearby the mouth of the Pio Quinto River between Port Barrios and Coco Point in Bahía de Amatique are also of border type comprising *R. mangle* and *A. germinans* being the red mangrove, the predominant species. These forests are confined to a small fringe of less than 15 m. wide, of low density (3 to 12 trees/0.1 ha) and basal area (0.39 to 0.51 m^2/0.1 ha). The complexity index is 0.48 (**Station 2**).

The NE side of El Golfete also shows mangroves of border type found mainly along the fringes of inland lagoons (Calix and Salvador lagoons). This region has the best developed forests of the study area. The average height of the trees is about 11.6 m, with a density of 42 trees per 0.1 ha and a base area of 1.77 m^2/0.01 ha. The predominant species in this zone is *R. mangle* (**Station 3**).

10. Sea Grass Beds

- ***Species Identification***

Based on in situ surveys and the analysis of information gathered from the sampling stations it was determined that *Thalassia testudinum*, is the predominant species. However, other species such as *Halodule wrigthii and Syringodium filiform* may occur. In the Salvador lagoon (Golfete area) there is a large bed of *Vallisneria americana.* (**Fig. 9) (Table 2**).

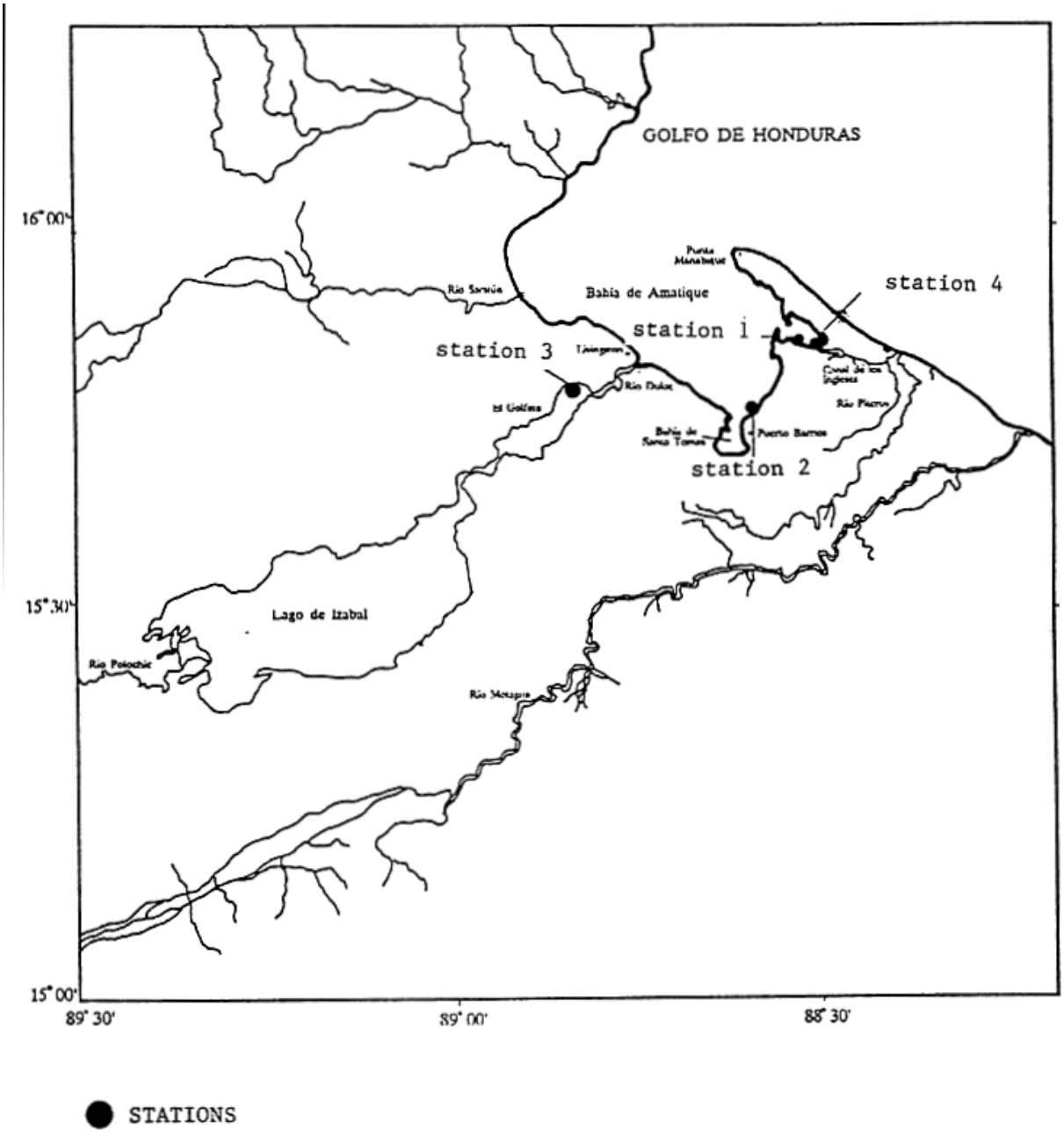


Figure 9. Stations for sea-grass studies.

- ***Extent and Distribution***

From the analysis of the satellite photographs and field studies, the extent and distribution of sea grass beds in the region were determined. The distribution of underwater vegetation is shown in **Figures 4-7**.

The presence and distribution of sea grass beds in any tropical region is related to the degree of water transparency, relatively surf-free environments, shallowness and sandy bottoms. In the study area, these features are present only in the east central section of Bahía de Amatique and in Graciosa Bay. It is precisely in these regions where the analysis of the satellite image reveals the presence of evenly distributed sea grass beds (**Fig. 7**). The area covered by this type of vegetation is about 3750.5 ha. In La Graciosa Bay the sea grass beds reach a density of 1433 plants per m^2 and a biomass in dry weight of 12.48 g/m^2 (**Table 2**).

There are some important patches of sea grass beds of about 82.8 ha. in the shallows by the mouth of the San Carlos River and Punta de Palma as well as in the Santo Tomas de Castilla Bay.

Table 2. Structural comparisons for submerged vegetation and environmental parameters in the sampling stations *

Site	Density	Biomass in dry weight (g/m^2)	Temp. (^oC)	pH	Oxygen (mg/l)	Salinity
Station 1 Thalassia testudinum	1,433	12.48	30.2	7.4	6.9	23.2
Station 2 Halodule wrigthii	4,690	2.77	29.4	6.0	5.6	4.4
Station 3 Valisheria americana		8.72	28.1	6.1	4.2	0.0
Station 4 no vegetation			27.0	5.8	0.89	14.1

* Department of Ecology of the University of San Carlos (USAC)

The Salvador Lagoon in the Chocón-Machacas River delta, *Vallisneria americana* covers an area of 14.9 ha (**Table 2**). In Laguna Grande in the Sarstún River, a small area of 9.0 ha was found from the satellite imagery analysis, but, as an in situ sampling was not performed given the existing conditions of low salinity it could probably be a growth of *V. americana* variety.

11. Oceanography

- ***Hydrodynamics***

The Bahía de Amatique, could be considered as an estuarine ecosystem due to its hydrodynamic and geo-morphological characteristics. It is a body of semi-enclosed coastal waters with a connection to the sea and in which salinity is considerably diluted due to the influence of fresh water coming from land drainage (Pritchard, 1967). The bay covers an area of 54160.8 ha (by considering an imaginary line between Punta de Manabique and the mouth of the Sarstún River). It is a body of shallow water with an average depth of less than 10m.

The tides takes place twice a day with heights ranging from 0.1 to 0.5m in low- and high-water, respectively (IGM, 1984).

Two major systems discharge the waters into the bay, the Sarstún River and the Polochic-Lago Izabal-Río Dulce. Draining directly into the Caribbean Sea are the Motagua River and its tributary, the San Francisco River, whose sedimentary load and watercourse have contributed to the formation of Punta de Manabique as a large sand barrier lying in a SE-NW direction.

The rivers discharge in the area, geomorphology, dominant winds (NNE) and tidal effects are factors that influence the circulation patterns in the estuarine system. Water circulation follows an anticyclonic pattern beginning around the mouth of the Sarstún River and closing the circuit at Punta de Manabique (**Fig. 10**) as a result of the presence of this sand barrier. The main indicators of this type of flow are the presence of the barrier reef along the Belizean coast north of the mouth of the Sarstún River. This assumption is based on the fact that if the water discharged by this river were to flow in a northerly direction, the barrier would not be there. Other indicators of the circulation pattern are the sedimentary load carried away by rivers and the orientation of deltas following the flow of currents, as well as the distribution of shallow banks in the central basin, whose direction is in accordance with the proposed circulation pattern.

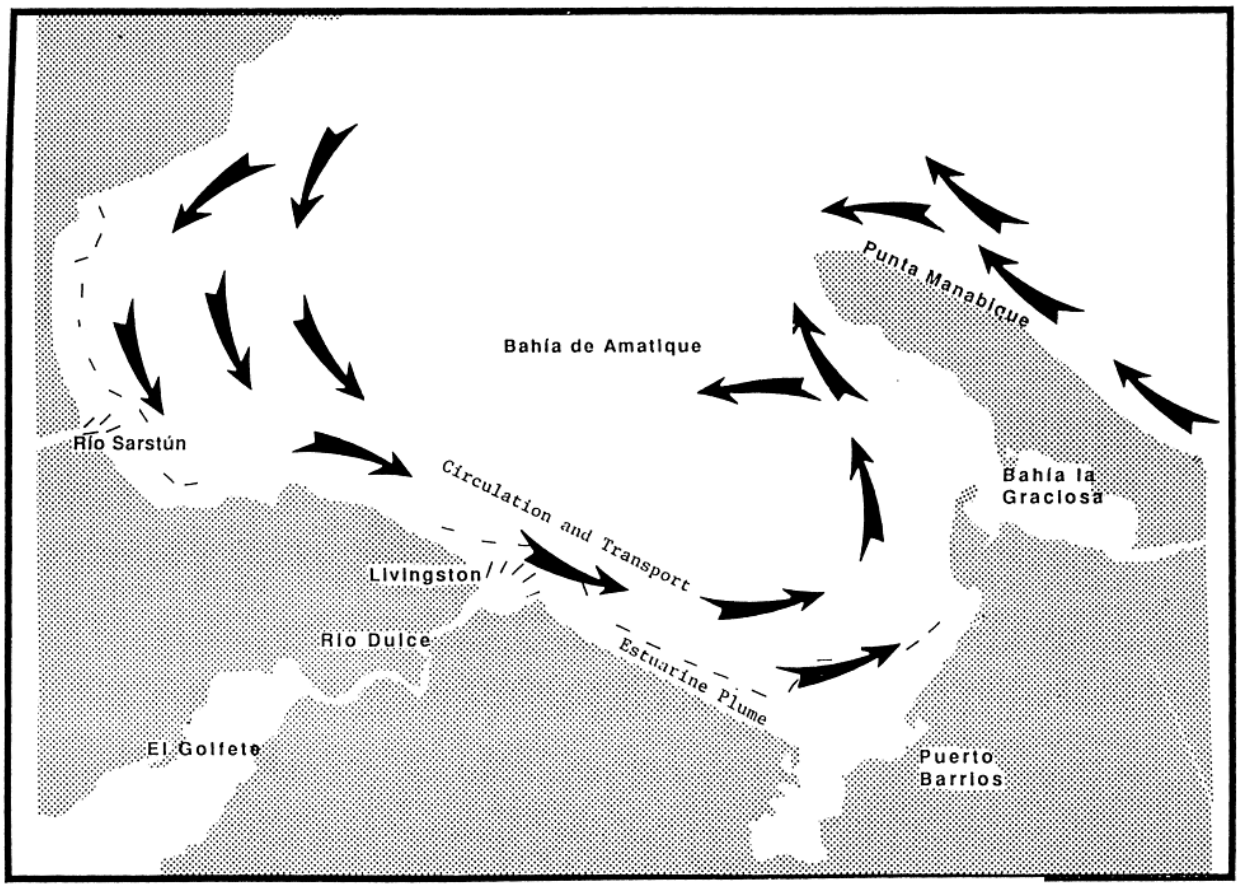


Figure 10. Circulation and transport pattern of the estuarine system of Bahia de Amatique.

- ***Physico-chemical Characteristics***

  The majority of the physico-chemical parameters in the estuarine system showed a gradient due to the rivers discharges, currents and tides existing in the area.

  Salinity, fluctuates throughout the year from 10 to 30 ppm (INSIVUMEH, 1981). In accordance with data provided by Salaverría and Rosales (1993) for the rainy seasons, there is a clear gradient with readings from approximately 10 pp/mt at the mouth of the rivers to 16 pp/mt in the outermost part of the bay. Eventually, there is also a stratification of this reading, with average surface readings of 11.9 pp/mt to 33.7 pp/mt at the bottom as a result of the circulation of two masses of water, one being superficial (less saline), heading towards the sea and the other (more saline), penetrating the bay from below.

  The annual variation in water temperature is from 20 to 33^{o}C (INSIVUMEH, 1981). Salaverría and Rosales (1993) report for the rainy season, a system average of 29.2^{o}C and a 5.0 mg/l dissolved oxygen concentration in the water column.

- ***Environmental dynamics***

  As a result of the field work the following characteristics were identified:

a) The river discharge draining in Bahía de Amatique affects its productivity and regulates the distribution of sea grass.

The suspended and solution material discharged by the rivers and distributed by the currents along the coast, including the mouth of the Sarstún River and Port Barrios (**Fig. 11**), create conditions of water transparency, sedimentary load and salinity hardly favourable for the large-scale development of sea grass beds. However, the current in the east central part of Bahía de Amatique and Graciosa Bay presents waters of medium salinity and of a particularly high transparency, which permits the development of this type of vegetation (**Fig. 7**).

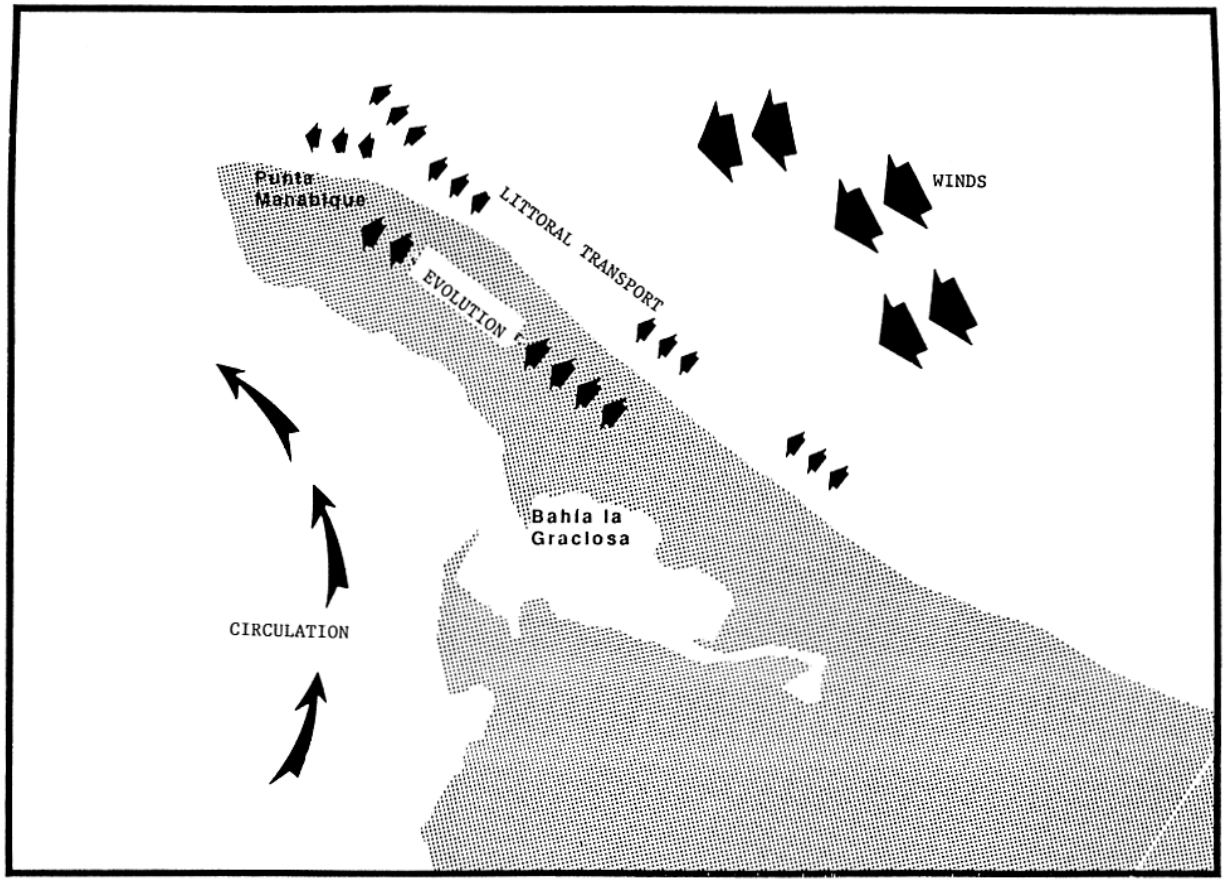


Figure 11. Formation dynamics of Punta Manabique.

The discharge of the rivers also regulates the natural productivity of the ecosystem, as it is converted into one of the main energy sources for the supply of nutrients and organic matter for sustaining the ecosystem's metabolism and energy for the food chains.

b) The Canal de los Ingleses impacts significantly on the productivity of Graciosa Bay and regulates the productivity of mangroves and sea grass beds in the region.

This canal gushes forcefully from the Piteros and San Francisco rivers, in addition to draining across the densely vegetated marshes of the river delta. The vegetation in the Canal de los Ingleses suggests the presence of a large amount of nutrients while, simultaneously, this vegetation buffers the transport of terrigenous materials. Nonetheless, the water transported by

the canal has significant levels of organic matter, a small amount of terrigenous sediments and produces a salinity gradient towards Graciosa Bay. These are favourable conditions for the establishment of sea grass beds in Graciosa Bay and stimulate the productivity and structure of mangroves as well as the metabolism throughout the water column.

c) Punta de Manabique is an active, growing sand barrier which is fast advancing towards its end, showing areas of accretion and erosion. This sedimentary type of environment conditions the structure of the mangrove forests along the coastline.

The currents inside the Bay, water and terrigenous sediments discharges, particularly from the Motagua and Piteros Rivers diverted to a SE-N-W direction by the coastal currents, are the main factors accounting for the formation of Punta de Manabique (**Fig. 11)**. This sand barrier is a very dynamic system which is formed along the same direction as the coastal currents due to the continuous discharge of sediments. Areas of erosion and accretion which appear alternately along the external coastline of the barrier affect the structure and distribution of the mangrove forests. By being high energy environments (erosive environments), they contribute to the growth of poorly developed, low, shore mangroves. Trees fall due to the erosion, leaving the coastline even more exposed to the currents and surf. The formation of Punta de Manabique is the result of the outer littoral currents on the one hand, and the internal currents in Bahía de Amatique, on the other.

V. Environmental Analysis

1. Analysis of Current Land Use and Types of Vegetation

Based on the analysis of subject maps, aerial photographs, satellite imagery and field verification, a study was done to determine the current land-use and types of vegetation (including mangroves and sea grass). The analysis of the satellite imagery involved the same four phases mentioned in the section dealing with evaluation of coverage and distribution of mangrove ecosystems and sea grass.

In **Figure 12** the land-use units and types of vegetation identified are presented. The following is a description of each of them:

- ***Mangroves***

This unit appears in soils influenced by tides and are covered by mangrove forests, *Rhizophora mangle*, primarily.

- ***Wetlands***

These areas occur in soils that are water-logged for the greater part of the year and covered by marshy forests.

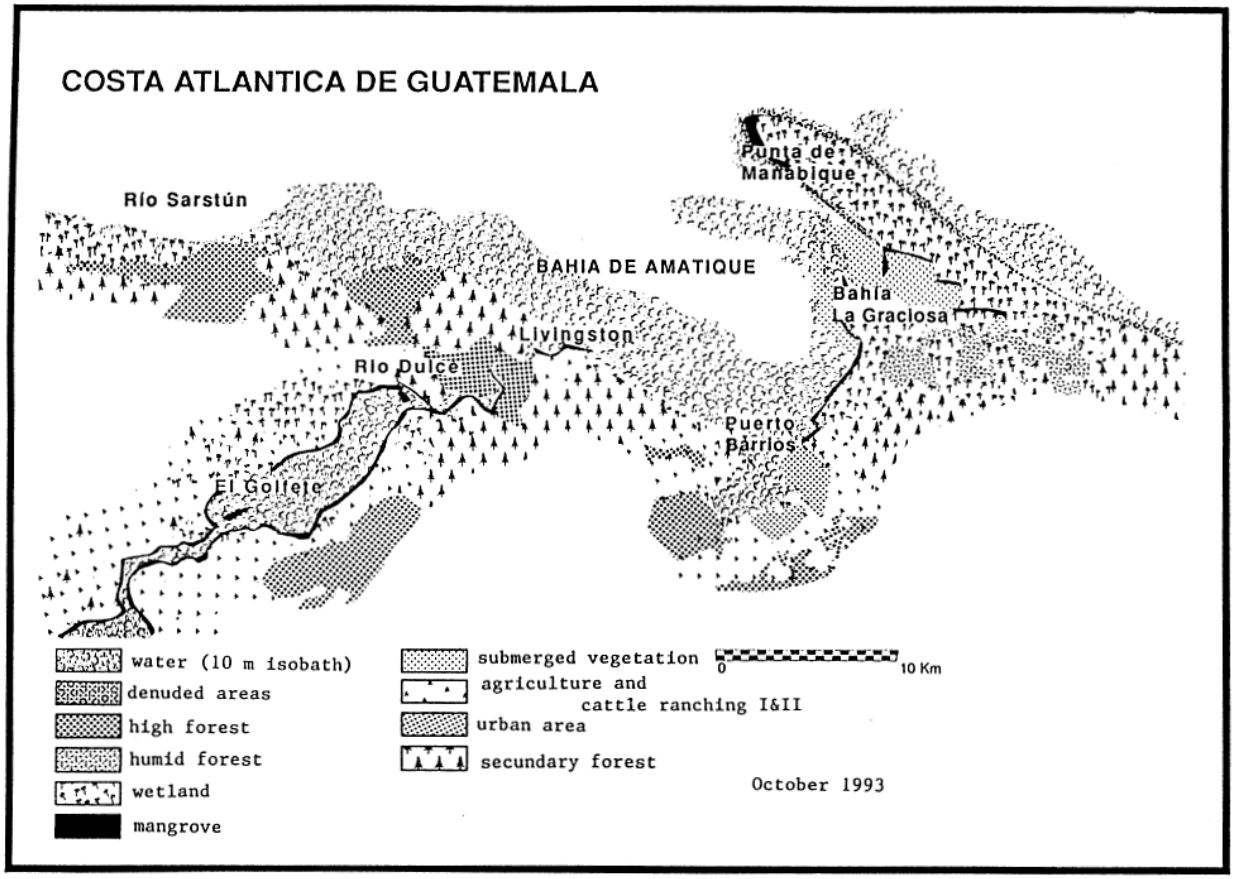


Figure 12 Land use and vegetation map of the study area (5 km inshore limit).

- ***Wet Forest***

  This unit corresponds to soils that are flooded during one season of the year or have a certain level of humidity. The vegetation that covers these soils corresponds to that of Very Humid Tropical Forest.

- ***High Forest***

  This unit is known to be present in areas with an altitude of more than 10 m. The type of vegetation falls within the High Density Forest classification.

- ***Water***

  This term is used to label all those areas covered with continental or marine waters and also includes the river basins down to the 10m isobath.

- ***Submerged Vegetation***

  These are estuarine freshwater/marine areas covered by sea grass beds, mainly of *Thalassia testudinum.* There are some regions presenting freshwater vegetation such as *Vallisneria*

americana.

- ***Denuded Area***

  These are areas devoid of vegetation and are primarily located in the beach area.

- ***Urban Area***

  In these areas, the vegetation has been totally changed by urban or suburban neighbourhoods.

- ***Agricultural Area 1***

  Agricultural areas labelled type 1 are those where the vegetation has been completely replaced by agricultural crops (corn primarily) and to a lesser extent by pastures induced by herding practices.

- ***Agricultural Area II***

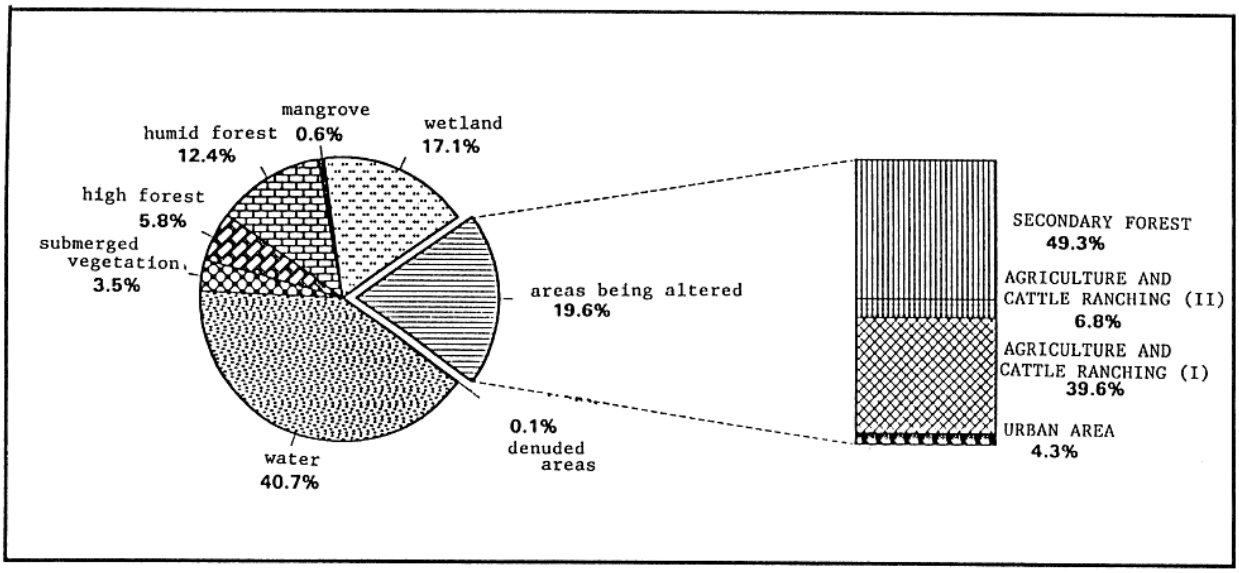
  Type II agricultural areas are on soils that have been subjected to agricultural activity and then abandoned once they have ceased to be productive. These soils are covered with secondary vegetation.

- ***Secondary Forest***

  This unit is associated with soils having secondary vegetation under and advanced state of succession. It is primarily made up of trees with heights of 8-12 m.

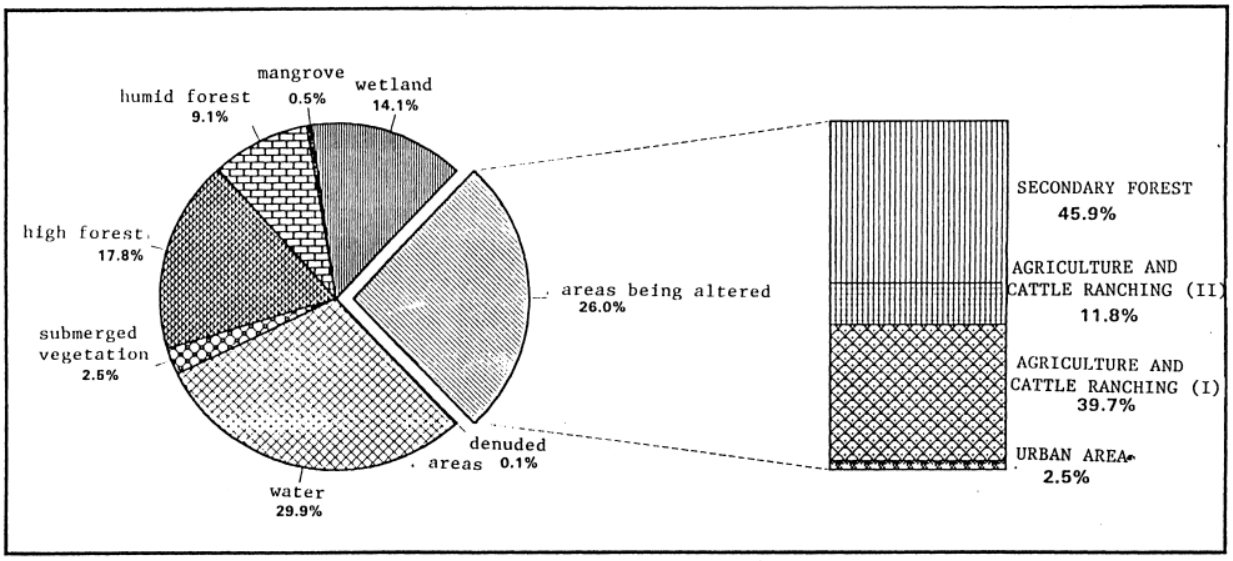
In **Table 3 and Figure 13** the surface area for each identified unit and its percentage in relation to the study area is shown. Both figures show that there is already a significant degree of degradation, considering that 19.6% (taking the surface area covered by water and 33% without water) of the surface area has undergone a change in the characteristics of the soil and a loss of natural vegetation which impair the ecological functions performed by the ecosystem.

Figure 13. Land use and vegetation surface (as %) of the study area



A further analysis was carried out of soil use and vegetation in the area within the coastline and a distance of 5 km inland. The reason for considering this area is that it is federal property and can be included in the Integrated Management Plan for Environmental as a buffer zone. The final classification of the satellite imagery coincides with that of the study area and is shown in **Figure 12**. The statistics and percentages are given in **Table 4 and Figure 14**.

Figure 14. Land use and vegetation surface (as %) of the Atlantic Coast up to 5 km inland.



2. Environmental Impact:

The extensive and growing environmental degradation of the region and the entire municipality of Izabal in general is due primarily to ignorance of the ecological and sociological value of the ecosystems and the lack of planning instruments for monitoring and evaluating land-use and the natural resources. The main factors affecting the environment are: inadequate agricultural practices, over-fishing, the development of coastal and port infrastructure, human settlements and urbanization as well as activities having to do with the prospecting and exploitation of hydrocarbons, dredging, illegal hunting and unregulated sporting.

Table 3. Statistics on units of land-use and vegetation identified in the study area (ha)

	Sarstún	**Golfete**	**Puerto Barrios**	**Punta Manabique**	**Total**
Mangrove swamp	189.81	269.62	24.06	224.12	707.62
Wetland	1,444.12	6,754.0	1,192.56	9,700.43	19,091.12
Wet Forest			1.06	13,797.43	13,798.5
High Forest	1,242.93	1,056.31	1,431.87	2,775.0	6,506.12
Water	11,101.81	6,896.25	11,757.43	15,613.68	45,369.18
Underwater vegetation	9.0	14.87	82.81	3,750.5	3,857.18
Denuded Area	11.62	0.25	27.5	107.0	146.37
Urban Area	52.12	24.0	856.12	12.87	945.12
Agricultural Area 1	224.0	4,823.0	1,554.43	2,054.12	8,655.56
Agricultural Area II	183.93	512.43	249.75	535.25	1,481.37
Secondary Forest	664.18	2,664.87	1,619.56	5,837.0	10,785.62

- ***Agricultural Practices***

Agriculture is the activity that has had the greatest impact on the loss of woodlands, mangroves and marshes in the region, although the region soils are not suited to that type of activity. Agriculture can be considered as a seasonal activity due to the fact that soils are used as long as they are productive and later are abandoned.

Lands to be cultivated are prepared by slashing and burning without any conservation or management procedure. The most important crops in the region are corn, beans and rice and to a lesser extent banana, coconut and pineapple crops. Herding is a complementary activity to agriculture and is done on a large scale, in pastures which are prepared by burning forest and mangrove areas. Livestock activities are primarily associated with cattle and pig rearing (CIESEG, 1993).

The main environmental problems associated with agricultural activities and the removal of vegetation are: the loss of critical habitats for species of commercial value or that are endangered: loss of soils and erosion, transport and carriage of sediments towards the coastal zone which affect water quality. Another associated problem is the carrying of agro-chemicals used on crops, which reduces the quality of water and affects the fishing resources.

Table 4. Statistics on units of land use and vegetation identified in the area between the coastline and 5 km within (ha).

	Total
Mangroves	707.62
Wetlands	21,346.31
Wet Forest	13,798.50
High Forest	26,965.50
Water	45,369.18
Underwater Vegetation	3,857.18
Denuded Area	175.93
Urban Area	998.87
Agricultural Area I	15,641.00
Agricultural Area II	4,657.00
Secondary Forest	18,096.81

- ***Fishing***

Fishing in the region is primarily carried out by unskilled fishermen mainly in the Graciosa Bay, Punta Manabique, the mouth of the Sarstún River, Livingston and the Río Dulce-Golfete areas.

Salaverría and Rosales (1993) reported more than 45 species of fish, mollusks and shellfish in the region. The distribution and abundance of these resources depend on the river discharge, salinity and concentration of oxygen during the rainy season.

The species having commercial importance are: mackerel, snook, calale (colorado), jackfish, mojarra, palometa, corvina and shark as well as shrimp, lobster and tarpoon. The current regulation (fishing seasons) is based upon limited information on the biology and ecology of the species. The little information available is limited and is related to fish prospecting studies such as those of Aweigh Engineers (1975) and Matthes (1986), anthropological studies such as that by Maldonado (1991) and studies focused primarily on the distribution of mollusks for example those by Cazali (1988) and Prado (1990).

The lack of information on the current state of fisheries, in terms of their biology and of volume of catch as well as the lack of management of resources and planning of the fishing activity can lead to problems of over-exploitation of this resource. This will lead to a reduction in the region's production of fish, with the resultant economic losses. It is also important to bear in mind the effect which other sources of environmental impact can have on fishing productivity in the region, for example contamination from agro-chemicals and sewage as well as the destruction of critical habitats, food or protection (sea grass, mangroves and wetlands).

- ***Forestry***

The removal of precious wood by legal and illegal loggers as well as the cutting down of trees such as mangroves for use as building materials, fuel and energy are common practices in the study area and are not subjected to any form of sustainable management. The results of these activities are the destruction of critical habitats for the fauna, soil loss and transport of materials and contaminants towards the bay, thus reducing the quality of water and the ecosystems. One of the ecosystems most vulnerable to this alteration are the sea grass beds which are susceptible to the accumulation of excessive nutrients and changes in water transparency (CIESEG, 1993).

- ***Hydrocarbons***

Activities associated with hydrocarbons are currently limited to transportation and storage at Puerto Barrios and Santo Tomás de Castilla while exploration was considered outside of the study area, (Lake Izabal). There are few studies done on the levels of concentration

of hydrocarbons in the region. One study done by DGEN-Shell (1991), shows the existence of traces of oil in the area linking Lake Izabal to Río Dulce (Castillo de San Felipe).

Despite the non-existence of significant levels of hydrocarbons in the sediments and the water column, the risk of accidents or spills as potentially serious sources of contamination in the area must be considered. In April, 1975 there were spills off the Atlantic Coast of more than 25,000 gallons of asphalt and about 6000 gallons of bunker oil by the sinking of a ship near Punta de Manabique. The result of this spill was a considerable reduction in the population of fish, shrimp, lobster, squid, clams and snails and a financial loss of more than 31 million quetzales (Bastarrachea, s/f).

Oil exploration and production activities being planned for Lake Izabal could induce, if adequate preventative or mitigating measures are not established, a deterioration in water quality and habitats. This could occur not only in the lake but also in its area of influence up to Río Dulce, - the Golfete and the marine/coastal zone, due to chronic release or accidental oil spills or interruption of natural run-offs by the development of canal and access routes. Also, activities, such as dredging, can bring about negative effects such as the suspension of this contaminant in the water column, directly affecting sea grass beds. Another unwanted effect associated with oil development activities is the immigration of people induced by the demand of manpower for the industry with the resultant problem of pressures on land use and increased demand for services such as drinking water, solid wastes disposal, sewage, etc.

- ***Human Settlements and Urbanization***

There are three important population centers in the study area - Puerto Barrios, Puerto de Santo Tomas de Castilla and Livingston as well as small villages or rural areas spread along the entire coastline. The main environmental problem is the lack of a sewage disposal system, drainage and sewage treatment plants. The ecological implications and environmental effects of the discharges are the reduction in the quality of water and the ecosystem; changes in transparency and light penetration which could affect the processes of photosynthesis and the productivity of phyto-plankton and sea grasses. Under conditions of anoxia the production of compounds such as mercapthanes and sulphuric acid would cause changes in the pH of the water as well as an offensive odour. Apart from particulated material and nutrients entering the system; sewage can transport germs that cause bacterial diseases (e.g., cholera and typhoid) as well as viral infections (e.g., poliomyelitis and hepatitis), among others, that can be transmitted through eating contaminated fish and shellfish.

- ***Tourism***

Despite the fact that tourism generates 211.3 million dollars per year (1991 data), which makes it the second largest foreign exchange earner for the country after coffee (INGUAT, 1992), coastal tourism in the region is basically domestic and there is very little tourism infrastructure and services. There are some hotels providing basic services in Port Barrios, Santo Tomás de Castilla, Livingston and Golfete.

The non-existence of treatment plants for waste water generated by hotels or boats anchoring in Golfete and the release of this water into the marine area are the principal causes of environmental degradation in the region. The environmental effects are similar to those mentioned earlier.

- ***Ports Infrastructure and Activities***

The heavy traffic of small, medium and large boats crowding the ports of Santo Thomas de Castilla and Puerto Barrios, as well as the existing infrastructure causes spills of grease, oils and chemicals as well as waste water, most of the time without any form of treatment. According to 1992 data provided by the National Port Authority, there are now, in the Santo Tomas de Castilla Bay, high levels of contaminating nutrients and fecal matter (from 750 - > 25 000 NMP /DL) which exceed the maximum permissible limit prescribed by COGUANOR for drinking water (3 npm/DL for fecal matter).

Dredging activities in the navigation canal of Santo Tomás de Castilla Bay is another source of impact on the region, due to the re-suspension of sediments and contaminants which alter water quality and that of the ecosystem, primarily of sea grass beds. Due to the coastal currents the sediments and suspended solids are carried along the littoral towards Bahía la Graciosa which reduces water transparency, thus diminishing productivity or resulting in a total loss of the vegetation in extreme cases.

3. Environmental Analysis by Regions

A brief analysis by regions is presented below based on documentation available (CIESEG, 1993), National Port Authority, Moreno et al., 1993; Godínez, 1993 a and b; Gonzalez et al., field studies and the analysis of maps and satellite imagery.

- **Río Sarstún Region**

This area includes the Río Sarstún Game Reserve, and the coastline between this area and Livingston.

- ***Río Sarstún Game Reserve***

North east of the study area includes part of the Type III Protected Area called the Río Sarstún Game Reserve.

It represents a region of important ecological and socio-economic value due to its great biodiversity and the presence of critical habitats (mangroves an subtropical forests). The socio-economic and political value of this region is based on the fact that it forms the political boundary between Belize and Guatemala.

The standard vegetation of this region is characteristic of a very humid subtropical forests which includes riverine mangroves associated with the Sarstún River, Sarstún Cay and the flood plain of the basin. Both types of vegetation can be considered as critical habitats for many species, some endangered (e.g., starks, herons, fishing eagle, toucan, jaguar, manatee, tapir, wild boar, otter and crocodile) and others of commercial value such as fish, crustaceans and mollusks found at the mouth of the river.

The main problems of contamination and environmental impact in the region are those having to do with unplanned human settlements which exert pressure on forests and mangrove areas by removing trees form large areas primarily for the cultivation of corn or for obtaining lumber. Another problem in the region is illegal hunting of species such as the jaguar and crocodile for trading in hides or the wild boar for food.

- ***The Punta San Juan-Livingston Coastline***

  * Punta San Juan

    There are five important areas in this region having good potential for tourism and agriculture -Punta San Juan-Livingston, Cocoli-Siete Altares, Siete Altares, the Siete Altares-Rio Quehueche coastline and the Rio Quehueche-Livingston coastline. The region is now having some tourism activities due to its hidden fine sand beaches. This has resulted in the removal of coastal and inland vegetation as well as beach refilling activities. Due to a lack of sanitary infrastructure, sewage is released directly on to the land and sea from human settlements.

  * Punta de Cocolí-Altares

    Along the coast in this region are many narrow fine sand beaches interrupted by karst areas, which makes them not very accessible by land. In spite of this and due to its great aesthetic value, there are beaches which can support some permanent tourism installations with adequate plants for sewage and waste water treatment and disposal.

  * Siete Altares

    In the Siete Altares region, erosion due to the river flow is continuous. This region, though not having any beaches, has great aesthetic value and is utilized for recreational purposes.

    The vegetation is made up of coastal forests and some species such as *Vochysia hondurensis* (San Juan) and *Pachira acuatica* (zapotón). There are abundant bromeliads and orchids. Towards the beach area, there are coconut trees and sea grapes (*Coccoloba belizensis).*

    The interior coastline is marked by deforested valleys and flat areas due to agriculture (primarily corn and bananas, to a smaller degree). These lands are abandoned once worn out and are converted into wasteland. Vegetation is also removed for lumber and firewood, building materials and energy. Another problem in the region is the area dedicated to military exercises, which affect the natural conditions by deforesting and penetrating areas.

  * The Siete Altares-Quehueche Coastline

    This region begins at the mouth of the Quehueche river. There are narrow fine-sand beaches with tourism potential although in some regions the removal of coastal

vegetation has brought about problems of coastal erosion and salinity. The main indicator of this process is the exposure and destruction of certain coconut palm trees. In areas with good drainage, there are red, white and button mangroves, the red mangrove being predominant.

Agriculture and firewood removal from lands that were abandoned earlier on are for the most part covered by bitter cane (*Gynerium sagittatum)* as well as other gramineae. Large-scale deforestation has taken place.

* The Quehueche-Livingston Coastline

The part between the mouth of the Quehueche River and Livingston is a suburban-urban area. A number of houses are located closer to the Quehueche river. There are some narrow fine sand beaches along the coastline where special villas for tourism have been constructed.

The main problems of this region are health related; storm water and sewage are directly discharged into the sea without prior treatment or, in most cases, into improper latrines. The release of sewage into catchment areas produces an offensive odour and endangers public health. Another problem is the cutting down of trees for use as energy in the form of firewood and charcoal. Areas

already deforested are covered with secondary vegetation. The remaining vegetation is primarily made up of coconut trees and palma confra (*Manicaria sacciera).*

- ***The Golfete Region***

This part of the study area is comprised of two protected areas - the Río Dulce National Park and the Biotopo Chocón-Machacas. Also included are the Golfete plains which are located outside the protected area (**Fig. 15**).

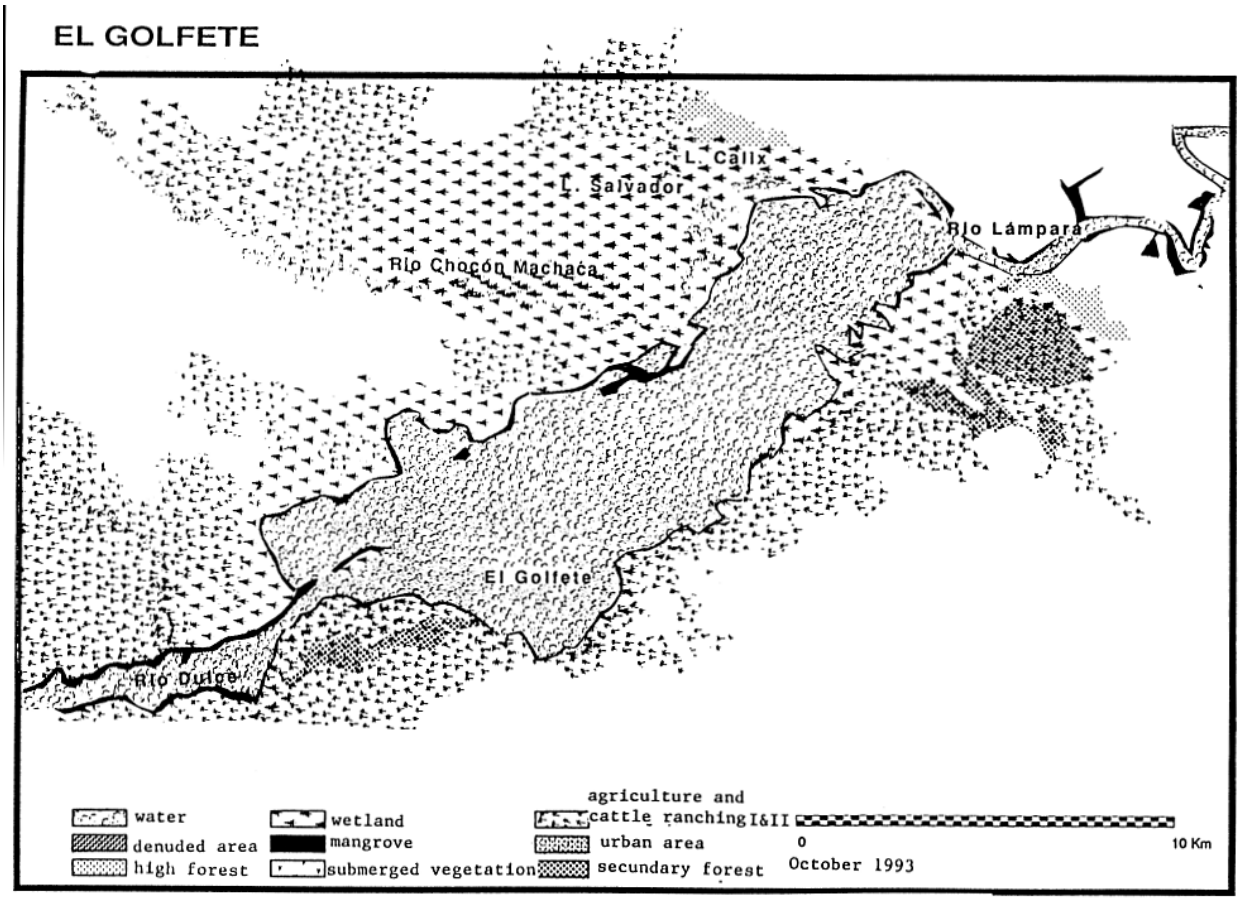


Figure 15. Land use and vegetation map. El Golfete Region.

* Rio Dulce National Park

This protected park includes a fringe 1 Km wide and 39 Km long on both sides of Río Dulce and Golfete. It is a region of great ecological importance and has been declared a protected area for the preservation of tropical rain forests and as a habitat and shelter for the manatee.

The river banks in the Golfete region are being used for tourist housing and infrastructure (lodgings and water facilities). These activities, in addition to the destruction of coastal vegetation (mangrove primarily) cause a deterioration in water quality and habitats as well as fishery resources in Golfete, by means of contamination resulting from the release of untreated waste water.

In addition to housing and tourism infrastructure, the unplanned development of forestry and agricultural activities on the plains adjacent to Golfete is an important source of contamination and environmental impact in the region. The removal of vegetation leads to the loss of habitats critical for the numerous species of fauna, problems of erosion and soil loss. Contamination of lagoons and associated fisheries by agro-chemicals is also a problem.

* Biotopo Chocón-Machacas

This protected area adjoins the Río Dulce National Park. The region is home to wetlands (mangrove and flood prone forests) located in the flood plain, delta and inland lagoons of the Chocón Machacas River. It was formed by preserving wetlands and their associated flora and fauna, the antillean manatee in particular (*Trichechus manatus*).

The main problems of degradation in the region are the illegal hunting of exotic species, the loss of woodland areas to subsistence agriculture and the heavy unregulated traffic of fishing and tourist boats, which lead to the deterioration of the manatee's habitat and population.

- ***Puerto Barrios Region***

This region extends from Punta de Palma to Punta Pichilingo and, for analytical purposes, was divided into 2 areas:

* Bahia de Santo Tomas de Castilla

This area includes Punta de Palma up to Puerto Barrios. In the section from Punta de Palma to Ensenada San Carlos, are some wide, medium-sized, fine-sand beaches which, given their slope (2-15%), are suitable for urbanization. The coastline located between Río Las Escobas and Río San Carlos is marked by the presence of border mangroves in which the dominant species is *R. mangle.* The mangrove species grows at the mouth and banks of Río San Carlos. On the flood plains of the San Carlos and the Pavas rivers, the marshy forests are well preserved. The presence of mangroves on the flood plain and delta of the San Carlos river, besides being of a high ecological value, also has considerable economic value, due to its potential for ecotourism. In addition to mangroves, there are other types of coastal vegetation such as *Coccoloba uvifera, Cocos nucifera, Thespesia sp., Hibicus tilliaceus* and the confra palm *Manicaria saccifera.*

The main sources of environmental impact in the region are: The removal of coastal vegetation (mangrove included) for use as building materials and in order to develop agricultural activities. The removal of vegetation leads to loss of habitats and migration of numerous species.

Towards the interior coastline there are highly developed activities primarily dedicated to livestock rearing and a few areas to the cultivation of corn, sugar cane and coconut trees. Also, in the entire coastal zone of the study area is the frequent practice of preparing land by slashing and burning, whether for livestock pastures or agricultural activity. Another source of impact in the region, is the construction of a highway that runs parallel to the coast between Santo Tomas de Castilla and Punta Herreria. This construction being undertaken without taking into account in its design, the natural drainage in the region, which could potentially lead to erosion and

loss of coastal vegetation. In the Bahia de Santo Tomas de Castilla, there are serious problems of organic and microbiological contamination caused by the release of agro-chemicals and sewage into the bay. Currently the readings for nutrients and fecal matter much exceed the maximum permissible limits established by official standards.

* Punta de Palma Coast

This region includes from Punta de Palma to Punta Herreria at the mouth of Rio Dulce. There are some fine-sand beaches of 2 to 3 metres wide that are accessible via a track which runs from Punta Herreria to the Puerto de Santo Tomas de Castilla. Along the coastline there are houses and facilities for vacationers, fishermen and peasants, a few ports and activities for the replenishment of the beaches. The reason for there being only a few docks and refilling activities is the effect of currents and coastal erosion. Also available, are storage facilities for fishing boats. In certain sections of the coast there are enclosed areas which do not appear in the maps of the region.

The main impacts in the region are: a) the high degree of removal of the adjacent interior coastal vegetation for agricultural and livestock purposes or for firewood. In some fringes of the coastline erosion problems exist as shown by the land slides of the high platform edges and the exposure of the roots of coconut trees. Another significant impact in the region, particularly in Punta Herrería, is the destruction of coastal vegetation to develop the tourism potential of the region.

- ***Punta de Manabique Region***

This zone forms part of the Specially Protected Area Punta de Manabique. It is located on the flood plain of the Motagua River, between Pichilingo River and the San Francisco River basin up to the point where it meets the Atlantic. (**Fig. 16**).

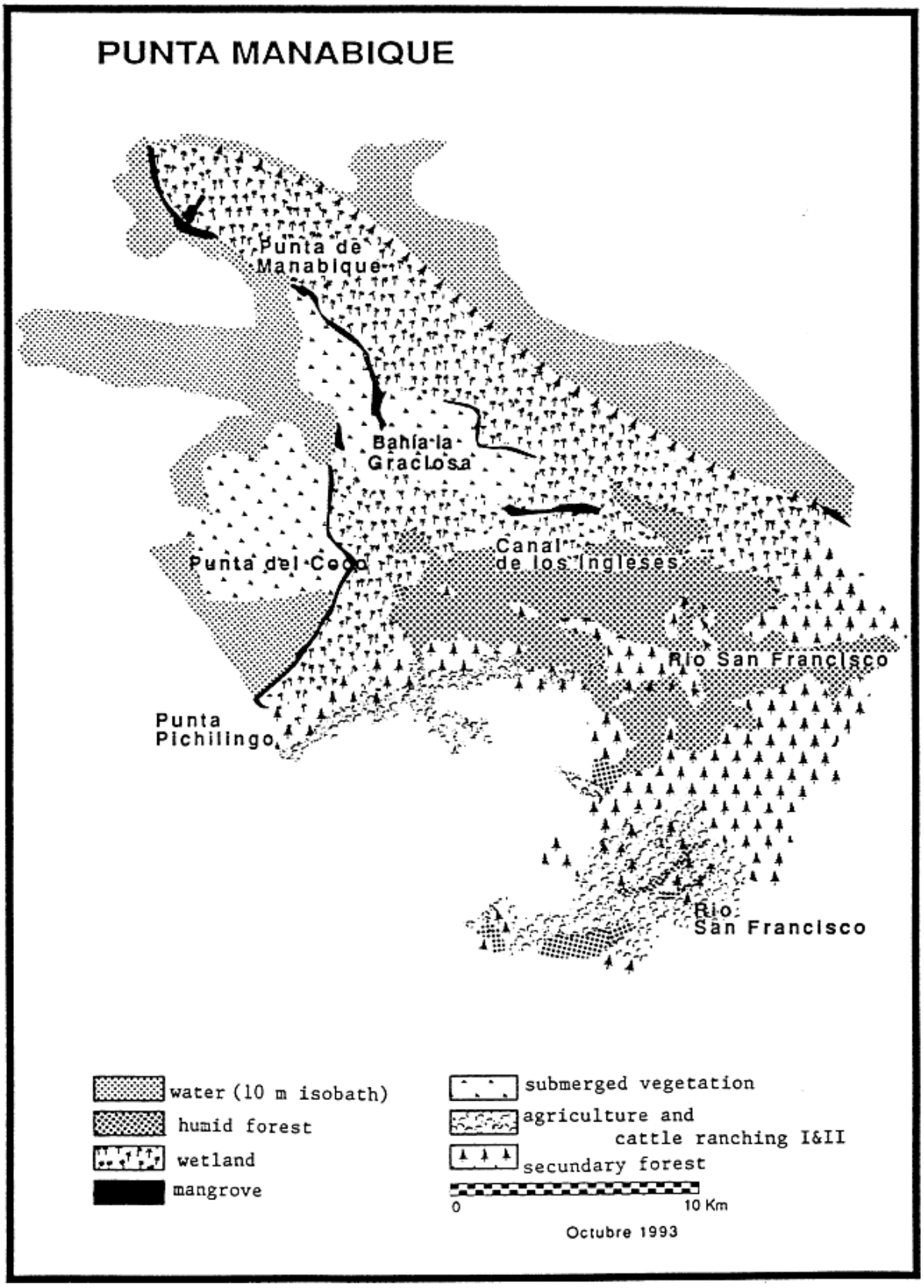


Figure 16. Land use and vegetation map. Punta Manabique region.

The predominant coastal vegetation is classified as border mangrove, reaching from the mouth of the Pichilingo River up to Punta de Manabique. The most important mangrove areas are on the Bahia la Graciosa coastline, thinning out upon its approach to the Santa Isabel lagoon. In this region there are some mainly narrow, fine-sand beaches (2-4 m wide) although some, such as Cambalache Beach and Punta de Palma Beach are as wide as 20 to 45 m, respectively. These beaches are only accessible by sea, which creates limitations for developing hotel infrastructure due to the instability of the land. The soils are water-logged having drainage problems.

The Bahia la Graciosa and Piteros River region has much potential for ecotourism activities, due to its scenery, the presence of the most highly developed mangrove forests in the region as well as sea grass beds. Notwithstanding, their ecotourism potential, further studies should be done before developing ecotourism activities given that this area is a critical habitat.

The coastline from Punta de Manabique to the mouth of the San Francisco River is marked by the presence of beaches with even fine sand. These beaches are wide (between 35 to 100 m) and are evenly distributed from Punta de Manabique to the mouth of the San Francisco River. The Cabo Tres Puntas, Palo Blanco, La Maquina and San Francisco del Mar beaches belong to this area. The first three have tourism potential due to their size, dimensions, sand quality and water transparency. However, their use is limited due to their inaccessibility and instability of the land for construction. In the case of San Francisco del Mar beach, its tourist potential is limited due to its dark coloured sand and water resulting from the export of hides and organic materials from the mangrove and wetlands areas to the coast.

The predominant vegetation in the interior section of Punta de Manabique is wetlands to the north and woodlands that are somewhat water-logged to the south.

It is a well preserved region with an increasing degree of degradation. The main sources of environmental impact are agriculture and small-scale livestock rearing. There is also charcoal production from mangrove forests and wetlands. Illegal and legal hunting are other significant human activities in the area.

VI. Definition of Management Guidelines

An integrated management plan for the Atlantic Coast of Guatemala should consider the environmental characteristics of the area to allow for the continuous operation of the system and to provide recommendations to diminish environmental degradation resulting from human activities. Following an environmental management framework and a set of management guidelines aimed at a regional, sectorial and ecosystem levels for the area of study are proposed.

1. Regional Level

This section comprise the planning and management strategies applicable to the Atlantic coast of Guatemala. The strategy is multisectorial in nature, although it can be focused on one sector alone such as tourism, but should always consider the interactions with the other sectors involved in the region.

The model considers the following components (**Figure 17**):

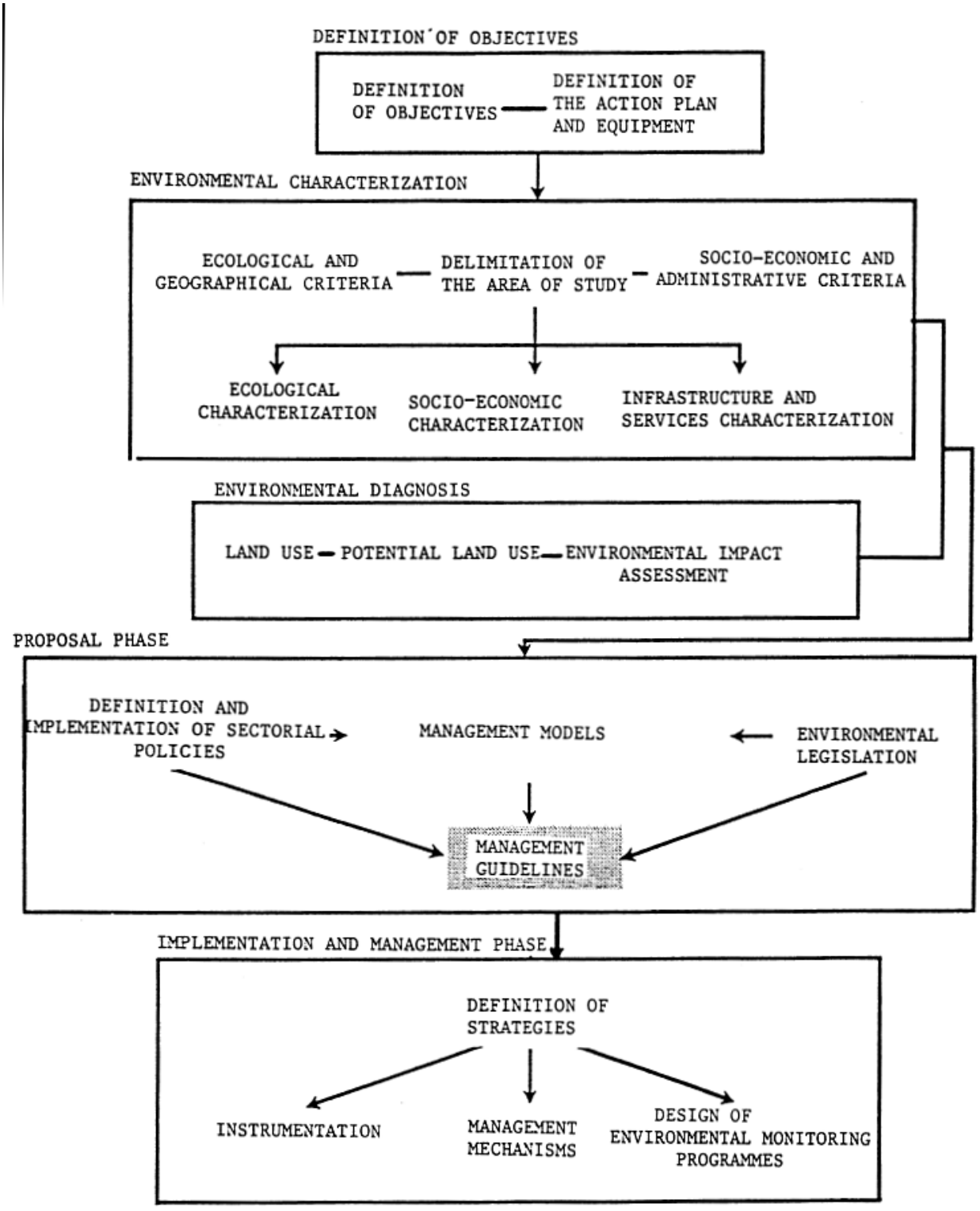


Figure 17. Planning methodology applicable to the Atlantic Coast of Guatemala (Yanez-Arancibia et al, 1993)

2. Definition of Objectives

This component combines the ecological, social and economic criteria and elements to allow for the identification of management guidelines leading towards the sustainable development of the area and the activities which have influence upon the coastal zone, such as tourism and related activities in the area. Also, this section aims at the preservation of the ecosystems or critical habitats (mangroves, wetlands and sea grass) and the existing natural resources.

3. Environmental Characterization

This phase involves defining and characterizing the main environmental (e.g., climate, soils, geology, water, land use and types of vegetation and identification and characterization of habitats and critical ecosystems) and socio-economic features (population, current productive activities and potential, municipal, state and federal development plans and programmes). Also the characterization and description of the existing infrastructure and services (e.g., drainage, coastal and tourism infrastructure, communication media, etc.) are considered under this planning phase.

- ***Definition of the Study Area.*** In a functional or natural way, the basin or water tables which drain on the coastline define the most appropriate environmental boundary for defining the study area. This approach can be adjusted considering the political and/or administrative limits as well as the geography of the area. The next step will consider the regionalization of the area based on ecological or geographical criteria. this approach will be utilized in the identification and characterization of the environmental subunits.

4. Environmental Diagnosis

The objectives of this phase are aimed at identifying and evaluating, the characteristics of the area and the main environmental problems. It also encompasses the actual and potential land use, and allows for a determination of the extent and directions of the environmental degradation.

5. Proposal Phase

- ***Management Model***. Based on the above information and legal aspects, a planning model for the study area is drafted defining land-use, (agricultural, cattle rearing, urbanization, ports, industry and tourism) and the exploitation of natural resources. Also, included are mitigating measures for areas with a high level of degradation as well as preservation measures for critical areas, ecosystems and the natural resources.

- ***Management Guidelines***. The objective of this stage is to define in a concrete way, together with all the institutions involved in the project, the standards, actions, regulations, criteria and managerial issues which permit, environmental planning and management for the use and sustainable development of the study area and its natural resources.

6. Implementation and Management

This phase involves the establishment of intersectorial collaborative programmes involving public, private and social entities; considering environmental and legal monitoring programmes. Also defined are programmes for the protection of critical habitats, flora and fauna, broadcasting and communication programmes, etc.

In the present phase is also necessary to include, the definition of legal instruments at municipal level to strengthen the programmes.

Any project to be designed or implemented should consider an environmental impact assessment, for evaluation. The level of studies and type of data on environmental impact that would be recommended to be undertaken will depend on the magnitude of the project, or the ecological and socio-economical value of the area.

An acceleration of the legal and administrative procedures aimed at protecting critical areas as soon as possible (i.e., the four areas within the region: Sarstún, Río Dulce, Biotopo Chocón Machacas and Punta Manabique), should be seriously considered. Otherwise, the biodiversity and environmental quality will be largely affected jeopardizing the achievement of the proposed objectives.

The legal and administrative procedures for establishing of the protected areas, as well as for their administration and operation, must consider:

- Definition of geographical limits and the application of adequate zoning criteria such as the primary and buffer zones in which are included zones of restricted, moderate or intensive use (this is applicable to the Río Sarstún and Punta de Manabique).

- Solution of conflicts related to land occupancy through the up-dating and enforcement of the national land registers with a view to properly enforcing the laws related to the management and establishment of the reserves (La Forgia, 1991).

- Definition of management plans that regulate the different activities and compatible uses in the protected areas (i.e., Biotopo Chocón-Machacas, Río Dulce and Punta de Manabique). Also, whenever required, the level or status of the protected areas must be re-considered, (i.e., Punta de Manabique) due to the fact that it may require a higher degree of protection due to its great ecological value, biodiversity and fragile environment (CIESEG, 1993).

- Participation of the local community in the administration and management of protected areas. This would be a source of income and reduce the impact of the invasion of these areas by people with limited economic resources.

- Implementation of environmental education programmes and public awareness campaigns, aimed at incorporating the management and sustainable development ideas and procedures for the conservation of the area and its natural resources.

- Establishment of coordinating mechanisms that permit the harmonization of municipal and national legal aspects to avoid conflicts of interest related to the territorial concessions within the protected areas (La Forgia, 1991).

- Inclusion and participation of federal and municipal governmental institutions with non-governmental organizations (NGOs) and institutions in the coordination and administration of the protected areas due to their potential for tourism and ecotourism.

- Installation of sanitary infrastructure (drinking water, drainage for waste water and rain water), electricity and communications at the heart of the population for the benefit of the environmental quality and standard of living, as well as tourism activities planned for the region.

- Establishment of technical schools related to tourism and fisheries could be of great value in order to support the programmes on capacity building for the management of the resources in the area. Also, with a view to fulfilling the objectives of the integrated management plan, it is necessary to consider strategies for environmental education for the local population through training of primary and secondary school teachers. Radio and television programmes, conferences, documentaries and meetings, etc., should also be considered for the population in general.

VII. Sectorial Level

One strategy for coastal planning and management that has been applied in many countries, is based upon a type of sectorial planning which in turn is based on capital projection and implementation, land use planning and the identification of the necessary infrastructure for managing and developing specific sectors (Sorensen et al., 1992). This type of strategy could be applicable to different sectors of the Atlantic Coast of Guatemala, such as agriculture, fishing, ports, and for the development of tourism in particular. It is valid as long as it considers the environmental characteristics of the place and the environmental impacts to be produced due to the specific activities. Ultimately, this approach reaches the integrated strategy.

Based on the foregoing, some guidelines and recommendations for planning and managing the main sectors in the region are provided:

Tourism

It is important to consider a tourism management plan based on the following recommendations:

- Evaluate the carrying capacity of the ecosystem in order to determining the population size and size of infrastructure that the area can support.

- Define zoning areas in the coastal areas with potential or earmarked for tourism activities based on the type of soil, socio-economic and geographical considerations.

- Determine minimum standards for environmental quality and monitoring programmes for water quality to prevent problems of pollution and the degradation of the ecosystem, public health and tourism.

- Ensure that the local population benefits from the economic gains from tourism, considering their participation in the productive process through the supply of services and manpower. Tourism provides a source of employment, economic resources and an increase in the standard of living of the local population on the one hand, and on the other, a reduction of negative environmental and economic impact from an unemployed population.

- Regulate and restrict the passage of high-speed water crafts (i.e., boats, jet-skies) in the protected areas, as well as in Río Dulce, El Golfete and the northern section of the Manabique Peninsula, Graciosa Bay and Canal de los Ingleses. This is due to the fragility of the ecosystems and richness of fauna (including endangered species such as the manatee). Gangways, complement the landscape and should be designed in accordance to the dynamics of the ecosystem (e.g., maintaining run-offs and natural flows through use of elevated platforms or columns).

- Undertake studies on the ecological viability considering the identification of the most appropriate places, extent of the project and adequate infrastructure required such as waste water treatment plants and a system for the collection, management and disposal of solid wastes. This is particularly important in areas with a medium potential for developing recreational and conventional tourism, such as Punta San Juan, Punta Cocolí, the coastline south of Punta de Manabique and the high intensity in the coastal area of Quehueche, Livingston and Punta de Palma. Also, to be considered is the maintenance of coastal vegetation and the utilization of indigenous species. The issuance of a preventive study or an environmental impact assessment prior to authorization of beach refilling activities is recommended.

- Construction of a waste water treatment plant and drainage systems, and the adequate collection, treatment and disposal of solid waste is vital in Livingston and Río Dulce-El Golfete, particularly as the current infrastructure such as hotels, marinas and water facilities lack adequate management of waste water and solid wastes.

1. Hunting and Fishing

Due to the high level of hunting activity and illegal as well as legal trade of species of fauna and flora (some of which are threatened or endangered) which are threatening the biodiversity in the region, there should be a promotion of specific actions or mechanisms to declare protected areas and to eliminate or restrict these types of activities. Special emphasis should be given to the enforcement procedures.

It is also necessary to promote the development of a list of flora and fauna and the establishment of a monitoring programme as a tool for the follow-up and evaluation of wildlife communities.

Fishing activity ought to be stimulated because it represents a tourist attraction by virtue of its products (food) and services (recreational fishing) which is a major source of income for the local population. It is necessary to define management and development strategies for fishing, which permit the maintenance of a resource base and sustainable development of the activity. The following are some recommendations:

- Continue making efforts related to the assessment of the fishing resources in order to define their structure and function as well as the environmental factors that determine and regulate them. Using the results of these studies, guidelines or regulations for identifying fishing seasons, fishing permits, definition of fishing tackles, etc., could be clearly defined.

- In order to prepare adequate management strategies, undertake studies related to fishing yields and statistics, existing infrastructure, fishing strategies, variations in the supply of fish depending on the location of fishermen or fisheries, zones and times of the year to fish depending on the species, fishing techniques being used, operations and cost of operations.

- Avoid the practice of trawling in sea-grass areas.

- Consider an implemented ecological monitoring programme as an instrument to follow-up resources management and evaluation.

- Regulation of fishing activities should be formulated and adequate legal and administrative instruments defined for their application (LaForgia, 1991).

- Design and undertake technical training programmes for unskilled fishermen in the region.

- Encourage the organization of fishermen cooperatives and put in place some financial mechanism for them to obtain services, boats and adequate fishing skills.

- Encourage recreational fishing to support tourism in the region.

- Undertake studies prior to developing aquaculture activities in the region.

- Avoid conversion of marshy or mangrove swamp areas into aquaculture grounds due to the range of tides and characteristics of the soil and terrain as it is not suitable for this activity.

The planning and management of marine resources should complement activities related to the protection of habitats and the associated populations. Their exploitation will be included within the framework of the integrated planning approach considering the following aspects (Yañez-Arancibia, et al., 1993):

- Maintenance of marshy habitats including sea-grass beds due to the linkage between them and the availability of fishing resources in the region.

- Maintenance of the local fishing populations, for optimum catch volumes and recruitment.

- Protection of the coastline and vegetation from impacts, such as dredging of marshes and canals which are harmful to the species.

- The development of research activities aimed at evaluating the impact due to ports activities bridge construction, and future prospects for urban expansion.

- Understanding the biological interactions between the tourism activity, oil exploration and extraction, with the native species and populations.

- The control of chemical waste contamination of rivers and basins, which affect areas where fish life cycles take place.

- The implementation of ecological models that permit an evaluation of the potential of the populations and their relationship with the functioning of the ecosystem.

2. Agriculture and Livestock Farming

Agriculture and livestock farming on high and low lands are the activities that have led most to environmental degradation in the region, and for which there is need to develop a short-term management strategy that allows for the definition of a model of land use. This strategy should be based on the state of environmental degradation, ecological value of ecosystems, biodiversity and type of soil. Thus, areas with potential for developing agriculture and livestock farming could be defined, and strategies for protection, restoration or change in land use could be developed for areas where the potential does

not exist. The following is a list of recommendations:

- Promote the use of conservation and management techniques for soil and water resources, adequate management of agro-chemicals (pesticides, herbicides and fertilizers) and crop diversification or rotation, as well as a credit and finance programme. This would be relevant mainly in areas dedicated to agriculture and livestock.

- Expand agriculture to areas that have already been reduced to secondary vegetation, or are abandoned, as it is the most viable option in economic and ecological terms for coastal soils rather than destroying the mangroves and wetlands.

- Consider the development of reforestation programmes due to the degree of degradation or ecological importance.

- Promote technical training programmes for the region's farmers.

- Formalize land ownership in order to be able to standardize and regulate land use.

- Design of access roads should consider the preservation of the ecosystem's dynamics.

- Avoid the conversion of areas with great economic potential, such as mangroves and wetlands into areas for agriculture and livestock rearing.

3. Urbanization

- Promote an urban management plan considering the soils potential. This plan would help in the identification and zoning of urban areas as well as establishing buffer areas (green areas) to diminish the direct effect of the urban settlements on the ecosystems nearby.

- Encourage capital investment for basic sanitary infrastructure, such as sewage treatment plants, rain and waste water drainage systems, as well as the use of latrines or absorption wells. Also to be encouraged is a programme for solid wastes collection, handling and disposal.

- Implement a programme for monitoring the quality of water and fishing resources with a view to preventing public health problems.

- Regulate, wetlands and mangroves for obtaining building materials, wood and charcoal and for preparing lands for cultivation. Monitoring and reforestation programmes in highly degraded areas to arrest the process of leaching and soil erosion. Its effect on the coastal zone, should also be considered.

4. Oil-Related Activities

- Establish a technical advisory committee and a regional contingency plan to prevent and control oil spills, since the risk of accidents and oil spills in the Bahía de Amatique from transportation and storage activities is high.

- Carry out detailed studies on environmental impact related to oil exploration and exploitation activities for Izabal and the study area to allow for the identification and evaluation of the direct and indirect effects of these activities on the ecosystem, as well as to define measures to reduce or prevent such impacts.

- Undertake a detailed cost-benefit analysis of environmental impact which sets standards for or is used to regulate all activities in the area. This is very important due to the presence of protected areas and critical habitats such as mangroves, wetlands and sea grass, and the tourism and ecotourism potential of the region.

5. Ports and Means of Communications

- Consideration should be given to the establishment of basic infrastructure which permits the treatment and proper disposal of liquid and solid wastes from land facilities and ships.

- Consider the impact of dredging operations on the benthonic and nectonic organisms, due to the reduction of oxygen in the water column and the re-suspension of sediments, contaminants and organic matter, as well as the effects of increasing turbidity on sea grass beds. This should be primarily considered in Bahía de la Graciosa as suspended material is transported towards this region due to the coastal circulation. Thus, it is necessary to consider the use of mud traps or dredging strategies which ensure that the transportation of suspended material does not reach away the sea grass beds.

- Any proposed port engineering project such as jetties, waterfronts or ports should include in their design, the maintenance of the natural basic watercourse circulation to avoid or lessen the impact of erosion and deposit, particularly in areas of sea grass, mangrove and wetlands.

- It is necessary to encourage the construction of communication infrastructure in the coastal zone to support projected tourism activity and to provide access to areas of recreational or ecotourism importance. This infrastructure would encourage communication between different towns which would stimulate trade and access to the products and services in the main urban areas. Any construction of access roads or highways, especially in marshy or mangrove areas must, as

much as possible, be parallel to the flow of surface waters to mitigate the effect of water retention and droughts. In this regard, the construction of drains and bridges must also be considered.

VIII. Ecosystems and Habitats

Ecosystems such as mangroves, wetlands and sea grass which are of great ecological and socio-economic importance in the region, have been identified as areas for protection, however, no regulation existis on their use and protection. The following is a list of proposed recommendations and guidelines for their management:

- Preserve the structure and function of the ecosystems, mainly the interaction between marshes (mangroves and wetlands), and sea-grass in Bahía de Amatique and the adjacent Continental Platform.

- Assess the evolution of resources and habitats by permanent ecological monitoring.

- Define the legal and administrative instruments and regulations for the protection of the different ecosystems.

- Avoid the construction of canals and dredging activities which could affect the productivity and lead to ecosystems degradation, lessening their economic value or causing their disappearance by flooding, water retention and salinization.

- Maintain the hydrological balance between salt and fresh water in order for the mangroves to flourish. It is necessary that planners dealing with water resources, as well as communications, ensure the maintainance of the hydrological balance when designing their works. An example could be the regulation of the unloading of fresh water from dams into the watercourse, making embankments parallel to the coastline and providing drainage system on the highways.

- Avoid the conversion of mangroves and wetlands into agricultural areas. However, this transformation could be considered in degraded swampy areas as long as ecological viability and environmental impact assessment are undertaken.

- Define legal and administrative instruments for the use, conservation and protection of sea grass beds.

- Develop environmental education programmes which include the ecological and economic value.

- Develop an environmental monitoring programme for sea grass beds, with the objective of evaluating their potential and preventing any alteration or change as a result of environmental degradation.

- Regulate the type of boats, routes and speed in areas were sea grass beds are present, in order to avoid the suspension of sediments and the resultant degradation of the ecosystem, particularly in Bahia de Graciosa.

- Avoid trawling activity in sea grass areas as it leads to their elimination as well as the re-suspension of sediments and the alteration of the substratum.

- Consider the coastal water circulation when constructing docks, ports and waterfronts so that sedimentation and erosion does not occur in areas where sea grass beds are thriving.

- Avoid activities such as dredging and beach refilling in areas of sea grass beds. When these activities are carried out in adjacent areas, mud traps or dredging strategies must be used which ensure that by virtue of the water circulation and wind direction, they are dispersed into other areas. It is likewise recommended that spillage of liquid wastes such as waste water, run-offs from urban areas and water from pumping stations be avoided.

- Avoid contamination of the waterways and estuaries originating from agricultural practices and dumping of organic matter from domestic and industrial activities which seriously affect the coastal ecosystems as mangroves, wetlands and river basins which are natural traps of contaminants.

In concluding, it is recommended that the integrated management plan for the Atlantic Coast of Guatemala be grounded in a development strategy based on scientific knowledge geared towards the solution of the priority problem, and the definition of planning and development policies. **Figures 18 a-f** present a framework of policy management for coastal areas in the State of Campeche and the Terminos Coastal Lagoon (Mexico).

Figure 18 (a) Policy framework for the management of the coastal areas and Terminos Lagoon in the State of Campeche

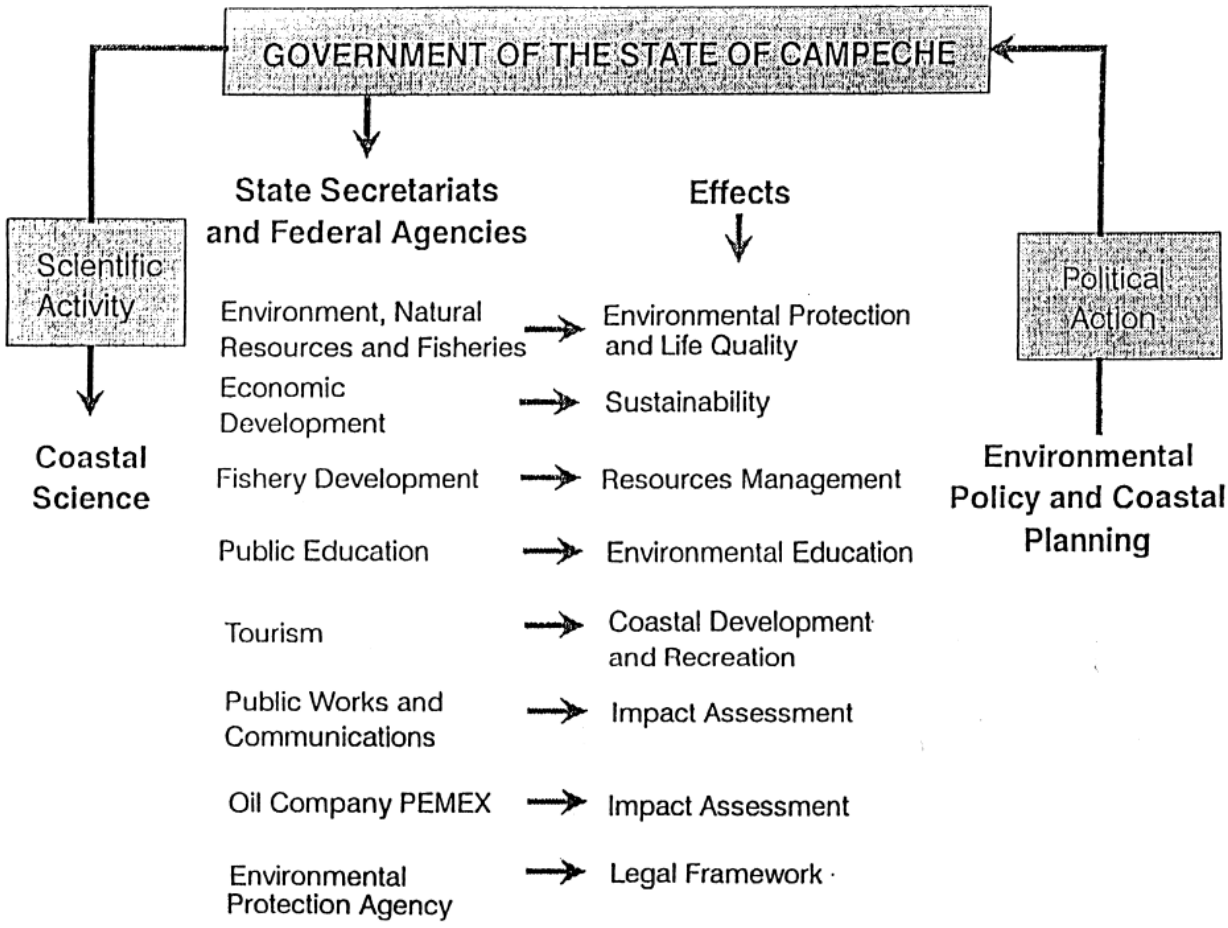


Figure 18 (b) COASTAL ECOLOGICAL MANAGEMENT PLAN OF CAMPECHE

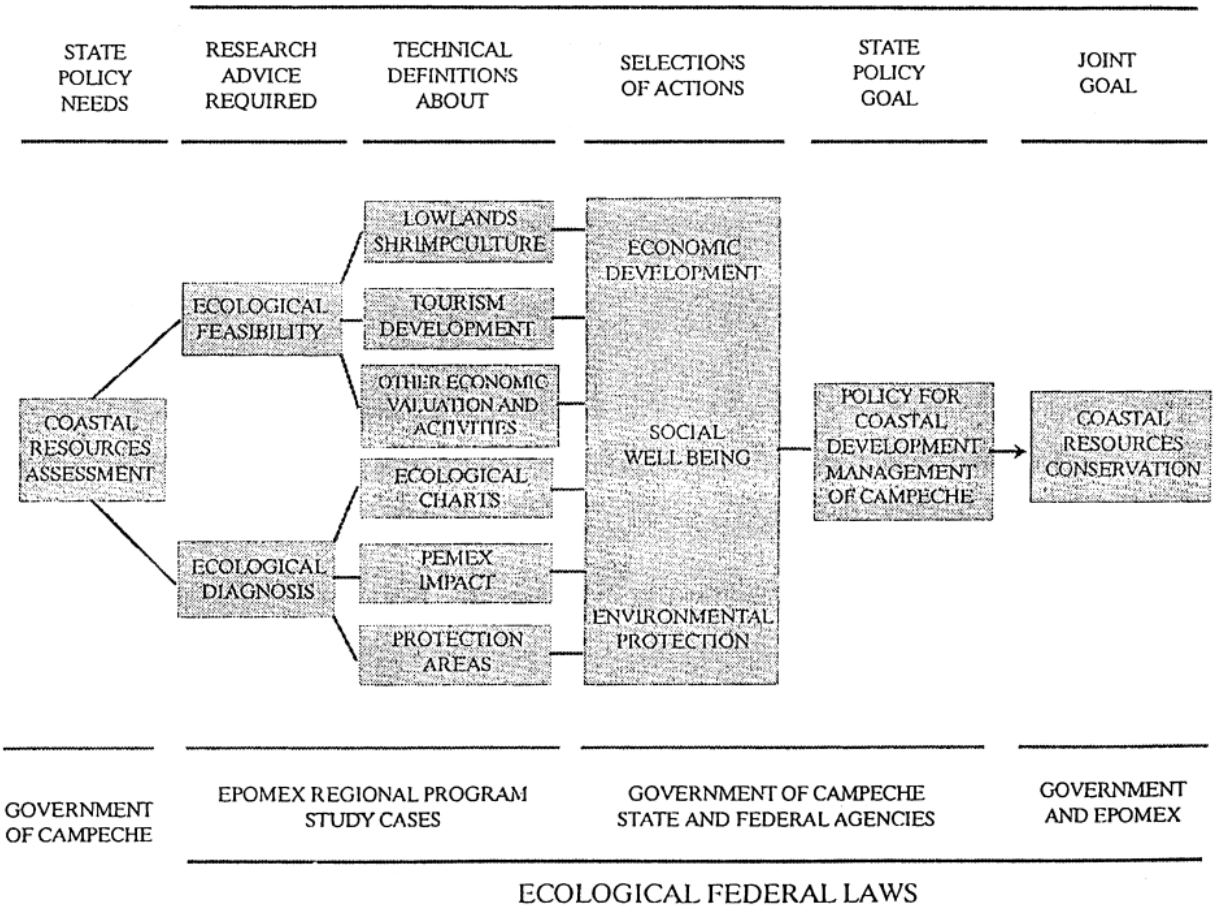


Figure 18 (c)

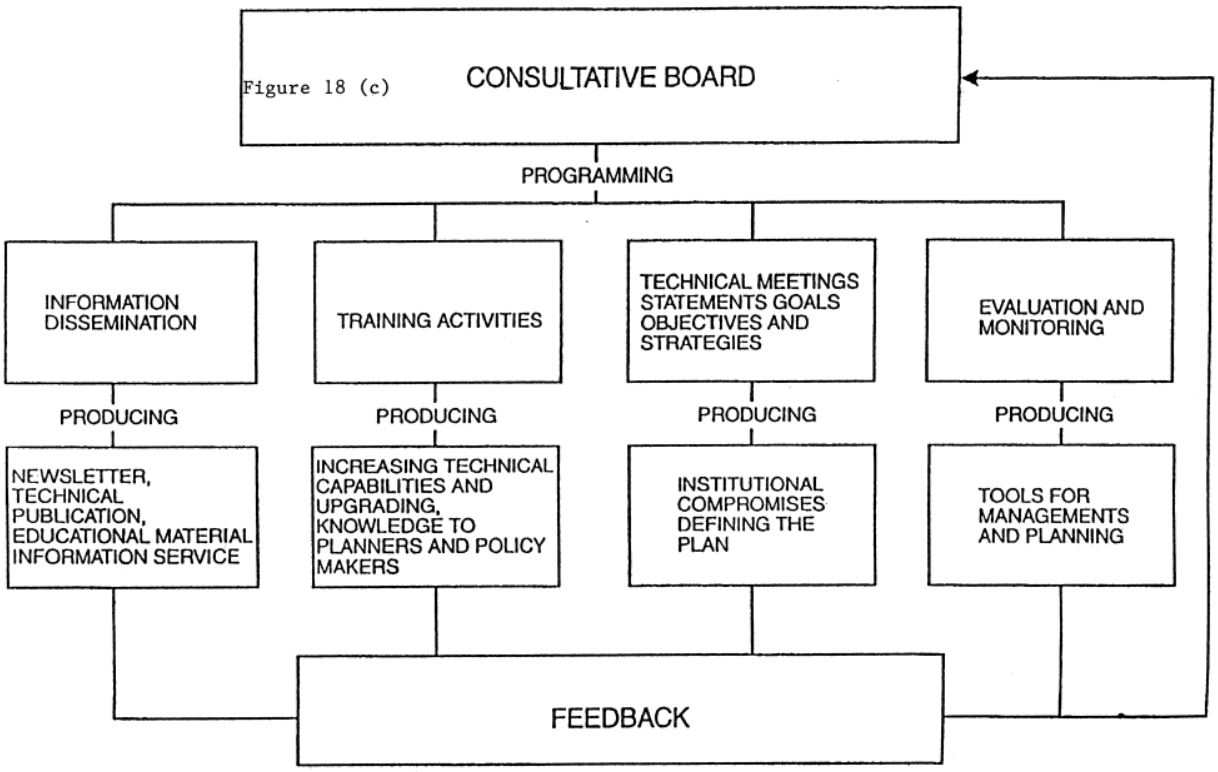

CONSULTATIVE BOARD
PROGRAMMING
INFORMATION DISSEMINATION
TRAINING ACTIVITIES
TECHNICAL MEETINGS STATEMENTS GOALS OBJECTIVES AND STRATEGIES
EVALUATION AND MONITORING
PRODUCING
PRODUCING
PRODUCING
PRODUCING
NEWSLETTER, TECHNICAL PUBLICATION, EDUCATIONAL MATERIAL INFORMATION SERVICE
INCREASING TECHNICAL CAPABILITIES AND UPGRADING, KNOWLEDGE TO PLANNERS AND POLICY MAKERS
INSTITUTIONAL COMPROMISES DEFINING THE PLAN
TOOLS FOR MANAGEMENTS AND PLANNING
FEEDBACK

Figure 18 (d)

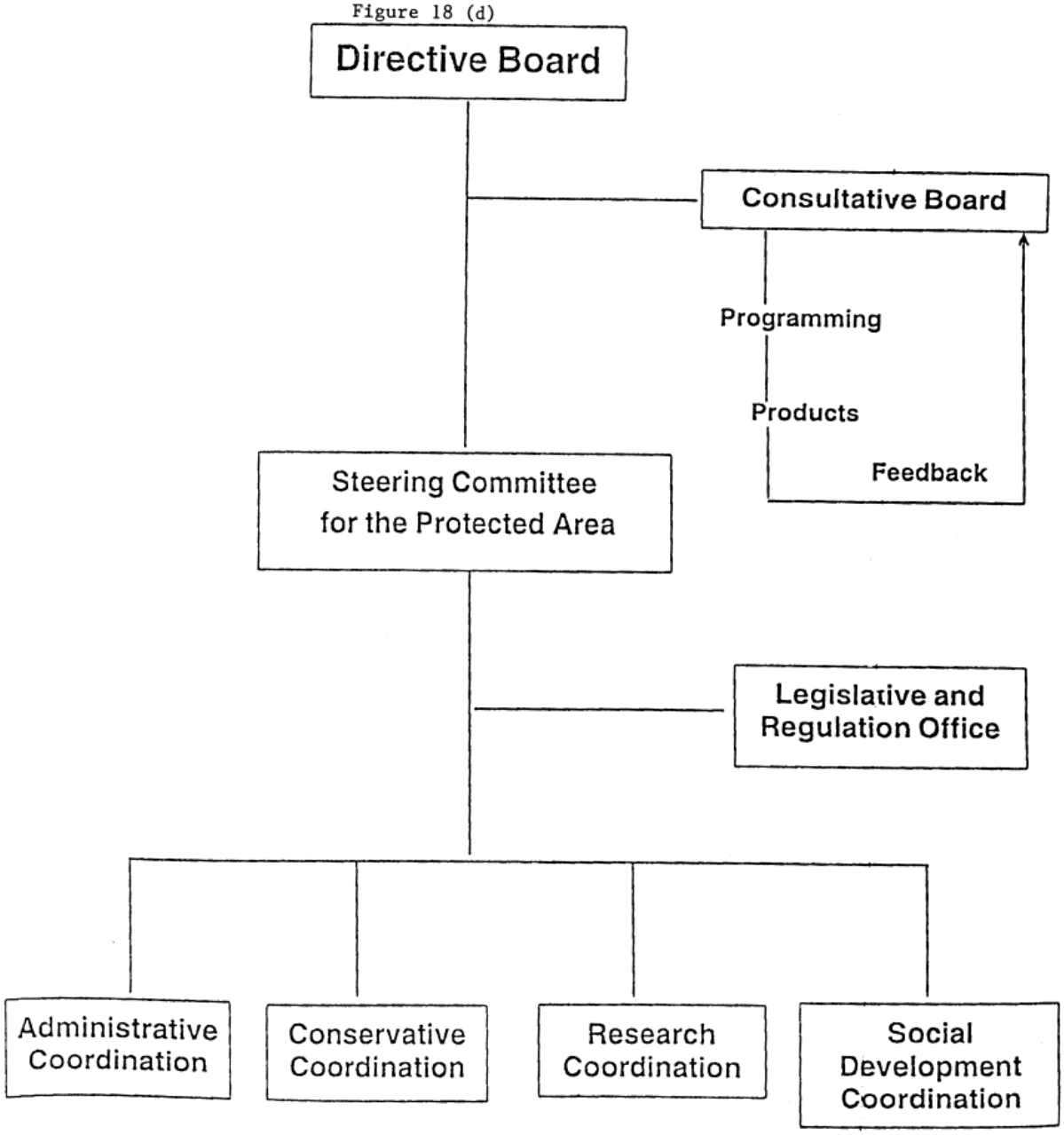

Directive Board
Consultative Board
Programming
Products
Feedback
Steering Committee for the Protected Area
Legislative and Regulation Office
Administrative Coordination
Conservative Coordination
Research Coordination
Social Development Coordination

Figure 18 (e) TERMINOS LAGOON AS AN ECOLOGICAL PROTECTED COASTAL ECOSYSTEM

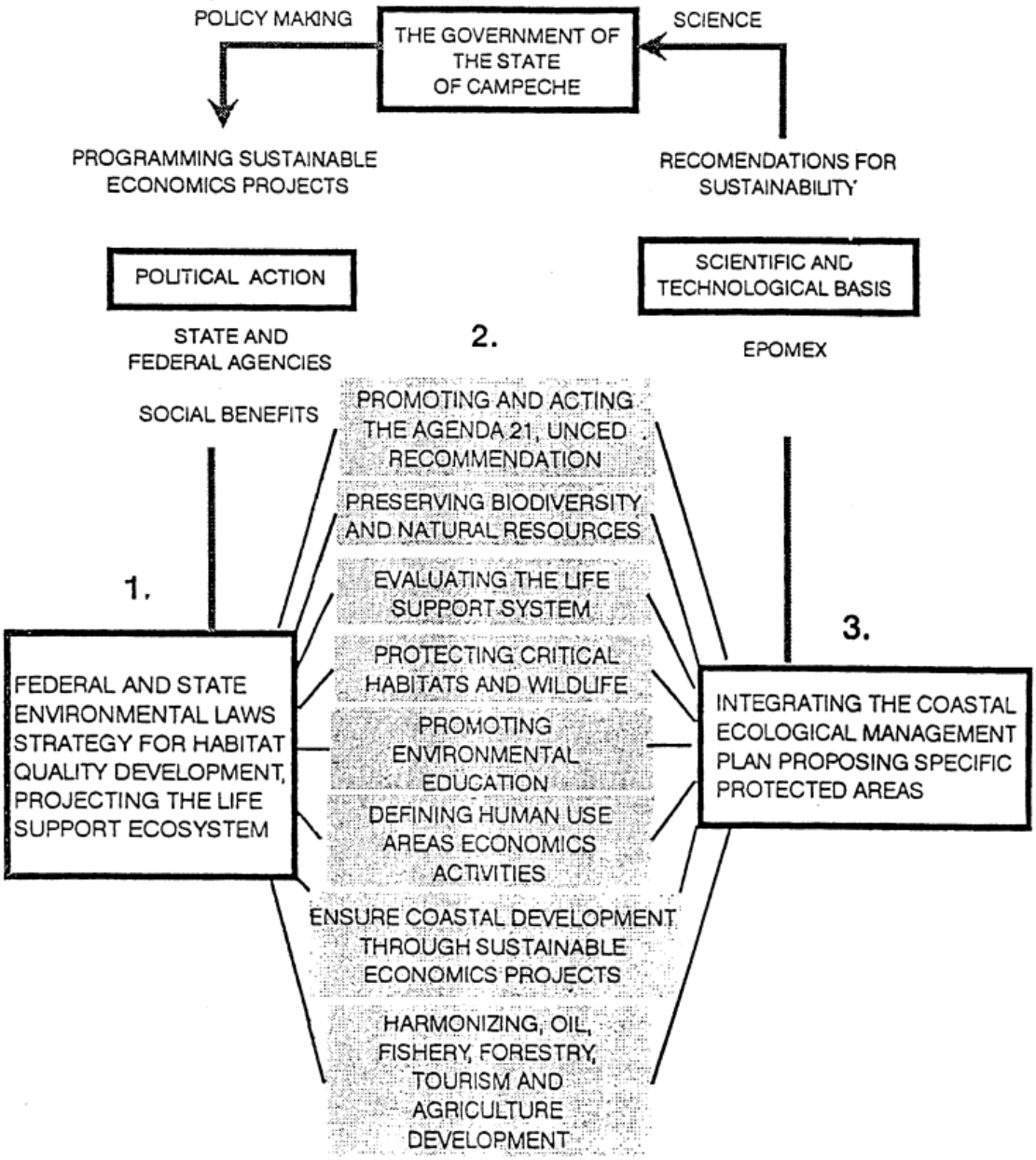
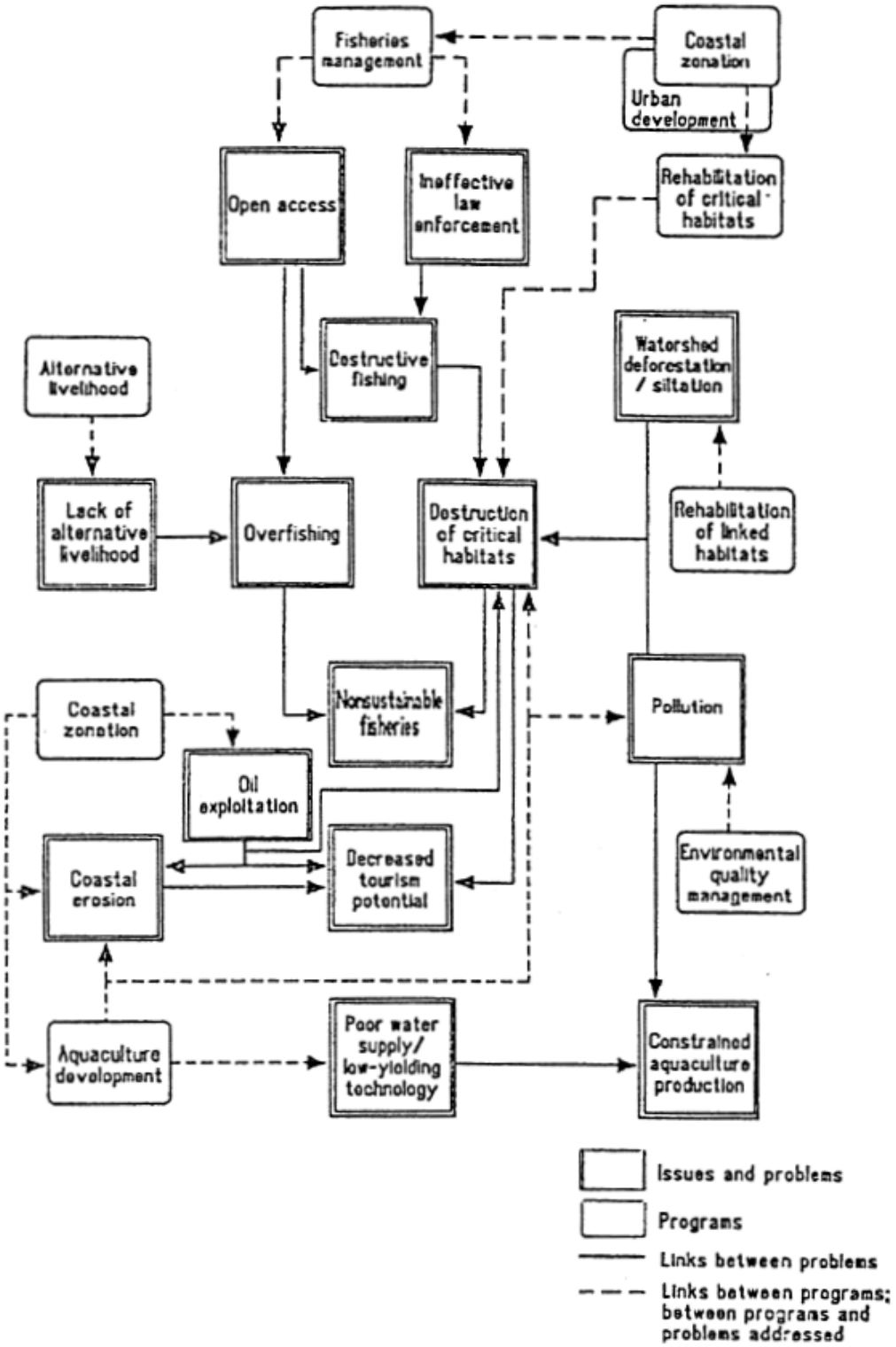


Figure 18 (f) Linkages between issues/problems and programmes



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