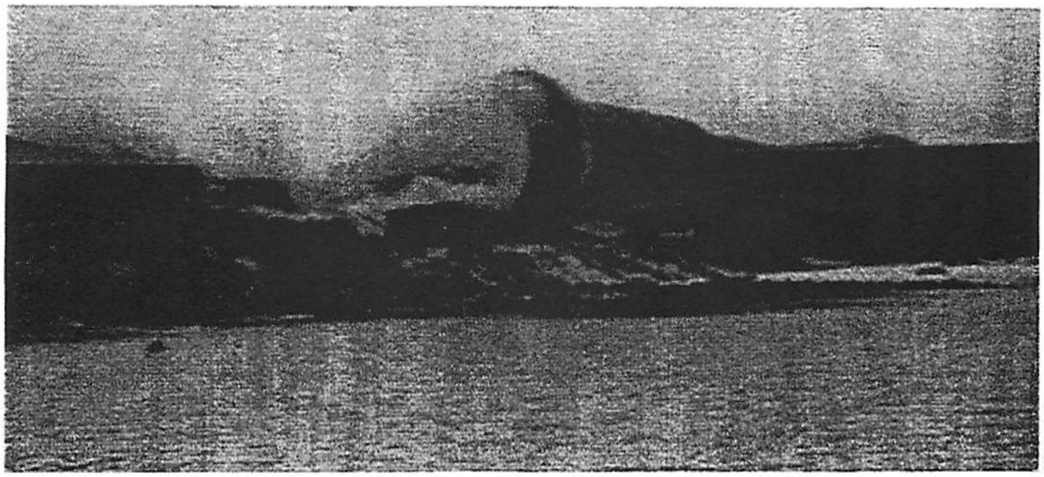
Caribbean: Planning For Adaptation to Global Climate Change



Component 4: Formulation of a Policy Framework for Integrated Coastal and Marine Management.

Climate Change Issues, Adaptation Planning and Management Mechanisms.

(A Preliminary Report)

By

Marlon Khan

September, 2000

(Prepared for the National Ozone Action Unit of Guyana)

Technical Report 5C/CPACC-00-09-1

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Published by Caribbean Community Climate Change Centre, Belmopan, Belize

Digital Edition (December 2013)

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ISBN-978-976-8236-93-7 (pdf)

Component 4

Formulation of a Policy Framework for Integrated Coastal And Marine Management

By

Marlon Khan

Cover Photograph: Seawater Overtopping on the East Coast of Demerara.

(Prepared for the National Ozone Action Unit of Guyana)

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1.0 Executive summary

1.1 Introduction

The Caribbean Countries and Islands are primarily small islands and low-lying countries with delicate coastal ecosystems. Exploitation of the coastal resources, namely agriculture and tourism, provides the major foreign exchange earners of these small islands and countries. The lack of comprehensive information systems and a co-ordinated institutional structure, all hamper an integrated approach to managing these resources. Predictions of global warming, changes in sea level, sea surface temperature, wind and ocean currents will probably compound these problems.
In attempt to solve these impending problems, The Caribbean: Planning for Adaptation to Global Climate Change (CPACC) was formulated to specifically assist Caribbean countries to measure and adopt to the adverse effects of Climate Change. This plan has been sub-divided into several regional and pilot based components.
This report is Guyana's response to the *Formulation of a Policy Framework for Integrated Coastal and Marine Management, Component 4,* of CPACC's guidelines.

1.2 National Circumstances.

Guyana is a tropical country situated on the northeastern coast of South America. The Atlantic Ocean, on the east bound it on the north by Suriname, on the south by Brazil and on the west by Venezuela. It is an English-speaking country with close ties with the English-speaking Caribbean Islands. It is a member of CARICOM, which has its headquarters in Georgetown, the capital city.

Guyana has the following characteristics:

- It is a low-lying state with a vulnerable coastal strip 77 km wide in the east and 26
- Ninety percent (90 %) of the population resides in the coastal strip where the main urban centres and commercial activities are to be found.
- There is a wide range of geographic types with coastal, hilly sandy, highland, forested and savannah regions.
- There is no current tectonic activity in Guyana and indications are that the Guyana shield (and the coastal strip, in particular) will not be affected by convergence of the South and North American plates.
- There is a high level of rainfall variability in the country and the seasons and climate are determined mainly by this variability. There are four seasons:

First Dry Season (February to April);
First Wet Season (April to July)
Second Dry Season (July to November); and the
Second Wet Season (November to January)

The country can be divided into climatic regions ranging from very dry (annual rainfall less than 1788 mm) to extremely wet (annual rainfall greater than 4100 mm).

The major weather system is the Inter-tropical Convergence Zone and the major climate system is the ENSO. Large-scale floods and droughts are a consequence of the ENSO events impacting on Guyana's weather.

Guyana was a British colony prior to its independence on May 26, 1966. The population is approximately 750,000 and comprises five major ethnic groups: East Indian, Africans, Amerindians, Chinese and Portuguese. There is a land area of 216,000 km^2 and a very low population density of about four persons per km^2. The major religions are Christianity, Hinduism and Islam.

With a GDP of US$ 528 in 1990, the economy grew, as a consequence of structural adjustment measures, by 8.5 % in 1994. The positive growth rate was primarily due to the effects of price liberalisation, market-determined exchange rate and the positive results of private sector investments in the gold, timber and rice industries.
km wide in the western Essequibo region.
Agriculture is the major economic activity in Guyana. In 1994, this sector increased by 12 percent compared to 6 % of the economy in 1993. This was due to recovery of sugar output and expansion of rice, timber and other crop production. The forestry sector was influenced by new governmental policies, which facilitated significant foreign investment. The fishing industry experienced an increase in production by 7 %. The manufacturing, services, construction, mining, (and quarrying) sectors also contributed to the healthy growth rate in 1994. Tourism, in the form of eco-tourism, has been expanding and will be a major contributor to the economy in the future.

Guyana is very dependent on imports of fossil fuels for its energy needs. Fuel and lubricants accounted for 16 percent of total imports in 1994. Bagasse is used for the co-generation of steam and electricity in the sugar and rice industries. There is the potential for substantial use of renewable energy sources such as hydropower, solar, wind and biomass.

The preparation of Guyana's national GHG inventory for 1994 showed that Guyana was not prepared, institutionally, to address its commitments under the UNFCCC. There is the need to address capacity building in the government (including local government), the sector agencies and the private sector.

1.3 Vulnerability Impacts of the Coastal Zone

The records in Guyana have shown that there has been an increase by 1.0°C of the mean annual temperature in Georgetown over the period 1909 to 1998. Cooling periods in the record appear to be due to the influence of major volcanic eruptions in several parts of the world. Prior to 1960, annual rainfall amounts were generally above or about normal. From 1960 and onwards, there has been a tendency for below normal rainfall. El Nino Southern Oscillation (ENSO) events have severely affected Guyana especially in the last decade of the twentieth century.

Tide guage data in Guyana for the period 1951 to 1979 indicates a mean relative sea level rise of 10.2 mm yr^{-1}. This is about 5 times the global average and suggests a mechanism other than sea level rise may be operating on Guyana's coast.

The GCMs indicate average rises of 2 to 4 mm yr^{-1} in the first half of the twenty first century and rises of 3 to 6 mm yr^{-1} in the latter half. Therefore, in Guyana, sea level is projected to rise by about 40 cm by the end of the twenty first century. If meltwater contribution from land ice is considered, then the rise can be about 60 cm.

The predicted sea level rise coupled to extremes in rain events and storm surges and increased wave action can exacerbate an already critical situation where water accumulation off Guyana's coast has been resulting in breaching and overtopping of the sea defences.

Many sectors will be affected, however the agriculture sector, using analyses based only on changes in climate variables, will be affected most as yield losses will affect sugar and rice. These losses are expected to trigger by salt water intrusion,increased water demands from crop transpiration and greater respiration losses as a consequence of higher temperatures. There may be changes also in yield quality due to a decreased diurnal temperature range.

Other sectors that are expected to be affected are sea defences, drainage system, coastal erosion, submergence and inundation of Coastal Wetlands, hydrology and water resources, human settlement-infrastructure, human suffering and loss of life, the economy of Guyana, Fisheries, the physical nature of the ocean, sewer systems, highways and roads and tourism.

1.4 Adaptation Issues: An Introduction.

Adapting to the impacts of climate change will require substantial financial and technical assistance. The overall goals of adaptation are to promote sustainable development and to reduce vulnerability. The areas of study that were looked at are expected impacts of climate change, expected trends of other potential stresses, expected interactions between climate-related impacts and non-climatic developments, and expected autonomous adjustments to combine climatic and non-climatic impacts.

The governmental capacity to deal with climate-related issues is at present very weak . From surveys done (Paulette and Mark Bynoe), it was found that the local communities are also not even aware of their vulnerability to the effects of global warming. The business community has also not shown any trepidation even though some components of business are cognisant of the problem. The reservations in the predictions and impacts have resulted in a resistance towards policy development and the development of the capacity to deal with future vulnerable situations, focusing on the three main stages of adaptation, i.e., retreat, accommodation, and protection.

Based on the preceding chapter, it would appear that Guyana, especially the Coastal Plains where most of the population and economic activity are located, would be most vulnerable to the impacts of sea level rise. One of the major likely impacts of sea level

rise in the coastal zone of Guyana would be the loss of coastal wetlands that serve as protective barrier to the inland coastal area.
The current estimates place the cost of sea defences in Guyana at $ 35,000.00 US per km. A more rapid rise in sea level would increase the costs of shore protection. In the short term then there is the need for anticipatory adaptation action in response to rising sea levels in Guyana. Where communities are likely to adapt to erosion, anticipation can be important. The cost and feasibility of moving a house back depend on design decisions made when the house is built. The willingness of people to abandon properties depends in part on whether they bought land on the assumption that it would eventually erode away or had assumed that the government would protect it indefinitely. Less anticipation is necessary if the shore will be protected. Nevertheless, some advanced planning may be necessary for communities to know whether retreat or defending the shore would be most cost-effective.

In the medium term, adaptation to sea level rise in the coastal zone of Guyana may involve the further fortifying of sea defences and the introduction of legislation relating to setback limits so as to reduce the vulnerability of the peoples and structures.

In the long term however, Guyana may have to choose between further fortifications of sea defences or a more drastic population policy whereby peoples and infrastructures will be moved inland, where even at 25 miles the land is at 74 ft above mean sea level (GD). Guyana's population is relatively small and land space in the hinterland is abundant, although soils are mainly sandy. However, the rich agricultural soils are found mainly in the low-lying coastal area.

1.5 Appropriates Mechanisms to give effect to the National Policy

In formulating the National Climate Change Policy, CPACC countries are encouraged to develop short, medium, and long-term strategies and approaches to be used for adaptation planning and management. The National Policy should give effect to the formulation of Integrated Coastal Zone Management, the use of Environmental Impact Assessments, Disaster Contingency Planning Management, Economic Instruments, Building Codes and Standards and Environmental Management Regimes.

1.6 Key Issues, Adaptation Planning and Management Mechanisms.

To fully implement and sustain a National Policy on Adaptation in Guyana, several issues must be addressed. These includes the availability of finance, human resource, training, and the necessary equipment for institutional strengthening and capacity building. This scenario is a major handicap of all agencies in Guyana and will have to be addressed as an initial programme towards adapting to climate change impacts.
However, important roles for climate change issues should be addressed by or are being addressed by the Ministry of Finance, the Ministry of Public Works, Ministry of Agriculture, Office of the President, the Ministry of Housing and Water, thev Ministry of Health and the Coast Guard.

2.0 Introduction

2.1 General

The Caribbean Countries and Islands are primarily small islands and low-lying countries with delicate coastal ecosystems. Exploitation of the coastal resources, namely agriculture and tourism, provides the major foreign exchange earners of these small islands and countries. Generally, the coastal areas of these countries hold the majority of the population and economic activities, and are therefore of utmost importance to the survival of these Small Islands and countries. The Coastal areas are usually the most agriculturally and biologically developed areas, and have supported a magnitude of agricultural and biological diversity that has recently come under increasing stresses including:

- Tourism related infrastructure
- Inadequate disposal of waste
- Decaying drainage infrastructure
- Severe weather and climate systems that has produced economic losses
- Mismanagement of sea grass beds, mangroves, and wetlands.

The lack of comprehensive information systems and a co-ordinated institutional structure, all hamper an integrated approach to managing these resources. Predictions of global warming, changes in sea level, sea surface temperature, wind and ocean currents will probably compound these problems. The Intergovernmental Panel on Climate Change (IPCC) has estimated a cost of US $ 11.1 billion will be needed by Caribbean countries to overcome these impending changes. International concern about the rapidly changing climate and its eminent impacts prompted the international community to initiate a United Nations Framework Convention on Climate Change (UNFCCC). The legal framework of this convention was established in 1991 to respond to the global climate change and specifically to mitigate and prepare for adaptation to its adverse effects. CARICOM Countries are primarily small Islands and low-lying states. They are particularly vulnerable to the impacts of Global Warming. Sea-level rise and severe weather/climate events pose a treath to the socio-ecomnomic development of the peoples of th Caricom . Consequently, at the Global Conference Sustainable Development of Small Islands Development States(SIDS) , a project was develpoed by the Organisation of American States(OAS) in order to plan for adapting to Climate Change. It is known as Caribbean: Planning for Adaptation to Global Climate Change (CPACC). The formation of CPACC was to support Caribbean Countries in preparing to cope with the adverse effects of Global climate change, with emphasis on sea level rise, adaptation planning, and capacity building.

2.2 CPACC Components

The project follows a regional approach; it is being executed through the co-operative effort of the participating countries and through a combination of national pilot/demonstration actions and regional training and technology transfer linked to adaptation planning. The project seeks to build on existing institutions and experiences, and to liase with other important regional initiatives and programs underway in the Caribbean. Project activities focus on planning for adaptation to global climate changes in vulnerable areas. These enabling activities are complemented by selective capacity-building activities. The project executes a comprehensive program of human resource development for upgrading the skills of technicians and officials from participating countries in areas relevant to Global Climate Change and adaptation planning. Project execution will take four years and involve both regional and pilot-based components. There are four regional components, which includes the following:

1: Design and Establishment of Sea Level/Climate Monitoring Network

2: Establishment of Databases and Information Systems

3: The Inventory of Coastal Resources and Use.

4: Formulation of a Policy Framework for Integrated Coastal and Marine Management

There are four pilot-based components, which includes the following:

5: Coral Reef Monitoring for Climate Change. (the Commonwealth of the Bahamas, Belize, and Jamaica).

6: Coastal Vulnerability and Risk Assessment (Barbados, Grenada, and Guyana)

7: Economic Valuation of Coastal and Marine Resources. Dominica, Saint Lucia, and the Republic of Trinidad and Tobago

8: Formulation of Economic/Regulatory Proposals Antigua and Barbuda and Saint Kitts and Nevis

2.3 Guyana's Participation in CPACC

Guyana is already participating in Component 1,2 and 3, which are carried out region wide. Also Guyana is already participating in Component 6 as a pilot country. Component 4, Formulation of a Policy Framework for Integrated Coastal and Marine Management now being addressed. As part of the implementation of Component 4,a Draft study by de Romilly and de Romilly Limited (Canada) was done with guidelines on the methodology that CPACC countries may consider for the implementation of Component 4. This Draft study reported on:

- The review and analysis of current policies, legislation, and institutional mechanisms for adaptation planning for Climate Change in the context of coastal zone management.

- The review and analysis of existing policies, legislation, and institutional mechanisms in selected countries.

- The outline of the most appropriate policies, legislation ,and institutional options to be used in the implementation of Component4, and ,

- An outline of the data, human resource, and institutional arrangements to implement appropriate policies, legislation, and institutional options to be used in the implementation of Component 4.

3.0 National Circumstances

3.1 Geography

3.1.1 General

Guyana is a tropical country, situated on the northeastern coast of the continent of South America between 2 degrees and 9 degrees North latitudes, and 56 degrees and 62 degrees West longitudes. The Atlantic Ocean, on the east bound it on the north by Suriname, on the south and southwest by Brazil and on the west by Venezuela. It occupies a total landmass of approximately 216,000 km^2 and has a coastline that is about 434 km long and a continental extent of about 724 km. About 35 percent of the country - the area approximately below 4 degrees north latitude – lies within the Amazon Basin. There are three main rivers – the Essequibo, Demerara and Berbice - which all drain into the Atlantic Ocean, and the three counties – Essequibo, Demerara and Berbice derive their names from them.

Guyana is closely affiliated with the Caribbean countries because of its similarities due to its past British Colonial influence and is a member of the Caribbean Community Secretariat (CARICOM), which is head-quartered in Georgetown, the Capital City.

Guyana has five (5) natural geographic regions:

The Coastal Plain (CP)
The Hilly Sand and Clay Region (HSC)
The Highland Region (H)
The Forested Region (F)
The Savannah Regions (IS & RS)

3.1.2 The Coastal Plain (CP):

The Coastal Plain lies on the northern edge of the country. The width of this region varies from 77 km in the east to a mere 26 km in the western Essequibo region. Topographically this region is virtually flat and, comprising heavy (Holocene - Pliocene age) fluvio-marine clays, is prone to flooding during the rainy season. A series of sand ridges (0.5m to 2.5m high and between 10m to 600m wide) running almost parallel to the Existing coastline is the main relief variation, often impeding drainage to create pagasse swamps and, in the case of western Essequibo coast, lakes. Sand ridges (or possible fault lines) may also be responsible for the marked westward or northwestward bend in the many rivers which traverse the coast. A cyclical process of erosion and accretion related to the Equatorial and Guiana currents off-shore and to local longshore drift, has led to the build-up of submarine bars across the mouths of the rivers leading to periodical dredging.

A complex system of drainage and irrigation canals allow the fertile clays to be utilised for sugarcane and rice cultivation; cattle ranching; and coconut, vegetable and fruit production which all add to the hub of economic activities supporting the 90 percent of the total population that inhabits this region. The main urban centres are found within the Coastal Plain and most commercial activities are concentrated there.

3.1.3 The Hilly Sand and Clay Region (HSC):

Occupying the northeastern section of Guyana, this undulating upland varies in height from 2 m to 400 m. This geosynclinal trough of sediment is thickest (2000m) along the Berbice River and extends into Suriname. Of Pliocene-Pleistocene age, the unconsolidated material comprises 85 percent white quartz sand with pockets of brown and yellow sand. The high porosity enhances infiltration and leaching of the thin layer of dark humus of the topsoil, giving stream water a reddish tint.

Despite low drainage density relative to other regions, four rivers originate here: Abary, Mahaicony, Mahaica and Canje. In some areas, the crystalline basement rock outcrops to create hills, as well as falls and rapids across rivers.

3.1.4 The Highland Region (H):

The Pakaraima Mountains form a part of the extensive Guiana Highlands that covers an area of 1,300,000 km^2 in Guyana, Venezuela and Brazil. It comprises a series of horizontal beds of quartzitic sandstone, conglomerate and intrusive rocks of almost Pre-Cambrian age. Varying in height from 500 m to 2777 m at Mt. Roraima, this formation comprises a series of plateaux and tablelands with sharp edges and precipitous escarpments. Many streams and gullies creating deep gorges and waterfalls dissect plateaux.

There are small settlements in this region of thin soil and low-grade montane vegetation. It seems paradoxical that the riches of this region, i.e. its gold and diamond deposits, are washed down to other areas by its great rivers or extracted directly only to benefit other regions. Communities are small and may be temporary mining sites or indigenous in nature. A few Government centres provide basic services such as health and education.

3.1.5 The Forested Region (F):

This large physiographic region almost spans the entire length of the country with elevation in-creasing southwards from 90 m to about 210 m culminating in the Akarai Mountains. This is also the tropical rainforest region of Guyana, a continuation of the Amazon Forest. Among the vast untapped forest resources, wood species include the highly commercially valuable greenheart (*Chlorocardium Rodiaei*), crabwood (*Caropa Guianensis*) and purpleheart (*Peltogyne Venose*). Selective logging is done in a sustainable manner in the forest. This region is also rich in minerals and gold deposits. Mining of gold also occurs in this region.

3.1.6 The Rupununi Savannah (RS) and Intermediate Savannah (IS)

The Savannahs consist of the Intermediate Savannah and the hinterland or Rupununi Savannah. The Intermediate Savannah (IS), in the eastern part of the country, lies between the Coastal Plain and the Hilly Sand and Clay region. The larger interior or Rupununi Savannah (RS) is located in the southwest and is divided into the North and South Savannahs by the Kanuku mountains. The North Savannah is hilly than the South Savannah and grasslands characterize both areas. Cattle ranching and farming are two of the main activities in the Interior Savannah.

3 .2 Plate Tectonics

The Theory of Plate Tectonics is principally a description of the geometry and kinematics by which the Earth's lithosphere experiences displacements which affect sea levels specifically within the proximity of coasts. Two assumptions are postulated: that the lithosphere is rigid except at specific boundaries at which displacements occur and that specific boundaries are of three types – spreading centres, transform faults and compression sites.

Compression sites appear to be: An oceanic lithosphere under thrusts another lithospheric plate, known as subduction todepths of several hundred kilometers, a thin oceanic lithospheric plate over thrusts an adjacent lithospheric plate called abduction, and compression between two plates in an intervening thickened zone of faulted and deformed lithospheric material.

3.2.1 Evidence of Present Tectonic Activity

"The present tectonic activity of the Caribbean region is evidenced by large variations in topo-graphic elevations from deep sea trenches to high mountains, by linear chains of volcanoes, by a high degree of seismicity, by large negative and positive free-air gravity anomalies, and by high heat flow in some localised areas." (Bowin 1976) Active volcanoes are dramatic evidence that tectonic plates are being compressed within the Earth. Volcanoes that are associated with the sites of lithospheric plate, experience underthrusting in long linear chains that are limited to a narrow zone and a small number of volcanoes stray beyond these narrow limits of volcanic activity.

The active zones of the Caribbean region indicate that there are at least three zones of under-thrusting at present. One beneath western central America where the Cocos plate

3.2.2 The Physiography

The coastal sediments forms a low lying area bordering the Atlantic coast while the Pre-cambria basement dips seawards in the coastal monocline. The same basement rock continues to the Intermediate Peneplain in the north, centre and south of Guyana. Laterites are found in British Guiana over planation surfaces and presently found capping isolated features above the general level of the terrain
The coastal plains are made up of young and old coastal plains, the latter is underlain by sediments of the Corropina formation and has been dissected during the last glacial period. This produced the valleys, gullies and low points that were filled with younger clays of the Demerara Clay Formation during the post-glacial period. The deposition of sediments on the old coastal plain returned it to its former elevation with respect to the existing sea level during this post-glacial Period.

The young coastal plain's elevation therefore lies close to the present sea level, which rises to a maximum of two meters above it in some areas. The old coastal plain rises from three to eight meters higher above the present sea level, alongside its contact with the Berbice white sand sediments. The young coastal plain has extensive swamps, many underlain by pegasse (peat) particularly in the North West District along the forested coastal fringe, where mangrove dominates. Southeast of the Essequibo River mainly open swamps occur, large areas of pegasse and forests covers elevated features such as sand ridges or cheniers and old river levees associated with the present standstill in sea level.

3.2.3 Coastal Subsidence

A Hydrologist and former Director of the Hydrometeorological Service had sounded a warning, during the late 1970s, that the coastal area of Guyana may be subsiding. His hypothesis is based on the fact that ground water on the coast is being withdrawn at a faster rate than the aquifer can be recharged, resulting in a loss of head in some areas (over 14 m in Georgetown) due to the high density of wells, hence the resulting postulate. As a result any sea level rise would be accentuated as a result of subsidence occurring on the coastal area

3.3 CLIMATE OF GUYANA

3.3.1 General

Guyana lies within the equatorial trough zone and the climate is influenced primarily by the seasonal shifts of the Inter Tropical Convergence Zone (ITCZ).

The seasons and climate are determined mainly by the variation in rainfall patterns. This is so because the spatial and temporal variations of other meteorological parameters are relatively small.

3.3.2 Different Seasons of the Year

Seasons in Guyana are identified by rainfall amounts resulting from the north/south movement of the Inter-Tropical Convergence Zone (ITCZ). There are four seasons:

3.3.3 Rainfall

On the macro-scale Guyana can be described as having a Wet Tropical Climate. However, due to geographical influences such as mountains, ocean, etc. There is spatial variability of rainfall resulting in three major climate types on the meso-scale. These are as follows:

3.3.3.1 Very Dry – Areas with annual rainfall less than or equal to 1788 mm (70 inches). Such areas are the Rupununi Savannah, the Intermediate Savannah, the Upper Cuyuni and the East Berbice Coast. The Secondary Wet Season is absent in the Rupununi Savannah and often absent in the Intermediate Savannah.

3.3.3.2 Wet-Dry – These are areas with rainfall between 1778 mm (70 inches) and 2800 mm (110 inches). This climate type is the most widely experienced one in the country and can be further subdivided into:

3.3.3.3 Very Wet – Areas with annual rainfall above 2800 mm (110 inches). They can be subdivided into:

3.3.4 Duration of Sunshine

As a result of Guyana's proximity to the equator there is little variation in the hours of daylight. It varies from a minimum of 11.6 hours per day in December to a maximum of 12.5 hours per day in June. Bright sunshine is inversely proportional to rainfall. It therefore varies from an annual average of 4.5 hours per day in the Pakaraima Mountains to 7.0 hours per day on the coast. During the Wet Seasons, it can average as low as 3.0 hours and 6.0 hours per day respectively at these locations.

3.3.5 Temperature, Relative Humidity and Wind

Diurnal variation of temperature is smallest on the coast where the maritime effect is mostly pronounced. In that area daily maximum temperatures average 29.6 °c while daily minimum temperatures average 24.0 °C. However, the lowest temperatures occur in the mountainous regions. At Kamarang, daily maximum temperature averages 28.6 °c and daily minimum 19.6 °c. At the peak of Mount Roraima daily minimum temperatures are expected to average about 5.0 °c.

Seasonally, temperatures are higher in the dry periods with the highest temperatures occurring in September/October and the lowest in January/February. The October average daily maximum temperature ranges from 34 °c in the Savannahs to 30 °c at Kamarang and less in the higher regions. The January average daily maximum temperature ranges from 32 °c in the Savannahs to 27 °c at Kamarang while the daily minimum ranges from 23 °c in Georgetown to 19 °c at Kamarang. Relative humidity is high averaging about 70 percent in the Savannahs, 80 per cent on the coast and 88 percent in the rainforest. Morning fog can be widespread and persistent in the hinterland districts.

Guyana's coast is subject to the northeasterly trade winds with speeds of about 6 meters per second decreasing further inland where light winds generally prevail. However, in the Rupununi Savannahs the wind speeds approach that on the coast.

3.4 Climate and Weather Systems

There are many tropical and extra-tropical weather systems which influences Guyana's weather. The major ones are:

3.4.1 Inter Tropical Convergence Zone (ITCZ)

This convergence area is brought about by the confluence of the Northeast and Southeast Trade Winds. When the convergence is strong, copious rainfall is experienced but when it is weak rainfall may even be absent.

3.4.2 Tropical Waves

During the hurricane season, these precursors of the hurricane can affect Guyana's coastal and inland areas particularly west of the Demerara River. It is the system, which is responsible for larger rainfall amounts in the northwestern parts of the coast and is often the cause of the extension of the First Wet Season into the Second Dry Season.

3.4.3 Upper Level Troughs

Especially during the Northern Hemisphere winter season, extra-tropical troughs in the upper Westerlies can push southward and create divergence zones, which produce moderate to heavy rainfall especially when they interact with the ITCZ.

3.4.4 Southern Hemisphere Upper Troughs

During the Southern Hemisphere winter, these troughs in the Westerlies produce cloud blow-ups in Amazonia and copious rainfall in Guyana's rain forest, inland areas and coast.

3.4.5 ENSO Events

These are equatorial pacific climate events, which have dramatic effects on Guyana's seasons. When the Pacific is in the El Niño mode, as in 1997 - 1998, drought conditions can affect Guyana. When it is in the La Niña mode, as in 1996, flood conditions can affect Guyana. ENSO (El Niño Southern Oscillation) events significantly change the intensity and duration of the traditional seasons and, in recent years the El Niño/La Niña modes have been alternating much more frequently.

3.5 The Economy

With a Gross Domestic Product (GDP) per capita of US $528 in 1990, Guyana was the second poorest country in the Western Hemisphere, after Haiti. Guyana's economy was responsive to structural adjustment measures, with real GDP growing by 8.5 percent in 1994. Since 1991, this positive growth rate reflected the effects of price liberalisation, a market-determined exchange rate and the positive results of private sector investment in the gold, timber and rice industries. The consumer price level rose by 16.1 percent during 1994, after an increase of 7.7 percent in 1993. The overall deficit of balance of payments rose to US M$63.9 in 1994 from US M$49.7 in 1993.

Guyana remained committed to a market-determined exchange rate. During the year 1994, the exchange rate depreciated by 9 percent to reach G$142.50 per US dollar in December 1994. All five sectors of Guyana's economy have special relevance to climate change issues. These are the agriculture, forestry and fishing sectors which made up 29.2 percent of the GDP in 1994, the manufacturing sector 12 percent, the services sector 39.6 percent, the mining and quarrying sector 12 percent and the construction sector 7 percent.

3.5.1 Agriculture, Forestry and Fishing Sector

The agriculture sector is the single most important sector of Guyana's economy, both in terms of foreign exchange generation and the number of persons employed. In 1994, this sector increased by 12 percent, compared with 6 percent recorded during 1993. This improvement reflected the recovery of sugar output and the expansion of rice, timber and other crop production.

The sugar industry is expected to continue to be one of the important engines of growth in the future especially since it gained access to non-traditional regional markets in addition to traditional markets. Output of sugar for 1994 was 256,669 tonnes, 4 percent above the 246,528 tonnes recorded for 1993. This additional production reflected the impact of a stable political climate and good weather conditions experienced in the year.

Despite the constraints in irrigation, drainage and the poor state of access roads, rice output for 1994 was 233,435 tonnes, which was 11 percent higher than in 1993. The liberalisation of the rice market, and the continuous rise in the price of paddy resulting from a strong external demand for rice affected the strong supply response in the year.

After declining for several years, livestock output recorded a positive growth for 1994. The growth for this sector rose by 15 percent compared with 11 percent for 1993. The principal contributors to this performance were poultry and eggs, increasing by 53 to 112 percent respectively.

The output of the forestry sector continued to be influenced by the new governmental policies, which facilitated significant foreign investment. These investments, the ability to pay higher wages, training and the exploitation of new markets induced higher production. Output of timber increased to 469,557 cubic meters or 98 percent over that of 1993.

Value added in the fishing industry increased by 7 percent during 1994. Gross output of fish, small shrimp and prawns increased in 1994. The upturn of this industry resulted in part from changes in climate conditions.

3.5.2 Manufacturing Sector

Growth in output in the manufacturing sector during 1994 was 6 percent compared with 3 percent during 1993. This resulted primarily from the 11 percent expansion of rice milling. There were also encouraging trends in other manufacturing activities, primarily consumer non-durables and sugar processing, which grew by 6 and 4 percent respectively during 1994. The growth in non-durables was explained by significant increases in pharmaceuticals, garments, soft drinks, alcoholic beverages, margarine and edible oil production. The production of consumer durable and semi-durable goods, including that of stoves, refrigerators and textiles declined during 1994.

3.5.3 Service Sector

During 1994, the services sector grew by 6 percent compared with 3 percent in 1993. The performance of distribution and transportation paralleled the increased activity observed in physical production. During this year, there was stronger growth in the financial services industry reflecting the establishment of two new banks.

3.5.4 Mining & Quarrying

The output of this sector continued to be encouraging mainly on account of the good performance of the gold industry. Value added increased by 7 percent in 1994.

Gold declaration for 1994 were 375,618 ounces, 65,846 ounces more that during 1993. The increase in declaration arose primarily from OMAI's output of 276,464 ounces compared with 222,676 ounces during 1993. The declared output of diamond declined by 12,141 metric carats or 28 percent compared with 1993 level to reach 36,792 carats. This may have been the result of a decline in quality and size of diamonds found and the consequent lower returns to diamond mining relative to gold mining.

3.5.5 Construction

Available data on application for new residential housing developments in road building, trends in cement imports and production of stone all support the 20 percent expansion in the construction sector during 1996.

3.5.6 Tourism

Ana possesses a vast interior area, that is pristine, and untouched forests that are so diverse they can show the entire spectrum of tropical rainforest at its best. The potential for a thriving Eco-tourism industry is promising but several key constraints to the sector's development must first be addressed. In 1994, one hundred and thirteen thousand visitors arrived in Guyana. New efforts are now directed towards attracting more visitors to the country.

Guyana will continue to promote its 276 waterfalls including the Kaieteur Falls, with a sheer-drop height of 225 meters. This fall is located in thick jungle in the hinterland but is easily reached by small aircraft, which are chartered by travel agencies.

The Orinduik Falls is a cataract of ten, visited by vacationers. The Ireng River, which forms the border between Guyana and Brazil, thunders over steps and terraces of solid jasper. In the distance is the Pakarima Mountain.

In the Savannah plains of the Rupununi, riding, hunting, fishing and swimming are available. There are several tourist lodges in the hinterland and on the banks of Guyana's main rivers.

3.6 Energy

The energy sector is receiving extensive focus from the government because energy is seen as an important driving force for growth and development. Consequently, there was a preparation of a National Energy Policy in 1994. The objectives of this policy are to provide stable, reliable and economic supply of energy; to reduce dependency on imported fuels; to promote, where possible, the increased utilisation of domestic resources; to ensure that energy is used in an environmentally sound and sustainable manner. A National Development Strategy Chapter on Energy supplements the National Energy Policy.

In Guyana the primary sources of energy are petroleum products, Bagasse and fuelwood. Currently all petroleum products are being imported. Fuel & lubricant imports accounted for 16 percent of the total imports of 1994.

3.6.1 Imported Petroleum

Imported petroleum, taken together forms the major source of energy in Guyana. Seven products were imported in 1994. These were leaded gasoline, unleaded gasoline, dual-purpose kerosene, diesel/gasoil, No.6 fueloil (Bunker 'C'), Liquefied Petroleum Gas (LPG) and aviation fuel. However, importation of leaded gasoline was discontinued sometime in the year 1998.

3.6.2 Bagasse and Fuelwood

The other main sources of energy in Guyana are bagasse, a by-product of sugar production, and fuelwood. Bagasse is used for the co-generation of steam and electricity in the sugar industry.

Fuelwood becomes available from direct forest harvesting, timber industry waste, 'slash and burn' operations associated with land clearing for agriculture, and from self gathering. Some types of woods are transformed into charcoal.

3.6.3 Other Sources

Guyana is well endowed with other indigenous energy resources, apart from bagasse and fuel-wood. With its many rivers and waterfalls, the country has significant hydropower potential.

Construction of the Moco-Moco hydro power station has been completed and it is operational with an installed capacity of (2*250 kw), and annual energy of (3*10) kwh. The power will be transmitted from Moco-Moco via a 13.8kv transmission line to Lethem and the surrounding communities.

In order to further the development of the Energy Sector, a letter of intent was signed for the Tumatumari Hydro power project on March 5, 1998. The installed capacity is expected to be 45MW. The power will be transmitted to the load center at Omai Gold Mines Limited. For the Amaila Hydropower project, a Memorandum of Understanding for a feasibility study was signed on April 24, 1998. This project, when implemented, will produce under 106 MW in the first place. Hydropower is estimated to be in the region of 7000 MW and is seen as a potential source of energy in the long run.

Rice chaff also has considerable potential as a source of energy but currently, minimal use is being made of this resource.

Animal waste is used to generate biogas. There are approximately 10 operational biogas plants in the country.

Wind plays an extremely small part in the energy spectrum. Small-scale application is being encouraged. A feasibility study is necessary to determine its viability.

Solar energy is still being promoted in the hinterland areas of Guyana. Photovoltaics systems are being used mainly by hospitals for lighting and refrigeration. Plans aere afoot to build an energy centre at an abandoned airstrip in the Kaieteur area. Construction/installation will begin at the end of year 2000 and will be completed over an eight to ten year period. Total electricity generation capacity in Guyana is placed in the vicinity of 300 MW.

3.7 Transportation

The transportation sector can be divided into three main categories namely: land, air and water. A number of factors (such as increased availability of credit facilities and easy access to suppliers), have led to more persons being able to acquire their own vehicles. Consequently, there has been an increase in the number of registered vehicles in 1994 to 6898 from 6535 in 1993.

3.8 Land use and Forestry.

Guyana's coast accounts for almost all of the commercial agriculture and the hinterland contains the vast natural resource wealth of the country. Three quarters of the country, or 164,500 km^2, are covered by tropical moist evergreen rainforest, containing over 1,000 known species.

The hinterland is also rich in minerals. Being part of the pre-Cambrian shield, the western area has rich deposits of gold and diamonds, with the south and center having good mining potential also. Large deposits of bauxite and kaolin are found in the south-east – north-west belt just behind the coast. Petroleum is also known to exist in scattered locations.

The hinterland possesses many waterfalls with potential for hydroelectric power generation. This area is also rich in biodiversity, with thousands of species of flora and fauna, which exist in a pristine environment. This, together with the magnificent waterfalls and varied topography, lend itself to almost limitless eco-tourism potential.

3.8.1 Spatial Pattern of Land Use

Guyana has a very low overall population density – less than 4 persons per km^2. However, the spatial pattern of the population and development is far from uniform. The spatial distribution of natural resources, the pattern of climate sub-regimes and the pattern of resource utilisation have influenced the geography of population, settlement and development. About 90 percent of the country's population live on the coastal plain, with occupations tied to agriculture in the rural areas, and manufacturing and services in the urban areas. This relatively small strip of land has therefore been the recipient of most of the physical and social infrastructural development of the country, and has become the geographic locus of economic and political power.

The remainders of the population live and work in the hinterland, where the vast wealth of the country lies. Most of the hinterland wage earners are employed in logging, saw milling, gold, bauxite mining and processing and cattle ranching.

Most of the hinterland residents are Amerindians who number some 45,000 and are spread among some 150 villages. Characteristically traditional in lifestyle, this segment of the population has fallen out of stride with mainstream development. The principal economic activity in these areas is mixed subsistence farming.

Some communities, particularly those in proximity to mining or forestry operations, have been turning to wage labour. However, the very activities that can bring material well being to these communities also bring vices in the form of pollution and erosion of traditional values. This interface between commercial economic activity and traditional communities is a growing source of conflict.

A significant conclusion that arises from the spatial distribution of development is that regional inequity co-exists with vast development potential and a gap in spatial planning.

3.8.2 Status of Land Use Planning

National land use planning was limited in Guyana. Land-use planning in relation to human settlements on the coast was being practised. However, with the upswing in the economy in the last few years, and the concomitant agricultural expansion and increase in natural resources utilisation, several problems have manifested themselves:

- Illegal resources extraction
- Inadequate co-ordination of land use policies and regulations
- Multiple use conflicts both in the hinterland and on the coast
- Environmental degradation and pollution

These problems are the consequences of the absence of a comprehensive and well co-ordinated land use policy and a formal land use planning mechanism. Government, in recognition of this situation, engaged two major efforts.

In 1994 the Government of Guyana and the Federal Republic of Germany entered into a technical co-operation agreement for the establishment of a Natural Resources

Management Project (NRMP). This project has several components including the building of institutional and human capacity, legislative reform and land use planning, utilising a Geographic Information System (GIS).

Under the land use planning component, a Geographic Information System (GIS) for natural resources management has been established, and a Land Use Action Plan has been prepared.

At the present teamwork is under way to perform a pilot regional land use planning exercise. This exercise is intended to produce a regional level land use plan, and to realise a planning methodology that can be utilised in other regions of the country.

Secondly, the land use planning component of the NRMP also had a provision for groundwork studies aimed at laying the foundation for development of land use policy. In 1995, the Government of Guyana, the University of Guyana, The Guyana Environmental Monitoring and Conservation Organisation, World Resources Institute and the Carter Center came together as the key partners on a project aimed at producing a baseline document that the Government of Guyana can accept as an instrument that will inform a land use policy for Guyana. Under this project a baseline document was prepared under the guidance of a broad-based National Steering Committee, and benefited from countrywide stakeholder consultations. In 1996, the final version of the baseline document was completed and presented to Government.

With the land use baseline report completed and a pilot land use planning process in progress, a decision has been taken to expedite the preparation of a national land use policy. This process will utilise existing, approved policies and strategies and useful outputs from the NRMP.

While policies have been formulated at the sectoral level, a comprehensive national land use policy is one instrument that had eluded previous administrations. Under ideal circumstances, one would develop a land use policy, which would then inform the formulation or amendment of sectoral policies. In Guyana, as in many other countries, development has tended to precede a national land use policy. Given this situation, a conscious strategy has been adopted whereby the land use policy will recognise and be consistent with all existing and recently approved sector policies and strategies, and will also set the stage for informing future policy development in all related sectors.

3.8.3 Forestry

Guyana is at the heart of the Guiana Shield, contiguous to the Amazon Basin and represents one of the best-conserved areas of the region. Approximately seventy-six percent (76%) of Guyana's land area, is covered with forest. Of this, 135,800 km^2 is classified as State Forest. The remainder is classified as State Lands, Amerindian lands, and private property. Approximately 47 per cent of the State Forests have been allocated to logging concessions, in a zone parallel to the coast.

Guyana's forest types include rain forest, seasonal forest, dry evergreen forest, marsh forest, swamp forest, montane forest, and mangrove forest. Guyana has over 1000 tree species, thousands of other plant species and innumerable animal species. Selective logging has been the traditional approach to timber harvesting, where an identified number of commercial species above a specific diameter breast height (DBH) are extracted per hectare with little effect on the forest canopy.

Forestry, along with rice, sugar, fisheries, bauxite, gold and diamond mining, constitute the main components of the economy as sources of foreign currency earnings. In 1994, forestry contributed 4.42 percent of Gross Domestic Product. The performance of the forestry sector has continued to improve significantly. The average contribution of the forest sector to GDP for the period 1994 to 1997 was 4.69 per cent, as compared with the average for the preceding 5 years of 2.29 per cent. The improved performance in the sector is due primarily to an increase in plywood exports as a result of foreign owned Barama Company Limited entering the industry in 1992.

3.9 Biodiversity

While Guyana is one of the smaller countries of the wider Amazon region, it contributes significantly to the biodiversity of that region, both in terms of number of species and number of endemics. Its natural ecosystems are relatively intact due mainly to low population pressure and to limit commercial activity. The importance of the Amazon basin lies in its holding of more than half of the world's biodiversity, its collective magnitude of endemism, its role in ameliorating global climate and in the hydrology of a large part of South America.

There is limited knowledge of Guyana's biodiversity richness, but it is safe to suggest that this have been well preserved. However, current increase in entrepreneurial activity in the natural resources sectors places pressure on the biological resource base and raises real possibilities of increased threat to biodiversity. Hence there are 14 endangered animal species which are either threatened with extinction, not threatened with extinction or need strict trade regulation. Additionally there are some plant species, which are rare, but current information in relation to their status is not available.

Recent policies and practices in Guyana are leading to the building of a tradition in support of participatory decision–making and establishment of a policy to conserve and sustainably use the country's natural resources. These policies are reflected at the international level in the signing of a number of international and regional treaties, conventions and other instruments relating to the conservation and sustainable use of natural resources. Cabinet recently approved a National Biodiversity Plan and it will seek to promote conservation and sustainable use of Guyana's biodiversity. At the national level, the strengthening of the Environmental Protection Agency must be seen as a national effort to ensure the conservation of Guyana's rich biodiversity.

4.0 Vulnerability Impacts on the Coastal Zone

4.1 Sectors

4.1.1 The Coastal Plain (Extracted from Khan and Sturm, 1994)

The coastal plain extends from Punta Playa at the Venezuelan border in the northwestern part of the country to the Corentyne River, which is its eastern boundary. The length of the coast is approximately 430 km, of which 360 km are maintained, including the islands of Leguan and Wakenaam.

In their natural state the coastal lands comprised swamps caused by the overflowing of the many rivers passing through or by flooding from the sea. To reclaim the coastal lands, lying at a level of 0.5-1 m below the level of spring tides, a system of dykes was constructed to form polders. The empoldered land was thus protected from flooding by the sea and segregated from the remaining swamps.

At the boundaries of each polder or estate, dams were built at right angles to the shoreline extending backwards to the dam closing off the polder from the remaining swamps. For irrigation purposes this backdam was provided with water inlets. At the seaward side a dam situated on the shore ridge protected the polders. The foreshore in front of this dam in general consisted of a mangrove belt some few hundred meters wide. In the sea dam sluice gates were built to obtain gravity drainage at low tide.

As the foreshore, mangrove belt, shore ridges and sea dams eroded from time to time and as the cost to maintain the defences under adverse conditions became greater, the proprietors would retrieve inland and build a new sea dam and sluice gates. This policy continues today where there is land available for retreat. In built-up areas however, a general policy of maintaining the sea defences in their existing position, by the construction of rigid defences consisting of concrete seawalls, has been followed over the last decades.

At present about 110 km of coastline is protected by these concrete defences, 250 km by a mangrove belt backed up by an earth embankment and 70 km by natural sand banks. Addressing coastal vulnerability is important for Guyana because the coastal zone is vital for over 90 % of the population reside there and the important economic activities are to be found there.

4.1.2 Coastal Morphology (Extracted from Khan and Sturm 1994)

The coastline of Guyana is dominated by the occurrence of large mud-banks travelling along the coast at fairly regular intervals. The banks are composed of very fine sediments originating from the Amazon River some 1000-km away. The coastal plain itself is composed of similar clays but derived from the Pre-Cambrian Guyana Shield. Its great age ensures that erosion products are low, in spite of the presence of many large rivers. It has been estimated that 5-10 million tonnes/year of silt is carried by the rivers into the coastal system compared with 100 million tonnes/year moving along the shore.

The banks move along the coast in a series of waves or macro-ripples at an average rate of some 1.3 km/year. The macro-ripples have an average length of about 40-km. Thus a trough or crest will pass a given point on the coast about once in 30 years. The deeper water in the troughs between two banks will provide passage in the direction of the coast for higher waves from the wave trains of the Atlantic Ocean generated by the Northeast Trade Winds. This effect will be strengthened due to refraction and concentration of wave energy through the trough. The increased wave attack often causes erosion of the foreshore (DHV 1992).

The highest waves breaking on the sea defences rarely attain a height of more than 1.5 m. As such the wave attack occurring along the coastline of Guyana can be described as minor. These circumstances combined with the regular, relatively small tidal variations and the absence of storms, storm surges and tsunamis constitute a mild marine environment. Serious erosion does not always take place in front of the trough. Local circumstances such as the occurrence of "sling mud", a highly viscous mud in suspension dampening the waves, the width of foreshore at mean high tide, the type of beach material and variations in the level of the foreshore prevent severe erosion in many cases.

Accretion and growth of the mangrove belt might occur when, due to the passage of the higher part of the mud-bank, the level of the foreshore rises. As in the case of erosion, accretion of the mangroves does not always take place. Actually the regular pattern of travelling mud-banks and a 30-year cycle of erosion can be observed only along the coasts of East Demerara and East Berbice. In the other areas the influence of the Corentyne and the Essequibo rivers distorts this pattern to a great extent.

Erosion, comprising essentially a lowering of the near-shore zone and higher waves, affects the coast in different ways dependent on the nature of the foreshore. Where the shore is overgrown the roots of the mangrove trees become exposed and the mangrove area will start to suffer from increasing wave attack for which it is not designed. Strengthening of the seaward side of the dam by providing a slope protection is required if it is decided to maintain the existing line of defence. Due to this process the length of permanently defended coastline is continuously increasing.

It has been attempted in the past to predict in the medium to long term where areas of erosion are likely to occur in order to reserve the necessary funds and make the preparations required. As indicated above serious erosion is generally co-incident with the passing of a trough. Consequently, only along stretches of coastline where mud-banks can be clearly identified such forecasting would be possible, although the randomness of the erosion phenomenon reduces the usefulness of this activity.
There are indications that over the last decades accretion does not balance erosion along the Guyanese coast and that there has been a general retreat of the coastline. At locations where permanent sea defences are present the regression of the coastline will be halted.

4.1.3 Geomorphology

The coastal plain of Guyana is on e of the five main physiographic units (morphological units) identified in Guyana, with each having a characteristic combination of rock, soils, and vegetation types. Geomorphologically this coastal plain is divided into recent and old coastal plain.

The old coastal plain, geologically the Coropina Formation, consists of a former coastal plain with small, elevated areas of variable altitudes between 3 m and 10 m above sea level. It is formed of silty clays and sands. The coastal plain has been eroded and dissected before the formation of the recent deposits.

The recent coastal plain corresponds geologically to the Demerara Formation and comprises the low-lying lands with altitudes between 2m below sea level and 3m above sea level. It consists dominantly of soft clays and silts occasionally intercalated by sands.

The Demerara Formation is subdivided into Mara and Coronie deposits. The Mara deposits. The Mara clays settled during the period of the rapidly rising sea level at the beginning of the Holocene (10 000 years before present (B.P.). The rise of sea level ceased about 6000 years B.P. The Coronie sediments were deposited during the subsequent period of more or less a constant sea level. The sedimentation phases are separated by periods of erosion.

The thickness of the Demerara clay unit and Coropina Formation is approximately 30m and 15 m, respectively. The stratographic unit under the Coropina unit is called the white sand series. It has an outcrop area further south from the coast. The sand layers however, continue towards the sea and can be found under the Coropina Formation.

4.1.4 Climate Factors

4.1.4.1Climate change and Sea Level Scenarios for Guyana

For this analysis, the climate records (temperature and rainfall) for the Botanical Gardens in the Capital City, Georgetown, is used. Georgetown is located at 6^0 47' North Latitude, 58^0 09' West Longitude, on the mouth of Demerara River in the Coastal Plain. Temperature data span close to 89 years (1909 to 1998) and rainfall data coverage exceeds 100 years (1884 to 1998).

4.1.4.1.1Temperature:

The yearly temperature variation with mean maximum and minimum temperatures also included. Using linear extrapolation, the maximum temperature has shown an increase of 0.8^0C while the minimum temperature has shown an increase of 1.2^0C with a mean annual increase of 1.0^0C over the period of record. This supports the observed indication elsewhere in the Caribbean (Singh, 1997) that a greater increase in night-time temperatures has been contributing to the observed global warming. This observed trend also corresponds to a decrease in the diurnal temperature range of about 0.5^{0}C . Both the relatively greater increase in the night-time minimum temperature and the decreasing diurnal temperature range are symptomatic of global warming which is being demonstrated by increases in the night-time temperatures (Singh, 1997).

Seasonal temperatures are modulated by the rainfall amounts during the seasons. Hence, there is not expected to be significant fluctuations in the seasonal temperature records.

When Georgetown Botanical Gardens mean air temperature is compared to Global Average Temperatures then there are some similarities:

- Temperatures have been rising from about 1890 up to about 1940,
- Then there was a decrease until the late 1970s, when temperatures increased again,
- The highest average temperatures were recorded in the 1980s and 1990s. However, there was a short period about 1940 when comparable high Average temperatures were recorded.
- The highest average temperature was recorded in 1998.

The annual air temperatures at Georgetown Botanical Gardens also showed a pattern of responding to the cooling effect of major volcanic eruptions around the world. The last cooling period during the early 1990s correlated with the Pinatubo eruption. It is therefore a consideration that the increase in air temperature in Guyana is being significantly masked by the cooling effect of the abundant aerosols introduced into the olcvanic atmosphere during eruptions.

4.1.4.1.2 Rainfall

The five-year running mean anomalies of annual rainfall amounts from the international normal (1961-1990) for Georgetown Botanical Gardens. Prior to 1960, annual rainfall amounts were generally above or about normal. However, from 1960 and onwards, there have been more below-normal periods than above-normal periods.

While ENSO events have been shown to be affecting Guyana (Simon, 1997) there seems to be a mechanism which is resulting in decreasing annual rainfall amounts during the last two decades when surface air temperature has been increasing. It appears that increased evaporation due to higher surface air temperatures did not result in higher rainfall. It could very well be that cloud cover has increased but this was due to more stratiform cloudiness rather than connective cloudiness. However, within the 1990s it has become apparent that connective storms have become more intense but fewer. The result was high intensity rainstorms leading to short - period flooding. The clusters in the Intertropical Convergence Zone off the Guianias are smaller and fewer but more intense. The monthly rainfall is therefore being accounted for by fewer days with higher rainfall.

With regards regional climate events, the ENSO has been very pronounced especially in the 1990s. While the EL NIÑO of 1982-3 did have an impact on Guyana's rainfall, the effect was not sufficiently intense to cause concerns for agriculture, etc. Increased but this was due to more stratiform cloudiness rather than convective cloudiness. However, within the 1990s it has become apparent that convective storms have become more intense but fewer in occurrences. The result was high intensity rainstorms leading to short-period flooding. The clusters in the Intertropical Convergence Zone off the Guianas are smaller and fewer but more intense. The monthly rainfall is therefore being accounted for by fewer days with higher rainfall.

With regards regional climate events, the ENSO has been very pronounced especially in the 1990s. While the El Niño of 1982-3 did have an impact on Guyana's rainfall, the effect was not sufficiently intense to cause concerns for agriculture, etc.

However, the 1997/1998 El Niño event produced widespread drought with accompanying forest fires and a significant impact on the economy of the country. The La Niña of 1996 caused severe flooding to affect several parts of the country. In 1999 and 2000, La Niña's influence can be blamed for sporadic flooding especially of coastal regions.

- **The questions for which there are no answers as yet are:-**

- ***Will rainfall continue to decrease as temperatures increase?***

- ***Will rainstorms become more intense as global warming continues?***

- ***Will ENSO events intensify as a consequence of global warming?***

- ***Will doubling/tripling of concentration of greenhouse gases in the***
- ***Atmosphere increase/decrease rainfall amounts in the rainy seasons?***

- ***Will the rainy seasons shift or extend or shorten as a consequence of global warming?***

These questions may be answered but significant monitoring of climate and research will have to be done. These are needs which will have to be addressed in accordance with Article 5 of the Convention.

4.1.4.2 Scenarios of Future Climate Change

There are now discernible evidences that increases in atmospheric concentrations of greenhouse gases due to anthropogenic activities would warm the earth-atmosphere system (IPCC, 1996). In order to assess the effects of future climate change and to take appropriate adaptation measures against any adverse effects, estimates of how fast and to what extent global warming will occur are necessary. The most convenient and expeditious method has been the generation of future climate change and sea level rise scenarios using the A-O GCM (Atmosphere-Ocean General Circulation Model) approach.

Recent A-O gcms adequately couple the atmospheric and oceanic circulation and in some cases emission scenarios of future greenhouse gases, tropospheric aerosols and, assumptions on population and economic growth, energy availability and fuel mix, are considered (IPCC, 1992). The climate simulations derived from these A-O GCM's have been extensively used in the development of scenarios of regional climate change for impact assessment.

4.1.4.2.1 CGCM I

In this chapter, we use the results generated by the most recent A-O GCM of the Canadian Climate Centre (CGCM 1) run in transient mode with CO_2 increasing by the observed values to the present and then by 1% per year into the future, to create regional climate change scenarios for the region in and around Guyana

4.1.4.2.1.1 Temperature Change

For a doubling of CO_2 concentration in the atmosphere, the temperature of Guyana is expected to rise in the early part of the twenty-first century by 1.2°C on average but the Second Wet Season (SWS) is predicted to attain the highest increase of 1.4°C. Southern Guyana inclusive of the Rupununi Savannahs are expected to have the highest increase in excess of 1.5°C during the Second Dry Season (SDS) and the SWS.

For the latter part of the twenty first century, with a tripling of the concentration of CO_2, temperature will rise by 4.2°C on average. Here again, Southern Guyana, including the Rupununi Savannahs, are expected to have the highest increases, in excess of 4.5°C during the SDS and the SWS.
Water deficit is defined as the difference between rainfall and evaporation. A positive value indicates that rainfall exceeds evaporation while a negative value indicates that rainfall is insufficient to meet the loss of water due to evaporation.

With a doubling CO_2 scenario, the average deficit is expected to be 0.27-mm dy^{-1} or about 8 mm per month. Southern Guyana will experience large water deficits especially in the FWS and SWS. With a tripling CO_2 scenario, the average deficit becomes 0.8-mm dy^{-1} or 24 mm per month. However, in this case it is Northern Guyana, which will encounter deficits in excess of 0.73-mm dy^{-1} or 22 mm per month with large deficits expected in the FWS and SDS.

A common observation, with both scenarios, is that Southern Guyana is expected to have positive water deficit values in the SWS. That is, rainfall is expected to be higher than evaporation.

4.1.4.2.1.2 Rainfall Change

For a doubling of the concentration of CO_2, rainfall is expected to decrease by an average of 0.34 mm dy $^{-1}$ or 10 mm per month. The decrease appears to be higher, 17 mm per month and 12 mm per month in the First Wet Season (FWS) and the SDS respectively.

For a tripling of the concentration of CO_2, the average decrease is expected to be 0.69 mm dy^{-1} or 21 mm per month. Here again, the FWS and the SDS will experience decreases higher than 1 mm dy^{-1} or 30 mm per month.

Again, Southern Guyana is targeted for the largest decreases in both the doubling CO_2 and tripling CO_2 scenarios of CO_2 concentration. However, with the tripling of CO_2 concentration, Northern Guyana (including the coast) is can expect significant rainfall decreases.

4.1.4.2.1.3 Evaporation and Water Deficits:

As for the change in evaporation rate, the slight (~ 1 °c) average increase in temperature, as a consequence of CO_2 doubling, does not translate into significant evaporation (less than 0.1 mm dy $^{-1}$). However, for a tripling of the CO_2 concentration, evaporation generally increases, in response to the higher temperature increase, to about 0.11 mm. Dy The southern parts of Guyana will not be significantly affected but northern Guyana will, in general, experience increases of about 0.22 mm dy $^{-1}$ or 7 mm per month. The northwest region will be subjected to evaporation rate increases in excess of 0.40 mm dy $^{-1}$ or 12 mm per month in all seasons.

4.1.4.3 Hadley Centre A-O GCM

For purposes of comparison and validation, we also use the results of the Hadley Centre A-O GCM (hadcm2gsal) retrieved from the scenario generator SCENGEN within MAGICC (Model for the Assessment of Greenhouse gas induced Climate Change). Two future time periods centred around 2030s (2016-2045), corresponding to the 2 x CO_2 scenario and 2090s (2076-2105), corresponding to the 3 x CO_2 scenario, have been used, to generate scenarios of changes in surface air temperature and precipitation for Guyana. However, the grid spacing (5° x 5°) are slightly different

The SCENGEN version of the Hadley Centre A-O GCM project similar changes as the Canadian Model in increases in air temperature and rainfall with the increases in greenhouse gas concentration. In fact, the CGCM 1 and Had CM2 results are remarkably similar for the 2 x CO_2 scenario for air temperature and rainfall, although the latter gives the changes of rainfall as a percentage instead of mm/day.

For the 3 x CO_2 scenario however, Had CM2 gives lower temperature projections, of the order of 1.5 to 2.0°C lesser than the CGCM 1. This may be explained by the fact, that the Had CM2 projections are from MAGICC, based on patterns of change and by the fact that Had CM2 uses the IS95a sulphate scenario which is thought to be too high. However, the 3 x CO_2 rainfall scenarios are somewhat similar, although the Had CM2 projections of decreases in rainfall are more severe, especially for the FWS.

4.1.4.4 Extreme High Temperature & Precipitation Events

An analysis of model-simulated daily temperature and precipitation data for the present-day atmosphere and for the two future time slices (2050s and 2080s) suggests that the frequency of extreme temperatures during Northern Hemisphere summer season, which more or less coincides with Guyana's First Wet Season, is likely to be enhanced thereby increasing the probability of thermal stress conditions during 2050s and more so during 2080s. Similarly, there is a possibility of a lesser number of rainy days in a year, although an increase in the daily intensity of precipitation is also expected (Lal et al., 1999). This suggests an increase in the probability of occurrence of more frequent droughts as well as floods for the future.

However, one important aspect of the observed temperature change over the globe during the past century relates to its asymmetry during the day and night. Observed warming in surface air temperatures over several regions of the globe has been reported to be associated with increases in minimum temperatures, accompanied by increasing cloudiness, and decrease in diurnal temperature range. Any future changes in the diurnal temperature range (DTR) are important in respect of its crucial role in agriculture. GCM simulations with increasing concentrations of ghgs in the atmosphere suggest relatively more pronounced increases in minimum temperature than in maximum temperature over the North Atlantic and Caribbean region on an annual mean basis as well as during Northern Hemisphere winter for both 2050s and 2080s and hence a marginal decrease of 0.3°C to 0.7°C in diurnal temperature range

4.1.4.5 ENSO and Precipitation Variability

In general, Guyana suffers acute droughts during El Niño phase and oppositely, heavy rainfall accompanied by flooding during La Niña phase. In recent years warm episodes (El Niño) have been relatively more frequent or persistent than the opposite phase (La Niña). The ENSO phenomenon is the primary mode of climate variability on the 2 -5 year time scale. At present the weight of evidence from both observations and A-O GCM projections is that it is uncertain whether there will be any significant change to the amplitude or frequency of ENSO in the future. Thus, the current large inter-annual variability in the rainfall associated with ENSO is likely to dominate over any effects attributable to global warming. However, the frequency and increased intensity of ENSO – related effects in Guyana will need to be examined.

4.1.4.6 Tropical Cyclones

Guyana, in close proximity to the equator, has not in the past suffered significant ill effects of hurricanes. On account of its equatorial location, climate change will very unlikely change this condition, except for the increased effects of sea swells and tidal surges, in the event of major shifts in hurricane numbers, patterns and intensities in the North Atlantic and Caribbean Sea to the north of Guyana.

There is no consensus regarding the behaviour of tropical cyclones in a warmer world. However, recent studies indicate a possible increase of about 10 to 20% in intensity of tropical cyclones under enhanced CO_2 conditions. Studies also suggest that, during ENSO events, tropical cyclones and hurricanes are likely to more severe (Jones et al., 1999; Tonkin et al., 1997; Holland, 1997). However, another study found no significant change in hurricane frequency or geographical extent for the North Atlantic under a 2 x CO_2 Climate (Royer et al., 1998). The concern for Guyana is the possibility of spiral bands of the hurricanes that pass to the north affecting Guyana with more frequency than in the past.

4.1.4.3 Sea Level Rise

4.1.4.3.1 Past Sea Level Rise

While the severity of the threat will vary regionally, sea level rise of the magnitude currently projected by A-O gcms (i.e. 5 mm yr $^{-1}$), with a range of (2-9 mm yr $^{-1}$), is expected to have disproportionately great effects on the economic and social development of many small island states and coastal low-lying land masses such as Guyana, parts of which are already at or below mean sea level.

Real or eustatic sea level rise as would be driven by climate change has to be combined with relative sea level rise as caused by land displacements in the vertical. In some locations, land movements of various kinds dominant current sea-level change: local tectonic movements, isostatic rebound or local anthropogenic effects. These processes are not related to current climate change. By selection and correction of tide gauges, these processes are excluded from the assessment of global average eustatic sea-level change, which is estimated to lie in the range 1.0-2.5 mm^{yr-1} averaged over the last hundred years (Church and Gregory, 2000). The primary source of information on secular trends in global sea level during the past century is the tide gauge data set of the Permanent Service for Mean Sea Level (PSMSL). Estimates of global average sea-level rise using this data set fluctuate over a wide range varying from 1.0 to 2.4 mm^{yr-1} (Douglas, 1995;

Smith et al 1999). The sum of these processes indicates that between a third and a half of 20th century eustatic sea-level rise is due to thermal expansion. Thermal expansion and changes in air/sea momentum, heat and freshwater fluxes associated with climate change will alter the ocean circulation and the pattern of sea-surface height. These processes are therefore expected to have a geographically non-uniform signal in sea level change (Church and Gregory, 2000). However, Singh, (1997) reported rates of mean relative sea level of 8 to 10 mm yr^{-1} in Trinidad and Tobago but, this data set is limited by its short period (15 yrs) and lack of measurements on vertical land movements.

In the case of Guyana, based on available tide gauge data for the period 1951 to 1979 for Port Georgetown, mean relative sea level rise, using a linear extrapolation is 10.2 mm yr^{-1} – see. High tide change has been calculated to be 9.7 mm yr^{-1} with the low tide change being 11.1 mm yr^{-1}. This rate of relative sea level rise is about 5 times the global average and close to that observed in Trinidad, albeit for a later time period. This is therefore suggestive of some mechanism other than eustatic sea level rise, such as subsidence due to water extraction, ocean floor sediment loading or plate tectonics. Plate tectonics, however, does not appear to be contributing to this problem. Subsidence and sediment loading may both be contributing to the high rises noted in Guyana. The high rises observed in Trinidad and in Guyana may suggest a generalised increase of sea level in the region.

This discussion did not examine the effects of the North Equatorial Counter Current, the Guyana Current and the eddies within the Guyana current on the level of the sea off Guyana. These will definitely result in changes in water accumulation off the coast and may contribute to acute rises over short periods of time resulting in overtopping of defences and inundation of vulnerable areas especially where weak earthen dams and mangrove defences exist. Studies will have to be done on these effects to gauge the seriousness of the vulnerability.

4.1.4.3.2 Future Sea Level Change

For the oceans, time-dependent experiments to simulate the evolution of the climate over the next century have been run with a number of AO-gcms. Several of these have followed similar scenarios for climate forcing, starting from the beginning of this century or earlier with greenhouse gases increasing as they did historically up to 1990, then with the IS92a scenario, namely 1 % per year, for the future. Some experiments have also included the direct effect of sulphate aerosol emissions, which counteracts part of the positive greenhouse radiative forcing.

The experiments with only greenhouse gases show a range of about 0.1 to 0.2 m for the first half of the 21st century, corresponding to rates of rise of 2 to 4 mm yr^{-1}. In all the models, there is acceleration through the century; for the second half, the average rates are in the range 3 to 6 mm yr^{-1}.

4.1.4.3.3 Extremes of Sea Level: Storm Surges and Waves

Changes in the highest sea levels at a given locality will result from the change in mean sea level at that location and changes in storm-surge heights. If mean sea level rises, the present extreme levels will be attained more frequently, all else being equal. This effect can be estimated from knowledge of the present-day frequency of occurrence of extremes of various levels (Flather and Khander, 1993; Lowe and Gregory, 2000). The increase in maximum heights will be equal to the change in the mean, and this may imply a significant increase in areas threatened with inundation (Hubbert and mcinnes, 1999).

Changes in storm-surge heights would result from alterations to the occurrence of strong winds and low pressures. At low-latitude locations, such as the Tropical (North) Atlantic and the Caribbean Sea, tropical hurricanes are the major but not the only cause of storm surges. Changes in frequency and intensity of tropical storms could result from alterations to sea surface temperature, large-scale atmospheric circulation and the characteristics of ENSO (Pittock et al., 1996). Prediction of such changes is at present rather uncertain. Some recent climate model experiments have predicted a decline in tropical cyclone frequency, but no consensus has yet emerged (Royer et al., 1998; Jones et al., 1999).

Guyana's coast is presently subjected to sea water overtopping the sea defence when high tide prevails. Noting that it is water accumulation which results in higher sea levels off Guyana's coast it is necessary to understand how changes in the Northeast Counter Current, the eddies in the Guyana current and the outflow of the Amazon and the other larger rivers along the Guianas affect the divergence of sea water off the Guianas and into the Caribbean Sea. It is also necessary to understand how climate change may affect the circulation of the Tropical Atlantic Ocean.

4.1.4 Hydrology

The Coropina Formation together with Demerara clay confined groundwater in the underlying White sand Series. The clay layers yield no water to wells. Mainly for this reason, the Artesian water in the White Sand series is considered a very important source of potable water. The main source of supply is the "A" – sand sub-unit.

Th natural replenishment of the whole aquifer system is by percolating rainfall over the White Sands outcrops. Despite the same replenishment area for all the subsequent aquifers, the quality of ground water is not the same through the vertical sections of the formations. The water in the Upper Sand unit has a high iron content (more than 5 mg/l) and salinity (up to 1200 mg/l). The "A"-Sand aquifer has also a considerable high iron content (1-5 mg/l). The water quality in "B"- Sand aquifer is better than that of the "A"-

sand aquifer, with only a trace of iron. Also, the "A"-aquifers are relatively acid in comparison to the "B"- aquifer, the amount of total suspended solids is usually lower in "B" waters and total hardness is lower in "B" waters. The chlorine content of the "B"-aquifer is , however, higher than that of the "A"-unit (50-170 and 7-35 mg/l respectively)

The initial water level elevation of the upper sand unit was around 1-2m above sea level. The initial water levels of "A" and "B" –sands were 4-5m and 10-11 m above sea level., Respectively. However, the abstraction of all these units has increased rapidly and caused a noticeable decline of water levels. Today (2000) the water levels elevations of "A" and "B" Sands are approximately 15m and 17m above sea level respectively. No data concerning the Upper Sands Limit is available

According to a ground water flow simulation model constructed by Dr. Mercado(1997) it is expected that the water levels are going to decline ion the future in all the aquifers, including the upper sand unit. However the ground water will still be artesian, which, together with the seeking effects of clays, will provide very good protection for the aquifers from the contamination activities caused by man.

The decline of ground water levels may cause land subsidence in the long run. Due to the absence of any historical lèvel data, it is not known if any subsidence has already occurred. Even assuming that the amount of subsidence is not significant, the rising sea level may result in greater salt-water intrusion, and therefore, fresh water contamination.

Other potential sources of salt-water intrusion can be through the estuaries and rivers of Guyana. Unless water discharge from rivers is high enough to repel the incoming salt water, there will be incursions into the fresh water reserves.

4.1.5 Condition of Sea Defence

The existing sea defences are generally in a bad condition. Consultants funded by international funding agencies, such as EEC, IDB and WB have developed rehabilitation and reconstruction programmes for the medium term. The Sea and River Defence Division of the Guyanese Ministry of Public Works and Communication is being supported in managing of the new capital construction works through technical assistance programmes funded by the international agencies.

4.1.5.1 Drainage System

Generally drainage of the polders is carried out by gravity flow during periods when sea or river levels experience low tides. The period of discharge is conditioned by the level of the land to be drained relative to the mean sea level at the outfall and by the tidal amplitude. Gravity drainage sluices typically discharge for 7 to 14 hours in every 24 hours due to the various hydraulic and morphological conditions. A rise of the sea level will reduce the discharge period.

Presently pumped drainage is required in some areas, especially at the sugar estates of the East Coast Demerara and the Corentyne Coast. In future conditions, demands for pumped drainage will increase and this will impact heavily on the economic development of the country.

4.1.6 Impact Zones (Extracted from Khan and Sturm, 1994)

The effects of accelerated sea level rise (ASLR) are included. It shows the "flatness" of the curve and subsequently the great increase of the frequency of occurrence for a particular water level. The impact of the ASLR will effect the coastal area in different ways. The coastal area of Guyana is therefore subdivided into two impact zones according to the differences in the population density and the nature of the coastal protection. Those two impact zones are:

Impact Zone I: the coastal belt of this region mostly comprises mangrove swamps and its people already know the problems, which come with floodwaters. Transportation is mainly by boats and canoes. Houses are built very near to the river water line. The shoreline is expected to retreat with a rise of the sea level and this retreat can be as much as 2.5 km with a rise of 100 cm.

Impact Zone II: in this densely populated region, comprising several islands, there is a combination of concrete and earthen sea defences. The problem of inadequate maintenance of the sea defences has become evident and substantial breaches and overtopping have occurred.

In both zones, the matter of drainage is a current problem. It is therefore necessary that the entire Drainage and Irrigation System be revisited with a view towards implementation of measures to alleviate the almost yearly problem of inadequate drainage during the rainy seasons and during ENSO cold phases.

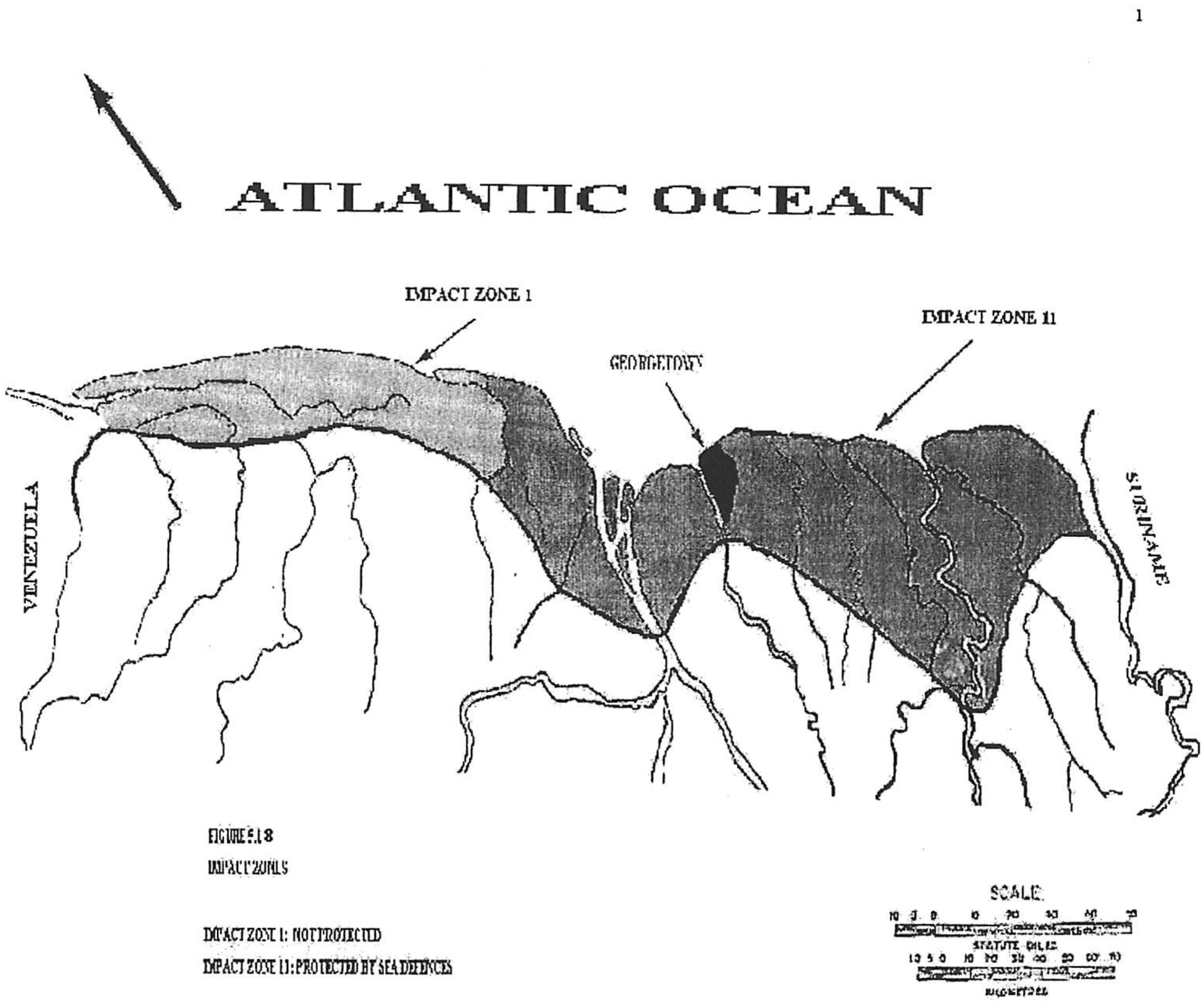

Figure 1-Showing the Impact Zones In Guyana.

4.1.7 Submergence and Inundation of Coastal Wetlands

The most direct impact of a rise in sea level for Guyana would be the inundation of areas that had been just above the high water level before the sea rose. Coastal wet lands are generally found at elevations below the highest tide of the year and above mean sea level. Thus, wetlands account for most of the land less than 1 m above sea level.

Mangrove forests are found at the interface between the terrestrial and marine ecosystems. They are also found in estuarine wetlands and in tidal reaches of riverine areas. The main species of mangroves found in Guyana include Avicennia germinans (Black mangrove), Rizophora mangle (Red Mangrove), and Laguncularia racemosa (White mangrove). A.germinans known locally as "Courida" is accepted as the main species in the region. Large sections of the Atlantic coast from the Corentyne to the Essequibo Rivers have become monoculture stands of Avicennia.

Mangrove ecosystems are an important coastal resource having a variety of functions and uses, including:

- Bee keeping: Approximately 75% of the honey produced in the country is from mangrove areas.
- Fisheries: The mangrove swamps are natural breeding and nursery grounds for brackish water shrimp and finfish species. Estimates of fishing harvest based on mangrove-dependent species are important.
- Wood: This is one of the most important uses of mangroves because it provides an easy source of fuel wood. It is used domestically for cooking, for making fences, tents and arbor for gardens.

In addition to their economic use, mangroves play an important role in coastal protection and sea defence. Depending on the width of the strip of mangroves, they can act as barriers to diminish or buffer wave action. Therefore, they play an important role in protection of the sea wall or embankment and reduction of damage to the sea defence system. Mangroves also help to accelerate the process of deposition of soil particles, which are suspended in tidal water thereby raising the level of coastal lands in the intertidal zone.

Mangroves also provide a habitat for a number of different species of phytoplankton, shrimps, crab and manatee as well as birds.

Mangroves are being increasingly threatened in Guyana today. It is unclear which agency has the mandate for mangrove protection and management. As such the use of mangrove forest is not monitored or regulated. There is also a lack of current data on the status of mangroves in terms of distribution, extent and removal. Furthermore, there is a lack of public awareness regarding the importance of mangroves. This makes management of this invaluable resource very difficult.

Much of the destruction of mangroves resulted from conversion of these ecosystems into other uses. This is attributed to mangroves being viewed as wastelands, useless unless converted or exploited directly for cash products. For example, the cutting of mangroves for fuel wood is not done in a sustainable manner. The practice is not supervised and trees are badly damaged in the process. Fishermen also cause local damage by pulling up boats on mudflats in some areas, creating paths through the mangroves. Mangroves are also affected by natural processes such as the cycle of erosion and accretion along the coast. As a result, there is considerable loss of foreshore and mangroves become affected in the process.

While mangroves are likely to play an important role in reducing the impacts of sea-level rise by protecting the coast, this ecosystem may itself be seriously affected by sea level. It seems that mangroves find it hard to cope with rapid sea level because it endangers their way of interacting with the surrounding environment of trapping sediment with their roots. If the sediment is washed away, then the swamp cannot be formed. Instead what can be observed are individual trees or thin patchy areas in which they cannot survive.

Marine animals, which are of economic importance to man, feed directly on detritus (i.e., Shrimps) or feed on detritus feeders (i.e., Fish and crabs). Without mangrove and other coastal fringe ecosystems, neither the habitat nor adequate food to support these ecosystems will be available nor these populations will decline.

For the rates of sea level rise of the last several thousand years, marshes have generally kept pace with sea level through sedimentation and peat formation. As sea level rose, new wetlands formed inland while the seaward boundary was maintained. Because the wetland area has expanded, one would expect a concave marsh profile, i.e., That there is more marsh area than the area found immediately above the marsh. Thus, if sea level rose more rapidly than the marsh's ability to keep pace, there would be a net loss of wetlands. Moreover, a complete loss might occur if protection of developed areas prevented the inland formation of new wetlands.

4.1.8 Oceanography, Coastal Erosion and Accretion

The Brazil current, a branch of the South Equatorial current, flows along the northern coast of Brazil, into the region of Guyana, and then into the direction of Trinidad & Tobago. This current, known as the Guyana current locally, moves along at approximately 5 knots in offshore measurements. However, nearer to the shore they are slower due to the influence of river discharge and topography.

Processes other than sea level rise also contribute to erosion, including storms, structures, currents, and alongshore transport. Greater wave energy associated with higher sea level will cause increased rates of beach erosion and coastal land loss. Rates of retreat will be influenced locally by a range of factors including nearshore bathymetry, incident wave energy, wave amplitude spectra, wave approach direction, physico-chemical, geologic and morphologic properties of shoreline materials, sediment transport pathways, production rates and sources of eroded sediments.

Sea level rise can also result in the loss of land above sea level through erosion. Bruun has shown that the erosion resulting from a rise in sea level would depend upon the average slope of the entire beach profile extending from the dunes out to the point where the water is too deep for waves to have a significant impact on the bottom (generally a depth of about 10 meters). By comparison, inundation depends only on the slope immediately above the original sea level. Because beach profiles are generally flatter than the portion of the beach just above sea level, the "Bruun Rule" generally implies that the erosion from a rise in sea level is several times greater than the amount of land directly inundated. Bruun found that a 1-cm rise in sea level would generally result in a 1-m shoreline retreat, but that the erosion could be as great as 10 m.

The potential erosion from a rise in sea level could be particularly important to recreational beaches, which include some of Guyana's most economically valuable and intensively used land. Relatively few of the most densely developed beaches are wider than about 30 m at high tide. Thus, the rise in relative sea level of over 60 centimetres projected in the next 40 to 50 years could erode most recreational beaches in developed areas, unless additional erosion response measures are taken.

In Guyana, beach profile measurements collected at a number of beaches show that, on the one hand erosion rates, as measured by the retreat of the high ground above the high water mark may be as high as 20 meters per year in some cases. On the other hand, accretion, which occurs mainly in mudflats and at the base of shoreline protection structures, may also be as high as 15 meters per year.

4.1.9 Flooding and Storm Damage

A rise in sea level could increase flooding and storm damages in coastal areas for three reasons: erosion caused by sea level rise would increase the vulnerability of communities; higher water levels would provide storm surges with a higher base to build upon; and higher water levels would decrease natural and artificial drainage.

In addition to community-wide engineering approaches, measures can also be taken by individual property owners to prevent increased flooding. In Guyana, there is no government policy in place to restrict development along neither the coast nor a National

Flood Insurance Program to encourage communities to avoid risky construction in flood-prone areas.

4.1.10 Water Resources

Water supply for domestic, industrial and commercial purposes are abstracted from about 170 wells drilled mainly from two aquifers known as the "A" and "B" sands. The water is distributed through a network of pipes estimated at about 3000 miles, laid in urban and rural areas along the coastal plain.

The drainage system is natural and depends on the main rivers, which extend beyond the coast. The major rivers include Essequibo, Demerara and Berbice. Smaller rivers such as Mahaica, Mahaicony, Abary and Canje are also part of the drainage network. All these rivers are within tidal influences of the Atlantic Ocean and this effect is noticeable for some distance upstream. Sea level will exacerbate this condition.

Additionally, to facilitate the country's agricultural output, irrigation waters are also supplied from water conservancies (i.e., Reservoirs). There are four conservancies along the coastal plain: Boeraserie, East Demerara, Tapakuma and Mahaica/Mahaicony/Abary. In the Corentyne, irrigation water for rice, sugar and other crops, is extracted by a number of pump stations along the Canje River in its lower 50-km stretch (which is vulnerable to saline intrusion). This practice can be found on some of the smaller rivers.

The majority of the population is concentrated in a narrow strip along the Atlantic coast. Their main supply of water is the wells located in close proximity to the coastline and therefore the risk of salinisation of these coastal wells is highly likely with any sea-level rise.

Seawater intrusion is a common phenomenon today in coastal aquifers. Although Guyana's coastal aquifer is characterised by some favourable conditions, such as the fact that the clay percentage increases gradually northwards possibly sealing the aquifer from the sea, the risk of salinisation due to sea water intrusion should not be ignored. Over-exploitation of the "A" sand aquifer results in the decline of their piezometric head, as exemplified within the Georgetown area. This might result in a leakage from the upper sand into this aquifer causing further seawater intrusion into the already saline water bodies of the upper sands. Saline water can then migrate downward into the aquifer creating the conditions of an inland moving interface. A similar process might take place between the "A" and "B" sand aquifers.

4.1.11 Agriculture

Agriculture is the dominant economic activity on the Guyanese coastal plain. The coastal belt has favourable soil and climate for lowland crops such as sugarcane and rice.

Agriculture is a major source of employment, economic growth and foreign exchange in Guyana. In 1997, the Gross Domestic Product (GDP) for agriculture was G$ 53.6 billion (US $297.8 million). The economic contribution of this sector to the national economy is vital and hence the need for sustaining its vitality cannot be overemphasised (Khan and Rahaman, 1998). Almost all of the agriculture products important to the national economic are harvested along the coast.

The impacts of global climate change should not be taken lightly in so far as agriculture is concerned. Inundation and salinisation associated with sea-level rise could possibly devastate this activity along the coast.

A direct impact of rising sea levels will be the threat of saline intrusion into cultivation fields. Drainage during the raining seasons may require additional and more intensive pumping facilities. The possible intrusion of salt water into the water conservancies and estuaries needs to be examined since these are the prime source of irrigation water.

If weather systems become more intense, then the effect of flooding conditions must be addressed. More frequent El Niño/La Niña events can subject the coast to cycles of drought/flood which can have serious effects on the soil and, therefore, on food production. Cattle and other livestock may not be spared because of the severity of the conditions associated with these rainfall extremes. Apart from the effect on rice and sugar, scarcities of cash crops will be a problem and an economic hindrance.

4.1.12 Fisheries

After agriculture, fisheries are the second most important economic activity along the coast. About 6.5 million tonnes of fish were exported in 1998 comprising about 6% of the nation's GDP. The value of fish and fish products for local needs has been also recognised by the Government. The fishing industry has four components: industrial, artisanal, inland aquaculture and ornamental.

Vulnerable resources to sea level include the fish resource itself, wharves/landing sites,co-operative buildings, fishers and mangroves.

More severe and frequent flooding will cause the potential destruction of landing sites and co-operative buildings that are situated along the coast. Fishers must have a place to land their catch for market purposes and this must be a place that is clean and healthy since most of the fish and shrimp caught in Guyana are exported.

The readjustment of mangroves will also affect the fish resources since some of the species caught have nursery areas in the mangroves. If the mangrove forest has to re-establish itself at a new location then valuable fish resources will be lost. At the local level, persons living in rural areas also depend heavily on fish as their source of protein. Hence, a decrease in fish production can see many persons not having this essential nutrient since other alternative sources of protein can be too expensive.

Disruption of coastal and marine ecosystems will also have an effect on species being caught. The Chinese seine fishers will have to move their fish pens nearer to the shore since most of the target species will be closer to the shore. This will include building new fish pens since the older ones will be lost to more frequent flooding or permanent inundation. Biological studies should be conducted to assess the differences, if any, on the biology of the fisheries, checking for growth patterns for example.

Freshwater aquaculture will be impacted from salt-water intrusion. While some species are salt tolerant to some degree (i.e., Various Tilapine species) others are not (i.e., Hassar). In addition to freshwater species, flooding will also impact brackish species and erosion caused by sea-level rise. Pond banks will erode away and cultured fish will escape. Extensive flooding of soil will leach away nutrients, resulting in poor carrying capacity of ponds under extensive and semi extensive production. The introduction of predacious species via flooding into culture operations will result in the inability to practice aquaculture unless painstaking drying and removal activities are carried out. Aquaculture will not longer be a financial viable operation if the introduction of predators cannot be controlled.

4.1.13 Human Settlement-infrastructure

Human settlement and infrastructure that are concentrated in the coastal zone of Guyana would, in all likelihood, be vulnerable to climate-driven sea level rise.

Guyana has a population of about 750,000 inhabitants, 90% of which reside on the coastal plain. The population is concentrated in certain locations influenced by the availability of land for housing and other utility services. Higher population densities are observed in Georgetown, the Capital City and adjoining areas due to the proximity and closer links with the important urban centre. Major highways and secondary roads are also concentrated on this narrow coastal strip. Georgetown is served by a conventional main sewerage system, which consists of 24 sewerage basins each draining to a dedicated pumping station. In the rest of Georgetown and the coastal plain, sewerage is discharged into septic tanks or pit latrines.

There are developed housing schemes and squatter settlements. This latter have their roots in the rural areas where socio-economic conditions are poor and extended households are overcrowded. The Government has improved the allocation of titled house lots but the capacity to accelerate the allocation process is weak. Another problem lies in the fact that the areas identified, legally and illegally, for housing settlements are all in the vulnerable low-lying coastal zone.

Sea-level rise will cause permanent inundation of the entire coastline if no response measures are taken. Houses will be severely damaged by more frequent flooding. In addition, households could suffer from water borne diseases due to contamination of water. It would also seriously affect communications, medical facilities, and transportation infrastructure, which are the basis for human survival.

Sea-level rise may lead to increased erosion that would cause damage to the foundation upon which houses are built.

Salt-water intrusion will have similar effects on human settlements as described above. In particular, saltwater intrusion affects plant soil and lumber tends to rot faster.

4.1.14 Sluice Gates and Sewer Systems

Sluice gates for draining excess water to the ocean are very common in the coastal region of Guyana, parts of which are already below sea level. Sewer systems provide for drainage of surface water from streets in the event of a rainstorm. The sewer systems of the city of Georgetown rely on gravity drainage: water flows downhill from the streets into the sewers, then continues toward some outfall area. Should the sea level rise, it could limit the effectiveness of gravity drainage systems and necessitate the installation of mechanical pumping stations to aid drainage of water. This is already being done at present and, indications are that this type of drainage must be intensified.

4.1.15 Highways, Roads, and Sewer Systems

Guyana is divided into distinct physiographic regions by its numerous rivers, notably the Demerara, Berbice and Essequibo rivers. Road transport is very common and there are a number of bridges creating nodal links. A rise in sea level of 0.6 m can inundate, weaken, and erode coastal roads. Low-lying roads would be especially jeopardised. During storms, risking the lives of motorists. Bridges would be threatened as well. Rising sea levels can also increase bridge structural load, as well as scour bridge foundations.

4.1.16 Human Suffering and loss of Life

Each year floods bring discomfort and losses to thousands of people throughout the coastal region of Guyana. Despite lessons of the past, people continue to settle and build on the coastal plain. The people of Georgetown and surrounding regions of the coastal plain live behind an elaborate system of sluices and dykes. They are therefore even today very vulnerable to flooding from excessive rainfall and from enhanced sea level rise. Further rise in sea levels would most certainly threaten human lives. Flood losses can also be expected to show higher costs.

4.1.17Tourism

Tourism, which is a minor foreign exchange earner in Guyana, could also be adversely affected by global warming and sea level rise. Guyana's tourist industry is not as developed as the Caribbean neighbours and it is mainly centred on Eco-tourism in the hinterland of the country.

The climate of Guyana is already warm and humid. Besides, Guyana's beaches are not as extensive as those of the Caribbean Sea or for that matter even Brazil. If the climate warms to extend the seasonal use of beach facilities in the middle latitudes, and if temperatures and humidity become overbearing, then Guyana may not have a comparative advantage over the northern countries.

Tourist attractions on the coast of Guyana include Georgetown, the capital city and few beaches. Other major tourist attractions include the tropical rain forest, major water falls and rivers which are concentrated in the hinterland regions and therefore less vulnerable to sea level. Guyana can make use of its hinterland attraction in promoting this sector.

Georgetown is situated on the Right Bank of the Demerara River. Most of the city's historical buildings are wooden structures, reflecting the unique 18^{th} and 19^{th} century architecture and are major tourist attractions. Further, the major administrative facilities, hotels and shopping centers are located in Georgetown making this city the "heart" and "brain" of the country.

In Guyana there are three major shores types: muddy coasts, shell and sandy beaches.

Mud or clay accretionary coasts start as a tidal flat at the landward end of a shoal and extend as much as 0.8 km. As soon as the tidal flat begins to emerge above the high water level, mangroves establish themselves and stabilise the flat. Sand and shell material transported toward the shoreline during high water levels is deposited in the foreshore region.

Sandy beaches occur on the West Bank of river mouths and they are not as extensive as the mudflats. They extend for approximately 50 – 70 m during low tide.

Stretches of beach entirely composed of shell fragments occur in several places along the northwestern coast of Guyana. Their average length is about 1,300 m and they extend for a distance of about 100 m (Daniels, 1981). The landward part of these beaches is very old, but on the seaward side, fresh materials are continuously deposited.

Shell Beach is one of the country's major tourism attractions. This area runs from Waini Point in the mouth of the Pomeroon River on Guyana's northern shore. This is the only beach in the world where four species of sea turtles nest: Leatherback, Green, Olive Ridley and Hawksbill. Most other nesting beaches in the world have only one or two species. Shell Beach is also an important habitat for a large number of other animal species, some of which are now endangered. Blue and Gold and Red bellied macaws frequent the Shell Beach forests and the mudflats and mangrove lining the shores home to an impressive number of flocks of the striking Scarlet Ibis. Other birds that can be seen mixing with the common egrets and herons are Roseate Spoon Bills and Caribbean Flamingos. Many of Guyana's mammal species can also be found here, such as manatees, jaguars, tapirs, deer and several species of monkeys.

Other beaches include the Number 63 Village Beach located in Corentyne and others at Hope, Parika, Bushy Park, and Unity Beach. These places are both used for religious and recreational activities. A major part of the Guyanese population is Hindus for whom cremation of the dead is a part of their funeral rites. Hindus conduct the burning of the dead on the beach. They also perform ceremonial rituals on the beach since they hold the ocean to be sacred. These beaches are also used for picnics and playing sports especially during weekends and public holidays.

Georgetown and coastal centres of attraction can be vulnerable to accelerated sea level rise. Rising temperatures and humidity will not help to promote beach activities.

However, successful tourism depends on efficient communications, transportation, networks and other social services. It may be required to have substantial investments in these areas.

4.2 Health Effects

Much of what is known concerning how climate change might affect human health has been inferred from correlation of health conditions with weather variables or seasonability. Recent studies have focused on the possible impact that changing climate, season, and weather variables might have on the incidence of disease.

Clear links have not yet been established between climate change and human health. Probably modest effects on human health, however, could occur through:

The direct impact of temperature (heat stress and cardio and cerebro-vascular conditions related to temperature extremes);

Climate-related chronic, contagious, allergic, and vector-borne diseases (e.g., Malaria and dengue fever); asthma and hay fever, linked to plants or fungi whose ranges and life cycles are strongly affected by climate and weather; and mosquito- and tick-borne diseases, such as encephalitis and Lyme disease, especially where conditions are already warm and humid, with poor drainage, as in the coastal region of Guyana;

- premature birth, which has an adverse effect on human reproduction;
- Pulmonary conditions such as bronchitis and asthma related to urban and rural smog that may increase with climate change; and effects of increased ultraviolet radiation on suppression of the immune system.

While there is a lack of data in Guyana, there have been reports that skin cancer is on the rise in a region of Guyana inhabited mostly by Amerindians (region 9). This report seems to suggest that Amerindians, who are repeatedly exposed to solar radiation, are being affected by higher incidences of UV-b radiation and possibly higher surface temperatures.

Climate-induced effects on other sectors such as agriculture, fisheries, water and coastal resources, and social and economic conditions might also affect human health. Decreases in food production might result in poorer diets, and rise in sea level and changed precipitation patterns may result in the deterioration of water supplies. Greater numbers of humans could migrate from one area to another, changing the geographic ranges and susceptibility of human populations to many diseases. In general, any event that reduces standards of living will have an adverse impact on human health.

5.0 Adaptation Issues: An Introduction

According to the Intergovernmental Panel on Climate Change, (1992),"Adaptation is concerned with responses to both the adverse and positive effects of climate change".
This is concerned with the responses to the expected or present happenings associated with anthropogenic climate change and means of reduction of the adverse effects in both the short and long term. The pervious chapter on coastal vulnerability has identified and discussed the expected climatic impacts and their effects.
The adaptation and mitigation aspects of these climatic impacts and effects will now be discussed while considering the implications of longer–term climatic changes and planning to address the impacts of these changes in a phases framework of actions and processes.
The aims of these adaptation recommendations are the overall promotion of sustainable development and the reduction of coastal and marine vulnerability.
Sustainable development will ensure the protection of the environment, and therefore guarantee the economic development of the country, while the mitigation of coastal and marine adverse effects will reduce the risks of impacts, economic losses the hardships while building the institutional response mechanisms for the detection and warning of the signals of the impacts and for responding to emergencies and other activities required to address vulnerable ecosystems.

5.1 Framework for Coastal and Marine Adaptation to Climate Change.

After assessing climate change, climate variability, and other stresses, a comprehensive analysis can be had of the impending socio-economic and environmental impacts on the coastal and marine areas of Guyana. To further plan for the response to the socio-economic and environmental impacts, a prioritised set of activities must be put in place.

This should include the access to information and public awareness, formulation of plans for adaptation, the implementation of these plans, and lastly, the evaluation of the implemented plans, to measure the extent of success.

These stages are now described in a little more detail.

5.1.1 Information

Access to information is crucial for coastal adaptation. The more thorough and precise the information that is available, the more capable and successful adaptation strategies can be developed.
The climate– associated information required for coastal adaptation can be placed into four categories.

- Expected impacts of climate change;
- Expected trends of other potential stresses;
- Expected interactions between climate-related impacts and non-climatic developments
- Expected autonomous adjustments to combine climatic and non-climatic impacts.

The above information is usually obtained by vulnerability assessments. Errors in the vulnerability assessments can occur due to personal judgements of the writers as to the interactions between climate change and non-climatic stresses.

5.1.2 Planning.

Planing for adaptation must start before all uncertainties are reduced to a minimum. Adaptation is a continuous process and the information, planning, implementation, and evaluation cycle will continue many times over as new information become available. To cater for this iterative cycle of adaptation to new knowledge, the implementation strategies must be designed and executed in such a way that flexibility must be incorporated so that there is adjustment to new knowledge and technologies. Public awareness, participation, and education should be an important component of this planning. Planning involved deciding which action cold best be taken, who is responsible, what should be done, where an activity should be done, when these activities should be done, and how this could be implemented.

5.1.3 Implementation

Implementation occurs after an adaptation strategy has been selected. Generally, an adaptation strategy contains three parts, namely, *retreat* (i.e. Building setbacks), *accommodation* (raise buildings on piles above sea level) and *protection* (seawalls).

However, what must be considered is the context in which these technical measures are implemented. Technical options therefore, can only be realised where appropriate legal, economic, and institutional framework exists.

5.1.4 Evaluation

Evaluation of the performance of any implemented measures against the stated goals is a key step in any management strategy. This comparison can yield new insights and information, which can allow the management process to learn and hence improve itself. Therefore, the continuous need for evaluation implies that coastal adaptation assessment should include considerations of how the performance of suggested adaptation can be measured. This process should be continuous at all levels of implementation.

5.2 Identification of Adaptation Options

Adaptation mechanisms will differ and is dependent on the level of vulnerability and the region that is affected. The paramount importance of the coastal plain to Guyana's economy and socio-economic situation indicates that adaptive responses to the vulnerability assessment will be required to cope with the impacts of climate change. It is therefore necessary to firstly ensure that the capacity – to *detect, plan and respond* – exists in all relevant sectors. Hence, a requirement is that capacity building be given precedence to be addressed at all levels of Government and in the sectors.

A significant aspect for realising the necessity for adaptation is to integrate its options to other sectors and national policies, such as economic development policy, disaster prevention and management, and environmental management plans. Guyana may have more urgent and pressing concerns, and climate change will therefore be assigned a low priority on the national agenda since it is beyond human memory. Given the long lead-time for implementing adaptation, it is significant to incorporate it with the other issues, in particular to the framework of sustainable development and Integrated Coastal Zone Management (ICZM) and to the objectives of the National Development Strategy.

5.2.1 Capacity Building

The governmental capacity to deal with climate-related issues is at present very weak. From surveys done (Paulette and Mark Bynoe), it was found that the local communities are also not even aware of their vulnerability to the effects of global warming. The business community has also not shown any trepidation even though some components of business are cognisant of the problem. The reservations in the predictions and impacts have resulted in a resistance towards policy development and the development of the capacity to deal with future vulnerable situations. It is also a fact that, because of the many "stress" issues, which have to be dealt with in the immediate future, climate change is not given the prominence it deserves, an issue, which has to be planned for now rather than in the future. Situations of floods and droughts are dealt with after the effects have been observed- a reaction process rather than a response mechanism.

5.2.1.1Detect

One of the main organisations concerning Climate Change in Guyana is the Hydrometeorological Service of the Ministry of Agriculture. It's technical expertise level especially at the professional level and its capital and recurrent funds are lacking to address training, purchase of equipment to monitor climate, recruitment of field technicians and maintenance of reliable continuous records of climate. To remedy this situation, the Department requires human, financial, technical and technological resource building if it is to play the crucial role of alerting the nation to changes (or variability) of climate and issuing warnings to the sectors which will be affected.

Case studies for the Guyana situation for the past and current climates of Guyana needs to be documented and simulations developed on how the climate is expected to change in the future. The resources for these studies will have to be provided from external assistance since global and regional models will have to be used and professional and academic resources will be needed.

Observations of the impacts such as erosion, inundation, changes in pest abundance, health signals, changes in fisheries, rice and sugar yields will require that staffing in the various agencies, in and out of Government, be available, be trained and be capable of detecting the impact signals. Climate Change data collection and analysis have to become routine tasks for the relevant agencies.

5.2.1.2Plan

Based on current and future indications of the impacts of climate change, planning to respond will become essential if Guyana is to act in a proactive or purposeful way, rather than in a reactive manner. Planned and autonomous adaptation must be done at all stages of government and society and must involve all sections of the Guyanese population. The National Development Strategy (NDS) which is has been developed does not directly address the impacts of climate change. This should be remedied so that a integrated framework, at least, for addressing responses to the adverse impacts of climate change can be developed and incorporated into the NDS.

5.2.1.3Respond

The typical reaction to climate-related problems in Guyana are often reactive .The Civil Defence Commission and other agencies are often ill-prepared to respond to losses due to floods/droughts. These disaster – preparedness agencies (at all levels of the Guyanese Community) and including the military, Non-Governmental Organisations (NGO) and local communities must be provided with the capacity to respond effectively to abrupt and prolonged adverse conditions.

With regards to agriculture, the main foreign exchange earner in Guyana, which predominates in the coastal zone, the banking and insurance sectors must be prepared to come to the assistance of farmers should they suffer losses. Systems must be put in place to assuage hardships faced by farmers and others that are expected to suffer from the adverse impacts of climate change. Since agriculture is the backbone of the country's economy, it will be necessary for the farmers to be capable of adjusting rapidly to the adverse effect.

5.3 Adaptation Strategy

The Intergovernmental Panel on Climate Change (1995) has provided the following types of response strategies, which can be considered, for Guyana. They are:

- Prevention of Loss: Taking precautionary actions to reduce the intensity of the hardship. A controlled programme of actions to protect sections of the coast, retreat from very vulnerable areas and accommodate the rise in sea level in some areas will be required.

- Tolerating Loss: Using crop types which can minimise losses and accepting short-term changes which will not result in serious long-term losses.

- Spreading or Sharing Loss: Take actions to distribute the burden of losses over a region rather than having the area, within the region, bear the full loss. National and/or regional relief measures can be effected here.

- Changing Use or Activity: The main activity or activities in an area may have to change because it will no longer be viable to continue with it.

- Changing Location: When an activity is very important to the country, it may be wise to move it to a more friendly location.

- Restoration: A damaged system can be restored to its original condition. An example here can be flooded housing schemes.

The vulnerability of the coastal plain will have to be identified in sections in terms of intensity, extent and human and material losses.
Given the large uncertainties in the climate change projections, there may be two main categories of adaptation strategy: *low cost, no-regrets responses* and *high cost, reactive measures*. For Guyana, with inadequate financial and technical capacity, a narrow resource base and low flexibility, the implementation of a low cost, no-regrets adaptation would appear to be an appropriate approach to adopt. While this strategy acknowledges that there is uncertainty regarding climate change and its impacts, it however seeks to minimise exposure to future risks, that may be intensified by sea level rise and climate change. Figure 2 below (Nicholls and Leatherman, 1966) best exemplifies these changes and type of adaptations recommended.

Response Strategy	Type of adaptation	Timing of Adaptation

	Autonomous adjustments	Strategic action	Reactive	Pro-active
(Managed)Retreat				
Emphasis on progressive abandonment of land and structure in highly vulnerable areas and resettlement of inhabitants.				
No development in susceptible areas				
Conditional phased out-development	X	X		X
Withdrawal of Government subsidises		X	X	X
Presumed mobility		X	X	X
		X		X
Accommodation				
Emphasis on the conservation of ecosystems harmonises with the continued occupancy and use of vulnerable areas and adaptive management responses.				
Advance planning to avoid worst impacts	X			
Modification of land use		X		X
Modification of building styles and codes	X	X		X
Protect threatened ecosystems	X	X	X	X
Strict regulation of hazard zones		X		X
Hazard insurance to reinforce regulation				X
		X	X	X
		X	X	
Protection				
Emphasis on the defence of vulnerable areas, population centres economic activities and natural resources.				
Hard structural options				
Dikes, levies, and floodwalls	X			
Seawalls, revetments, and floodwalls	X	X	X	X
Groynes	X	X	X	X
Detached breakwaters		X	X	X
Floodgates and tidal barriers		X	X	X
Saltwater intrusion barriers		X	X	X
Soft structural options		X	X	X
Periodic beach nourishment(beach fill)			X	X
Wetland restoration and creation		X	X	X
Afforestation			X	X
		X		X
	X	X		X

Figure 2- Adaptation Measures.

5.4 Coastal Zone

Based on the preceding chapter, it would appear that Guyana, especially the Coastal Plains where most of the population and economic activity are located, would be most vulnerable to the impacts of sea level rise. One of the major likely impacts of sea level rise in the coastal zone of Guyana would be the loss of coastal wetlands that serve as protective barrier to the inland coastal area.

Coastal land loss due to a combination of inundation and coastal erosion is projected to have widespread adverse consequences in the low-lying Coastal Plain of Guyana. Land loss from sea level rise especially in coastal locations is likely to be of a magnitude, which can disrupt virtually all-economic and social sectors in the country. Recent estimates indicate that with a 1 m sea level rise, up to 10 km^2 of land could be lost, just on account of inundation. This figure would increase more than threefold to37 km^2 (14%) with storm surge superimposed on a 1m sea level rise scenario. Similarly, based on the Brunn rule, a retreat of up to 100 m is projected with a 1m elevation of sea level.

The elevation of mean sea level at Georgetown on the coastal plain of Guyana is 51.05 ft (Georgetown Datum: GD). Furthermore, the mean elevation of the roadways on the coastal plain of Guyana is 55.0 ft GD. The elevation of the highest tide level recorded at Georgetown is 56.41 GD and the elevation of the high spring tides is 55.31 GD. On the other hand, the elevation of the sea defences in the coastal plain of Guyana range from 62.0 to 64.5 GD. These figures show how vulnerable the coastal plain of Guyana would be to rising sea levels, especially when accompanied by tidal surges.

Several options have been identified for reducing land loss due to sea level rise. Abandonment of developed area inland of today's marginal wetlands could permit new wetlands to form inland. In some cases, it might be possible to enhance the ability of wetlands to accrete vertically by spraying sediment on them or as in the case of deltas, restoring the natural processes that would provide sediment to the wetlands. Finally, Guyana has managed to artificially protect itself from high water levels through the use of a network of sea defences and gravity-controlled locks and dykes and, in extreme cases, pumping stations. The widespread use of pumping stations will have to be considered since gravity outflow may become an inefficient drainage strategy.

One of the most serious considerations for low-lying coastal Guyana is whether it will have adequate potential to adapt on the coast to sea level rise or retreat. Guyana may have the option to pursue adaptation measures such as retreat to higher ground and even raising the level of the land since sand and other aggregates are abundantly available, costs and resources permitting. The use of building setbacks aimed at discouraging further developments in the vulnerable coastal area would also appear to have great practical utility.

In extreme circumstances, sea level rise and its associated consequences could trigger abandonment and significant 'off-near shore migration' at great economic and social costs. A planned retreat seems to be required now since the coastal zone is being taxed with population and developmental stress. The responses to inundation then fall broadly into the categories of retreat and creating stronger and higher sea defences in all vulnerable areas to hold back the sea. Sea defences are today used extensively in the coastal plains of Guyana. The flooding of unprotected areas below high tide level could be similarly constructed around other coastal areas at risk to sea level rise. In sparsely developed areas, however, the cost of sea wall construction might be greater than the value of the property being protected. Moreover, even where sea walls prove to be cost-effective, the environmental implications of replacing natural shorelines with manmade structures would need to be considered.

Potential responses to coastal erosion deriving from sea level rise fall generally into three categories: construction of walls and other structures, the addition of sand to the beach, and abandonment. A number of structures other than seawalls can be used to decrease the ability of waves to cause erosion, including groins (jetties), rip-raps and breakwaters. Bulkheads are often used where waves are small.
A more popular form of erosion control has been the placement of sand onto a shore area through beach nourishment procedures. Although costs can exceed one million dollars (US) per km, it is often justified by the economic and recreational value of beaches. What is being done in Guyana's interior to create Resorts can possibly be done in particular locations on Guyana's Coast. Importing clays and sand from elsewhere in the country sometimes creates these Resorts.

Although shore protection is often cost-effective today, the favourable economics might change in the future. Current estimates place the cost of sea defences in Guyana at $ 35,000.00 US per km. A more rapid rise in sea level would increase the costs of shore protection. A number of countries have adopted erosion policies that assume a retreat from the shore. Many countries are now requiring homes that can be moved to be set back from the shore by a distance equal to shoreline recession from 30 years of erosion, while high-rises must be set back 60 years. Other countries require people to demonstrate that new structures will not erode for 100 years.

Other jurisdictions discourage the construction of bulkheads and seawalls. In many undeveloped countries, small, relatively inexpensive houses are found very close to the shore. Because the value of these houses is less than the cost of protecting them, they must be moved as the shore erodes. An accelerated rise in sea level would speed this process of shoreline retreat.

In the short term then there is the need for anticipatory adaptation action in response to rising sea levels in Guyana. Where communities are likely to adapt to erosion, anticipation can be important. The cost and feasibility of moving a house back depend on design decisions made when the house is built. The willingness of people to abandon properties depends in part on whether they bought land on the assumption that it would eventually erode away or had assumed that the government would protect it indefinitely. Less anticipation is necessary if the shore will be protected. Nevertheless, some advanced planning may be necessary for communities to know whether retreat or defending the shore would be most cost-effective. The relevance of the Coastal Plain to Guyana and its economy indicates that there will be more emphasis on protection rather than retreat or accommodation.

In the medium term, adaptation to sea level rise in the coastal zone of Guyana may involve the further fortifying of sea defences and the introduction of legislation relating to setback limits so as to reduce the vulnerability of the peoples and structures.

In the long term however, Guyana may have to choose between further fortifications of sea defences or a more drastic population policy whereby peoples and infrastructures will be moved inland, where even at 25 miles the land is at 74 ft above mean sea level (GD). Guyana's population is relatively small and land space in the hinterland is abundant, although soils are mainly sandy. However, the rich agricultural soils are found mainly in the low-lying coastal area.

6.0 Appropriates Mechanisms to give effect to the National Policy

In formulating the National Climate Change Policy, CPACC countries are encouraged to develop short, medium, and long-term strategies and approaches to be used for adaptation planning and management. The following areas are some of the strategies to be implemented, with assistance from CPACC where necessary.

6.1 Integrated Coastal Zone Management.

The management of the coastal resource systems requires a holistic and comprehensive approach if they are to remain productive. A multi-sector management programme must be in place so that all stakeholders and affected government agencies are involved along with broad public support.

The action plan for integrated coastal zone management is intended to guide the work of stakeholders involved in integrated coastal zone management either directly or indirectly in an effort to foster a more co-ordinated and integrated approach to management and development of the coastal zone.

Approach. Integrated coastal zone management can be defined as the planning and co-ordinating process, which deals with development and management of coastal resources that focus on the land/water interface. The integrated coastal zone management process provides the opportunity to allow policy orientation and development of management strategies to address the issue of resource use conflicts and to control the impacts of humans' intervention on the environment. It provides an institutional and legal framework focus on environmental planning and management and co-ordinates the relevant activities of agencies to work together towards a common objective.

Sectored planning and management should operate within the general framework of integrated coastal zone management.

Objectives

The objectives of the plan are:

- To strengthen the capacity of key national institutions to execute effective integrated coastal zone management programmes.
- To promote and support sustainable development of coastal resources.
- To increase public awareness, education and hearings.
- To improve coastal data compilation, management and sharing.

- To facilitate research and training.

To provide a guideline towards alleviating the adverse impacts of coastal zone with special reference to sea level rise.

Level of Integration. .

In order to effectively fulfil its mandate for integrated coastal zone management, the Environmental Protection Agency (EPA) established the Integrated Coastal Zone Management Committee with responsibility for:

- Co-ordinating the activities of the various sectored agencies with some involvement in coastal zone management;
- Recommending policies for the identification, monitoring, utilisation and management of resources within the coastal zone;
- Performing advisory function on issues of concern to coastal zone management;
- Advising the EPA on priorities for research, management and monitoring of activities within the coastal zone;
- Advising the EPA on strategies, plans and programmes relating to coastal zone management;
- Participating as necessary in training activities for coastal zone management.

Several other agencies and institutions have undertaken some form of activity or programme related to coastal zone management

6.2 Environmental Impact Assessments

Of equal importance to the Integrated Coastal Zone management Plan are Environmental Impacts Assessments (EIAs). This is a very capable tool of addressing changing climatic conditions, and, utilises limited human, financial, and technical resources. The Government of Guyana should seriously consider the establishment of an environment impact Assessment process that combines adaptation planning and management as an integral part of the enforcement process.

Approach-The results oaf an environmental Impact assessment can be used as an informal decision making tool, the result of which will indicate where monitoring and protection planning can be established to eliminate or mitigate environmental impacts.

Administrative Aspects. The Environmental Protection Agency in Guyana presently requires a favourable environmental Impact assessment before certain industries can proceed with plans to construct or invest in infrastructure development.. This should be expanded to include specific areas of the coastal zone where the effects of seal-level rise most likely will affect.

Procedural Aspects. The procedures already implemented for activities that are likely to affect human or natural environment are:

- Registering the proposed activity for assessment purposes
- Developing guidelines for the assessment report.
- Undertaking the assessment
- Public consultation and review
- Making a decision on the application.

Adaptation to climate change.

All environmental Impact assessments should have incorporated in them explicit and appropriate mechanisms to ensure that the impacts of climate change are integrated into the review process.

6.3 Disaster Contingency Planning and Management

Disaster Contingency Planning and Management has been identified as one of the option to prevent loss arising out of changing climatic conditions.
A thorough regime for disaster contingency planning and management planning will involve the following elements:

- Risk Management-This includes the identification, assessment, and cumulative impacts of major hazards
- Risk Mitigation- this includes long term planning to prevent, avoid, or the reduction of hazards before, during and after the occurrence of a hazard. It includes warehousing of food , building materials, clothing etc.
- Preparedness- this short-term activity is undertaken after warnings of an eminent disaster, e.g., Evacuation of affected population.
- Response-This is short term emergency aid and assistance immediately following a disaster, e.g., Search and rescue, provision of food, shelter, medical facilities, restoration of services, and elimination of health hazards.

- Recovery-This includes the instantaneous support needed to restore operating conditions and long-term actions to return affected communities to normalcy.

Institutional Aspects- The establishment of a National Disaster Management Council/Committee to provide the co-ordination between the various agencies and individuals concerned. Specific issues to be addressed are:

- the establishment of a National Disaster management Office and Operations Centre for the co-ordination of all disaster concerns; and setting up of regional centres.

- the establishment of powers, duties, and functions of Disaster controllers and staff of the National Disaster management Office

- the initiation, preparation, and implementation of special management practices in the event of disasters.

- the identification of impact zones to be declared as Disaster Areas during the declaration of the State of Emergency.

- Special powers during State of Emergency.

- Co-ordination of relief assistance, and restoration activities.

- The establishment of penalties in the event of violations to any requirement of the National Disaster management Office.

Adaptation to Climate Change. To ensure that the appropriate mechanisms for the planing and management of disaster risk, the following steps must be implemented.
- Disaster risk assessments or mitigation measures should include vulnerability assessments developed at the national level to ensure that the necessary assessment tools are utilised in the disaster risk assessment and planning process.
- National Disaster Contingency and Response Plans should be consistent with the *National Climate Change Adaptation Policy.*
- Losses resulting from disasters to be shared by insurance arrangements.

6.4 Economic Instruments

Economic instruments, principally insurance institutions, should be used as a mechanism to share in the loss of revenue or to support restoration activities. These institutions are best suited to aid the recovery process from natural disasters.

Adaptation to Climate Change.

Both the Private and Public sectors need assistance in the establishment of economic instruments. The key issues that the insurance companies may consider are:

- A higher premium for high risk areas
- reduce premiums for companies that invest in mitigation measures
- Reduce premiums for companies which adhere to proper building codes (See section 6.5 below).
- The Government of Guyana should consider the establishment of economic instruments to cover activities that may not presently be covered by insurance. This must be backed by appropriate legislation.

6.5 Building Codes and Standards

From studies internationally, it has been shown that strict adherence to engineering building codes and standards has reduced the destruction caused by natural disasters. Thus, all building coded presently in place should, be revised to adapt to the anticipated changes of climate change, and here specifically, sea levels rise.
For example, a standard can define the minimum strength that a seawall should have to withstand certain levels of wave activity and water accumulation.

6.6 Environmental Management Regimes

One of the more intricate attitudes to adaptation planning and management contains mechanisms aimed at tolerating loss through the establishment and maintenance of standard through enforcement of quality standards in the coastal and marine environment which ensure that receiving waters can better tolerate of some of the impacts of climate change, principally pollution caused or intensified by severe climate events.

Objective-It is the role of the Government of Guyana to set policy objectives and provide a regulatory framework for sound and sustainable industrial development. In Guyana, this process has already started and an industrial effluent standard is in its final stage. This is a joint effort between the Environmental Protection Agency and the Guyana Bureau of Standards, and industrial companies in Guyana.

Approach

Proper Environmental Management Regimes can be established and maintained by following four steps, namely, policy formation, policy implementation, policy verification, and enforcement. The specifics of the Environmental Management Regime are now summarised.

- The Environmental Protection Agency has been founded and legislation drafted to give this agency authority where the environment is concerned.
- The Environmental Protection Agency and the Bureau of Standards are working together to draft and implement standards for hazardous substances.
- The Private Sector Commission in Guyana has voluntarily begun the implementation of international environmental standards.

Adaptation to Climate Change.

None of the above mentioned standards have specifically targeted the coastal zone and marine waters in their legislation. This action is pertinent and should be incorporated into existing environmental standards. This process is already started by the Environmental Protection Agency, in its studies on Integrated Coastal Zone Management. However, it is still in its draft form.

7.0 Key Issues, Adaptation Planning and Management Mechanisms.

7.1 Key Issues

Issues	Rank	Reason(S)
Agriculture	1	Highest single foreign exchange earner (rice &sugar,43%) Most fertile lands on the coastal plain. Most cattle, livestock and cash crops are on coastal plain Majority of Guyanese work in the agricultural field.
Sea Defence	2	Generally in bad condition, overtopping of water is common.
Drainage System	3	Recent floods have indicated that present drainage systems are inefficient and ineffective. Pumped drainage is only solution, but expensive. Retreat of shoreline will encroach upon some houses and most agricultural lands
Coastal Erosion	4	Greater wave energy increases beach erosion and coastal land loss. Disappearance of recreational beaches.
Submergence and Inundation of Coastal Wetlands	5	Destruction of agricultural lands. Destruction of mangroves diminishes protection from the sea. Mangrove areas produce 75% of Guyana's honey.
Hydrology and water resources	6	1. There is a decrease in the water level 2. Salt water intrusion into aquifers of most populated areas. 3. Salt water in conservancies will destroy rice and sugar crops
Human Settlement-infrastructure	7	The capital of Guyana, Georgetown is below sea level. 90 % of Guyana's population lives on the Coastal Plain. All housing schemes are on the Coastal Plain.
Human Suffering and loss of Life	8	Increased flooding will increase human suffering and loss of revenue.
Economic Impacts	9	The Economy of Guyana will be severely weakened from unchecked sea level rise and its impacts.
Fisheries	10	Second most important activity, 6% of GDP. Wharves and fish processing industries at risk. Within mangroves roots are breeding grounds of shrimp and some species of fish. Freshwater aquaculture is prevalent on the coastal plain
Ocean Monitoring	11	The changing scenarios of the ocean will affect fisheries and erosion rates. Thus, ocean currents, eddies in the ocean currents, sedimentation, sea surface temperature, and salinity

		needs to be monitored.
Sewer Systems	12	All sewer systems drain into the Atlantic Ocean, mostly relying on gravity drainage.
Highways & Roads	13	Main method of transportation, there may be weakening and corroding of coastal roads and highways. Bridge foundations and structural loads will increase.
Tourism	14	Minor foreign exchange earner Beaches will be encroached on. The famous Shell beach, the nesting ground of four near to extinct sea turtles, may be permanently covered.

Figure 3- Table of Prioritised Issues.

7.2 Key Capacity Building Issues.

Item	Rank	Reason(s)
Finance	1	The present inadequate budgetary allowance hampers the development of key capacity building issues
Human Resource	2	The lack of trained staff is an impediment to development
Training	3	Training is important since the technical capability is either weak or non-existent. Training in Coastal Adaptation Technology Transfer is necessary to ensure that climate change impacts are managed properly.
Equipment	4	There is an inadequate budgetary allowance that hinders purchasing of data gathering equipment etc.

Figure 4. Table of Institutional Strengthening Issues.

This scenario is a major handicap of all agencies in Guyana and will have to be addressed as an initial programme towards adapting to climate change impacts. There is no one agency or department of an agency, which is responsible for climate, changes matters and for ensuring that Guyana complies with its commitments. This needs to be corrected. However, staff, equipment and other resources must be provided for this agency/department.

The sector agencies also do not have staff or equipment to do the tasks, which are required to be done. This is unsatisfactory and needs to be corrected.

7.3 Institutional and Legal Arrangements

Coastal Management Function	Agency Responsible	Government Ministry
Building Development Control within Coastal Area	Town planning Department	Ministry of Finance
Regulation/Design/Construction of Civil Works	Engineering Department	Ministry of Public Works
Protection/Management of Mangroves	Fisheries Division, Environmental Protection Agency, Guyana Forestry Commission	Ministry of Agriculture, Office of the President, Ministry of Crops and Livestock
Water Quality Monitoring: Setting of Coastal Water Quality Standards	Environmental Protection Agency, Ministry of Housing and Water	Office of the President, Ministry of Housing and Water, Ministry of Health
Enforcement/Marine Surveillance	Coast Guard, Environmental Protection Agency	The Army, Coast Guard Division, Office of the President.

Figure 5. Responsible Organisation for Institutional and Legal Arrangements.

The President of Guyana has the mandate for environmental issues including climate change. There is an Advisor to the President on the environment who reports to the president on climate change matters.

A Natural Resources and Energy Advisory Committee (NREAC) which comprises of the heads of the relevant agencies is chaired by the Advisor to the President. All Climate Change matters are discussed at this committee level before being taken to the President or Cabinet.

The National Climate Committee (NCC) oversees all activities relating to Climate Change, ozone depletion and desertification and reports to the Chairman of the NREAC. It is chaired by the Chief Hydrometeorological Officer and its membership comprises all agencies which are relevant to climate change issues. There is no other legislation in this regard.

For the successful implementation of the proposed Integrated Coastal Zone Management and for Marine Protection, new legislation will be necessary. The Environmental Protection Act, 1996, provides for new legislation to be made for the protection of the environment.

This Act provides for the management, conservation, protection, and improvement of the environment, the prevention or control of pollution, assessment of the environmental impact of economic development, the sustainable uses of natural resources, and for matters incidental thereto or connected therewith.

To fully Co-ordinate Climate Change issues, a Climate Change Unit needs to be set up within The Environmental Protection Agency, Office of the President. Also, Institutional Strengthening should be done within all relevant Ministries as outlined in the above Table. The Hydrometeorological Department within the Ministry of Agriculture is presently involved in the monitoring of Climate Change in Guyana. However, the Guyana Energy Agency, the Guyana Natural Resources Agency, the Guyana Forestry Commission, and the Environmental Protection Agency can also be active in the monitoring of Green House Gases etc.

8.0 Conclusion

Guyana will need to establish and maintain a number of management mechanisms for integrated adaptation planning and management to become a reality. These mechanisms cannot all be developed simultaneously and in almost all instances substantial human, technical, and financial resources will be required to establish and maintain the policy, legal, and institutional structures that are necessary for the successful operation of this Framework on Climate Change.

9.0 Bibliography

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