NATIONAL REPORT

ON

Integrating
The Management of Watersheds and Coastal Areas
in
Trinidad and Tobago

Prepared
by

The Water Resources Agency

for

The Ministry of the Environment
Eric Williams Financial Complex
Independence Square, Port of Spain

March 2001

EXECUTIVE SUMMARY

The Republic of Trinidad and Tobago is an archipelagic state located at the southern end of the Caribbean island chain. The islands have a tropical wet climate of the monsoonal type. Rainfall that averages 2,200 millimetres, is seasonal with a wet season from June to November and a dry season from December to May. Temperatures range from 25 to 27 °C, humidity ranges between 50 to 100% and wind speed averages between 20 and 28 km/hr. Trinidad's landscape is characterised by steep mountains, undulating hills and plains. Tobago's landscape is however, characterised by a highland area, which runs through the island and a small coastal plain. The islands are endowed with extremely varied coastlines, a fair share of wetlands and richly diverse flora and fauna.

The population is estimated at 1.25 million with an annual growth rate of 1.2 percent. Trinidad's population is concentrated in urban areas along the west coastal areas and at the foothills of its northerly located mountain range. On the other hand, Tobago's population is concentrated in the southwest part of the island. Relative to the rest of the Caribbean islands the country is highly industrialised with a petroleum based economy and a small but rapidly growing tourism industry concentrated mainly in Tobago.

The Water Resources Agency has a rain gauge network of one hundred and ten (110) recording and non-recording rainfall gauges and a network of twenty-eight (28) streamflow stations, for the monitoring of the hydrological regime. These stations are well distributed over both islands but major deficiencies exist in relation to their upkeep and the quality of information provided. The groundwater network in the twin island state boasts of one hundred and sixty-eight (168) production wells and one hundred and ten (110) observation wells. The Agency has recently completed the installation of a telemetry network consisting of eighty-one (81) sensors with the objective of providing automatic recording and transmission of hydrological and hydro-meteorological data from the river basin to the central office. Much still needs to be done by way of the quality control process before the telemetry system can have the desired impact on data provision and management nationally.

Current water demand in Trinidad and Tobago amounts to 317 MCM/year while the water supply figure amounts to 273 MCM/year, representing a 44 MCM/year deficit. Investments over the last five (5) years to address the past and existing deficits amount to $US 431 million, including the imminent installation of a desalination plant at Point Lisas and the application of new technologies for locating and abstracting deep groundwater in bedrock aquifers. Ironically, investments in water resources management initiatives have been limited to just under $US 5.5 million over a corresponding period.

Much research and investigations are ongoing in the areas of Climate Change and Sea-Level rise. Trinidad and Tobago is a signatory to the Framework Convention on Climate Change (FCCC) which is directed towards achieving drastic reductions in the emissions of CO_2 and other greenhouse gases. Flooding is the natural hazard of major concern to the population by virtue of its frequency of occurrence and the extent of damages resulting. This phenomenon is normally linked to poor watershed management practices and the unsavoury disposal habits of the population, particularly in urban areas.

Pollution is a problem that is on the rise throughout the country. The main water pollutants are urban, domestic and industrial waste, solid and toxic agricultural products and waste, sediments, petrochemicals and oil spills form the oil and energy industries, waste from fishing vessels, ships, tourist facilities and yachts. The pollutants affect both inland freshwater and coastal water resources, including the beaches and shores. The most serious threats to groundwater come from nitrate and bacterial contamination arising from agro-chemical use and sewage effluents from pit latrine soakaways and septic tanks. Another serious concern is saltwater intrusion as a result of overabstraction in coastal aquifers.

There is no fully organised institutionalised public awareness and stakeholder participation programme in place for watershed/water resources and coastal zone management in Trinidad and Tobago. The key agencies have been involved in various initiatives targeting their spheres of interest. Such initiatives have generally not been sustained and have usually failed to recognise the integrated nature of the watershed and coastal zone sectors, essential for their success into the medium and long terms. There is no firm plan to enhance public awareness about watershed/water resource and coastal zone management and to involve community stakeholder participation. This reflects the fragmented institutional framework and approach which currently exist in relation to the sector where efforts are uncoordinated and are unrelated to each other.

Other key institutional issues include the need for closing the severe existing skills gap in several key competencies relating to watershed/water resources and coastal zone management through the provision of relevant training locally and abroad. The introduction of appropriate policies, legislation and master plans to govern and direct the respective sectors are seen as critical. Assistance with the provision of up-to-date equipment to facilitate the operations of the various agencies in the areas of watershed/water resources and coastal zone management is another area which needs to be addressed.

Like other countries, economic growth and development coupled with growth of the human population is resulting in environmental degradation of watersheds, water resources and coastal areas. For Trinidad and Tobago, a twin island state, the coastal habitats and ecosystems assume significant

importance. The coastal areas support a variety of life systems and valuable natural assets and within them are located key industries and economic activities. Similar to the watersheds, these areas are subjected to threats arising from a variety of land based activities. The country experiences much of the full range of environmental problems, from widespread pollution of its waterways and coastal areas, chemical spills, illegal dumping, deforestation, excessive soil erosion, fisheries and wildlife depletion. These problems are attributed to poor land use practices and an inadequate legal and institutional framework for watershed/water resources and coastal zone management. The watersheds and coastal areas are also under threat from natural disasters (tropical storms, earthquakes, floods and droughts) as well as climate change and sea level rise.

The issues articulated above, present major challenges to the sustainability of a quality environment in the watersheds and coastal areas of Trinidad and Tobago. A national management framework must therefore be formulated to deal with the pressures of increasing growth (in population, urban development and industrial activity), and the accompanying pressures on the environment. Such a framework must undoubtedly recognise the direct impacts, which emanates from their supporting systems (upstream watersheds and the marine environment). It must also explicitly recognise the trade-offs between development and environmental sustainability. To establish this framework the following group of actions is recommended:

1. Implementation of the concept of integrated resource management to attain sustainable development of the nation's watersheds and coastal areas.
2. Establishment of an effective financially autonomous institutional framework that facilitates proper water resources, watershed and coastal zone management.
3. Protection of the environmental quality and ecosystems of watersheds and coastal areas
4. Development of capacity and tools within a suitable institution to support the decision making process.

ACKNOWLEDGEMENTS

The Water Resources Agency of the Water and Sewerage Authority and the Ministry of the Environment would like to thank Dr. Constantin Stere for his contribution on Coastal Zone Management and Integrating Watersheds and Coastal Areas and Ms. Judith Gobin for her contribution on marine and terrestrial ecosystems.

Study support, guidance and technical contributions were also provided by the following staff of the Water Resources Agency:

Dr. U. Maharaj
Dr. S. Fletcher
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Mr. W. Clement

Credit must also be given to Judy Francis, Randolph Sankar, Nerisha Bachu, Sharon Archie, Giselle Rogers and Lynette De Coteau (typist) for their various contributions in the preparation of this report.

FOREWORD

It is recognized that Small Island Developing States (SIDS) of the Caribbean are very vulnerable to natural and anthropogenic interventions and climate change variability. The resource limitations of SIDS make the sustainable management of these resources extremely important. In the Caribbean, freshwater supplies are frequently limited while coastal waters support living resources that are also limited. The increasing demands placed on these resources are likely to cause increasing conflicts over allocation and use in the foreseeable future. There is a definite need for the integration of freshwater and coastal water management to sustain and protect both freshwater supplies and coastal and marine aquatic resources.

Trinidad and Tobago, the most southerly of the Caribbean chain of islands is located just off the South American main land. The island comprises one of the most diverse and productive ecosystems in the Caribbean with its tropical forests, fertile flood plains, swamps and abundant streams. The richness of its natural environment, unique blend of the world's major cultures, thriving industrial base and expanding population combine to present major challenges to the sustainability of a quality environment. Due to the country's limited land space, increasing levels of development have and continue to alter the environmental integrity of the coastal areas. These negative impacts are the results of poor land use practices in the coastal zones, and in their adjoining watersheds, as well as activities in the marine environment.

In recognizing that the environmental health of the coastal areas depend on activities which occur both in the coastal zones and watersheds, a regional workshop was held at the Crowne Plaza Hotel, Kingston, Jamaica from March 30 to March 31, 2000. This workshop served as the first initiative for a major project entitled "**Integrating Management of Watersheds and Coastal Areas for Small Island States in the Caribbean".** The project is being funded by the World Bank's Global Environment Facility (GEF) and implemented under the United Nations Environment Program (UNEP) and the United Nations Development Program (UNDP). The Caribbean Environmental Health Institute (CEHI) has been designated the executing agency.

The overall objective of the proposed project is to assist participating countries in improving their watershed and coastal zone management practices in support of sustainable development. Key issues identified for attention include Freshwater and Coastal Area Resource Assessments, Freshwater and Coastal Habitats and Ecosystems, Water Availability, Supply and Demand, Land Use Practices and Impacts, Groundwater, Freshwater and Coastal water Interactions, Public Participation/Public Awareness and Education, Data and Information Systems, Management and Research, Policy, Financial, Legal and Institutional Frameworks, Tourism and Health, Land-Based Pollution, Climate

Change and Natural Disasters, Transboundary Conflicts, Living and Non-living Marine Resource Exploitation, Integrating Watershed and Coastal Area Management and National and Regional Action Programs.

The project will eventually inform the development of a full-scale project for thirteen (13) countries in the Caribbean, including Trinidad and Tobago. This is to be preceded by the development of a Regional Project Brief for endorsement by the GEF, with a target of March 2001. Activities toward this end include: Preparation of National Reports and the Regional Synthesis of Common Issues and Actions. Participating countries are now in the phase of the development of the National Report, an activity which is scheduled for completion by end January 2001.

Specific potential benefits of the overall project for participating countries include strengthening the institutional capacity for freshwater and coastal zone resource management, providing assistance to countries in understanding the linkages between problems in the freshwater and marine environments and assisting countries in integrating the management of watersheds and coastal areas.

This report represents the deliverable under the project component entailing the preparation of National Reports and is specific to Trinidad and Tobago. The report provides an overview of the management of Trinidad and Tobago's water resources /watershed management and coastal zone management systems and proposes an Action Plan for Integrating the Management of Watersheds and Coastal Areas.

Dr. Steve Fletcher and Mr. Keith Meade of the Water Resources Agency (WRA) together with Dr. Constantin Stere, invited lecturer in Coastal Zone Management in the Department of Civil Engineering, UWI, St. Augustine, worked on the compilation and review of this Draft Report. Dr. Utam Maharaj and Mr. Kerry Mulchansingh of the WRA carried out the final review of the document.

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1.0 BACKGROUND INFORMATION

1.1 General characteristics of the islands

Location

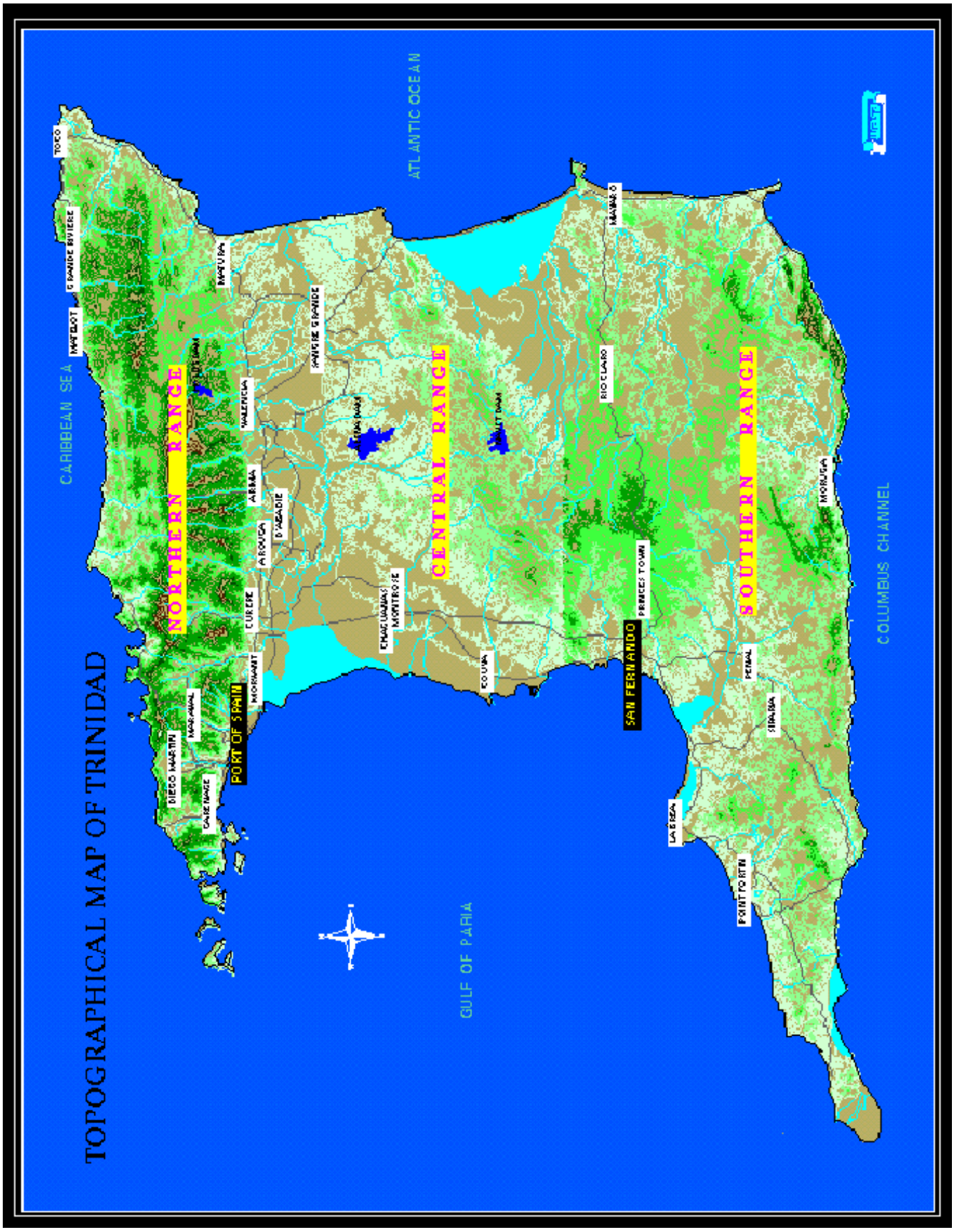
The Republic of Trinidad and Tobago is a twin island nation located at the south-eastern end of the Caribbean archipelago lying roughly between 10 degrees North and 11.5 degrees North latitude and between 60 degrees West and 62 degrees West longitude. It comprises a total land area of 5,126 km^2, with Trinidad having an area of 4,826 km^2 and Tobago (the smaller), an area of 300 km^2. In addition to the main islands, Trinidad and Tobago's Exclusive Economic Zone is estimated to be 104,000 nautical km^2.

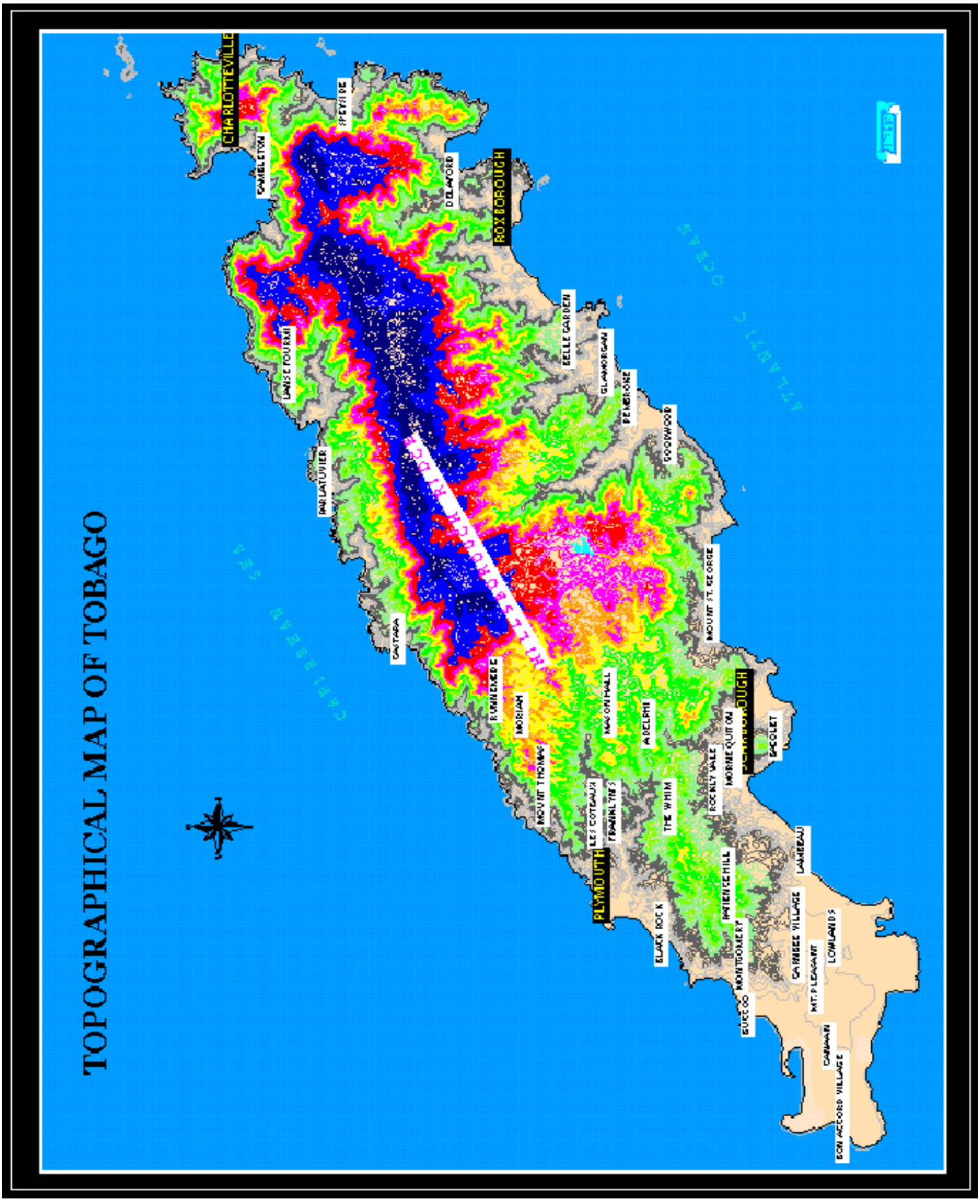
Trinidad is the most southerly of the Caribbean Islands, bounded on the north by the Caribbean Sea; on the west by the Gulf of Paria; on the east by the Atlantic Ocean and on the south by the Columbus Channel. Tobago lies approximately 32 km north-east of Trinidad, and is separated from Trinidad by a channel, the Tobago Sound which is nearly 12 km in width.

Physiography

Trinidad features three (3) mountain ranges, the main one in the north extending the east-west boundaries (maximum height of 900 m), the smallest one in the central (maximum height of 300 m) and the other in the southern part of the island characterized by low hills. Undulating land, plains and swamps separate the ranges. The ranges decrease in altitude from north to south. These features allow for the division of the island into five (5) physiographic regions, namely, the Northern Range, the Northern Basin, the Central Range, the Southern Basin and the Southern Range.

The dominant relief feature of Tobago is a metamorphic and volcanic mountain, the Main Ridge, which runs for about two-thirds of the length of the island in a south-west to north-east direction. Running parallel to the coastline, it attains a maximum elevation of 550 metres above mean sea level. This ridge slopes off steeply to the north-east and more gently to the south-west. The south-western end of the island is occupied by a flat coral limestone platform that extends seaward to form the off-shore coral reefs.


TOPOGRAPHICAL MAP OF TRINIDAD
CARIBBEAN SEA
ATLANTIC OCEAN
GULF OF PARIA
COLUMBUS CHANNEL
NORTHERN RANGE
CENTRAL RANGE
SOUTHERN RANGE
PORT OF SPAIN
SAN FERNANDO
PRINCES TOWN
TOCO
MATURA
VALENCIA
ARIMA
CHAGUANAS
CUREPE
MORVANT
DIEGO MARTIN
MARACAS
CAVE RANGE
COUVA
MONTROSE
RIO CLARO
MORUGA
PENAL
SIPARIA
LA BREA
POINT FORTIN


TOPOGRAPHICAL MAP OF TOBAGO
CHARLOTTEVILLE
ROXBOROUGH
PLYMOUTH
SCARBOROUGH
CARIBBEAN SEA
ATLANTIC OCEAN

Climate

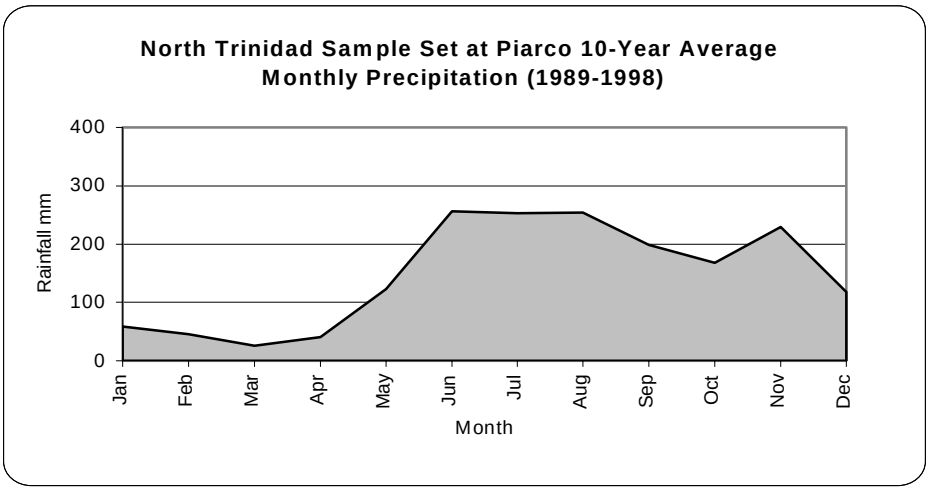
The islands experience a climate that is tropical, warm and humid with two (2) major seasons. From January to May is the dry season with the wet season in June to December. A short dry spell of two (2) to three (3) weeks called the "Petit Careme" occurs in the middle of September or October.

The prevailing winds are the North-East Trades which bring the heaviest rains to the highland areas of north-east Trinidad and in Tobago which lies along a south-west to north-east axis, there is no clear cut distribution between the windward and leeward districts.

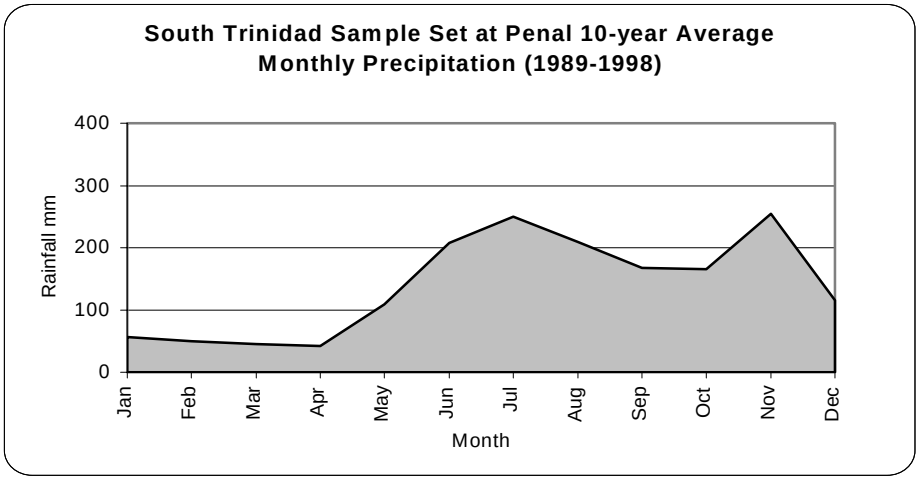
The average annual rainfall of Trinidad is 2,000 mm. The evapotranspiration rate is very high accounting for up to 60 % of the total rainfall received in some areas. In Tobago the average rainfall ranges from 3,800 mm in the Main Ridge to less than 1,250 mm in the south-western lowlands. The average annual minimum temperature varies between 22 and 25^{o}C at night and the maximum between 29 and 31^{o}C during the day.

The following graphs show the ten (10) year average precipitation for the north (graph 1.1a) and south (graph 1.1b) of Trinidad and of Tobago (graph 1.1c).

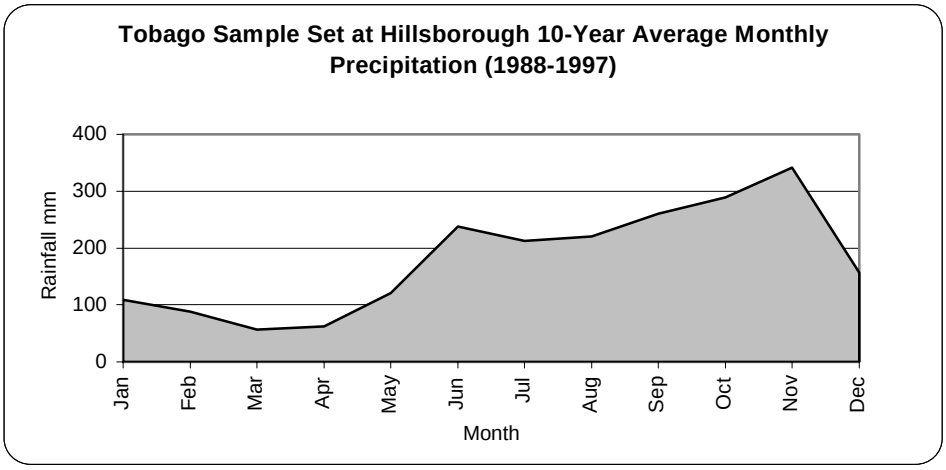
Graph 1:1a



Graph 1:1b



Graph 1:1c



Socio-Economics

A recent survey estimates the population of Trinidad and Tobago at 1,249,738 with 50.4% and 49.6% representing the male and female proportions respectively. On the island of Tobago the resident population accounts for only 4% of the total population. With a growth rate of 1.2%, the population is expected to grow to 1.78 million by the year 2025. This represents an annual increase of 15,500 persons to the population. However, this growth is not expected to stabilize within the next 30 years. The two (2) main ethnic groups comprise persons of African and East Indian descent with each group accounting

for approximately 40% of the total population whilst others of mixed origin comprise the remaining 20% of the population. Trinidad's population is concentrated in urban areas in the north-west and in the city of San Fernando and the boroughs of Arima and Chaguanas. Scarborough, the capital of Tobago, is the island's major population centre.

The main water related socio-economic activities in Trinidad and Tobago are industry, agriculture, recreation and tourism. Key industrial areas include Point Lisas in west-central Trinidad and Point Fortin and La Brea in the south-west, where the energy and energy based industries are concentrated. Facilities relating to the petroleum industry are located in the southern areas of the country and offshore. Greater emphasis is placed on the tourism industry in the island of Tobago than in Trinidad, but a steady growth is being experienced on both islands. This is clearly evident by the rise in both islands of the eco-tourism industry.

Land-Use Trends

Recent land use trends in Trinidad and Tobago have been dominated by a steady growth in urbanization and housing development, uncontrolled settlements, agricultural activities, such as slash and burn, water harvesting and deforestation. This is particularly valid for the southern foothills of the Northern Range in Trinidad, where it is evident that considerable expansion of urban areas is taking place at the expense of forests and agricultural lands.

In Tobago, at least 15 % of the topsoil has been lost through inappropriate land use. Its topography is characterized by a high percentage of steep slopes with soils that are highly prone to erosion. The problem of soil erosion is manifested mainly in the south of the island as the northern areas which receive the most rainfall are still under original forest or permanent tree crops. The island of Trinidad is characterized by a high percentage of both flat or gently sloping land and steep land. Along the foothills of the Northern Range, particularly in the west, considerable gully and sheet erosion has taken place in areas where intensive cultivation is carried out. Significant erosion has also taken place within areas of the Central and Southern Ranges where the original forest cover has been removed.

A major feature of the landscape along the western portion of the Northern Range is the vast number of squatting settlements, the siting of which have resulted in loss of forest on the steep hills. Generally, the watersheds in this region are subject to rapid growth in housing developments, quarrying and agricultural activities.

A sizeable sector of the economy depends on income generated by the agricultural and quarrying sectors at the levels of both private individuals and the state. However, the practices generally adopted in these activities have resulted

in the wide scale degradation of many watersheds within Trinidad and Tobago. The general consensus is that the hydrological response of rivers to rainfall has changed over the years due to such degradation. Peak flows are thought to have increased whilst baseflows seem to be lower than previously computed, leading to the assumption that total water availability has decreased. Higher sediment yields leading to an increase in the cost of drinking water production and more regular maintenance of water treatment plants, together with increased incidences of flooding in areas along the east-west corridor and in the Caroni Basin, the country's major river basin, are other associated negative impacts.

Road improvement programmes have slowed the urbanization trend of the greater Port-of-Spain area, encouraged industrial, commercial and residential development and created opportunities for the accelerated development of urban centres. As one moves from rural Toco in the east to Chaguaramas on the north-west peninsula, the changes in the physical, social and economic infrastructure are easily discerned as being more developed, complex and extensive.

1.2 Administrative Boundaries

For the purpose of managing the national water resource, the country has been divided into four (4) Water Resource Management Units (WRMUs), each comprising a group of Hydrometric Regions.

Each hydrometric area is centred on a major hydrologic unit, which usually groups a number of these hydrologic basins for administrative purposes. The hydrologic boundaries of the basins and hydrometric areas correspond to surface water divides. For ease of reference, these areas have been numbered 1 to 9 for Trinidad and 11 to 15 for Tobago (Table 1.1). The islands have also been subdivided into catchment areas (Figure 1.1) fifty-five (55) in Trinidad and fifteen (15) in Tobago.

Table 1.1 Hydrometric areas of Trinidad and Tobago

Hydrometric Areas in Trinidad	Hydrometric Areas in Tobago:
1. North Coast	11. North Coast
2. North Oropouche	12. East Coast
3. Nariva	13. Windward
4. Ortoire	14. Courland
5. Southern Range	15. Lowlands
6. Cedros Peninsula	
7. South Oropouche	
8. Central West Coast	
9. Caroni	
10. Unassigned	

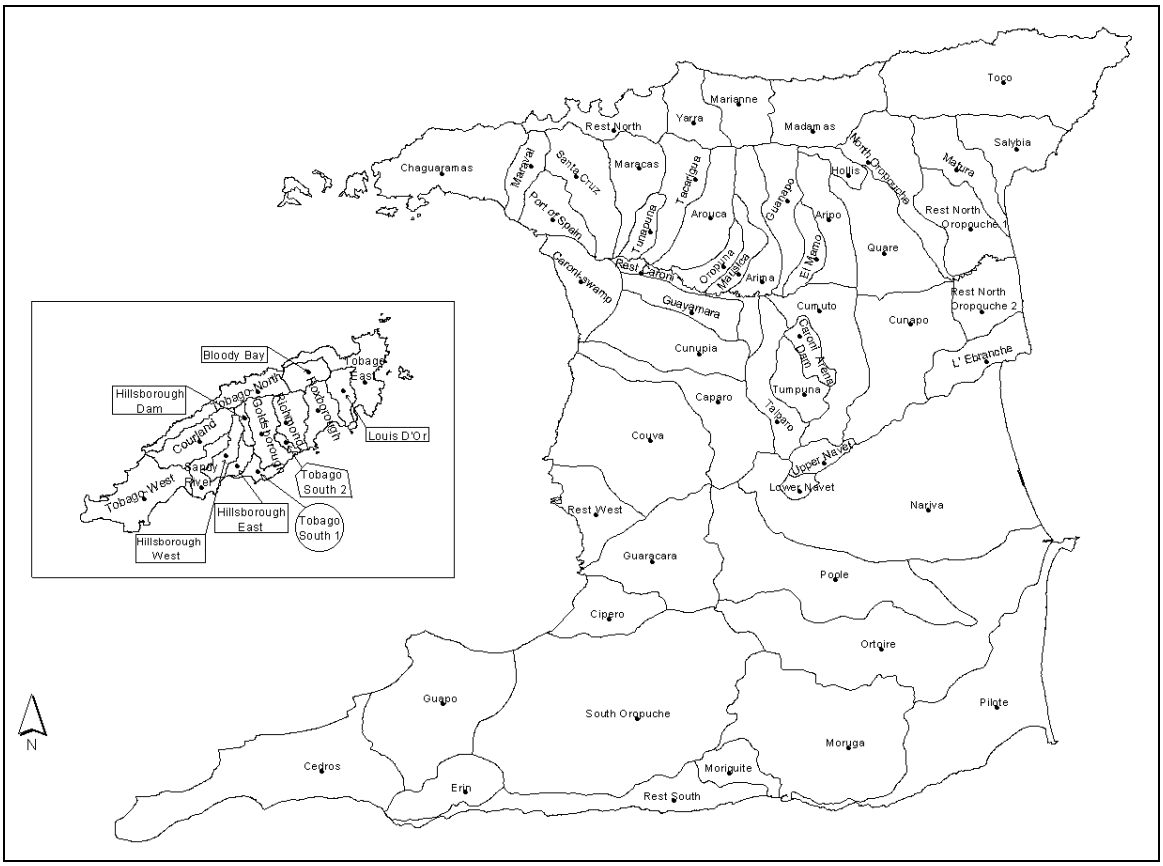
1.3 Hydrology

Hydrometric Network

Stream gauging of surface water sources commenced in 1968 with the measurement of flow at ten (10) stations. Over the years, additional gauging stations were established so that today a network of twenty-eight (28) gauges is in existence.

Three (3) types of streamflow recorders are in use by the Water Resources Agency. These are the float-operated Leopold and Stevens A-35 continuous strip chart recorders; Leopold Stevens A-35 recorder with a Manometer Servo which uses pressure sensing to record the water level in the rivers and a float operated vertical drum type Fuess recorder.

Figure 1.1 Catchment Areas in Trinidad and Tobago



There is an elaborate rain gauge network of non-recording and recording gauges throughout the island of Trinidad. The Water Resources Agency has a rain gauge network of one hundred and ten (110) recording and non-recording rainfall gauges. These rainfall stations are well distributed over the island with the highest density in the Caroni Basin and the southern slopes of the Northern Range. In its drive to update the rainfall network, forty-nine (49) recording rain gauges, (Lambrecht Recorders) have been installed, particularly in remote areas and in areas not previously gauged. These automatic recording gauges are associated with the stream gauges in forming the complete surface water monitoring network.

The collection of data to facilitate flood plain mapping commenced in 1981, using crest gauges distributed over seventeen (17) areas. Flood peaks above measured flows are estimated using channel slope and Manning's equation.

The groundwater network in the twin island state boasts of one hundred and sixty-eight (168) production wells and one hundred and ten (110) observation wells, distributed in the well fields from Chaguaramas in the north-west to Point Fortin and Guayaguayare in the south-west and south-east of Trinidad. The production well network accounts for approximately 31% of the potable water distributed by the Water and Sewerage Authority (WASA).

The national Water Resources Agency (presently incorporated within WASA), has recently completed the installation of a telemetry network with the objective of providing automatic recording and transmission of hydrological and hydro-meteorological data from the river basin to the central office. The computer hardware and software associated with the telemetry system are being utilized to convert the hard data (on rainfall, evaporation, river flows, groundwater levels) into digital data and to analyze and process them into useful reports for monitoring, planning, assessing and operating a variety of water resources systems.

The telemetry network comprises data collection stations as follows:

- 32 Rainfall
- 26 Stream water level and quality
- 01 Combination Rainfall and Stream water level
- 04 Reservoir water level and quality
- 09 Groundwater level and quality
- 09 Hydrometeorological (including Evaporation) stations

The overall system comprises remote terminal units, repeaters and base station.

Hydrologic Processes

Rainfall is largely influenced by the prevailing moisture laden North-East Trade Winds and topography of the island, so that rainfall decreases from the windward to the leeward coasts and increases with elevation.

As the islands experience two major climatic seasons, separate maps for dry season, wet season and annual isohyets are produced. Maps of isolines of runoff are produced from available streamflow records. It is necessary, however, to verify the estimate of runoff in basins with insufficient coverage by spot gauging or by the installation of additional flow gauging stations.

Hydrogeology

Geologically, Trinidad forms the eastern extension of the South American mainland of Venezuela. Sedimentary and metamorphic rocks occupy 99% of the land area with the fresh water occurring in these sedimentary rocks. In Trinidad, exploitable fresh water occurs in aquifers, which are of three (3) main types:

- Alluvial and piedmont gravel fans
- Sheet or blanket Sands
- Multiple Sands

The geology of Tobago is very different from that of Trinidad, as the island is composed largely of metamorphic and igneous rocks. Abstraction of fresh water occurs from the clastic sedimentary deposits in the southwestern part of the island where there is an especially high demand for potable water. Wells drilled into the limestone platform have encountered brackish water and are at present being used for observation purposes. Other areas with fresh water bearing potential are known to exist in the larger river alluvial to the north and central parts of the island. New technology targeting the bedrock underlying the traditional aquifers, has been employed in the drive to develop the ground water potential of Tobago. Investigations have been carried out with the aid of technology used to discover water in arid regions. This technology involves the use of a GIS database and the determination of bedrock fractures and faults through high-resolution satellite imagery. This process involves the identification of conduits for flow into and out of the bedrock aquifers. A significant level of success has been encountered with this initiative and the approach is now being extended to the island of Trinidad.

Total Safe Yield for groundwater production in Trinidad is estimated at approximately 477 ML/D. This value indicates that it is possible to abstract more groundwater than is being done at present. Additional groundwater

production can likely be obtained from minor aquifers, such as at Cano Ventura in the north- west and Guaico Sands in the north-east of Trinidad.

1.4 Water Resource Threats

The increasing pressure on the water resources of Trinidad and Tobago due to population and socio-economic activities is resulting in increasing rates of pollution which, if no measures are taken, will threaten the availability of the resource.

In order to improve and maintain the water quality in Trinidad and Tobago it is necessary to:

- define the water use function for each water body
- understand the causes of pollution
- obtain detailed information on the waste loads of the different sectors
- establish minimum quality standards
- institute water quality management programme.

Risks to the quality of the water resources, both surface water and ground water are presented from all sectors of the society. Large amounts of untreated or inadequately treated domestic waste, in particular sewage, enter the surface water sources. It is estimated that 60 % of households are at present connected to the sewerage system, and that the sewage from only 70 % of those connected is treated. Other risks such as over abstraction may induce salt-water contamination of coastal aquifers and deplete in-stream flows, which may adversely impact on the ecosystem.

The potential agricultural and industrial threats lie in the non-point or diffuse sources from pesticides and agro-chemicals, and from oil production, refining and toxic chemicals, inclusive of heavy metals. The disposal of solid waste in landfill sites is also a threat.

Groundwater

The natural groundwater quality in Trinidad generally falls within the limits set for potable water by the World Health Organization (WHO). In many instances the sources only require treatment by disinfecting before being put into the distribution system. However, on a local scale, there are threats by point source pollution. Most aquifers are very vulnerable, in the absence of thick overlying clay layers, to the infiltration of contaminants. Controlled dumping and the monitoring of wastewater discharges on a regular basis are measures that can be used to avoid such contamination.

Generally, the groundwater quality issues in Trinidad are related to:

- Concentrations of iron above the desirable limit of 0.3 mg/l. In the Central Sands and the Southern Sands aquifers, the source of iron is attributed to the iron deposits found in the clay beds.
- Hardness of water: in the aquifers, hardness range from soft to very hard, with hard waters sometimes occurring in the northern gravel aquifers where groundwater may come into contact with limestone lenses.
- Chloride content of the water: some coastal aquifers are closely monitored in a continued effort to prevent seawater intrusion.

Potential pollution to aquifers may result due to the presence of:

- hazardous waste dumps
- underground fuel storage tanks
- untreated sewage
- industrial activities
- pit latrines and septic tanks

Surface water

The quality of the surface water resources is in many places deteriorating, as evident by high levels of the biological oxygen demand (BOD) and bacterial content, turbidity and the presence of chemical pollutants in the rivers. The main threats are uncontrolled point waste discharges, in particular from industries and domestic sources, as well as, the high level of erosion in the upper catchment of the watercourses. Pollution of surface waters not only affect the production of potable water but also the ability of the rivers to provide productive habitats for terrestrial and aquatic species is also endangered.

In-stream problems resulting from pollution are generally manifested during the periods of low flows in the water systems when the dilution capacity is much too low to prevent violation of water quality standards.

The only major surface water source studied in great detail is the Caroni River Basin upstream of the water treatment plant. However, the following findings from this basin are generally applicable to the rest of Trinidad:

- all rivers and streams flowing through urban areas are heavily polluted
- most industries outside sewered areas discharge untreated waste directly into rivers or the marine environment

- untreated sewage is a major contributor of organic pollution causing low dissolved oxygen levels and high bacteria counts in rivers.

The major pollution sources are identified as:

- industrial effluent
- urban run-off
- municipal wastes
- agricultural run-off

Based on the origin of the pollution problems, surface water quality management programmes should target:

- changes in physical characteristics
- faecal contamination
- organic matter
- river eutrophication
- trace elements
- nitrate pollution
- organic micro-pollutants
- sound and regulated land use planning

1.5 Coastal Zone Management

There are several issues requiring a concerted Coastal Zone Management thrust in the islands of Trinidad and Tobago. These include environmental problems such as coastal eutrophication due to inappropriate sewerage treatment, contamination arising from agricultural pollutants, reduction in base flows of rivers, inappropriate coastal developments, sand-mining along beaches, heavy contamination from industries and sea vessels, over-fishing, degradation of coastal zone and marine species, including mangrove systems and coral reefs. Many of the problems being experienced are land-based in origin. Focus must be given to strengthening the planning and management capabilities of relevant institutions to ensure the sustainability of our marine and coastal resources and to integrating the management of watersheds and coastal zones.

The local Institute of Marine Affairs (IMA) is a research/technical services state-owned organisation that has done substantial work in coastal zone issues and management. While this information is available, it is not readily accessible to the public due to their confidentiality agreements. The Drainage Division of the

Ministry of Infrastructure is responsible for the provision of protective engineering works along the coastlines of Trinidad and Tobago and has undertaken numerous studies in this regard.

2.0 CURRENT WATERSHED/WATER RESOURCES MANAGEMENT ISSUES

2.1 Freshwater Habitats and Ecosystems

The islands of Trinidad and Tobago have been mapped under Hydrometric areas which are major hydrologic units, within which a number of watersheds/subwatersheds have been placed. While there is no "Protective Area System" *per se*, there are instruments for protection of some of these watershed areas. The "Forest and Nature Reserve" areas especially in the North Coast of Trinidad, allows protection of the upper reaches of some of the watershed areas, by virtue of their locations. In Tobago, the Hillsborough Main Ridge is one of the oldest protected areas (established since 1734) in the Western Hemisphere. The National Parks Project has proposed several areas in Trinidad and Tobago to fall under such a "protected area system"

The largest watersheds contain the major river systems (and fresh water ecosystems), which in Trinidad are the Caroni, North Oropouche, Navet and Ortoire, South Oropouche rivers and their associated wetland/swamp areas. The Caroni River is one of the main contributors to the potable water supply of Trinidad, draining an area of 1000 km^2 (approximately 1/5 of the total area of Trinidad). In Tobago, major systems are the Richmond, Goldsborough and Hillsborough rivers. The country's rivers directly support life (phytoplankton, fish, crabs, crayfish, teta, pui-pui) and other useful plants (used in local craft industry) which rural peoples depend on for local consumption and/or export trade.

These rivers are also popular tourism and recreational sites, especially Caroni and Nariva which support abundant avifauna, especially waterfowl (anhingas, cormorants, herons, gulls and egrets) and other wild life. These systems provide water for game animals (eg. lappe, deer, wildhog, tatoo and agouti) and non-game animals (howler monkeys, porcupines, anteaters, tayra (highwoods dog), ocelot, manicou and squirrels), small rodents, bats and insects such as damselflies and dragon flies. There is also large-scale agriculture on the alluvial flood plains of Caroni and Nariva.

The major threats to the management of watersheds and freshwater ecosystems in Trinidad and Tobago include the threat of groundwater and river degradation:

- from industrial, agricultural and domestic pollution

- from soil erosion, deforestation, habitation on steep slopes, annual bush and forest fires, indiscriminate and unplanned construction - this can reduce the free flow of fresh water resulting in changes in composition of fresh water plants, sedges and invertebrate composition
- from flooding, poor drainage and maintenance, pressures (and associated problems) of urbanisation
- from over abstraction from surface and groundwater sources

Further degradation of the watershed areas can result from

- pressure on land for housing and poor land practices
- reduced crop and land productivity,
- poor system of logging

In Tobago, some additional priority problems in watershed areas include - proximity to Scarborough and pressure on land for residences and buildings, improved vehicular access to forest and watershed areas and illegal sand mining.

Some relevant general recommendations towards management of watersheds (and by extension freshwater ecosystems) are presented here:

- enforce pollution laws, abstraction limits and land use regulations
- make appropriate changes in techniques used in site preparation and built development
- ensure changes in fire climax vegetation on hillsides
- improve systems of collection of solid waste
- improve road construction techniques
- address reversal of deforestation by expanding quality and coverage of forest
- establish a system of community participation
- help solve and provide lasting solutions to degradation to water quality and the environment
- implement public education targeting the general population and specific groups at the community level
- identify data needs and establish systematic collection programs
- regularise land tenancy arrangements in watersheds
- identify a system of community led eco-tourism projects to improve forest/hillside management

- additionally, in Tobago, there is need for enforcing of restriction on mining of water courses

2.2 Supply and Demand

Water Demand

The demand for water on the islands is classified as either consuming or non-consuming water. The former category includes domestic water, major industrial, minor industrial, irrigated agriculture and unaccounted-for-water. Computations and projections of the consuming demands and the year 2000 demand assessment are shown in Figure 2.1

Table 2.1 Consuming Water Demand (MCM/Year) for the Period 1997 to 2025

Demand Category	Year				
	1997	2000	2005	2015	2025
Domestic	118	120	142	171	203
Industrial, Major	36	51	66	92	112
Industrial, Minor	9	9	11	13	15
Irrigated Agriculture*	10	10	10	10	10
Unaccounted-for-Water	124	124	128	118	141
TOTAL	297	314	357	404	481

**** Estimates here are anticipated to increase dramatically if irrigated agriculture increases.***

The water demand for domestic customers were computed using a population growth rate of 1.2% per annum beginning with a base population of 1.3 million in 1995 and a per capita consumption of 2,000 litres/day. Industrial demands outside of Point Lisas were projected to grow at an average rate of 1.7% per annum in line with the population growth rate, while the Point Lisas demand was projected from actual development plans for the area. Estimates for unaccounted-for-water was 43% for 1995, declining to 30% in the year 2025.

Irrigated agricultural demand calculations have been based upon the irrigated area (present base of 3,040 hectares), the unit demand for each crop and the irrigation efficiency. Based upon current trends it was recognised that due to competing economic development of other business sectors, that this sector will most likely not expand significantly. However, the Ministry of Agriculture has indicated that there is a substantial amount of irrigable lands, which if developed will require substantial increases in the demand for irrigation water. This scenario has not been considered in the demand projections because of its unlikely occurrence in the near future. Notwithstanding, there are a number of initiatives that may be pursued in the future once irrigation water can be made available.

The main non-consuming demand in the country is related to the minimum flows required to maintain healthy ecosystems in rivers and swamps. Although there is an absence of sound scientific information to determine these minimum flows on a basin-by-basin basis, these have been set at a minimum of 20% of the natural river flow.

While there is no formal water policy, the general practice of allocating water among competing uses are in order of priority:- domestic, industrial, agriculture and ecological. Notwithstanding, there are many cases where the order of priority changes within selected basins. In addition, the growing awareness of environmental concerns has often set upper limits to total abstractions of the competing uses.

For the year 1997, Trinidad's estimated water availability per annum from surface, ground and reservoir sources was 3,691 MCM, surpassing the total annual demand of 1,044 MCM for both consuming and non-consuming demands. The dry season (January to May) availability was 573 MCM and combined demand was 224 MCM. The projections for the year 2,025 showed water availability to be 3,701 MCM and a total demand of 1,651 MCM. The dry season availability estimates for the same period are 583 MCM and 328 MCM for the water demand.

For the island of Tobago the 1997 water availability and demand were 141 and 37 MCM, while dry season figures were 29 and 9 MCM respectively. The 2,025 projections indicate the same total availability of 141 MCM with a slight increase in demand to 41 MCM and similarly dry season figures of 29 MCM water available to 10 MCM water demand. Therefore, the Per Capita Availability of 0.003 MCM/ year indicates according to the World Bank Standards (0.001 MCM/year), that Trinidad and Tobago is not a water scarce country.

The overall water balances as shown in Figure 2.1b for each island indicate that there is sufficient water available even during dry periods to satisfy the demands of the twin island state. However, due to the spatial and temporal availability of the water, localised imbalances occur, resulting in water shortages being experienced by the population. The ability to supply all the competing demands for water is further affected by bottlenecks in the water supply infrastructure.

Figure 2.1a: Consuming Year 2000 Demand

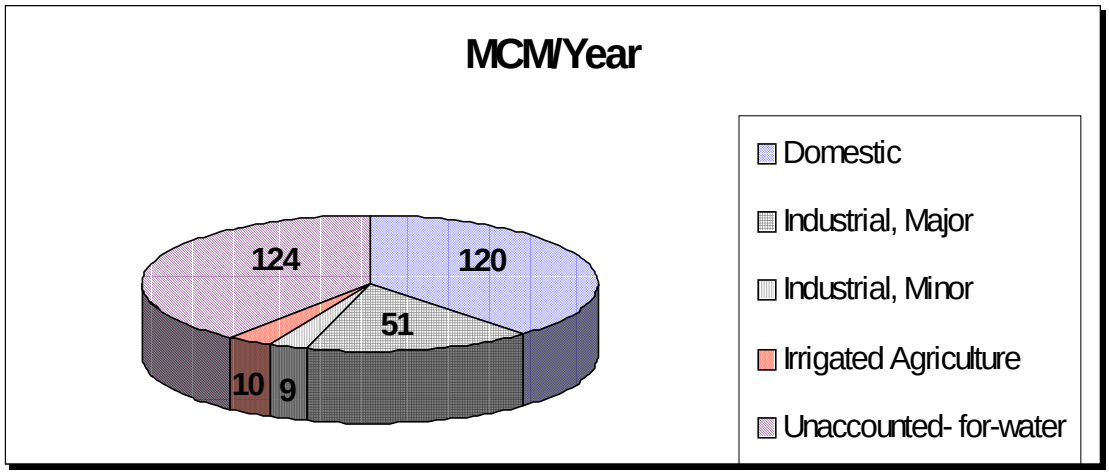
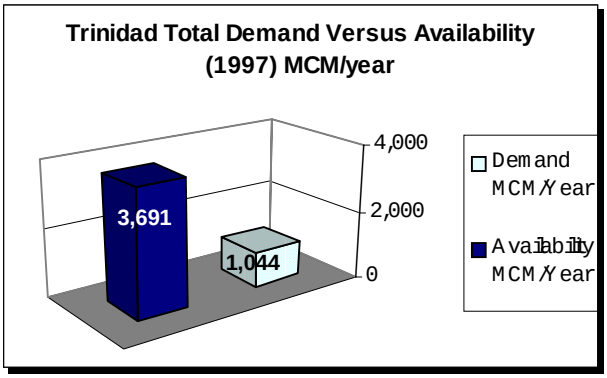
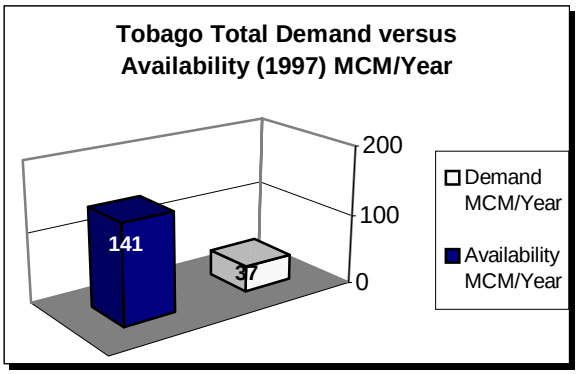


Figure 2.1b:





Water Supply

The public water supply system (PWS) owned and operated by the Government is managed by the Water and Sewerage Authority (WASA). Water infrastructure is installed throughout both islands to satisfy the potable and industrial water demands of the large majority of the population. The various components of the public water supply system for both islands are presented in Tables 2.2 and 2.3

Table 2.2 Components of The Public Water Supply System in Trinidad

System	Components
Northern Systems	Hollis Reservoir and other smaller intakes serves Arima and surroundings
North Oropouche	River intake to serve Sangre Grande, Arima and Westwards.
Caroni Dam and WTP	A major reservoir in the North Central to serve the North and South of the island in an approximately 50:50 ratio.
Northwest System	Water from Caroni North is supplemented by seven(7) wellfields and river intakes to feed the capital city, Port-of-Spain and suburbs
Southern System	Water from Caroni South for areas in Central,including Point Lisas and for South.
Navet Scheme	The second largest reservoir in the Central area serving the city of San Fernando and surroundings.
Isolated South Plants	Small intakes and wellfields within the South one-third of the island to supply localised demands.

Table 2.3 Components of The Public Water supply System in Tobago

System	Components
South West System	Comprising of the Hillsborough impounding reservoir, two (2) intakes and four (4) wells to supply Scarborough and the West of the island.
Isolated Plants	Small intakes and three(3) wells supply the rest of the island on a localised basis.

The 1997 water demand for customers served by the Public Water Supply System in Trinidad was computed to be 279 MCM, while an estimated 217 MCM was supplied by the system resulting in a deficit of 62 MCM. Due to a number of initiatives, several water source development projects were implemented to improve WASA's supply throughout the island. In Trinidad, this included the upgrade of the Caroni Water Treatment Plant to produce an additional 25 MCM/year, rehabilitation of many small plants and the redrilling/ rehabilitation of several wells to produce an additional capacity of 11 MCM/year. The situation in Trinidad in year 2000 still recognises a deficit between water supply and demand of 44 MCM/year. Two major projects are being implemented to offset this increasing deficit for the immediate to medium term (5 years). A desalination plant to produce up to 40 MCM/year industrial quality water for the major industrial estate at Point Lisas, and exploration of groundwater sources targeting 25 MCM/year.

On the island of Tobago an additional 4 MCM/year was obtained from new groundwater sources, via the Tobago Groundwater Assessment and Well Development Programme which was completed in year 2000. Water in excess of the estimated deficit of 3 MCM/year projected for year 2005 has been realised for this island. Notwithstanding, extreme events and bottlenecks in the distribution network will impact on the water supply situation but to a much lesser extent than prior years.

Tariffs

The Water and Sewerage Authority as the main provider of water and sewerage services has tariffs sets for both services. The tariffs for water supply services recognises different rates for domestic and non-domestic customers and for those who are metered and unmetered (Table 2.4).

Table 2.4 Water Tariffs for Trinidad and Tobago

Consumer Category	Water Rate
Domestic	Metered: US$0.28 per m^3/quarter for the first 150 m^3, then at a rate of US$0.56 per m^3/quarter.
	Unmetered: Based upon a proportion of the Annual Taxable Value of property within a range of US$17 /quarter to US$48 /quarter
Non-Domestic	Metered: US$0.56 per m^3/quarter for industrial and US$0.36 per m^3/quarter for agriculture.
	Unmetered: US$75 /month for commercial.

Tariffs for sewerage services are computed on the basis of the water supply rates. Sewerage rates are calculated as 50% of the water rates for all classes of customers.

In general, tariffs have been set below the marginal cost of the services, especially for sewerage services. Customer classes are defined in terms of activity rather than water consumption. Customers in the lower unmetered rates are subsidised by WASA. Most of WASA's domestic customers (99%) and about one third of the industrial customers are unmetered. This discourages water conservation and denies customers the opportunity to manage their water bills.

In 1998, a special water improvement rate was introduced for the Point Lisas Industrial Estate, the main industrial area on the island of Trinidad. The rate for industrial customers moved from US $0.56 per m^3 to US $1.19 per m^3. The

introduction of this new rate has had a positive impact on the operating profit of WASA.

Abstraction charges for private abstractors (i.e other than WASA) are subject to a royalty payment of US $0.00 per m^3 for domestic use, US $0.02 per m^3 for registered agricultural customers and US $0.06 per m^3 for industrial/commercial customers. The rate for agricultural customers was reduced from US $0.06 per m^3 to encourage the development of the agricultural sector. WASA at present does not pay water abstraction charges.

2.3 Groundwater vis-à-vis Surface Water

The demand for domestic, commercial, industrial and agricultural water has increased dramatically over the last few years. Exploitation of the resource is however constrained by its proximity to the demand centres. Ground and surface water availability and actual abstraction for the year 2000 are summarised in Tables 2.5 and 2.6. The abstractions of surface and groundwater for Trinidad and Tobago are 278 and 81.1 MCM/year respectively.

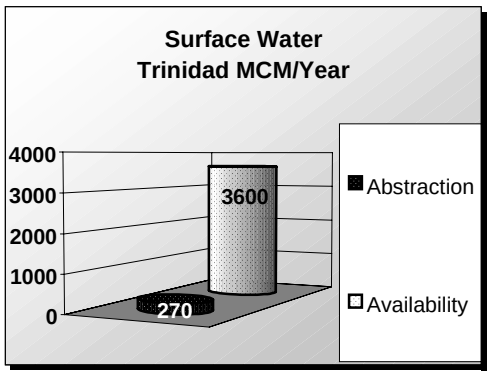
Table 2.5 Trinidad Surface Water and Groundwater Availability/Abstraction

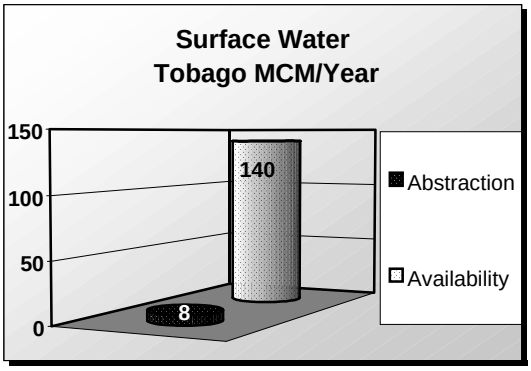
Available water	Actual Abstraction
Surface Water	
3600 MCM/year 513 MCM/dry season 3087 MCM/wet season 62 MCM/driest month (April)	270 MCM/year (8% of availability)
Groundwater	
120 MCM/year (from conventional aquifers)	77 MCM/year

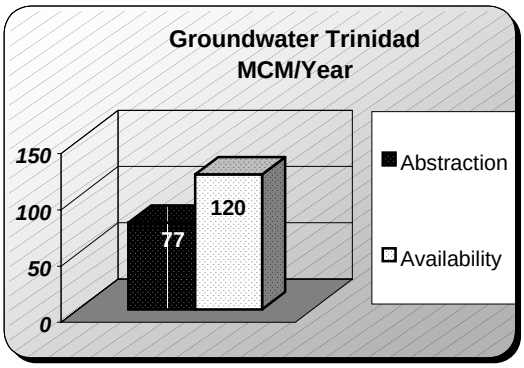
Table 2.6 Tobago Surface Water and Groundwater Availability/Abstraction

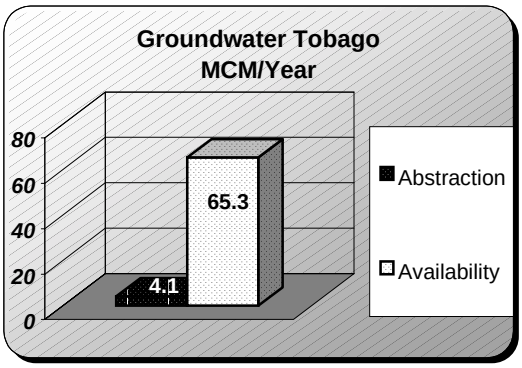
Available water	Actual Abstraction
Surface Water	
140 MCM/year 28 MCM/dry season 112 MCM/wet season 3 MCM/driest month (May)	8 MCM/year (6% of availability)
Groundwater	
0.66 MCM/year (from conventional aquifers) 65.3 MCM/year (from newly exploited bed rock)	4.1 MCM/year

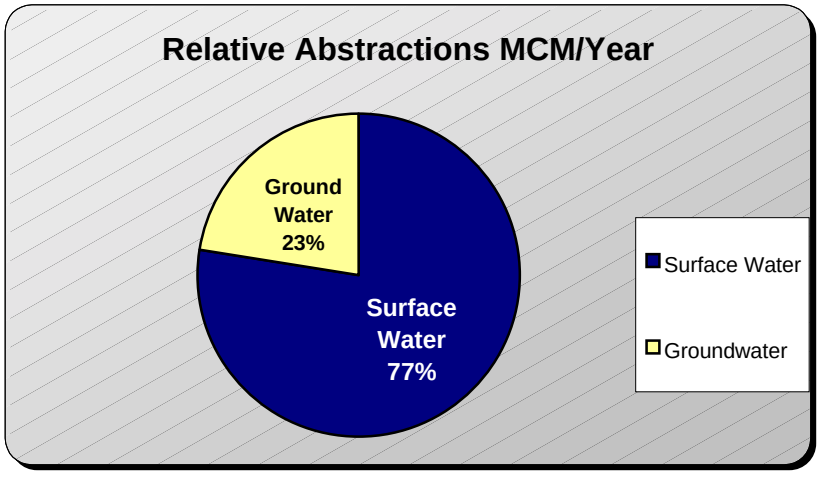
Figure 2.2 : Groundwater vis a vis Surface Water


Surface Water
Trinidad MCM/Year
4000
3000
2000
1000
0
3600
270
Abstraction
Availability


Surface Water
Tobago MCM/Year
150
100
50
0
140
8
Abstraction
Availability


Groundwater Trinidad
MCM/Year
150
100
50
0
77
120
Abstraction
Availability


Groundwater Tobago
MCM/Year
80
60
40
20
0
4.1
65.3
Abstraction
Availability


Relative Abstractions MCM/Year
Ground
Water
23%
Surface
Water
77%
Surface Water
Groundwater

Trinidad and Tobago utilised 7.5 % of its total surface water for the public water supply system. The figures for the individual islands are 7.4 % for Trinidad and 5.7% for Tobago.

Groundwater exploitation in the country is 43.6 % of the available amount, with Trinidad's exploitation level being 64.1% and that of Tobago being 6.2%. It must be noted that in the year 2000, a new hydrogeological assessment of Tobago revised its available groundwater levels from 0.69 MCM/year to 66 MCM/year. The study identified new sources of water located in crystalline bedrock aquifers, which are recharged from megwatersheds. A similar study, which has been initiated for Trinidad in the year 2001, is also expected to show significant increases in the available groundwater.

Mitigation of Groundwater Contamination

The groundwater systems of Trinidad and Tobago are subject to a variety of potential risks which include leaching from hazardous waste dumps, pit latrines, septic tanks and underground fuel storage tanks, and discharges from industry, agriculture and inefficient sewerage treatment plants.

Salt-water intrusion is also a major cause for concern. The El Socorro wells experienced sea water intrusion during and before 1970, due to high abstraction rates (approximately 30,000 m^3/day). The water level fell to below sea level. A cut back in production allowed the water level to recover during 1979-1983. Chloride concentration was higher than 600 mg/l on average in 1980. After the cutback the average concentration has been decreasing since 1985 and is now about 400 mg/l. The original level at the beginning of the operations in 1959 was about 40 mg/l. A similar situation was observed for the Valsayn aquifer.

The pumping of aquifers within their safe yield values, drilling wells further inland from the coast line and the frequent monitoring of coastal observation wells for water level fluctuations and quality (chlorides) are the measures in place to prevent salt-water intrusion. For the coastal aquifers between Chaguaramas and El Socorro in the North, the abstraction rates must not be higher than balanced yields, to keep a hydrodynamic balance and prevent sea intrusion. Groundwater quality is most certainly threatened by salt-water intrusion. A number of aquifers are opened ended to the sea. The Cocorite wellfield and Upper El Socorro Gravels in the North West of the island are examples where salt-water intrusion resulted in the abandonment of several good producing wells.

There are other types of contamination treats that were identified through specific studies. These can be described as follows:

- Nitrate levels in groundwater.

- Coliform in El Socorro wells.
- Methyl Tertiary-Butyl Ether possibly due to leaking gasoline underground storage tanks at service stations.
- Extensive oil well drilling throughout the Southern Basin may have resulted in shallow groundwater contamination. Isolated examples have been found in water wells in the Guayaguayare area.

The measures taken to mitigate groundwater contamination of the nation's water sources are as follows:

- Groundwater abstraction is controlled by safe yield determination, that are reviewed annually to prevent salt water intrusion.
- Sewer installations are required to be sited away from aquifer recharge areas.
- The coordination of several agencies when siting waste dumps, gas stations and industries.
- The use of pesticides and herbicides are being controlled through public education and import control measures.
- The introduction of new early warning design underground storage facilities for petroleum fuel installations.
- All oil and gas wells drilled require strict isolation of the shallow water bearing sands prior to drilling to greater depths.

2.4 Land Use

Before its occupation by European settlers, various types of natural forest species covered Trinidad and Tobago. Approximately one hundred (100) years ago the British Colonial Administration introduced the first systematic landuse, primarily for the conservation of forest, the production of timber, and cash crops consisting of cocoa, coffee, sugar cane, bananas, coconuts and tonka bean. Although forest cover still dominates the landscape of both islands, growths in population and economic activity have resulted in large scale degradation of watersheds throughout the country especially in the mountain ranges of Trinidad and the southern portion of Tobago.

In 1972, approximately 75% of the total land area of the country was covered by some form of permanent vegetative cover (Table 2.7). This included some 58.3% under forest cover and 16.8% under tree cover. Although there has been no recent comprehensive reassessment of the landuse in the country, a number of individual catchment studies have provided significant insight into the changes in landuse over the past thirty-eight (38) years. Recent estimates by the Forestry Division estimated the 1990 forest cover to have declined to 49.9% of the total land area. A study of the Santa Cruz catchment showed that between 1969 and 1992 forest cover decreased by 7.5%, while housing development increased by

20%. Other catchment studies while not giving quantitative data, have also shown significant increases in the percentage of built up areas in a number of catchments in the country.

Table 2.7 Trinidad and Tobago Landuse 1972

Land Use Category	Area (hectares)	Percentage
Natural Vegetation and Forest	298,955	58.30
Tree crops	86,171	16.80
Sugar cane	48,038	9.47
Developed and Industrial Areas	40,108	7.82
Pasture and Other Crops	20,064	3.91
Pulses and grains	7,006	1.47
Oil Field Areas	3,711	0.72
Vegetables and Fruits	3,109	0.61
Plaintains and Bananas	2,503	0.51
Root Crops	2,227	0.43
Airport and Experimental Strations	517	0.10
Tobacco	420	0.18
Totals	512,829	100.00

Source: Chalmers 1992

Coupled with the increase in watershed degradation, is an alarming increase in erosion rates. One particular study on the slopes of the Northern Range demonstrated that erosion rates under natural forest are less than 0.5 ton/ha/yr, that grasslands erode at a rate of 5-10 ton/ha/yr, that cultivated lands may erode at a rate of 1-100 ton/ha/yr depending on the crop type, soil and slope and that bare soils have high erosion rates, usually in the order of 50 ton/ha/year.

The effects of soil erosion and watershed degradation have not been fully assessed. However, the impacts on the water resource include increased sediment yields in rivers and canals, and changes in the distribution of the total basin runoff over peak flows and baseflows. Sedimentation decreases the discharge capacity of rivers and canals, consequently resulting in increased flood risk. These increases in watershed degradation have been attributed to:

- Indiscriminate clearing and degradation of forests for housing and urban development, shifting cultivation and squatting
- Loss of forest and protective vegetative cover by forest and bush fires
- Quarrying operations and road construction on steep slopes; and
- Cultivation on steep slopes, without the application of appropriate soil and water conservation measures.

Land-Use Policy

There is no clearly articulated land-use policy for Trinidad and Tobago that is presented in a single document, instead various legislation exist which relate to land and water issues. The responsibility for administering these legislation is dispersed among several governmental entities such as the Town and Country Planning Division, the Water and Sewerage Authority, Lands and Survey Division and the Forestry Division. The following Acts relate to land-use and water resources:-

***Town and Country Planning Act (1969)*:** This is the principal legal instrument for regulating land-use in the country. It provides for the orderly and progressive development of land and gives power of control over land-use and its acquisition. Policy instruments are also available for restricting development below the one hundred metre (100 m) contour level, preserving trees and correcting injuries to any garden, vacant site or other open land.

Environmental Management Act No. 34 (1995): This Act is the legislative framework for comprehensive control and protection of the country's natural resources. It has a very important role in regulating land-use and land development, and the prevention and control of water pollution. The Act provides for the requesting of a Certificate of Environmental Clearance by developers before proceeding with certain types of activities. It also provides for the designation of environmentally sensitive areas in order to protect and/or conserve the nation's natural resources.

Water and Sewerage Authority Act (1965): This Act is intended, *inter alia*, to ensure the development and control of the water supply as well as to promote the conservation and proper use of water resources. It also provides for the making of bye laws to prevent the pollution of surface and underground water.

Waterworks and Water Conservation Act (Revised 1980): This Act provides for matters relating to the control and use of water in the country. It also provides for the making of regulations for the control of the supply and use of water in "Water Improvement Areas" and the prevention of waste or misuse of water in those areas.

State Lands Act (180): Provision is made for the management of all state lands: the prevention of squatting and encroachment, the prevention of injury to forests, and the settlement and allotment of State lands.

***Forest Act (Revised 1980)**:* Provides for the preservation of trees.

***Agricultural Fires Act (Revised 1980)**:* Provides for the prevention and control of agricultural fires.

2.5 Climate Change and Natural Disasters

Climate Change

Islands in tropical areas, such as the Caribbean, are highly vulnerable to natural disasters such as cyclones, earthquakes, volcanic eruptions, tsunamis and storm surges. They are also susceptible to floods and droughts. The potential for rising sea levels and adverse changes to climate provides an additional threat to small low lying islands and the low-lying coastal areas of larger islands.

Present climate variability, particularly associated with the periodic El Niño/La Niña episodes, has a large impact on water resources of islands. The impacts of present climate variability on groundwater resources of small islands are particularly noticeable. Extended droughts can lead to an increase in the salinity of normally potable water. Depending on the island's location, significant droughts are associated with either El Niño or La Niña episodes.

Ten (10) years ago, global mean sea level was predicted to rise between 0.5 and 1.5 m within the present century, as a result of global warming. A more recent review of sea level rise indicates that sea level is expected to rise by about 0.5 m by the year 2100, with a range of uncertainty of about 0.2-0.9 m. Rising sea level may have major impacts on the freshwater lenses in low-lying areas and coral reef areas of islands such as Trinidad and Tobago. Rising sea level can lead to a reduction of island width with a consequent reduction in freshwater lens extent and thickness. Based on observed data, current global sea level shows an increasing trend of 18 mm/decade or 0.18 m per century. The trend varies according to location with most tide recorders showing an increasing level while some show a decrease.

In addition to the potential for sea level rise, other potential impacts on climate patterns are changes to rainfall and evaporation patterns. At this stage, regional impacts at the scale of island groups are not well described but it is likely that rainfall will increase in some areas and decrease in others. The same is likely to occur in relation to evaporation. Changes to these two very important elements of the hydrological cycle will impact on the input to groundwater systems, namely, groundwater recharge. In turn, changes to recharge will directly impact on the sustainability of groundwater systems. If adverse impacts of decreasing long-term rainfall and increasing long-term evaporation were both to occur in one area then the impact on groundwater resources could be quite severe.

There is also the potential for an increase in extreme events, for example, an increase in extreme rainfall and more extended drought periods. The predicted impacts of global warming on these aspects, however, is not well described, particularly in tropical regions. Possible increasing frequency of storm events would undoubtedly have an impact on small lying islands and coastal areas of larger areas, increasing the potential for over-topping and erosion.

Small island states like ourselves are not significant contributors to the global warming effect driving the climatic changes expected but are likely to experience the effects of these changes more than those nations primarily responsible for the phenomenon.

The international community has agreed to a joint and systematic approach to the imminent danger of a climatic change. At the Summit held in Rio in June 1992, 154 countries, including Trinidad and Tobago, along with the European Community, signed the Framework Convention on Climate Change (FCCC) in a united effort to drastically reduce the emissions of CO_2 and other greenhouse gases. Trinidad and Tobago's Petrotrin Oil Company is actively involved in the Caribbean Planning for Adaptation to Global Climate Change (CPACC). This requires the Company to show an awareness of issues relating to climate change and the Clean Development Mechanism (CDM). Consequently, they are presently in the process of establishing its own Climate Change Institute.

With this move, they hope to demonstrate a clear commitment to sustainable development and greenhouse gas reduction and is striving to become the first major petroleum company in the developing world to take such an initiative.

The regional belt located between the Northern Range and the Central Range of Trinidad, often referred to as the Caroni Basin is considered most vulnerable to the impacts of projected climate change and sea-level rise. It is the most densely populated area of the country and also has a concentration of critical biodiversity extending from the coastal mangrove and swamp fringes to the forested Northern Range. Critical life sustaining facilities are located within this belt, in particular the greatest reserves of surface and ground waters which are used for supplying the entire island of Trinidad.

The Caroni Basin is already under threat from poor land use practices, including the deforestation of the Northern Range, which results in perennial flooding in the lower regions of the Basin. The fresh water resources within this region have been deteriorating rapidly due to pollution from a multitude of small-scale industries, particularly poultry rearing and quarrying. These are exacerbated by the increasing use of pesticides and fertilizers in agricultural holdings. Recent years have seen the near disappearance of the national bird, the Scarlet Ibis, from within the Caroni Swamp, due to the destruction of this habitat as a result of human interventions, such as illegal hunting and poaching and an increase in the density of drainage channels and thoroughfares.

Sea-level rise along the southwest coast of Trinidad would threaten critical areas such as the Point Lisas Industrial Estate, a major GDP provider. Seawater encroachment in the coastal regions of south-west and east Trinidad continues to be an engineering challenge. Such encroachment has often been accompanied by severe denudation of the coastal areas. Limited encroachment and erosion continues to be experienced in some coastal areas of Tobago.

The impacts of climate change and sea-level rise in the island of Tobago would have to be considered particularly in relation to the tourism industry, a critical component of which relates to the coral-reef resources of the island. Tourism represents a mainstay in the socio-economic development of the island.

For Trinidad and Tobago, sensitive sectors and exposure units in relation to climate change and sea level rise have been identified as:

Water Resources Sector

1. Ground Water (Coastal Aquifers Northwest Trinidad and Southwest Tobago)
2. Surface Water Systems (Caroni Watershed System)
3. Flood Management (Caroni Watershed System, Caparo and South Oropuche Basins)

Forests and Biodiversity

1. Upper Watersheds (Northern Range Forests)
2. Wetlands (Caroni Swamp, Nariva Swamp and South Oropuche Lagoon)
3. Ecospecies (Scarlet Ibis, Cocrico)

Agricultural Sector

1. Commercial Agriculture (Sugarcane, Coconuts, Citrus)
2. Subsistence Agriculture (Short-term Crops e.g. tomatoes, lettuce, melons)
3. Livestock (Cattle, Chickens)

Coastal Regions

1. Inundation and Flooding of Coastal Areas (Manzanilla/Mayaro)
2. Erosion (Manzanilla/Mayaro, Mosquito Creek, Los Iros)
3. Tobago Southwest Coast

Human Health

1. Insect Vector Diseases (Malaria, Dengue, Yellow Fever)
2. Respiratory Diseases (Senior Citizens and Children)

Urban Development and Housing

1. Population and Housing Densities (East-West Corridor, San Fernando and Arima)
2. Centralized Administrative Services (Port of Spain, San Fernando and Arima)
3. Land use patterns (Lower to Middle elevations of Northern Range)

Marine Resources

1. Commercial Fisheries (Erin, Cedros, Mayaro, Maracas/Las Cuevas, Carenage, Charlotteville)
2. Subsistence Fisheries (Erin, Cedros, Mayaro, Maracas/Las Cuevas, Carenage, Charlotteville)
3. Coral Reefs (Bucco, Tobago)

Major and Minor Industries

1. Industrial Estates:- Petroleum, Petrochemicals, Iron and Steel (Point Lisas, Point Fortin, Trincity, Arima, Beetham)
2. Tourism (Tobago, Chaguaramas)
3. Transportation Sector (Transits along Sir Solomon Hochoy Highway, Churchill Roosevelt Highway and Eastern Main Road

In assessing the possible impacts of climate change and sea level rise on systems within Trinidad and Tobago, the following scenarios are considered:

Climate and Sea Level Scenarios

- Temperature rise of 1.0 to 3.5 °C through to 2100
- A sea-level rise of 15 cm to 95 cm higher than 1990 figure through to 2100. A mean sea-level rise of 30cm by 2050
- Rainfall deficit of 15% by 2100

Environmental and Socio-economic Scenarios

- Population projection to 2050 of 2.1 million
- Accelerated major industrial water demand to the year 2025
- Accelerated irrigation demand to the year 2025

- Increase in tourism water demand
- Increase in potable water demand
- Increase in water demand from the health sector
- Economic projections uncertain in light of the future of oil
- Developing strong non-oil sector

Possible impacts of climate change and sea-level rise within Trinidad and Tobago include:

Water Resources Sector

- Ground Water: Salt Water intrusion in Coastal Aquifers negatively impacting on the national water supply. Reduced rainfall would produce less ground water recharge.
- Surface Water Systems: Temperature increases evapotranspiration rate, which together with less available precipitation will negatively impact on storage in reservoir systems.
- Water Demand: Greater overall demand and less per capita water availability. To meet rising water demand, over-abstraction from aquifer systems with the accompanying risk of irreversible damage to such systems.

Human Health

- Insect Vector Diseases: Increases in temperature and humidity could lead to population growth of species such as the *Aedes aegypti* mosquito which could result in outbreaks of dengue fever and malaria.
- Respiratory Diseases: Temperature increases could stress the elderly and very young.

Urban Development and Housing

- Population and Housing Densities: There is no data to suggest that climate change and sea level rise would affect this exposure unit
- Centralized Administrative Services: No data available at present
- Land use patterns: Sea level change can cause a change in land use patterns.

Agricultural Sector

- Commercial Agriculture (Sugarcane, Coconuts, Citrus): A rise of 1°C in minimum temperature leads to approximately a three (3) tonnes per acre

decrease in sugar production. No data is available at present on coconuts and citrus.

- Subsistence Agriculture (Short-term Crops): Temperature rise can negatively impact on yields of short-term crops
- Livestock (Cattle, Chickens): No data available at present

Biodiversity

- Wetlands Management: Sea level rise would impact negatively on wetlands and ecospecies due to intrusion of saline water further inland.
- Forestry (Commercial): No data available at present
- Coral Reef Management: Temperature increases could kill reefs
- Wildlife Management: Temperature and sea level rise would stress wildlife

Flooding

Flooding in both urban and rural areas in Trinidad and Tobago is a frequent occurrence, leading to substantial losses of property, crop damage, health problems and severe inconvenience of whole communities. Some of the factors contributing to those conditions are easily identifiable and could be avoided, particularly in the urban setting. In Trinidad, in particular, such factors include the indiscriminate dumping of refuse and discarded material into streams and improper or illegal land development and agricultural practices, particularly in the upper reaches along the foothills of the Northern Range. The alleviation of flooding in the flood plains of the larger rivers such as Caroni, Caparo, North Oropuche and South Oropuche calls for substantial capital investments which may not be available within the short term.

Flooding has continued perennially throughout Trinidad, particularly flash-floodings along the east-west corridor at the foothills of the Northern Range and in the Caparo and South Oropuche Basins, moreso in recent years. There is generally an increasing concern about an apparent inability of the public authorities to institute satisfactory measures of flood control based on drainage engineering designs. Within recent years the concept of flood management has been assuming greater significance where recognition is being given to the integral link between the flooding problem and management of our watersheds, particularly in the upper regions. Greater efforts are also being placed on the integrated water resources management approach where linkages are being sought between drainage, water supply, irrigation and other water resources sub-systems in project implementation, as is being attempted for the ongoing World Bank sponsored Caparo Basin Flood Mitigation and Water Resources Management Project.

In a first effort at the management of flooding disasters, the National Emergency Management Agency (NEMA) is currently leading an initiative, supported by the Water Resources Agency (WRA), to establish a community based flood warning system within the Caparo Basin. The effort incorporates the development of flood plain maps and models to be used for providing warnings to the communities within the basin based on ongoing monitoring of the hydrometric network within the basin. The WRA will be primarily responsible for the automatic monitoring system centred on its rainfall and streamflow telemetry systems within the basin.

A lot needs to be done by way of Public Awareness and Public Education programmes to sensitize the general public on their individual and collective responsibilities in this critical area in particular and on the broader issues of protection and conservation of our water resources. For instance, in Trinidad and Tobago, there does not seem to exist an understanding that inappropriate actions, such as deforestation, unplanned and improper housing development and inappropriate agricultural practices, taken within the upper regions of our watersheds can negatively impact on downstream areas including our coastal zones. Problems like sedimentation of our coastal areas at the outfalls of watercourses require expensive engineering and maintenance solutions like dredging which can in turn have serious negative environmental impacts, as was the case with the dredging carried out close to the Caroni River outfall in the mid 1980's. The dredged material was improperly disposed within a vast stretch of the surrounding mangrove fringes which resulted in the death of not only the mangrove system but also several species resident within this habitat.

In Trinidad and Tobago, flood studies seem to have been undertaken on an ad hoc catchment by catchment basis. Generally such studies have not been placed within an overall integrated framework. There exists a highly inadequate database on flood occurrences and their parameters such as frequency levels and extent of damages, financial or otherwise. Rough flood plain maps have been developed for some regions by the WRA but these have to be completed and extended to cover the entire country. To have some idea of the scale of the impacts associated with flooding in Trinidad and Tobago, for the single event flood of 1993 within the Caparo Basin, damages were estimated at US $581,000 and 9,800 persons were affected directly. Much still needs to be done by way of quantifying such events throughout the country.

Earthquakes

Trinidad and Tobago lies within an active earthquake zone but generally in recent years there has not been significant widespread damages arising from the occurrence of such events, which are frequent in nature but mild in most instances. A significant level of damages occurred in Tobago with the earthquake event of 1996. In the instance of the physical water resource system, slight shifts occurred in relation to the underground aquifers resulting in the

emergence of springs at several points and an increase in the overall natural flows from the groundwater system. Since then, there has been a subsidence in the flow activity, which has returned to normal levels. There have been no reports on the impacts of earthquakes generally on coastal zones within Trinidad and Tobago.

Oil spills

Because of its petroleum-based industry, Trinidad continues to have a higher risk of occurrence of oil spills both inland and within its coastal and marine regions. In fact, serious spills have continued to occur up to as recent as the year 2000. Such spills have had short term damaging impacts on the coastlines, particularly within the Gulf of Paria. The beaches of Vessigny, La Brea and Mayaro in the south of Trinidad continue to be affected by the presence of petroleum based residues emanating from the nearby oil industries and oil tankers.

Tropical Cyclones

Trinidad and Tobago is situated on the southern fringes of the Atlantic Tropical Cyclone Tracks. As part of the North Atlantic/Caribbean region its official hurricane season runs from June 1 to November 30. Although Trinidad is less vulnerable than other Caribbean islands, it can be hit by tropical cyclones. Tobago is however much more vulnerable even though it is only 35 km north east of Trinidad.

As reported by the Meteorological Office, of the thirty-four (34) cyclones which affected the country during the periods 1725 to 1847 and 1878 to 1993, twenty-six (26) cyclonic disturbances affected Tobago, and thirteen (13) Trinidad. The most significant cyclonic event in Trinidad and Tobago was Hurricane Flora in 1963. Of the 7,500 houses in the island of Tobago, 2,750 were destroyed and 3,500 damaged. There was no significant damage to the healthcare facilities. Total damage in the two islands amounted to US $4.8 M.

The most recent cyclonic disturbances (1993-1994) were:-

- Tropical Storm Bret which occurred on August 6-7, 1993. Losses were minimal because the storm's centre passed through the channel separating both islands.
- Tropical Storm Debbie of 1994 which produced rainfall in the North and in Tobago.
- Tropical Storm Pablo of 1995 which produced heavy rainfall on the East Coast(including landslides) and East-West Corridor.
- Tropical Storm Iris of 1995 which produced rainfall on the West Coast.
- Tropical Storm Jose of 1999 which produced rainfall on the East Coast.

Tornadoes

Prior to 1988 there was doubt that tornadoes could occur in Trinidad, although there were previous report of damage done by strong whirlwinds. Over the past six years damage due to whirlwinds was reported in the south of Trinidad. The first recorded tornado occurred in October of 1988, in Central Trinidad causing an estimated damage of US $95,200.00 to twenty-four (24) buildings.

The occurrence of tornadoes in the island of Trinidad is apparently very infrequent. These tornadoes are estimated to be of an intensity of F 0.5 to F1 (expected damage, light to moderate) on the Fujita Scale. Present data on tornadoes does not permit the estimation of any quantitative recurrence interval.

2.6 Transboundary Threats

Trinidad and Tobago is a twin island sovereign nation and by virtue of this no Transboundary threats exist within its land areas.

2.7 Pollution

The land based water bodies in Trinidad and Tobago comprise rivers/streams, reservoirs and aquifers. These water bodies fulfil a wide range of uses including potable water supply, irrigation, recreation, religious rituals, waste disposal, small-scale transportation, ecosystem support and aesthetics. This heavy multiple use of the resource is occurring without a suitable water quality management framework, resulting in significant negative water quality impacts.

One of the most important issues contributing to watershed depletion and water pollution has been the lack of enforcement of environmental legislation. Although there has been some historical background on environmental legislation with at least one hundred and twenty-four (124) environmental law references dating back from the 1950's and 1960's, there has been little enforcement because of:

- Few environmental officers
- No qualitative standards i.e. the legislations are vague and difficult to strategically enforce and
- The spread of these historical laws among forty (40) different agencies.

The factors and activities, which impact negatively on the water quality in Trinidad and Tobago, are many and varied. These factors are usually the result of human activity, however, natural activities such as weathering of rocks and natural disasters (floods, storms and earthquakes) also contribute to the deterioration in water quality. The major pollutants found in the nation's water systems are solids (measured as total suspended solids), organics (measured as

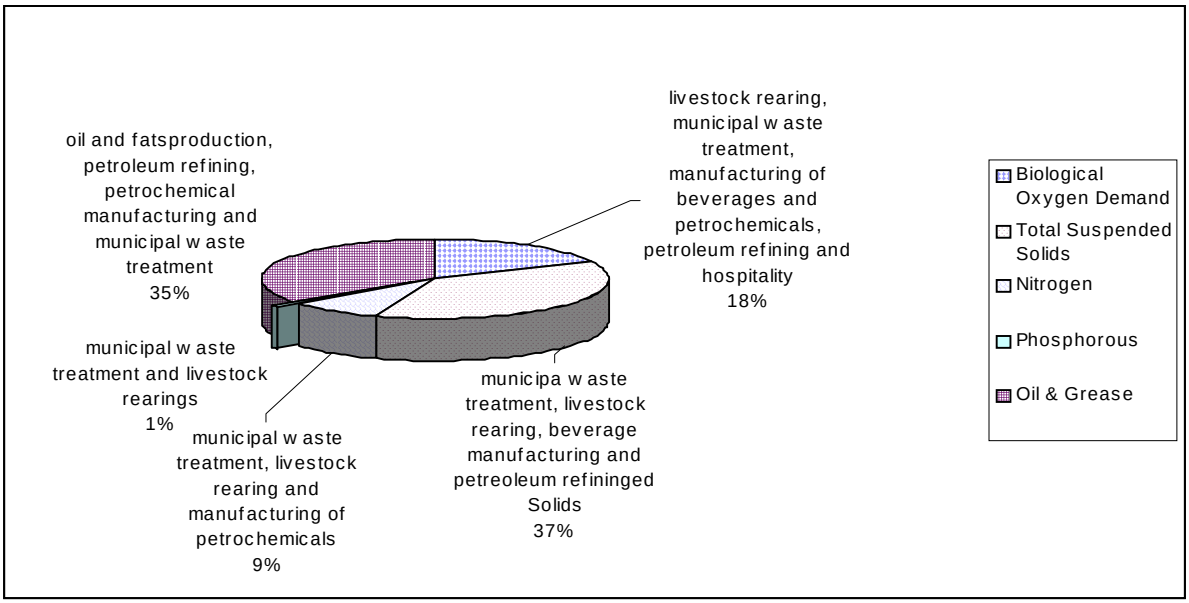
biological oxygen demand), oil and grease, nitrogen and phosphorous. The relative percents of these pollutant loads and their sources are shown in Figure 2.3

SurfaceWater Quality

WASA's Water Quality Monitoring at Intakes

The most extensive water quality monitoring in the country is conducted by WASA through its routine samplings at all surface water intakes. The sampling although limited in scope gives some idea of the state of the resource at critical water supply locations. Over the years it has been shown that the surface water bodies are affected by high levels of organic material (expressed as BOD), pathogens (expressed as faecal coliform) and solids (expressed as turbidity). Table 2.8 shows data from this sampling regime for the year 1995.

Figure 2.3 Contribution of Individual Pollutant Loads and Their Pollutant Sources



Source: Environmental Management Authority 1998

Table 2.8 Average per river of the mean 1995 concentrations for WASA sampling locations

Substance	BOD	Ortho Phosphate	Total P	DO	FC	Free N	Settleable Matter	Total NFR
River	mg/l	mg/l	mg/l	mg/l	nr/ per 100 ml	mg/l	mg/l	mg/l
North Oropouche	0.9	0.04	0.19	7.4	770	0.2	0.02	25
Caroni (main)	9.8	0.24	0.55	4.5	122 885	0.9	0.14	29
Caroni (trib.)	10.5	0.27	0.57	4.9	144 850	0.9	0.16	17
Couva	23.0	0.07	0.34	6.4	15 120	1.9	0.44	145
Guaracara	15.0	0.08	0.35	4.7	25 350	1.6	0.30	69
Cipero	342.5	0.17	0.50	3.1	171 213	1.5	0.94	66
South Oropouche	3.9	0.05	0.37	5.5	16 367	0.5	0.06	225
Average all locations	58.1	0.16	0.46	4.9	88 486	1.0	0.27	78

LEGEND: BOD- Biological Oxygen Demand
DO- Dissolved Oxygen Concentration
NFR- Non Filterable Residue
P- Phosphorous
FC- Faecal Coliform

Caroni River Basin Water Quality Studies

Most of the water quality studies in the country have been restricted to the Caroni River Basin. The intensity of work done in the basin is attributed to its importance as the major water-producing basin in the country. The Caroni River is one of the major rivers in Trinidad, being almost 35 km long, from its mouth at the Gulf of Paria and having some fourteen (14) associated tributaries. It is the main source of potable water in the country, with the Caroni Water Treatment Plant being the largest potable water treatment facility. There are two main industrialized areas along the Caroni River. For most of its length, the Caroni River flows through sugar cane fields with sporadic settlements. Two major water quality studies (1997 and 1999) were conducted in the Caroni River Basin.

The study of 1997 was conducted on the drainage area above the Caroni Water Treatment Plant. It showed that total solids accounted for eighty-eight percent (88 %) percent of the total pollutant load, while organics accounted for ten percent (10 %) and nutrients for two percent (2 %). The origins of the individual pollutants were identified as follows:

- Nitrogen(ammonia) — Mainly from the flushing of soil constituents
- Nitrogen (nitrates) — Mainly from point source (municipal and industrial) discharges.
  Soil constituents may also be a minor source.
- Nitrogen(nitrites) — Mainly from point sources and soil constituents
- Biological Oxygen Demand,
  Oil and Grease

- Total phosphorous
- Solids — Mainly from particulate matter derived from sheet erosion, bed mobilization and the flushing of soil constituents

Most of the rivers in the study area were found to be polluted with agricultural, industrial and domestic wastes as wells as poor land use practices.

The study of 1999 involved a comprehensive assessment of the water quality of the Caroni River and its tributaries. Monitoring of the Caroni River during the wet season showed a progressive increase in pollutant levels from the upper Caroni river, mid Caroni river to lower Caroni river. There were increases in levels of ammonia, BOD_5, chlorides, nitrites, phosphates, total and faecal coliforms. Consistently low dissolved oxygen levels and high BOD_5, total and faecal coliforms were indicative of considerable organic pollution in the Caroni River. Elevated levels of hydrogen sulphide and the foul smell of this gas were consistent with the anoxic condition of the Caroni River. Continued monitoring of the Caroni River for dry season showed a similar trend to that of the wet season. There were progressive increases downstream in BOD_5, nutrients, total and faecal coliforms with consistent lowering in dissolved oxygen. The anoxic condition of the Caroni River, as a result of its extensive pollution, makes the water quality extremely poor.

Data obtained from the study showed that suspended solids accounted for 74 % of the pollutant loading of the water treatment plant. Chlorides accounted for 18 % while both BOD_5 and organic nitrogen accounted for 4 %. Nutrients and phosphates accounted for less than 1%. BOD_5 pollutant load into the Caroni Swamp accounted for 17 % as opposed to 4 % in the water treatment plant. The higher levels of BOD_5 were largely attributable to the release of untreated effluents from distilling and brewing industries into the rivers of the Caroni River Basin.

In general the water quality studies in the watersheds of the Caroni River basin identified the major activities affecting the catchments as quarrying, industrial and domestic waste discharges, and domestic dumping of solid waste. The water quality problems were attributed to:

- Untreated effluent discharges by households and industry
- Limited waste water treatment capacity
- Low efficiency of existing waste water treatment facilities
- Lack of sewer systems and only a small fraction (40%) of households connected to available sewers
- Surface runoff (turbidity)

Oil Related Pollution

There have been several incidences of inland oil spills, in the southern one-third of the island that had resulted in severe pollution of the waterways in these areas. These spills often emerge within the coastal areas causing substantial damage to the mangrove and beach areas. Specific areas affected on a continual basis over the years are located in the South East and the South West of the island.

Recent efforts by the Local Ministry of Energy to limit such damage through the enforcement of clean-up actions by the polluters have had some, however limited, success to date.

Chronic oil pollution is not as severe a problem, however, the chronic discharge of oilfield brines from producing wells has changed the salinity of several small waterways and thus their natural environment. The impact of this form of pollution on coastal zones is considered minimal.

Activities That Affect Water Quality in Trinidad and Tobago

There is no comprehensive assessment of the quality of the water resources of the country. Instead a number of independent studies of varying levels of reliability have been carried out. Consequently the qualitative results of these studies together with expert opinion and the results of the Caroin River Basin water quality studies has been synthesized in order to arrive at an overview of the quality of the surface water resources of Trinidad and Tobago. The overview shows a dominance of relatively low water quality in the central and western part of Trinidad, while the northeastern part of Trinidad and the island of Tobago have relatively high water quality levels. The activities that affect the water quality and the aquatic environment are watershed degradation, modification of the hydrological regime, discharge of chemicals, disposal of sewage and farm wastes, and the dumping of refuse and solid wastes.

Watershed degradation: Watershed degradation is one of the major sources of water quality and aquatic-ecosystems impairment in the country. The WRM study has shown that 5.8 % (282.2 sq km) of the land in Trinidad requires soil and water conservation while 23.2 % (75.2 sq km) of the land in Tobago require soil and water conservation. The 1960 erosion status (no update is available) shows that 15 % of the catchments in Tobago had lost their entire topsoil and 42 % lost more than half of their topsoil, while for Trinidad the figures were 1 % and 10 % respectively. Watershed degradation has contributed to increased sediment yields, increased turbidity, and reduction in stream flow capacity. The relatively large increase in watershed infiltration through squatting, slash and burn agriculture, growth of elevated residential areas and logging has had a dramatic impact on the erosion status in the past forty (40) years. This has been most severe in the western areas of the Northern Range in Trinidad.
Modification of Hydrological Regime: Modifications of the hydrological regimes through structural and engineering works have also affected the water quality. These activities include the paving of waterways, channel realignment, diversion of

watercourses, location of residential (housing) settlements and over-pumping of aquifers. The major effects are drying out of watercourses and salt water intrusion in coastal aquifers, swamps and waterways. Also, the water wells along the East- West Corridor in Trinidad have been most severely impacted upon.

Discharge of Chemicals: Chemical pollution of the water resources result from agricultural, industrial and household activities. Occasional fish kills in rivers have been attributed to the excessive use of agrochemicals. The increasing use of cleaning agents in households is also contributing to the decline in water quality in the country.

Trinidad and Tobago is one of the most industrialised countries in the region. Its industries range from sugar and oil refining, rum distillation, manufacturing of petro-chemicals, paint and metal finishing, and agroprocessing. The impact of industrial effluents on the water resources is predominant along the foothills of the Northern range and the western coast of Trinidad. Industrial activity in Tobago is relatively small, being concentrated in the south-west and central parts of the island. Effluents from oil and sugar cane refining particularly affect the rivers in south Trinidad. Other areas in the country are also affected by petroleum products, which are discharged into the water courses from leaking tanks, washings, and improper disposal of waste oils. It is estimated that 75% of petroleum products discharged into the environment originates through the improper disposal of vehicle oils in open drains. The very high ratio of vehicles per 1000 persons in Trinidad coupled with the fact that 75% of all gasoline driven vehicles use leaded gasoline has lead to the widespread contamination of waterways by lead pollutants.

Disposal of Sewage and Farm Wastes: A preliminary estimate has indicated that approximately one hundred and ninety-five (195) sewage treatment plants exist in Trinidad and Tobago, of which only twelve (12) are operated by the Water and Sewerage Authority. Most of these treatment plants operate inefficiently, producing effluent, which exceeds the standards for faecal coliform and biological oxygen demand.

Non-functional sewage treatment plants, livestock farms and overflowing septic tanks, and pit latrines discharge significant quantities of organic waste into the nation's waterways. Farm waste has been estimated to produce over fifty-five percent (55 %) of the total waste load (Table 2.8) above. Serious contamination of over four (4) waterways has been attributed to primarily farm waste.

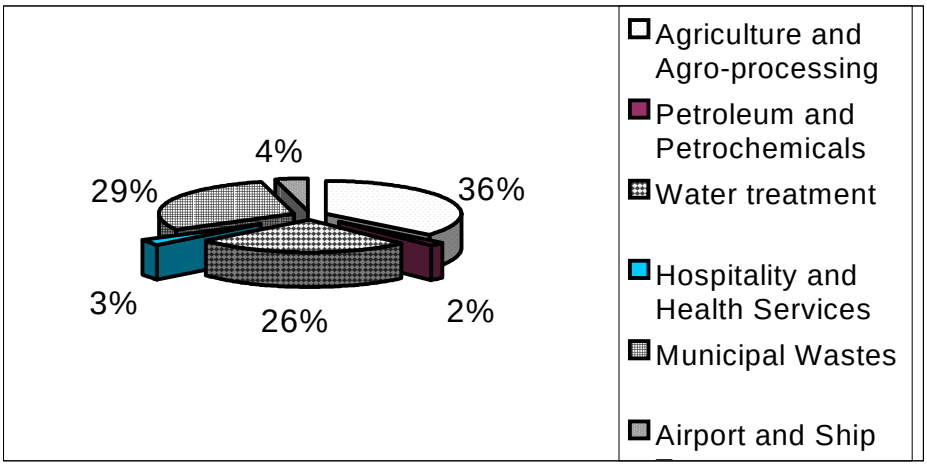
The total domestic and livestock waste for Trinidad and Tobago was estimated as 10.4 million killograms/year with 45 % being contributed from domestic sources and 55 % from livestocks. Table 2.9 shows the annual pollutant loads for biological oxygen demand (BOD), suspended solids, nitrogen and phosphorous. It must be noted that Tobago accounts for four percent (4 %) of both the domestic waste and livestock waste.

Table 2.9 Waste Load Produced/Discharged for Trinidad and Tobago

Source	Type of Load	BOD (x 1000 kg/yr)	Suspended Solids (x 1000 kg/yr)	Nitrogen (x 1000 kg/yr)	Phosphorous (x 1000 kg/yr)
Domestic	Produced	19,371	114,073	3,300	825
Livestock	Produced	39,444	105,980	3,460	562
Domestic	Discharged	1,438	2,593	492	131
Livestock	Discharged	197	5,299	173	28

Domestic Refuse and Solid Wastes: Substantial quantities of domestic refuse and solid wastes are disposed in the watercourses of Trinidad and Tobago. This waste comprises animal entrails, chicken feathers, faeces, used containers and bulky household items. Domestic refuse and solid waste not only clog the waterways and produce offensive odours, but may also dissolve to produce chemical residues which lower water quality. Figure 2.4 summarises the sources of solid waste in Trinidad and Tobago.

Figure 2.4 Summary of Significant Sources of Solid Waste



Source: Environmental Management Authority 1998

In summary the ambient water quality of Trinidad and Tobago is affected by both land use and water use. The most significant factors that contribute to the deterioration of the water quality are:

- The release of high loads of organic material, toxic pollutants and pathogens from domestic and industrial sources
- Considerable loads of solids (expressed as turbidity and suspended sediments concentrations), which are generated from indiscriminate and uncontrolled quarrying activities, deforestation, sewage discharges and solid waste dumping

- Excessive use of agrochemicals resulting in high levels of nutrient, pesticide and heavy metals being discharged into surface water bodies

Groundwater Quality

In general, the quality of groundwater in Trinidad and Tobago is quite good. However, each groundwater system has its own peculiar water quality problem. Aquifers of the Northwest peninsula Gravels and Limestones usually meet WHO standards, however well fields near limestone lenses may have hard water, with calcium carbonate values of up to 325 mg/L.

Contamination of aquifers by salt water intrusion have been experienced in the groundwater systems of both the Northwest Peninsula Gravels (Port of Spain/Cocorite),the Northern Gravels (El Socorro) and in the Mayaro Sandstone (East Coast of Trinidad). Largescale drawdown on the Northern Gravels due to population increase along the east-west Corridor has decreased water table levels in this area. This drawdown has been assisted by deforestation of the surrounding watershed forests and widespread change of land-use into housing settlements. The net effect of these activities resulting in the decrease of percolation and ultimately aquifer replenishment rates.

High Nitrate levels were detected at various times in the Port of Spain and Valsayn Gravels. These high levels have been attributed to leaching from nearby cemeteries.

Although the groundwater in the Central and Southern Sands are of good quality, high iron contents ranging from 8 to 11 mg/L have been recorded.

2.8 Tourism

Over the past years the Government of Trinidad and Tobago has started to focus its energies on developing the tourism sector of the country. This came as a means to diversify the country's dependency on the petroleum sector for a viable economy. In order for the tourism industry to flourish there was need to create a sustainable tourism sector that provided a source of economic and social benefits. One of the first steps that the Government had to take was to identify the natural resources that can be used to attract the tourist and then to develop such resources in order to make them competitive on the international market. The next step would be to create effective promotion and marketing skills in the major consuming centers of the world.

Trinidad and Tobago comprises a large biodiversity of exotic flora and fauna ranging from rainforest and mangrove forest to freshwater swamps and coral reefs as well as mammals such as the endangered manatee and the red and blue macaw. Consequently, these areas are earmarked to be protected areas or

national parks. However, proposals were made since the early 1980's and nothing has been done to date. Tourists coming from the countries of Latin America, North America and throughout the rest of the world are very interested in these types of eco-tourism adventures. They are interested in the rainforest and the wide variety of birds, monkeys, reptiles, snakes and other animals as well as the flowers and different types of plant species that exist there.

As a result, the Government of Trinidad and Tobago has developed National Parks in areas such as Clever Woods, San Fernando Hill and Vega de Oropuche together with a nature reserve at Asa Wright and a wildfowl trust at Point at Pierre, these are just to name a few. Hence, in these areas almost pristine conditions were to be maintained. This could only be achieved with proper watershed management, well maintained facilities, tree cover maintenance, the prevention of forest fires and proper disposal of waste of any kind (not in streams and waterways).

In creating an almost pristine natural environment for the tourist the vegetative cover of the areas are maintained and as a result the soil is protected thereby reducing soil erosion and flooding. The ability of the forested area to be a good recharge area to an aquifer system is great and water resources management is achieved. Selling the natural habitat can be beneficial to the tourist, the one who sells the environment and the flora and fauna of the country. The tourist benefits from the aesthetics of nature, the one who sells benefits from the economic value of the product (he has to ensure the sustainability of the product) and the wildlife as well as the vegetation are being saved and preserved for their inherent beauty and value. The balance of nature is hardly touched and watershed management is attained.

However, major developments in these areas e.g. large hotels and golf courses for the tourist industry will have adverse effects on the management of the watershed. Removal of a large percentage of vegetative cover will lend to flooding, soil erosion, destruction of habitat and poor aquifer recharge. Therefore, policies have to be developed to monitor any such activity and the potential effects that they might have. Here proper watershed management plays its role.

In 1997 the Government proposed policies to develop the Eco-tourism potential in the country as well as other tourism-related projects.

2.9 Health

The health of the environment and its inhabitants depend on proper watershed management. The major health concerns related to watershed management are with respect to the quality of the water. Poor water quality can be directly contaminating to humans when they consume water containing high levels of toxic chemicals, heavy metals or bacteria and viruses from sewage.

Contaminated water poses the indirect threat of harbouring many water-borne, water-washed, water-based and water-related diseases. Some of these are presented here:

- Water-borne diseases: They are contracted when drinking water is contaminated with human or animal faeces. Such diseases caused are enteric fever, diarrhoea, poliomyelitis and Ascariasis.
- Water-washed diseases: The unavailability of water causes an inability to keep things clean and causes diseases such as Tracoma and Leishmaniasis.
- Water-based diseases: Water provides a home for host organisms in which certain parasites spend part of their life cycle; when this host organism is ingested by a fish or freshwater organism it can be passed up through the food chain on to humans. Such diseases are Schistomiasis and Dracunculiasis
- Water-related disease: Some disease-carrying insects rely on water as a habitat. In this case disease contraction in humans occurs through indirect contact with the same insects. They cause diseases such as African trypanosomiasis, elephantiasis, yellow fever, dengue fever and malaria.
- Water-dispersed infections: Infectious agents which thrive in water are inhaled into the respiratory tract of humans with minute water droplets causing diseases such as Legionella.

In Trinidad and Tobago, there is poor disposal of waste e.g. faecal matter, toxic chemicals, industrial waste, domestic waste, pesticides, solid waste and dead animal waste into the environment. The situation poses serious threats to public health and therefore warrants much concern. Sewage contaminated water contains bacteria and viruses which transmit diseases such as cholera (e.g. through shellfish) and typhoid fever, hepatitis A, polio and gastroenteritis.

Certain segments of the population face threats of diseases like cholera, dysentry and gastroenteritis when they come into contact with contaminated and untreated water. Pesticides and insecticides that are used in agricultural plots can be washed into streams during heavy rains and either by themselves or as a result of synergism can prove harmful to the inhabitants within the watersheds. Some fish or other edible creatures may also bio-accumulate such chemicals and when eaten by man can prove to be harmful or even fatal.

In the poorer areas of the country pit latrines which, if not constructed properly will result in the seepage of faecal waste into the nearby soil and rivers or in some cases where the water table is high result in contamination of the groundwater systems. This could have deadly consequences as these waters may be used for drinking, bathing, watering produce and cooking.
Proper watershed management practices need to be adopted throughout the country. People need to be educated on the consequences of their actions and to

take pride in protecting the environment. There must be control measures put in place to stop the indiscriminate disposal of any type of waste product, be it organic or inorganic. Solid waste disposal systems and garbage disposal systems ought to be upgraded. Proper watershed management and waste disposal practices will not only protect human health, but also reduce the costs of water treatment.

In Trinidad and Tobago there is no regulatory framework that deals with the effective disposal of hazardous waste. However, some legislation exists within the various laws to deal with the matter. Nevertheless, serious threats to the environment and human health still exist and a means to remedy this situation is needed urgently.

2.10 Data, Information Management and Research

The following is an assessment of the programmes, systems, equipment and data/information pertinent to the management of the water resources/watersheds in Trinidad and Tobago:

Hydrometric Network

Trinidad and Tobago is sub-divided into fourteen (14) hydrometric areas; nine (9) in Trinidad and five (5) in Tobago. A hydrometric area comprises a number of watersheds for the purpose of hydrometric studies with the hydrologic boundaries corresponding to the surface water divides. Data on the climate, groundwater and streams are collected on each watershed using manual and automatic recording gauges.

Currently there are approximately thirty-one (31) streamflow gauges, two hundred and twenty-two (222) recording and non-recording rainfall gauges, ten (10) class 'A' pan evaporation stations and over three hundred and fifty (350) observation and production wells. Water levels are measured at five (5) reservoirs; four (4) in Trinidad and one (1) in Tobago. Limited ad hoc water quality sampling analysis is carried out at all measured streams and also at other selected streams.

Flood Data

Fifty-nine (59) crest gauges have been installed in the flood prone areas of some rivers. The levels have been related to mean sea level, and serve to provide measurements of flood levels, which contribute to the preparation of flood plain maps. Flood plain mapping commenced in 1981, and over the last twenty (20) years this data has been collected for seventeen (17) areas. However the data for the historic floods do not include either the flood return period or the associated storm return period. Flood peaks above measured flows are estimated using channel slope and Manning's equation. These flood studies have been

undertaken on an ad hoc basis for a few basins, as a result a country wide map with the extent of flood plains and depth of flooding is not available.

Drought Data

Although the collection of historical drought data is not of major emphasis, the following related data are collected on a routine basis:- minimum daily stream flows, average dry season, wet season and annual rainfalls.

Data Capture

Data collected on charts are digitized and the digital data analysed and stored in flat files or entered into databases for manipulations. Other hydrological and hydrogeological data collected are entered into databases manually or in spreadsheets, some data are provided in digital copy. Data are also collected by other institutions e.g. The University of the West Indies (UWI), Caroni 1975 Limited and the Meteorological Services. This data is made available to the Water Resources Agency (WRA) on a mutual-sharing basis.

A telemetry system with state of the art remote terminal units (RTU) is presently being installed to facilitate the transfer of data from remote stations directly to the central office. There is a total of eighty-one (81) RTU's distributed across the watersheds of Trinidad and Tobago comprising twenty-eight (28) recording rain gauges, twenty (20) streamflow gauges, six (6) evaporation, one (1) combination (rainfall and streamflow) and nine (9) groundwater in Trinidad. In Tobago there are four (4) recording rain gauges, six (6) streamflow gauges and three (3) evaporation remote terminal units. This would supplement the manual gauges allowing data from the field to be transmitted directly to the office for processing in the shortest possible time frame. Progress on the operationalization of this system has however been slow and is yet to produce the desired results.

Data Manipulation

Digitizing equipment and special software developed for this purpose are utilized in converting and correcting the data captured on charts. A Geographic Information System (GIS) is being utilized to supply a Decision Support System providing spatial analysis of the hydrological and hydrogeological data. GIS links spatial data with geographic information to provide the tools needed to make both aspatial and spatial queries. Coverages of the hydrological networks (streamflow, rainfall crest-gauges, wells), river network, hydrometric areas, watersheds, pipeline network, hydrogeological nework coastline and soils are available. This area has progressed slowly due to limited resources.

A database developed by the Institute of Hydrology in Wallingford, England for storing hydrological and hydrogeological time series data "HYDATA", is

utilized for processing, analysing and archiving of streamflow data. Presently, there is no database for groundwater data. In-house spreadsheet type applications are utilized for processing and storing of other hydrological parameters.

Annual data reports giving summary statistical data on each catchment such as drainage area characteristics, daily mean discharges, monthly flow summary, instantaneous peak flows, daily and monthly rainfall, depth area curves, isohyetal maps, groundwater levels, production data by wellfield, network maps and trend plots are available.

Watershed Management

Watershed management is presently the responsibility of the Forestry Department, with WRA and WASA having limited responsibility for downstream resource management. Integrated watershed management as initiatives proposed in the National Physical Development Plan (1989) and the National Forest Resources Plan (1990) have had limited success and watershed management programmes have concentrated on the western side of the Northern Range in Trinidad, and to a limited extent in Tobago. The watershed management activities usually involve:

- preparation of land capability maps in which slope and soil erodibility are used to demarcate the land into areas for protection forest, production forest, agro-forestry, agriculture with and without soil and water conservation measures
- reafforestation of denuded sloping lands
- construction of small-scale soil and water conservation structures

The data collected include land-use from aerial photographs, soil type and erosion status, slope, and growth rates of vegetation for reforestation.

Data Records

Of the thirty-one (31) streamflow stations, twenty-seven (27) in Trinidad and four (4) in Tobago, streamflow data exist for only three (3) stations with over twenty (20) years of continuous records and nine (9) other stations with between ten (10) to twenty (20) years of continuous records.

Daily rainfall data in excess of seventy-five (75) years exist for some sites in Trinidad with one (1) station, Botanic Gardens, having over one hundred (100) years of data. The majority of rain gauges are situated in the Western Peninsula and Caroni catchment. In Tobago the records indicate on average over thirty (30) years of records.
Suspended sediment data are collected on an irregular basis at a few streamflow sites and sediment /discharge curves are available in special reports from the

WRA. However, limited information is available on sediment delivery ratios as the frequency of sampling is on average one (1) per year.

Water quality data is available from the WRA, WASA and other organizations such as the EMA and Institute of Marine Affairs (IMA), however, there are no systematic waste water discharges monitoring programmes in any river basin except in the Caroni River Basin upstream of the water treatment plant.

Soil erosion data although not collected on a continuous basis is available from the UWI and consultants working on special projects in selected areas. A soil map produced and printed by the Surveys Division is available giving soil categories, slope and other related information. This map indicates that a significant amount of erosion has taken place with 15% topsoil erosion in Tobago and 42% lost in Trinidad. The watersheds on the south facing slopes of the Northern Range are heavily eroded except in the Poole basin to the east.

Land use information is available from the Town and Country Planning Division in GIS map format and paper based maps prepared from aerial photographs. Land capability information is limited to the potential of the land/soil for agricultural uses. In addition data is also available from the UWI, Planning Division and the Ministry of Agriculture Land and Marine Resources.

Research Projects

The Drainage Division of the Ministry of Works and Transport has the responsibility for flood alleviation works and river channel maintenance. A number of programmes, studies, projects are undertaken on their behalf to address the problems of flooding in areas such as Caroni, Cipero, Marabella, Vistabella, North Oropuche, Guaico and Caparo. One such project "Caparo River Basin Flood Mitigation and Water Resources Management Project" comprises a number of research initiatives, management and operational plans and construction activities.

Projects which incorporate research elements on other watershed management issues such as water quality have been undertaken with funding from World Bank e.g. "Caroni Water Quality Monitoring Project" undertaken by the Institute of Marine Affairs to identify and qualify the conditions of the surface waters in the basin. A number of studies have been carried out on the Caroni Basin and in particular the Caroni river system.

A National Parks and Watershed Project on the Courland, Maraval and St. Ann’s watershed was conducted by Kairi Consultants to propose development plans for effective management of these watersheds. Research initiatives have also been suggested in the studies developed.

2.11 Stakeholder Participation/Awareness and Education

Stakeholder Participation/Awareness and Education are crucial for successful water resources and coastal zone management. This approach is becoming increasingly important because:

- Laws and regulations work more effectively with willing compliance
- Resource allocation, protection and sustainability is becoming increasingly more difficult
- Individual groups and communities must understand each other's interest
- Socio-economic equity in the management of the resource must be evident
- Governments are faced with more complex resource issues
- Public awareness is crucial to ensuring control of community pollution, wastage and water quality

Nevertheless, there is no fully organised institutionalized public awareness and stakeholder participation programme in place for watershed and water resources management. The major players involved in watershed and water resources management include the Environmental Management Authority (EMA) and the Water & Sewerage Authority (WASA)/Water Resources Agency (WRA) and the Forestry Division. Minor roles are played by the Meterological Office (MET) and the National Emergency Management Agency (NEMA).

WASA/WRA

The Water and Sewerage Authority (WASA) has put into place a Public Awareness Action Plan to enhance its image and improve the flow of information to the public. WASA views the process of informing the public on issues of water conservation as long-term and is targeting children. A video production looking at all aspects of water management will be shown at schools, with WASA providing background training to teachers. The campaign will run for a five-month period with WASA hoping to achieve a 35% success rate. WASA is also addressing the conservation issue in the context of general household approach and its public awareness programme has a specific water conservation component aimed at adults. WASA's main themes are directed towards the improvement of the water supply situation through improved awareness and conservaton.

One useful example of a stakeholder participation project in watershed management was initiated by WASA in February of 1999. This project "The Caroni River Basin Watershed Project" was established to determine and

implement effective solutions to alleviate negative environmental impacts on the water resources. The Caroni River was chosen because it is the country's largest single water supply, servicing 30 percent of the country's potable water needs. Due to increasing soil erosion and watershed degradation, the major treatment facility in the basin has been subjected to shutdowns, higher water treatment costs and water supply disruptions from water intakes due to poor water quality. Various independent studies in the basin have revealed that some of the tributaries were bordering on the lowest raw water quality intended for potable use and that if the resource is to be sustained for multiple use then measures must be effected for its protection and conservation. WASA therefore recognized that a process of collaboration and shared responsibility was the most effective way to meet the management challenges. A committee comprising governmental departments, non-governmental organizations, businesses and community based organizations was convened and met every month to identify the issues/concerns in each catchment and to determine the solutions and strategies to alleviate major negative impacts. Individual organizational and group responsibilities were identified for implementation. Follow-up of the initiatives identified in the programme has not been monitored and in general has not been executed. No other such programme has been pursued.

In August 2000, a regional workshop on "Stakeholder Participation and Dispute Resolution in Integrated Water Resources Management" sponsored by the Commonwealth Science Council (CSC) and NIHERST (of Trinidad and Tobago) was conducted over a period of three days. This programme was coordinated by personnel of the Water Resources Agency (WRA) of WASA. The participants included a wide range of water resource stakeholders in Trinidad and Tobago as well as representatives of other States in the region. The workshop sought to:

- promote ownership and responsibility for the water resource,
- provide understanding of levels and benefits of stakeholder participation,
- provide techniques for strategically planning stakeholder participation,
- provide insights and tools towards dispute resolution in water resources management,
- introduce a computerized decision support system for stakeholder participation and integrated water resources management,
- formulate a mechanism for stakeholder involvement in the Caribbean region and
- initiate stakeholder participation in the formulation of a water resources management policy and legislation for Trinidad and Tobago.

<u>Environmental Management Authority (EMA)</u>

The Environment Management Authority (EMA) conducted a survey in 1966 to determine the level of understanding of environmental issues in Trinidad and

Tobago. The results of the survey were used to formulate a communications plan, which included the dissemination of information on water resources conservation and watershed protection through the use of the public media, newsletters, essay writing and public lectures. They have been involved in limited public awareness of all environmental issues, including water issues through the public media.

In 1995, the EMA established a complaints office to manage the flood of citizens' complaints which range form air, water and noise pollution, environmental degradation and hazardous wastes and spills.

Other Initiatives

The following are some of the other initiatives that have been pursued over the last three (3) years :

- Participation in World Water Day Exhibition - Annually by MET, WRA and WASA.
- Seminars to classes of high school students - On request by schools; average of three (3) to four (4) per year by WRA
- Media awareness programmes to protect water supply sources – Five (5) to ten (10) per year by WASA
- EIA consultations for specific developmental projects – Ten (10) to twenty (20) per year by EMA
- American Chamber Meetings – Six (6) per year by EMA and Petroleum Sector companies
- Flood warning and weather predictions - As required by MET and NEMA

In general, efforts are uncoordinated and are unrelated to each other. In addition, there is no firm plan to enhance public awareness about water resource management and to involve community stakeholder participation. The effectiveness of the limited education programme has not been measured but it is well accepted that the level of resources invested here has not resulted in a significant impact.

2.12 Institutional Frameworks

Water Resources Management Functions

There are specific functions, which are derived from the general concept of integrated water resources management. These are policy and strategy formulation, water resources assessment, water demand analysis, conservation,

allocation of water, pricing of water, legislation and enforcement, demand management, and water resources development:

1. *Policy and Strategy Formulation*: a policy is a course or principle of action adopted or proposed by an organisation or individual, while strategy refers to general methods and plans of action by which objectives might be achieved;
2. *Water Resources Assessment*: this refers to the continuous study of water availability.
3. *Water Demand Analysis*: the activity involved in determining the requirements of the various stakeholders in the water sector (for example, agriculture, industry, and households);
4. *Conservation*: the prudent use and preservation of water resources (the treatment/ re-use of water/ watershed management);
5. *Master Planning and Allocation of Water*: determination of how much water is to be provided to each sector or stakeholder;
6. *Pricing of Water*: arriving at an economic valuation of water, with due consideration to its social and ecological value;
7. *Legislation and Enforcement:* the process to ensure that proper regulations are in place through a licensing and permit system and that these are complied with regards to the abstraction of water, the prevention of water pollution and the use of the land;
8. *Demand Management*: the process of controlling the quantity of water abstracted by the various sectors and stakeholders and ensuring that this water is used in the most efficient way possible; and
9. *Water Resources Development and Distribution*: this covers the gamut of activities involved in making water available for use by its various consumers through the process of abstraction, storage, transmission and distribution. This would also include the proper sewerage and treatment of used water.
10. *Extreme Events Management*: this includes the planning and implementation of drought and flood control measures.

Responsible Agencies

There are a multitude of agencies and institutions involved in the water sector and in the execution of water resources management functions. Nevertheless the Water Resources Agency (WRA) which is part of the Water & Sewerage Authority (WASA), has primary responsibility for water resources management. The Water & Sewerage Authority (WASA) was established in 1965 by an Act of Parliament, and is responsible for public water supply which receives the highest priority in the allocation of the national water resource. In 1976 the Water Resources Agency, which formerly functioned as a separate body within the Ministry responsible for Planning, was transferred to the Water & Sewerage Authority. Since then the Water Resources Agency's role has been to collect,

analyse, document and publish hydrological data in addition to regulating the abstraction of surface and ground water. The dual and ambivalent role of the Water Resources Agency embodied within the country's main and by far its largest abstractor, negates its ability to adequately regulate, protect and manage all of the country's water resources. The Government of Trinidad and Tobago in recognising that this situation is undesirable has sanctioned the transfer of the water resources management functionality to a proposed financially autonomous body (an Authority) under the Ministry responsible for the Environment.

As mentioned above, a number of government organizations are involved in one way or another with the management of the water sector. These include the following key agencies:

Drainage Division, Ministry of Works and Transport, which is responsible for the construction and maintenance of storm water and flood control structures in the catchments of the major river basins.

Land and Water Division, Ministry of Agriculture, Land and Marine Resources, which is responsible for irrigation and the efficient use of water on farms.

Forestry Division, Ministry of Agriculture, Land and Marine Resources, which is responsible for forest management, the promotion of watershed management, and the management of wetlands.

Extension Division, Ministry of Agriculture, Land and Marine Resources, which is responsible for public awareness and extension activities related to the management of agricultural lands.

Town and Country Planning Division, Ministry of Housing and Settlement, whish is responsible for land-use planning and the regulation of land development**.**

Environmental Management Authority, a statutory authority reporting to the Ministry of The Environment and is responsible for the country's general environmental management, including water pollution control through the issuance of effluent discharge licenses.

Food and Drugs Division, Ministry of Health, which is responsible for monitoring and authorising the use of agrochemicals and toxic chemicals.

Public Utilities Commission and its successor, the Regulated Industries Commission (RIC), which is responsible for approving water rates.

In addition there are a number of other organisations that are indirectly involved in the water sector activities. These include the Institute of Marine affairs, the Central Statistical Office, the University of The West Indies, the Meteorological Services, the Tourism and Industrial Development Corporation, the Regional and Municipal Corporations (local governments), the National Emergency Management Agency, private abstractors and Non-Governmental Organizations. A summary of the allocation of water resources management functions among the various organizations is given in Table 2.10

Table 2.10 Allocation of Water Resources Management Functions in Trinidad and Tobago

No.	WRM Function	WASA WRA	Approval	Appeal	MOWT Drain.Div	MALMR LW Div.	MALMR For.Div.	MOPD T&C Plan	MOPD EMA	Mo Health	IMA	Met. Serv	Reg./Mun Corp.	Private Sector	PUC/RIC
1	WR Policy and Strategy Development		Cabinet												
2	Water Resources Assessment														
	Survey and monitoring	Resp			Resp.							Resp.		Coop	
	Research and development	Resp			Resp.						Resp.	Resp.		Coop	
3	Water Demand Analysis	Resp				Coop.		Coop.					Coop	Coop	
4	Conservation (WR sustainability)														
	Treatment/re-use of (waste-)water	Resp				Resp.			Consult	Consult			Resp.	Resp.	
	Watershed Management						Excl.Resp		Consult						
5	Master Planning and Allocation	Resp.	MOPU	MOPU	Resp.	Resp.	Resp.	Resp.					Resp.	Resp.	
6	Pricing of Water														
	Water Abstraction	Excl.Resp	WASA	PUC										Consult	
	Water Delivery		PUC	PUC										Excl.Resp	
7	Legislation and Enforcement														
	Water Abstraction Licnsing	Excl.Resp	MOPU	MOPU											
	Water Pollution Permits		MOPD	MOPD					Excl.Resp						
	Building/Land-use Permits		MOPD	MOPD				Excl.Resp							
8	Demand Management (efficient use)	Resp.				Resp.		Resp	Resp.	Resp.			Resp.		
9	WR Development and Distribution														
	Domestic water	Resp.						Consult						Resp.	
	Industrial water	Resp.						Consult						Resp.	
	Agricultural water	Resp.			Resp.	Resp.		Consult						Resp.	
	Multi-purpose dams/reservoirs	Resp.						Consult							
	Drainage/flood-control	Consult			Resp.	Consult	Consult	Consult							
	Sewerage/conveyance	Resp.				Resp.		Consult	Resp.	Consult			Resp.	Resp.	
	Water treatment	Resp.						Consult		Consult			Resp.	Resp.	

Excl.Resp	Exclusive responsibility: Only one organisation is fully responsible for (part of) any WRM function
Resp.	Responsible: Different organisations may have a certain and separate responsibility for (part of) any WRM function
Co-ordinate	One organisation is charged with the co-ordination of (part of) any WRM function. This entails efforts to streamline the different responsibilities of individual organisations
Co-operate	An organisation is expected to work with any other organisation to carry out (part of) any WRM function (Work together)
Consult	An organisation is expected to be heard and its opinion considered by the organisation who bears responsibility for (part of) any WRM function

EMA Environmental Management Authority
IMA ….. Institute of Marine Affairs
WASA ….Water and Sewerage Authority
WRA ….Water Resources Agency
For. Div Forestry Division
LWD .. Land and Water Division
T &C Plan … Town and Country Planning Division
Met. Serv. .. Meteorological Services
MALMR .. Ministry of Agriculture Land and Marine Resources
Mo Health . Ministry of Health
MOPD…… Ministry of Planning and Development
MOPU …... Ministry of Public Utilities
MOWT … Ministry of Works and Transport
Local Gov. …Tobago House of Assembly, Municipal and Regional Corporations
PUC/RIC … Public Utilities Commission/Regulated Industries Commission

Table 2.11 Legislation /Treaties Governing Water Resources Management in Trinidad and Tobago

Legislation	Synopsis
Environmental Management Act (1995)	Framework legislation for environmental management: conservation, policy-making, public education, enforcement, data collection
Water and Sewerage Act (1980 Revision)	Development and control of water supply; Promotion of conservation and Proper use of water resources; Powers to make bye laws to prevent pollution of surface and ground water
Waterworks & Water Conservation Act (1980 Revision)	Provides for the control and use of water; Powers to make regulations for the control of the supply and use of water in water improvement areas, and the prevention of waste or misuse of water in those areas.
Public Health Act (1950)	Require local authorities to inspect for and abate nuisances; Prevents dumping of offensive matter into streets, public places, river, drain and watercourses: Prevents pollution of wells, tanks, ponds and water courses.
Litter Act (1980 revision) (1981, 1990, 1992	Deals with the littering of public places and premises, including water courses and drains.

amended)	
Summary Offences Act (1980 Revision)	Deals with the pollution of rivers, streams and ponds coursing through state or private lands
Mines, Borings and Quarries Act (1980 Revision)	Powers to require the taking of precautions during drilling, production, storage and pumping operations to prevent the pollution of watercourses, foreshore and sea by oil/fluid/substance.
Petroleum Act (1980 Revision)	Powers to control the main elements of petroleum operations including pollutionon land and sea.
State Lands Act (1980 Revision)	Management (prevention of squatting, encroachment and injury to forest, controls digging and removal of materials) of State lands;
Forest Act (1980 Revision)	Powers to make rules for the preservation of trees; Gives permission to fell trees.
Town and Country Planning Act (1980 Revision)	Grants permission for the development of land; Powers to make tree preservation orders and to secure replanting.
Agricultural fires Act (1980 Revision)	Provides for the prevention and control of agricultural fires
The Conservation of Wildlife Act	Establishes game sanctuaries; regulates hunting
Fisheries Act (1980 Revision)	Powers to regulate fishing, declaration of prohibited areas
Pesticides and Toxic chemicals Act 1979 (1986 amended)	Regulates the importation, storage, manufacture, sale, use and transportation of pesticides and toxic chemicals
Pesticide Regulations	Controls importation of pesticides, registration may be denied on the grounds of being hazardous to public health and the environment
Standards Act (1980 Revision)	Provides for the establishment of standards to maintain/encourage industrial efficiency, to develop/ promote public and industrial welfare

Governing Legislation

Water resources issues are addressed either directly or incidentally in a substantial body of national legislation, and international treaties, which the country has adopted. These legal instruments are all summarised in Table 2.9, while the major ones are articulated below.

WASA is currently governed by the Water and Sewerage Act of 1965 (Volume 11 of the Laws of Trinidad and Tobago – Chapter 54:40). This clearly shows that in addition to the WASA's role of delivering water and sewerage services, the Act also allows for the Authority to license, control and collect fees for the abstraction of water from surface and ground water sources. Another key Act relates to Water and Waterworks Conservation, which allows for the declaration of Water Improvement Areas. This Act governs WASA and the Drainage Division.

The Environmental Management Authority, established under the Environmental Management Act of 1995 assumes the responsibility for the management of water pollution. Key aspects of their mandate include the coordination of pollution monitoring programmes, setting of and assessing compliance to effluent standards, issue of pollution permits, prohibition of water pollution and protection of watersheds. This Authority relies heavily on outsourcing of its environmental work. Funding of their programmes comes from Government or international funding Agencies. In collaboration with the Ministry responsible for the energy industries, some pollution monitoring work is executed within the areas the energy companies operate.

Other institutions also involved in water resource management include the Drainage Division, which is responsible for the construction and maintenance of storm water and flood control structures in watersheds of major water courses. The Ministry responsible for Food Production and Forestry maintains the responsibility for the efficient and effective use of available irrigation water and forest management to promote watershed management. Land use planning and regulation rests with the Ministry responsible for Town and Country Planning. The Public Utilities Commission or its imminent successor, the Regulated Industries Commission, has the responsibility of setting water rates and abstraction charges. Minor roles are played by the Ministry responsible for Local Government involved in street cleaning and fire-fighting, the Food and Drug Division which is responsible for monitoring agrochemical residuals and toxic chemicals in foods and the Meteorological Office/ National Emergency Management Agency involved in flood warning and weather predictions.

Water Policy

At present, there is no accepted water policy that governs the overall water and water resources strategy at the national level. A draft version based upon the imputed modus operandi and the directions of the currently concluded Strategy by the Consulting Team headed by DHV Consultants BV, is being prepared for public consultation.

Water Resource Development and Distribution Investments

Over the recent five-year period, substantial investment has been made to improve the water supply in the country. These investments include the South Water Project, the North Water Project, the Tobago Water Project and the Point Lisas Desalination Project.

The South Water Project

This project which lasted for twenty-nine months was completed in June 2000 at a total cost of US $ 102 M. The Government of Trinidad and Tobago funded the entire project. The project involved the drilling of thirteen (13) new wells and the refurbishment of four (4) old wells, which resulted in an increased water production of 11 ML/D. Water Treatment Plants (WTP's) at Caroni, Navet and six (6) rural stations as well as the San Fernando Booster also underwent refurbishment works. The Caroni WTP was upgraded to yield a capacity of 70 ML/D and a new WTP was constructed at Penal with a capacity of 6 ML/D. Plant and pipeline works were done in several areas of the South and 150 km of transmission and distribution mains were laid down. This project benefited customers who would have normally received a scheduled water supply that was very poor (less than 48 hours per week), or no supply at all and customers who depended on truck borne and rainfall supplies. The improvement in supply resulted in an increase from 49% to 80% of the population which receives a reliable water supply (more than 48 hours per week).

The North Water Project

This Government financed project is in the implementation phase, and is projected to cost about US$ 105M. It will include pipeline replacement, booster pump station rehabilitation, water treatment plant upgrade, replacement and setting up of service reservoirs and tanks, bulk metering, a wells programme, a rehabilitation programme for existing sewerage treatment plants and the design and construction of a wastewater treatment plant in the Beetham. The benefits of the North Water Project is projected to be significant as pipeline replacement alone is expected to improve the level of service of the water supply to 116,320 customers. Other expected benefits are: improvements in the service pressure and the level of service of the water supply for over 647,982 customers, improvements in the water supply to five (5) areas (estimated to be an increase of 70 ML/D). This project will also provide for the development of a comprehensive management information system for data use and leakage management. Sewerage treatment plants will be rehabilitated in eight (8)

districts, and so reduce the amount of domestic waste being discharged into the environment.

The Tobago Water Project

This project which is also being financed by the Government of Trinidad and Tobago, is scheduled to last three (3) years at an approximate cost of US$ 101 M. It is presently unfolding in several phases, the first phase being Groundwater Exploration and Development which was completed in October 2000. This phase of the project resulted in an increase of 10 ML/D in water production, which vastly improved the supply of public water in the island. Three (3) water treatment plants at Courland, Richmond and at Hillsborough were also upgraded to enable the processing of highly turbid raw water. This has increased the reliability of the plants during the rainy season, and provided an additional capacity of 7 ML/D. The other phases include the upgrade of the distribution system to reduce leakage, refurbishment of a main pumping station and its associated collection system, construction of a sewerage system for South West Tobago, the extension of the present sewerage system and the provision of loans to assist homeowners to connect to the present sewer system. The impact of these works is expected to reduce health risks, to improve efficiency of the water supply system and to reduce water pollution.

The Point Lisas Desalination Project

A desalination plant, which uses the technique of Reverse Osmosis, is due for completion by the end of the March 2001. It will have a capacity of 100 ML/D of desalinated water, which will be dedicated to the Point Lisas Industrial Estate. The plant which is projected to cost US$ 123 M, has the following advantages:The advantages of the Desalination Plant are many and can be listed as follows:

- A small land space is required close to the demand area resulting in a shorter time for delivery of water and at a better pressure level
- It is independent of weather patterns
- It is capable of modular expansion at short notice and the potential for decreased cost exists due to technological advances
- Comparable water cost and increased customer satisfaction
- The supply to Point Lisas (from Caroni) will be diverted to domestic customers, and
- It provides better quality industrial water

The plant will be owned and operated by the investor/ technology supplier who will provide high quality water to WASA at a rate initially pegged at US $0.7 per m^3 , and WASA will in turn via its distribution system, transfer the water to the Point Lisas customers at a rate of US$ 1.2 per m^3.

The total investment cost of this Integrated Approach to solve the water problems of Trinidad and Tobago is US$ 431 M. Objectives of this vast investment are many and mainly include the production of more water, protection for the environment, developments of new water sources, de-linking Point Lisas from the domestic supply and most importantly to improving the image of WASA and its financial viability.

Interim Operating Agreement

Deteriorating infrastructure, lack of water supply sources and a stagnated organisation has led to an increasing divergence of the supply/ demand situation with the effect of an ever-increasing deterioration of customer services with respect to water supply, water supply reliability and water quality. Combined with the lack of capital (and other) funding, the Government signed an agreement with a preferred foreign operator Trinidad and Tobago Water Services, a joint company between Severn Trent International and Wimpey Caribbean Limited to operate WASA for a three (3) year period beginning April, 1996. This period was referred to as an Interim Operating Agreement (IOA) at the end of which the Government would determine the form and strategy for the Long Term Arrangement (LTA).

The objectives of the IOA were:

- Improvement of level of water and wastewater services;
- Improvement of the quality of water and wastewater services;
- Achievement of financial viability by reduction of operating deficit; and
- Improvement of WASA's assets and infrastructure to "world class" standards.

Under the arrangement, Government guaranteed loans of the order of TT$ 1.2 Billion to address shortfalls in working capital, fund a voluntary early separation plan and to undertake critical projects.

Although the IOA initiatives were pursued, at the end of the three (3) year period the substantial improvements that were anticipated were not realised. Marginal improvements in service levels were achieved, staff moral was low, the enhancement in staff skills was not evident and technology introduction was stagnant. A new local management team was introduced to manage the Authority in April 1999.

<u>Water Resources Management Investments</u>

The Government of Trinidad and Tobago obtained a loan from the World Bank for a project called the "Water Sector Institutional Strengthening Project

(WSIS)". This project included five (5) water resources management components.

Water Resources Management Strategy (WRMS)

The Water Resources Management Strategy (WRMS) Study commenced in August 1997 and was completed in January 2000. The overall objective of the WRMS, was to develop a comprehensive framework for integrating cross-sectoral dimensions of water resources management in Trinidad and Tobago. The study complemented reforms promoted by other World Bank supported investments for the: (a) Privatization of the WASA, (b) Flood Control and Drainage Program, (c) Environmental Management Agency (EMA), and (d) National Parks and Watershed Management Project, and (e) non-World Bank supported irrigation sector. The specific objectives of the WRMS were to:

- Propose appropriate strategies and policy measures for water resources management
- Propose appropriate strategies for meeting future demands
- Propose an effective policy and institutional framework and adequate supporting legislative and regulatory instruments
- Propose strategies for building-up of institutional capacity, technical systems and provision of training
- Propose a strategy for sensitizing the public and building awareness
- Propose the development of efficient information systems
- Provide an implementation plan for selected priority areas of action.

The WRMS assessed the surface and groundwater resources to meet present and future demand in various sectors (domestic, industrial and agricultural supply). It also linked cross-sectoral dimensions of water management such as water pollution, implications of poor land use, watershed management, protection of aquifer recharge areas, flood control and drainage, and demand for environmental uses. The WRMS represents a "Best Practice" model of comprehensive institutional reforms for WRM supported by the Bank in the region. It has recommended the separation of the regulatory functions (being carried out by the WRA) from the service delivery functions of WASA; and the establishment of an independent, financially autonomous WRM Authority for regulating public and private utility operators and water suppliers, ensuring sustainable water use and protection of the water environment. Further, the strategy calls for both structural and non-structural controls for managing watersheds and protecting inhabitants and property against flood damage, and also provides a sound framework for environmental protection in the water sector. The WRMS study recommendations comprise actions to be taken over the short, medium and long term. These include:

- Implementation of the concept of integrated water resources management to attain sustainable development of the water resources of Trinidad and Tobago

- Establishment of an effective and financially autonomous institutional framework that facilitates efficient water resources management. The strategy includes a draft water resources management policy, a legislative and regulatory framework, and recommends alternative arrangements for establishing and housing a new water resource management authority (WRMA). The revenue base for the WRMA will comprise of: (a) abstraction fees, (b) sale of hydrometric information, and (c) technical support and advice for assessing and planning water resources development.

- Actions to meet the growing demand.

- The protection of environmental quality and ecological systems. The WRMS has developed a framework for protecting degraded watershed and important aquifer recharge areas. The water allocation priorities in the new water resources policies and legislation will reflect the flow needs for the Caroni, Nariva and other important wetlands.

- The development of capacity and tools within WRMA to support decision-making. (such as proper data and information management).

Other Water Resources Management Components

The WSIS also included funds for four other WRM components to strengthen the Water Resources Agency. These were: (a) installation of a telemetry system, (b) implementation of a surface water quality monitoring program, (c) purchase of computer equipment, and (d) provision of staff training. The objective of the telemetry system was to provide automatic recording and transmission of hydrological and hydro-meteorological data from the river basin to the central office. The objective of the surface water quality monitoring program for the Caroni River was to delineate the water quality condition of the Caroni River, to identify the point and non point sources of pollution in the river and to develop a water quality monitoring program. The computer hardware and software equipment was intended to provide tools for strengthening data management and analysis capabilities. Training was intended to develop and strengthen the human resource skills at the WRA.

Telemetry Equipment: The installation of the telemetry equipment is completed, but the system is not fully functional a few technical problems need to be solved. Training was provided for strengthening skills in the operation and maintenance of telemetry base stations.

Water Quality Monitoring: The surface water quality-monitoring program has provided information for establishing an important baseline for the main river system. It has included information on existing surface water pollution sources

in the Caroni River, the health implications of water pollution, results of the dry season and wet season sampling, and recommendations for long term monitoring.

Computer Equipment: The computer hardware and software are being utilized to convert the hard data (on rainfall, evaporation, river flows, groundwater levels, etc.) into digitized data and analyze and process them into useful reports for planning, assessing and operating a variety of water resources systems. Most of the equipment was absorbed by other Government agencies, notably the Ministry responsible for drainage.

Training: Training was earmarked in support of all WSIS components.

Caparo Integrated Water Resources Management and Flood Mitigation Project

In recent years, there has been a marked increase in the incidence of flooding and flood related damages within the lower Chaguanas region. This has been due to the overflowing of the Caparo River and its tributaries, which drain the area. To alleviate the severe hardships and inconveniences suffered by residents and commuters, the Government of Trinidad and Tobago with assistance from the International Bank for Reconstruction and development ("World Bank") commissioned a study in 1998. The objectives were to facilitate the design and implementation of flood management and flood control works, through the entire Caparo basin. The recommendations of the study were to incorporate the integrated water resources management concept at the river basin level, development of detention systems at strategic points in the basin, and the carrying out of channel realignment and upgrading works.

Human Resources in Relation to Water Resources Management

A Skills Gap Analysis (Table 2.12) between the present WRA and the future combined WASA and WRMA requirement was done. This skills gap has included specific skills required for Coastal Zone Management. Additional skilled persons are needed in the positions of Compliance Lawyer (1), Communications Specialist (1), Irrigation Engineer (1), Hydrologist (5), Geologist (2), Land Use Planner (2), Coastal Engineer (3), Oceanographer (3), Ecologist (3), Watershed Specialist (2), Water Resources Engineers (4), Environmental Specialist (3), GIS Specialist (1), Geological Assistants (2), Communications Engineer (1) and Water Economist (2).

A scholarship programme to train hydrological technicians to become professionals will be the preferred approach to staffing in the specialist areas identified so as not to lose the intellectual capital and local knowledge that has already been acquired. Continuous training of professional and technical staff is also required in other relevant specialist areas such as data analysis, modelling and system design.

Table 2.12: Skills Gap Analysis For Watershed/Water Resources And Coastal Zone Management

Job Title	Nos. Required	Nos. Available	Deficit (Surplus)
Hydrologist	8	3	5
Land Use Planner	2	0	2
Water Resources Engineer	2	0	2
Coastal Zone Engineer	3	0	3
Irrigation Engineer	1	0	1
Oceanographer	3	0	3
Geologist	2	0	2
Ecologist	3	0	3
Compliance Lawyer	2	0	2
Watershed Specialist	2	0	2
Water Economist	2	0	2
Communication Engineer	1	0	1
Environmental Specialist	3	0	3
GIS Specialist	1	0	1
Geological Assistants	2	0	2
IT Specialist	2	2	0
Hydrological Technicians	30	42	(12)

3.0 CURRENT COASTAL ZONE MANAGEMENT ISSUES

Within the coastal zone, potential sources for fresh water supply can be usually found, adding to the intrinsic value of such regions and requiring effective management for their sustainability. Such sources include:

- Fresh water lagoons
- Coastal creeks
- Superficial ground water strata, which emerge as springs at the coastal side
- Deep aquifers which may or may not penetrate under the shore zone - into the sea space

Brackish water sources are also located within the coastal region and can be used for purposes like recreation, aquaculture, coastal fishing, coastal boating and tourism. Such sources could include:

- Estuaries
- Inlets
- Lagoons

A preliminary delineation of the coastal zone can be made on the basis of the coastal processes affecting the coast and the coastal features influencing such processes.

- In this context, the coastal zone is generally defined as the area that is subject to the identified coastal processes or flooding caused by the sea, in the absence of protection measures/works

- For Trinidad and Tobago, the seaward boundary of the coastal zone is considered on the basis of:

    1. The mean low water level (MLWL), for all coastal sites where no navigation functionality is associated
    2. The low water spring level (LLWS), for the coastal sites where navigation is the major function (e.g. Orange Valley) or a seawall structure provides basic defence for the backshore and other national important activities

- The landward boundary limit is considered on the basis of:

    1. The line of potential erosion, at the inland side of the erosional profile, for the coastal sites confronted mainly with this aspect (Mayaro Beach, Cedros)
    2. The line of potential flooding of the hinterland, for the coastal sites that are currently experiencing such events (Mosquito Creek, Manzanilla Beach, Los Iros Bay, Icacos-Coral Point)
    3. A virtual inland line, to correspond to the landward extension of the region where losses of infrastructure have occurred directly induced by the erosional processes (southern Manzanilla Beach, Orange Valley)

The above limits have been defined on the basis of intensive reconnaissance and systematic observations of the geomorphic and hydraulic processes, at each coastal site and surrounding coastal stretches. This was conducted under the purview of the Drainage Division, Ministry of Infrastructure.

3.1 Coastal Habitats and Ecosystems

In Trinidad and Tobago, the critical significance of the coastal areas is due to their support of life systems, their economic contribution, their recreational and aesthetic value and their value as natural assets. These are highlighted as follows:

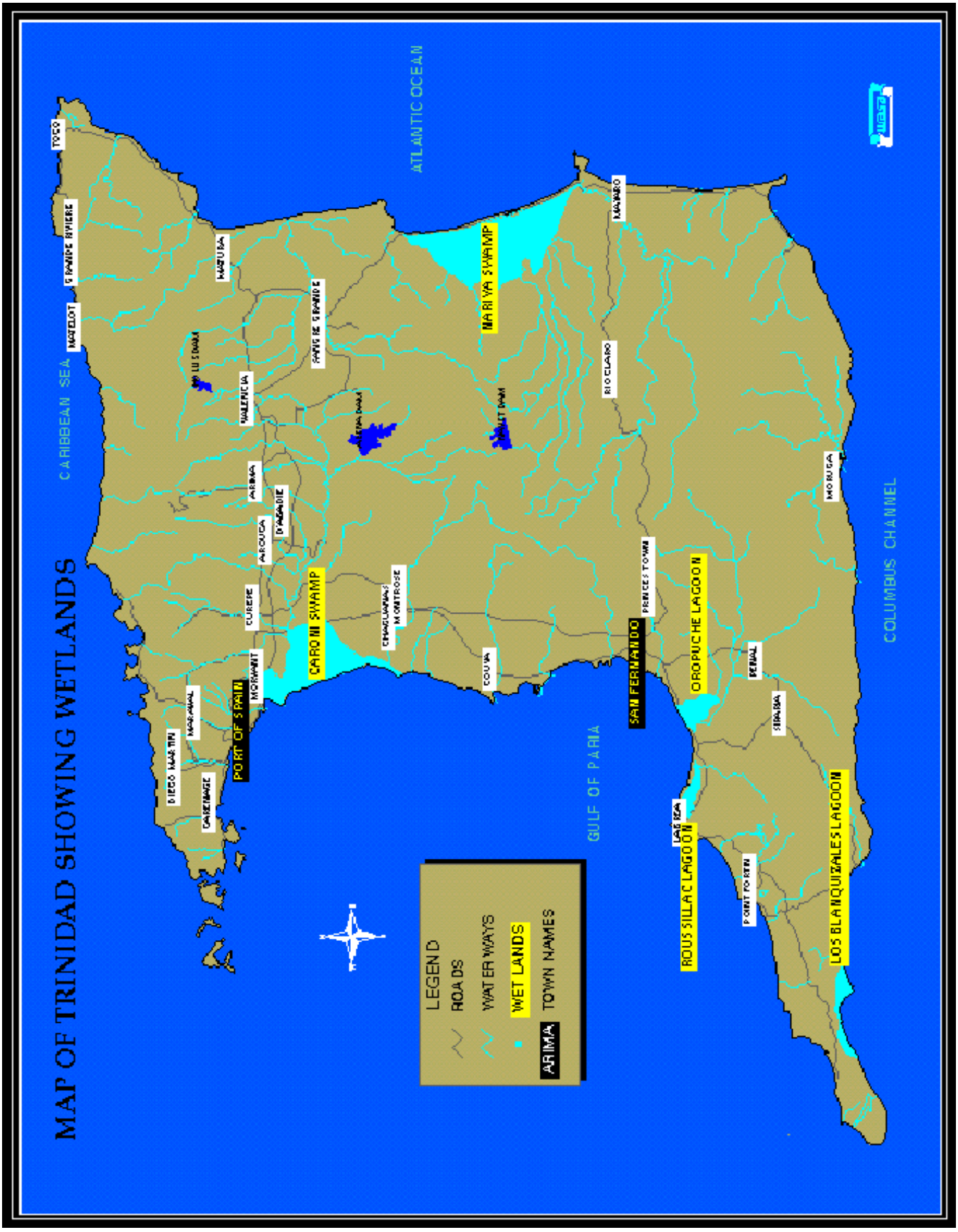
- the proportion of the land area of Trinidad and Tobago that is covered by coastal areas is 0.6% and 2.57%, respectively
- a sizeable percent of the population reside in coastal areas
- some 80% of industrial activities of strategic national importance are located within coastal areas
- some 60% of small scale economic activities significant for the support of human lives are located within coastal areas
- some 80% of urbanised land are located within or adjacent to coastal areas
- approximately 50% of the country's national transportation arteries (coastal roads, bridges etc), some of them providing important access to large towns and remote communities, pass through coastal areas.
- approximately 90% of tourist facilities and hotel room budget in the country are located within coastal areas
- coastal areas contain fisheries that produce about 90% of annual fish production
- coastal areas contain habitats critical to the sustained production of fisheries, maintenance of good water quality and scenic nature sites
- coastal areas contain rich bio-diversity reserves, which serve as sources of food and livelihood for many coastal residents, including: the worldwide famous coral reefs (Tobago), seagrass beds, mangrove fringes and forests and coastal swamps with unique coastal based fauna (Nariva, Oropouche, Caroni).

The coastal areas of Trinidad and Tobago support ecosystems, which are of direct importance to the island's economic resources. The resource value of the Buccoo Reef (an extensive coral reef) in Tobago was recognised by the GORTT and under the Marine Areas Preservation Enhancement Act (of 1970) was designated as the country's only protected marine area. Tobago enjoys this tourist attraction which brings numerous visitors on a daily basis with peaks during the holiday season (January to April and during the months of July and August). The fauna and flora of Buccoo Reef have been well studied and found

to support a variety of life which include algae, seagrasses, sponges, anemones, corals, annelids, echinoderms, molluscs, crustaceans, ascidians and reef fish. Inappropriate recreational use, through uncontrolled visitors' traffic has in the past 30 years resulted in the severe damage to many areas within the reef.

The coastal and marine areas also play a large role in the economics of the islands since they support coastal stocks of fish and crustaceans, which have sustained artisanal, semi-industrial and industrial exploitation. The most important artisanal fishery is that for carite, kingfish and sharks, with a smaller scale fishery for marine molluscs and crustaceans. Semi-industrial multi-gear fishery targets snappers, groupers, kingfish, dolphin fish, and sharks on the north, south and east coasts. Industrial and semi-industrial shrimp trawlers operate off the north, south and west coast of Trinidad and an industrial fishing fleet (mainly foreign-owned) exploits the tuna and swordfish resources of the east coast. A recreational fishery operates off the north and west coasts of Trinidad which targets both pelagic species (carite, kingfish, cavalli, wahoo, tuna, billfish) and demersal species (snappers, groupers, sharks, salmon and croaker). In Tobago, the main fisheries are the flying fish fishery and the fish pot fishery (which targets mainly snappers and groupers). Invertebrates such as pachro, queen conchs, whelks and lobsters are exploited at the artisanal level.

Marine turtles which form part of the island's resources are protected by law in Trinidad and Tobago (1984) under the Convention on International Trade in Endangered species (CITES) and by the SPAW Protocol (under the Cartagena Convention). The leatherback turtle (*Dermochelys coriacea*) is also completely protected in Trinidad under the Conservation of Wildlife Act (amended 1963) and by the Protection of Turtles and Turtle eggs Regulation (1975). Much research and conservation work towards management of this resource has been carried out in Trinidad. In its continued efforts to protect these threatened and endangered species, the Forest Act Chap. 66:01 declares nesting beaches such as at Matura, Fishing Pond and Grande Rivere a "Prohibited area". Presently, Non-governmental Organisations (NGOs) have become involved in these conservation/management efforts eg. Nature Seekers Incorporated (NSI) at Matura Beach, and Grande Rivere Environmental Awareness Trust. The group also conducts and co-ordinates eco-touristic nature tours and turtle watches in this area.


MAP OF TRINIDAD SHOWING WETLANDS
CARIBBEAN SEA
ATLANTIC OCEAN
GULF OF PARIA
COLUMBUS CHANNEL
TOCO
GRANDE RIVIERE
MATELOT
MATURA
RAPIDS DE GRANDE
MARIYA SWAMP
MAYARO
RIO CLARO
MORUGA
VALENCIA
ARIMA
AROUCA
DIEGO MARTIN
MARAVAL
CHAGUANAS
MONTROSE
CUREPE
MORVANT
PORT OF SPAIN
CARONI SWAMP
COUVA
PRINCES TOWN
SAN FERNANDO
OROPUCHE LAGOON
PENAL
SIPARIA
LAS CUEVA
ROUSSILLAC LAGOON
POINT FORTIN
LOS BLANQUIZALES LAGOON
LEGEND
ROADS
WATER WAYS
WET LANDS
ARIMA TOWN NAMES


TOPOGRAPHICAL MAP OF TOBAGO
LEGEND
ROADS
WATER WAYS
WET LANDS
TOWN NAMES
CHARLOTTEVILLE
ROXBOROUGH
PLYMOUTH
SCARBOROUGH
CARIBBEAN SEA
ATLANTIC OCEAN
BUCCOO REEF
KILGWYN LAGOON
BONACCO MD LAGOON

Coastal wetlands/swamps are an integral part of the natural environment on the islands of Trinidad and Tobago. From wetlands, a wide range of exploitable resources is derived for example; softwood, timber, charcoal, tannins, honey, medicinal plants and fish. Wetlands and swamps also act as nurseries providing habitat for juveniles and maintaining biotic and nutrient linkages with coral reefs such as; between the Bon Accord Lagoon and Buccoo Reef (Tobago). Wetlands are also extremely important in buffering the effect of waves on the coast. Removal of such wetland areas increases the rate of coastal erosion as seen in the west coast of Trinidad. The three (3) major ones in Trinidad are the Nariva swamp, Caroni swamp and South Oropouche (or Godineau swamp) areas. They are extremely rich in biological diversity and have been very well studied in terms of their faunal and floral compositions. The Draft National Policy on Wetland Conservation for Trinidad and Tobago seeks to prepare development and management plans for enhancement and preservation of wetlands. This is in recognition that wetlands are reservoirs of tropical biodiversity which provide a mix of scenery, interesting plant and animal life and provides both pleasurable and intellectual stimulation to visitors. It is in keeping with the Ramsar methodology (1997) that the Government of Trinidad and Tobago in 1993 designated the Nariva Swamp, the largest freshwater herbaceous swamp in the country of size 6,234 hectares, to be protected under the Ramsar Convention.

Coastal habitats and ecosystems in Trinidad and Tobago have suffered considerable perturbation due to coastal development, land based pollution and development activities (construction and quarrying) and agricultural activities. The major threats to management of the systems described above are listed here:

- Land based and maritime pollution
- Over exploitation of wetland species such as; birds, fishes and crustacea.
- Development and coastal structures-these results in changes in the coastlines such as reclamation which lead to fragmentation of major ecosystems eg. conversion of natural areas into agricultural and housing areas. Dredging of harbour and waterfront development (eg at Port of Spain, Point Lisas and Scarborough) and housing (eg. Westmoorings, Cocorite, Carenage). This fragmentation leads to degradation.
- Degradation of the environment due to poverty and squatting- removal of vegetation etc.
- Laying of pipelines, especially for natural gas.

A major problem with respect to the coastal and marine fishery resource is due to the “open-access” nature of fishery, permitting anyone to fish anywhere or anytime. This has led to conflict both internally (among fishing sectors) in Trinidad and Tobago and externally (foreign vessels and governments). This facility is also inconsistent with effective conservation and management of fishery stock.

The major threats to specific management of the wetland areas in Trinidad and Tobago are categorised as:

- Land reclamation/conversion especially the role in flood /water retention and ground water aquifer re-charge
- Pollution from agricultural, industrial and quarrying activities.
- Alteration to hydrology, alterations to natural drainage have resulted in changes to the hydrological regimes of wetlands which cause increased salinity of the water and drying out.
- Agricultural and industrial pollution have contributed to changes in species compositions and abundance in coastal areas. Recently, at Point Lisas, there were mangrove "die-back" which was attributed to the combined effects of ammonia, temperature and salinity associated with industrial effluents (SOER 1998).
- Over exploitation of species.
- Over exploitation of softwoods.

3.2 Living and Non-Living Marine Resource Exploitation

Petroleum

The most important non-living marine resource exploited in Trinidad and Tobago is petroleum and more recently, natural gas. Crude oil production in 1995 averaged 100.674 barrels per day valued at approximately $US 590 million per year (EMA Env Rep 1996). In 1995 production of natural gas was 560 million standard cubic feet per day giving an annual value of $US 194 million (EMA 1996). Exploration activities continue to grow as investors take advantage of incentives provided by the GORTT. Activities are mainly concentrated on the south-east and south-west coasts but have also started on the north coast.

Fisheries

The location of Trinidad and Tobago on the continental shelf of South America and the associated extensive shallow seas makes it a prime location for exploitation of fish and other invertebrates especially in areas such as the North Coast, the Columbus Channel and the East Coast. It has been reported that fish catches in Trinidad and Tobago were tripled between the years 1986-1995. This may have been due to innovations (at the time) in the industry such as; the use of multi-purpose offshore vessels which employ a variety of fishing methods (surface long lining, fish pots and drift netting), combined with the fact that the vessels are equipped with chilled storage. An assessment of finfish resources (Fisheries Division, MALMR) have fish are over-exploited such as; carite, croaker, snappers (red and vermillion) and yellow mouth grouper. Some of the

under-exploited species include; deep water shrimp, flying fish, offshore demersals and small pelagic fish.

Over-harvesting of oysters has led to a virtual collapse of the industry and the mussel populations may soon also be affected similarly. This has been as a result of wanton disregard for discrimination in "size" or "sex" of the faunal organisms, removed by collectors.

Figures for 1996 showed the fish resource contributed 13.2% of the total agricultural contribution of 3.46% to the Gross Domestic Product (GDP). The importance of the fisheries sector is notable with respect to export figures in 1992 US$2.4 M with shrimp accounting for US $1 M of the total (Ministerial Appointed Committee 1997).

Some management strategies to alleviate over-exploitation of fish stocks include:

- Industrial type-trawlers are now mandated to use fishing nets of a specific size in order to prevent the unlimited removal of juvenile fish.
- Attempts are being made to define the limits of foreign fishing effort.

3.3 Climate Change and Natural Disasters

Climate Change and Sea Level Rise

The coastal areas are the most vulnerable regions to projected climate change impacts. The projected trends indicate that sea storms become more powerful, occur more frequently, have longer durations, so that on their arrival at the shores they will inflict greater damages. Rainfalls are more intense and of longer durations (note catastrophic damages in northern Venezuela, December, 1999), resulting in floods in the coastal basins. Mudflows and landslides are then triggered more frequently with dramatic consequences. Human settlements located in the coastal river plains, transportation infrastructure along the coast, beaches, coastal tourism facilities and coastal native values (lagoons, mangrove forests, seagrass fields, reefs etc) are subjected to the increased risk of being destroyed, with irreversible losses (human and material) or severe damages necessitating high costs for restoration.

Changing global weather over the past few years has fuelled speculation that global warming is beginning to de-stabilize the earth and its inhabitants. Extreme weather conditions have historically affected coastal areas of Trinidad and Tobago by causing severe erosion. This continuous loss and degradation of coastal and marine resources has serious consequences at national level resulting in loss of land and property eg. at Cedros, Los Iros and at Galeota and Manzanilla and Store Bay in Tobago. Some beach levels are currently at an all time low, as a result of storms experienced during the last five (5) years. In some cases, extensive beach losses have left the seawalls without much of their natural protection from exposure to wave actions. Consequently there is now considerable danger of sea walls becoming eroded, and a risk of flooding in

several areas which may render several major roadways impassable eg. Manzanilla to Sangre Grande and at Mosquito Creek.

Flooding

Flooding may affect coastal and marine ecosystems by reducing the salinities in certain coastal areas and may cause stressful conditions to faunal and floral organisms there. Flood waters in Trinidad and Tobago also bring many potential contaminants to the coastal areas. These include elevated bacterial (eg. faecal coliforms) levels which pose a threat to swimmers and elevated concentrations of toxic chemicals and/or heavy metals (industrial effluents) which over time become concentrated in faunal tissues and may enter the food chain. Indiscriminate clearing of land, bad construction practices and non-maintenance of waterways, all contribute to flooding and subsequently negative coastal impacts. These activities are directly responsible for threats to the quality of life and to properties of the coastal inhabitants.

Natural Hazards Affecting Coastal Zones

Natural Hazards impacting on the coastal zones in the Trinidad and Tobago environment include:

- *Excessive Sea or Ocean Storms:* These may range up to Hurricane Level
- *Accelerated Sea Level Rise*: Over the last century, an average sea level rise of about 0.2m has been proven. In Trinidad, the sea level rise over the last century may have resulted in an estimated coastline retreat of about two (2) to five (5) metres. For the coming century, a further increase of some 0.6m is expected. Local variations to these figures are expected, as coastal impacts due to sea level rise may vary depending on specific local characteristics of water area layouts, neighbouring rivers and boundary connections with open sea/ocean.
- *Tectonic Movements*: Trinidad is situated in an active region of tectonic activity. The area is credited with earthquake magnitude of four (4) to six (6) on the Richter scale, and a recorded average of about eight (8) earthquakes per year. It is possible that a certain trend in tectonic activity can result in a gradual subsidence of certain coastal areas, in Trinidad. Such subsidence could trigger a retreat of large coastline stretches with low-lying coastal areas. In such areas, higher penetration of seawater into the land area and increased flooding events can result in irreversible consequences, including loss of life, means of production and properties.
- *Excessive Rainstorms*: These could generate floods of larger proportions, accompanied by increased destruction and losses.
- *Massive Landslides in Coastal Areas*: These arise mainly due to the erosive action of sea waves that hit the shore, at the toe level of higher shoreland, and storm runoff that accumulates (due to poor drainage and impervious

character of soil) within the higher lands/hills, forcing the slopes ultimately into failure. Typical failure cases, which involve the movement of massive slopes and entire hill regions (mostly located on the coast), have arisen in Tobago and to a lesser extent in Trinidad posing serious threats to life, property, infrastructure and normal life/business activities for coastal communities with significant population densities.

Various anthropogenic interventions also impact with negative consequences on the coastal environment, these include:

- *Subsidence Due to Oil/gas Exploration*: Trinidad's long history of oil exploration activities which include; the impacts of drilling fluids, drill cuttings, produced water, waste water, spent catalysts, oil sludge and oil spills on the west coast of the island, has contributed to the levels of petroleum hydrocarbon contamination observed there (IMA archival information). The east coast by comparison, where there is presently much oil and gas exploration activities, has not shown any clear indications (except in very localised areas of the coast) of such contamination. Petroleum hydrocarbon contamination has been described for coastal areas of Trinidad where it affects biodiversity and the distribution of macrobenthic (sediment dwelling) organisms (Agard, Gobin and Warwick 1993).

  There is however and absence of long term water quality data such as; levels of petroleum hydrocarbons, heavy metals and pesticides for coastal areas of Trinidad and Tobago. The importance of such information cannot be overemphasized if we are to attempt to assess deterioration or improvement of the coastal environment. In this respect, adherence (by developers and companies in industry) to the recently passed compulsory water effluent standards (TTBS 1998) is expected improve coastal water quality.

- *Sewage pollution from yachts:* The number of yachts visiting Trinidad and Tobago increased from approximately 400 to 3,500 over a ten year period. This increase in yachts also brought with it an increase in tourism/boating and marina type facilities in areas such as Chaguaramas, on the north western peninsula of Trinidad. This, together with the increase in population (and sewage generated) of the peninsula brought additional volumes to already overloaded and non functioning sewage treatment plants in the area. In addition, there is no legislation with respect to " yacht holding tank requirements" for Trinidad and Tobago. Hence, the increased yachting community combined with already faulty sewage systems has exacerbated this problem. These issues need to be addressed immediately, in an approach to solving this coastal pollution problem.

- *Sand Mining on the Beaches and Coastal Rivers*: This action is very damaging to the coastal environment despite the fact that the sand mined provides good quality building material for many coastal/non-coastal residences. Sand mining in a river lowers its bottom, enlarges the mouths of

rivers and inlets, causes bank erosion and, most important of all, reduces the supply of sand to the coastal circuit. Thus, coastal erosions are being triggered and sustained perenially at river mouth areas and long downdrift stretches of the shoreline, presenting increased opportunities for coastal breaches of sand barriers (for instance, Nariva swamp sand barrier). The direct mining from the beach is even worse. It leads to recession of the coast. Usually, the effects of mining combine with effects of sea level rise. Any volume of sand extracted from coastal river beds or the coastal beaches is lost to the entire coastal system and no natural process could ever replace it.

- *Disappearance of Mangrove Coastal Fringes and Forests*: Mangroves on the coast represent a very effective natural protection against erosion inflicted by waves. They are also rich ecological coastal habitats and provides a linkage ground for terrestrial, coastal and marine environments. It has been proven through coastal experience worldwide that the disappearance of mangrove allows for an accelerated coastal retreat. Loss of mangrove and/or beaches resulting from the coastal developments adjacent to the Buccoo Reef Marine Park has also been observed.
- *Subsidence Due to Ground Water Over-Pumping:* Coastal aquifers make up a major proportion of ground water. Control on abstraction must consider structural integrity of the aquifer and avoid subsidence.
- *Subsidence Due to Underground Layers of Peat:* Or other soft materials, which constitute the geology of some zones of Trinidad (e.g. Mosquito Creek area)
- *Salt Water Intrusion into the Inland Territory and Ground Water Reserves:* Deepening of inlets and estuaries - man-made interventions in the rivers and coast – favour the steady penetration of wedges of sea water upstream along riverbeds, with detrimental long-term consequences for the environment.

All the above hazards must be quantified in the process of undertaking dedicated studies, so that the consequences can be realistically assessed and evaluated.

3.4 Transboundary Threats

The main transboundary threat to the islands of Trinidad and Tobago is with respect to oil pollution from ships using the marine areas around Trinidad and Tobago. For example, each year more than one thousand (1000) large vessels pass between Trinidad and Tobago transporting oil, gas and chemicals. With respect to the management and protection of the seas from maritime pollution, recent Shipping (Marine Pollution) Bill 2000 (for Trinidad and Tobago) provides for powers and jurisdiction in relation to pollution of the seas from ships; intervention on the high seas in cases of oil pollution, dumping of wastes at sea, prevention of pollution from ships, and vessels navigation in the EEZ as well as the territorial sea of the nation.

Due to the location, marine ecosystems in Trinidad and Tobago are influenced by discharges from the Orinoco River in South America. The ocean current systems may bring concentrations of marine organisms and pollutants with adverse effects.

The physical transboundary system for Trinidad is related to:

- Its location in close vicinity to a large continent, South America, with only approximately ten (10) to fifteen (15) kilometres width of narrow straits. In such areas, tidal currents build up higher velocities, with impacts on level of coastal erosion, coastal stability and navigation safety. Also, differences in water levels are registered within the Gulf of Paria in relation to the outside ocean, with the higher levels occurring within the Gulf.

- The Gulf of Paria is a unique lake-like water body along the entire western coast of Trinidad. It is characterised by low water circulation, shallow depths and above average temperatures. These factors together with its quasi-closed environment make it more vulnerable to environmental threats from urban, agricultural and oil/gas activities. The intense industrial activities located within the Gulf area and on Trinidad's western shores increases the risk of environmental failure and disturbance of the natural equilibrium, with accompanying losses.

- The currents affect the salinity of the south-west Gulf of Paria especially in the wet season by an influx of freshwater from the Orinoco. This can have a myriad number of impacts, most of which are naturalized within the Gulf itself. The influx of high levels of sediment reduces the visibility of the water and allows smothering of benthic organisms in the sediment. The influx of material into the Gulf, however, also brings high concentrations of nutrients for marine organisms and creates the environment for the development of fishing grounds.

- Its close vicinity to enormous rivers which discharge large volumes of sediments annually. A large part of the sediment volumes settling along the coasts of Trinidad (mostly west coast) emanate from the Orinoco River, Venezuela. Ecological impacts are experienced on the southern and northern part of the eastern coast of Trinidad (turtle migration, deposition of large constituent debris originating from the Amazon River, sediments)

- Its open exposure to Atlantic ocean action (east and south coasts), which makes important stretches of the coasts the target of strong waves. In most cases, significant erosion results resulting in losses of property including expensive and strategic infrastructure (coastal roads, bridges, resorts), disruptions in economic activities, loss of economic interest (tourism and business), and losses and damges to valuable historical assets and ecological values. This situation may well lead to an exposure to hurricane tails, which could sweep the coastal zones and significant inland regions of central-

southern Trinidad, and all of Tobago, during the passage of hurricanes through their traditional Atlantic path, east of Trinidad.

3.5 Land Based Pollution

The water regimes that are relevant to coastal pollution include coastal rivers, coastal inlets, creeks, estuaries, lagoons, ground water sources and the sea/ocean itself. The main water pollutants are urban, domestic and industrial waste, solid and toxic agricultural products and waste, sediments, oil spills, lubricating oil discharge, waste from fishing vessels, ships, tourist facilities and yachts (as in the case of the seas of Tobago's south-west coast). Pollutants could affect not only coastal water resources but also the beaches and shores.

Groundwater is increasingly used for drinking. For the sustenance of the availability and quality of this resource, the rate of extraction must not exceed the aquifer's replenishment capacity. High rates of extraction, even at local level, will cause a dramatic drop of water level, wells to run dry and allow brackish water intrusion (e.g. El Socorro aquifers). The most serious threats to ground water come from nitrate and bacterial contamination. While nitrate pollution is due to the excessive use of nitrogenous agro-chemicals, sewage effluents from pit latrine soakways and septic tanks would cause bacterial contamination.

Land-based pollution is a major threat to coastal area management since the coastal areas and the seas are the receiving waters (from drainage by streams, tributaries and rivers) for it. The coastal areas are the immediate sink for these effluents which are a combination of industrial, agricultural, municipal and domestic liquid and solid wastes.

In Trinidad and Tobago, land-based pollution contains a variety of wastes. A recent WASA/IMA study (1998) confirmed that many of the rivers especially in their lower reaches were polluted from a combination of domestic, industrial and agricultural wastes. Bacterial counts were also found to be in excess of international guidelines for the respective water uses (e.g. swimming). Some of the wastes for coastal areas of Trinidad are identified here:

- *Industrial Wastes*: These emanate from agro-processing (organic wastes), oil refining (hydrocarbons), paint manufacturing (chemicals), the Petrochemical industry, sediments from quarrying, rum distilling, service stations (including leakage from underground storage tanks), sugar cane production and refining and maintenance industries (chrome plating etc.).
- *Agricultural Wastes:* These may include livestock remains, waste slurry, plants, agro-industrial effluents-pesticides and fertilisers. In Trinidad, there is a severe problem of an excessive use of certain fertilisers and pesticides and the release of high strength waste from intensive animal farm operations. Animal waste and wash down from estates such as the Golden Grove Estate in Tobago runs off into the coastal area.

- *Domestic Wastes*: Composed primarily of human faeces, wash waters and a slurry of organic particles (sewage) and solid wastes. Improper treatment of sewage can cause contamination in the food chain through crops, and shellfish poisoning. Discharge of sewage effluent is the most severe.
- *Solid Wastes:* This problem is very severe in some areas eg. at the Beetham /Laventille swamp (north of the Caroni River) where tyres, motor vehicles, major appliances, floating livestock, and an array of consumer disposables such as diapers, styrofoam, plastics and cans are deposited in the swamp area. Also, leachate problems from the landfill site at Beetham appear to be contaminating the ground waters. Many of the disposal sites, legal and illegal, throughout the country are closely linked with waterways and cause significant restriction in flows as well as pollutant seepage.

In addition to the above, two other main concerns to coastal management are the effects of deforestation of areas and increased sedimentation in rivers. In Trinidad, there is much squatting on the hillsides which encourages the indiscriminate clearing of the hillsides and the characteristic "slash and burn" agricultural practices. This and other major deforestation activities (which remove the protective vegetation layer) in the Northern range of Trinidad has resulted in severe situations of "the inability of slowing the water" running off the hills. This results in exacerbated flood situations especially in the rainy or wet season. Of greatest concern in the past few years is the upsurge of residential developments in watershed areas. These areas are located on private land holdings but impact significantly in the run-off rates, sedimentation levels of rivers and downstream flooding.

Many rivers are also affected by heavy siltation which blocks passages lower downstream. A large quantity of silt comes from improper practices of quarrying operations (57 registered sand and gravel quarries in the country in 1993 and other poor land use practices (eg. unplanned construction) which cause the removal of protective vegetation and increased soil erosion. These large amounts of sediment from wash plants enter directly into water courses. Silt from some quarries has raised the levels of the mouth and lower reaches of the Caroni River, affecting the hydrology of the river. High concentration rates affect rivers such as the North Oropuche and Aripo Rivers in the North East. The North Oropuche River deposits its sediment in areas close to the breeding grounds of the manatee.

The increased sedimentation and silt (from inland operations) are transported to the coastal areas via the water courses. The results are very visible in coastal areas (especially after heavy rains) as aesthetically unappealing murky waters and solid wastes (domestic and industrial garbage). It also brings with it all the associated problems eg. unhygienic water conditions (presence of pathogens), degradation of bathing beaches water quality, contamination of vegetables and fruit (where river water is used for irrigation), contamination of ground water and eutrophication (leading to fish kill).

The land based pollution described above has a significant impact on "human health" and "the quality of life" enjoyed by the citizens of Trinidad and Tobago. Contaminants such as heavy metals and pesticides may be directly toxic or bio-accumulate in muscle tissues of humans when contaminated seafood is consumed. Swimming in sewage contaminated water also increases the risk of skin infections and other water borne diseases.

3.6 Tourism

Coastal zones harbour a significant component of Trinidad and Tobago's tourism industry. Tourism involves travelling to relatively undisturbed or uncontaminated natural areas with the specific object of studying, admiring and enjoying the scenery with its wild plants and animals as well as existing cultural areas. This sector can be adversely affected by the lack of proper coastal zone and watershed management. Tourism is an important foreign exchange earner, particularly in Tobago, which hosts the majority of stay-over visitors to the country. Tourism provides employment for thousands of people especially in the island of Tobago as it is an attractive tourist destination, and the sector is earmarked for continued growth. Tobago now has a large number of hotels, mainly in the South-west region. The harbour at Scarborough has been deepened and improved to accommodate cruise liners. The airport has also been upgraded by extending the runway and constructing a new terminal. Tourist accommodation in Trinidad and Tobago ranges from large hotels associated with international chains to small guest houses. There are at least one hundred and twenty three (123) hotels and guest houses scattered throughout Trinidad and Tobago and the amount is significantly increasing in the island of Tobago.

The Tourism Master Plan for Trinidad and Tobago (TMP 1994) has as one of its key objectives the development of a sustainable tourism industry based on leisure, recreation and ***ecotourism***. The document proposed a national tourism policy which includes issues (highlighted here) pertinent to coastal area management under the following objectives:

- "specific programmes to strengthen and/or create linkages between tourism and entertainment and cultural industries, agricultural/fisheries suppliers, manufacturing and services exporters and technology firms"
- " a community tourism involvement programme which helps communities to determine their desired role in tourism and how they might achieve it"
- "a proactive development approval system that is environmentally responsive"
- "a system of revenue generating parks"
- "links to heritage resources to provide visitors with an appreciation of the country's history and culture and to provide heritage attractions with a revenue source from tourism"

The plan includes management and development in coastal areas of Trinidad and Tobago. For Trinidad, these include proposed beach (and beach facilities) improvement, turtle viewing reception centres, Matura turtle education centre, Nariva manatee observation area, Manzanilla beach beautification, Waterfront improvements (Port of Spain and San Fernando Harbours), National Parks (Northern Range and Chaguaramas), education and tourism programmes, visitor centres, rainforest trails , nature centres and scientific research centres. In Tobago (which is already very tourist-oriented), there are plans to further improve the waterfront developments at Scarborough to improve the beach and beach facilities at Pigeon Point, development of the scenic coastal roads/drives and the creation of a Tobago Highlands National Park.

The impacts of such tourist activities will directly result in:

- increased generation of solid wastes and sewage in areas of hotels and housing developments, especially, as sewage treatment facilities there are not being maintained and some are mal-functional. Consequently, these wastes enter into the coastal area.
- disturbance to fauna and flora in their natural environment due to activities such as reef walking by the tourist and by indiscriminate anchoring and moorings.
- change in coastal areas due to construction of infrastructure

Unlimited indiscriminate activities have resulted in certain large patches and areas of the reef dying off in addition to reduced numbers of reef fish observed. Much research has been done in the Tobago coastal areas and especially on the south west coast, including the Buccoo Reef. A Management Plan for the Reef, was done by the Institute of Marine Affairs (IMA 1994). The Tobago House Of Assembly (THA), in it's preservation thrust, commissioned this along with other identified coastal area plans. Unfortunately, many of the management options of the plans are yet to be implemented. This lack of management of the Buccoo Reef and other coastal areas in Tobago has led to the further deterioration of the reefs and their associated resources.

These coastal issues will have to be addressed in order to make the tourism development activities sustainable. Carrying capacity studies in the coastal areas will assist in this respect towards determining the feasibility of these activities. For example, one of the major determining factors of the success of the beach development will be in the maintenance of good water quality.

3.7 Health

Cities, industries and boats find coastal zones convenient and economical sites to dispose of treated and untreated sewage and wastes which is a major source of the many types of pollutants plaguing the coastal waters. Our coastal waters are also becoming polluted through poisonous "surface run-off" which comes from many varied sources - industrial wastes, farms (pesticides), streets and construction sites, with tremendous impacts on human and animal life. The Coastal Zone is a living, dynamic complex of interacting phenomena. Tides, wind, rainfall, temperature, currents, animals, plants and nutrients interact and influence the physical, biological and chemical processes which occur there.

Water pollution is caused by the discharge of substances into or which otherwise have an impact on the surface water, sea, groundwater, wetlands or marine areas within the environment and which, based on technical, scientific or medical evidence, is determined to cause, or likely to cause harm to human health or the environment. Since water plays such an integral part in our daily lives it is crucial to be aware of the different types of activities that can contaminate it, since if human or animal contact is made it can lead to serious illnesses and or death. In the Caribbean, declining coastal water quality, reef degradation and beach erosion are linked in a cycle threatening public health, shorefront properties and tourism.

The following are the major types of wastes in the local environment have significant adverse effects on our coastal zones:

- Industrial waste includes direct untreated effluent discharge by industries, which may contain a wide variety of organic and inorganic chemicals. This variation depends on the type of industry and processing activity. Agricultural waste results from the excessive application of certain fertilisers and pesticides by our farmers and the release of highly concentrated waste from intensive animal farm operations.

- Domestic waste is composed primarily of human excreta and washings. It does not generally contain chemical contaminants but may carry numerous pathogenic micro-organisms. The effects of such pollution can manifest itself in the eutrophication of surface water leading to fish kills and to contamination of ground water supplies.

- The abundant mineral and organic nutrients that are brought in from the sea are mixed with run off, circulated and distributed to form the basic building blocks for the plants and animals that abound within the coastal zone. Coastal wetlands and shallows are critical areas since they provide nutrients and nurseries for many important fisheries making it also economically important. Coastal Zone plants also provide breeding, hatching, nesting and protective areas for many forms of terrestrial and aquatic animals.

- Hazardous waste is waste or combination of wastes, which because of its concentration, quantity or physical, chemical or infectious distinctiveness may inter alia-

    - Cause, or significantly contribute to any increase in serious irreversible or incapacitating illness; or
    - Pose a substantial present or potential threat to human health, or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

The major health concerns related to coastal area management are with respect to the water quality at bathing beaches and the issues of contamination of both marine fish and shellfish as well as that harvested from the coastal swamps and wetlands. Poor water quality can be directly contaminating to humans by the direct intake of the water. In Trinidad, studies have shown poor quality water at certain beaches, especially so at the start of the rainy or wet season. Swimming in sewage contaminated waters may cause severe diarrhoea, gastroenteriitis and/or skin rashes. Sewage contaminated water which contains bacteria and viruses can also transmit diseases such as cholera (eg, through shellfish), typhoid fever , hepatitis A, and polio.

In Trinidad, the risk of consuming shellfish (oysters and mussels) because of the micro-organisms in sewage, is well documented for certain areas of the coastal swamps. In extreme situations, the Ministry of Agriculture has been forced to issue “bans on harvesting shellfish in certain areas”.

In Trinidad, a few studies (by the IMA and UWI) have attempted to determine levels of contaminants (eg. heavy metals in fish tissue) in seafood, especially in the coastal industrial estates. Such studies have not been on-going to ascertain and quantify the risks of consuming specific species of fish or shellfish. organisms. It is this kind of monitoring information which will be useful in management of the coastal areas.

Presently in Trinidad and Tobago no legal or regulatory framework exists for effectively dealing with hazardous waste. Bits and pieces of legislation exist within the various laws, nonetheless, the void in the legislation poses a serious threat to our environment and human health and a remedy to address this situation is required as a matter of urgent importance.

3.8 Data, Information Management and Research

Presently, there are no fixed monitoring programmes (through any one institution) in place, for collecting data on coastal management issues. Human resource and funding constraints in addition to major changes in objectives for Government institutions and/or divisions (Forestry, Institute of Marine Affairs (IMA), Fisheries etc.) preclude systematic scientific studies in potentially crucial

areas. This is unfortunate since there is need for focused attention to unravel many environmental relationships which are as yet, still unclear. For example, monitoring of direct links between environmental issues and health effects has not been done for specific communities in Trinidad and Tobago. Such public health information becomes crucial when coastal management issues such as the water quality of bathing beaches is being examined.

There is reasonable equipment in the country (at the IMA, UWI and other institutions (including private environmental consultancy offices) for data collection, measurement of environmental parameters and monitoring. These include tide gauges, current meters, meters for measurement of pH, BOD, COD, conductivity, dissolved oxygen, temperatures and other specific pollutants of coastal and marine waters. The UWI and the IMA also utilise satellite imagery from external sources to collect coastal and maritime information. The IMA is by far the repository with the most original amount of information with respect to coastal management and the status of coastal and marine resources, since the institution had been solely actively engaged in marine and coastal scientific research from 1976 to 1990. Since then the focus has changed to consultancies and the pure research/ monitoring etc. has suffered tremendously. The Fisheries Division (of the Ministry of Agriculture) has the best repository of fisheries data and information and the Forestry Division (of the Ministry of Agriculture) has the best repository of information on the coastal swamps and wetland areas in Trinidad and Tobago. However, due to financial constraints the more recent information out of these divisions have also been private consultancy contracts and the data tends to be more project-specific and located at various agencies, institutions and/or divisions of ministries.

Energy Companies such as BP Amoco, Trinmar, Petrotrin and Exxon have all commissioned numerous studies on all wasteland percentages. These are available from the Ministry of Energy.

In order to aggregate good information and data, there must be a more focused program with respect to the collection of the various kinds of data. This must be a co-ordinated effort to ensure the data collected is standardised and in formats which are easily retrievable to assist in making sound coastal management decisions in the future. For example, coastal fisheries data needs to be more focused in terms of assessment of the status of commercial stocks, including scientific information about the commercially important species. It is critical that a data collection program be set up using all the institutions which are presently involved (or are able to) in collecting routine data; notably the IMA, WASA, UWI, Drainage Division, oil companies, Ministry of Energy and Forestry and Fisheries Divisions of the Ministry of Agriculture. The data base should include quality controlled data which could perhaps be maintained by a single institution.

Data Collection

The Institute of Marine Affairs is the main source of data on coastal areas with tidal data and bathymetric data available from the Hydrographic Unit and from the Admiralty Tables. Coastal erosion and coastal morphology data have been collected and used in a number of reports and studies identifying the main areas of susceptibility to coastal erosion both in Trinidad and Tobago.

Two (2) tidal stations located in the Gulf of Paria and at Point Fortin have long term data while other gauges at Scarborough and Charlotteville in Tobago and Guayaguayare in Trinidad have data of various durations. The IMA had collected data from Chacachacare, Five Islands, Point Lisas, La Brea and Erin on special projects. Tides in Trinidad have been classified as being semi-diurnal, within the Gulf of Paria tidal changes range between 0.9 m. in the north and 1.2 m. in the south.

Coastal areas have been monitored to obtain beach profiles since 1980 and on a continuous quarterly basis since 1990 by the IMA, this frequency tends to give a reasonable indication of beach erosion.

Rainfall data coverage of the coastal areas is generally inadequate with very few gauges sited on the coast. On the northern and northwestern coastline there are a few gauges with more than thirty (30) years of data, this is insufficient for any national study.

Data on the coral reefs have been collected twice a year over the last five (5) years at two (2) sites in the Buccoo Reef. There is available data for 1998 at one (1) site, with a disease survey conducted on a pristine, intermediate and impacted reef system. Seagrass beds are monitored and data collected twice a year for the past five (5) years on the growth and five (5) times a year on the productivity of the seagrass system in the Bon Accord Lagoon. Data on the mangrove wetlands have been collected twice a year for the past five (5) years on the structure and productivity in the Bon Accord Lagoon.

In addition, a project to collect data at four (4) other coral reef systems; Salybia in Trinidad and Culloden Bay, Arnos Vale and Charlotteville in Tobago was initiated. Sampling is to be carried out at two (2) depths, ten (10) centimetres and three (3) metres using ten (10) metres lines/transects.

Wave data are available at the IMA, wind speed; wind direction, salinity and temperature data are also available from the Meteorological Office and from the IMA. Observations from data collected in 1961 indicate that average sea surface temperatures range from 26.5 ^{0}C in the dry season to 28.0 ^{0}C in the wet season. Salinity ranges from 15% in the wet season to 34% in the dry season.

Remote sensing data and aerial photographs are available but without any field calibration, this data can only provide generalized qualitative information. Data

on water and sediment quality are available from the IMA or from projects carried out on behalf of clients by the IMA.

From monitoring programmes, hydrocarbon contamination is evident in Point Fortin, Point-a-Pierre and Point Lisas which are considered to be hot spots. Research on water quality and sediment quality data collected by the IMA either for research or client projects are published and are available. Although insufficient to inform on a national level the evidence is there to suggest high levels of petroleum hydrocarbon contamination existing in coastal waters. Point Lisas hydrocarbon levels are not as high as that of Point Fortin or Point a Pierre but the heavy metals concentration may be higher. Natural oil seepages along the Los Bajos Fault in the south west coast off Point Fortin are some of the sources of these hydrocarbons.

Equipment

The equipment used is state of the art equipment, such as digital wave meters and S4DW digital current meters. Global Positioning Satellite technology (GPS) for pinpoint accuracy on the location of gauges is utilized where necessary.

Gauges used for measuring tides are chart based and have been known to malfunction from time to time, resulting in gaps in the dataset. Rainfall data is collected from either Cassella automatic or manual rain gauges and from Lambrecht recording rain gauges.

Grab samplers are used to obtain sediment data with Sokkia Surveying Level instruments for surveying shoreline change. YSI probes and sensor are used to obtain water quality data e.g. pH, temperature, dissolved oxygen, salinity.

Research Efforts and Findings

There is a significant amount of research studies/projects carried out on coastal areas in both Trinidad and Tobago by:

- The Institute of Marine Affairs (IMA)
- The University of The West Indies (UWI)
- The Ministry of Agriculture, Land and Marine Resources
- Ministry of Energy and Natural Resources
- Ministry of Works – Drainage Division
- Consultants working for special interest groups

Some of the reports on projects/ studies are restricted with respect to reproduction of its content by the client(s), but are available at the library of the IMA for on the spot perusal.

Coastal erosion data indicates the north coast beaches appear to be more stable than the east coast beaches with erosion ranging from 1-2 metre per year in Cocos Bay. In Trinidad, coastal erosion is more prevalent than accretion although accretion is more dominant along the western section of the south coast of the island. Coastal erosion is quite severe at Columbus Bay and Corral Point on the southwestern part of the West Coast of Trinidad. Erosion is estimated at 2.0 m per year.

In Tobago a field survey conducted by IMA revealed that the major physical changes taking place on the shoreline relate to coastal erosion. The main cause of erosion was identified as wave action, sand mining activities and inappropriate coastal structures with the highest incidences occurring at Great Courland and at Little Rockly Bays. Coastal erosion is evident at La Guira Bay, Little Rockly Bays, Rockly Bays, Goldsborough Bay, Great Courland Bay, Pigeon Point, and

Milford Bay. Data collected from 1980 suggests that beach sand mining is a serious problem.

Wave data is limited and most comparisons are made from data collected by ship observations between the period 1855-1987. IMA collects data on a project by project basis using their two (2) wave meters. One (1) of the meters can record both wave height and direction whilst the other can only record wave height.

Tidal data for short periods at different locations around the islands are available from the IMA. It is felt that this is adequate for oceanographic modeling, but long term data is required for trend analysis of sea levels. One gauge situated at Point Fortin has more than ten (10) years of data while the other two (2) gauges at Port of Spain and Scarborough have less than ten (10) years data with breaks in the records.

A comprehensive water quality and sediment quality monitoring program is necessary to assess improvements or deterioration of the coastal environment with particular emphasis placed on petroleum hydrocarbons, heavy metals and pesticides. It is evident from the data collected so far that a number of hot spots do exist. The East Coast of Trinidad while not as polluted as the West Coast has started to show signs of petroleum hydrocarbon pollution. Recent data on the Gulf of Paria is lacking. However, with some forty two (42) marine platforms and more than one hundred (100) kilometres of pipelines, together with frequent movement of oil tankers in this region, there is a basis for investigation and assessment of any negative impacts. A field survey by the IMA has revealed natural seepage of hydrocarbons offshore from the Pitch Lake and also in the Soldado Fields along the Los Bajos Fault.

There is a considerable amount of research papers, studies and reports compiled on coastal areas and in particular physical oceanography, water chemistry and coastal dynamics. The Library of the IMA and the Library of the UWI are two of the major repositories of information.

Data Manipulation

Most of the data collected are stored in databases or in flat files and processed using personal computers running specific applications for the particular analysis. For example, wave data is analyzed using S4 Application Software App 272 and tide data using Tide recorder software Term 26 and App 272. Microsoft Excel spreadsheet applications are also used where applicable.

3.9 Stakeholder Participation/Awareness and Education

In terms of overall coastal area management, there have not been any organized public awareness activities. However, the public relations activities of two (2) main institutions have assisted tremendously in educating the public on environmental issues which have covered the coastal areas. The EMA has been actively involved in promoting environmental awareness via the media (articles, anti-pollution and public health advertisements), green campaigns and in schools (providing environmental literature, posters, lectures and green competitions with prizes). The IMA has also been similarly promoting protection and conservation of the seas and coastal areas by a series of video presentations, lectures and open symposia for presentation of scientific research results.

While there is no current data as to the effects (measures of success or failure) of these activities, they (together with environmental groups and lobbyists) have been partly responsible for the environmental awareness of the general public..For most development projects in Trinidad and Tobago, the requirement for planning approval sometimes entails an Environmental Impact Assessment or Environmental Statement of some sort. The proposed legislation - Certificate of Environmental Clearance - will mandate an environmental assessment or EIS or ultimately an EIA for all developmental projects likely to have significant environmental impacts. Part of the terms of reference of these project documents suggests stakeholder participation/ town or village meetings. There are presently in Trinidad and Tobago, a few environmental groups such as (COPE), an organisation for the protection of the Environment), Fishermen and Friends of the Sea (FFOS) and Environment Tobago which have been actively taking part in terms of contributing ideas and suggestions towards developmental projects. Unfortunately, with most of the projects, this meeting takes place towards the end of the EIA, when the actual designs have already been done. In effect, the environmental groups as well as the affected public (eg. villagers and communities) feel that their opinions are not seriously considered early enough in the process which they feel can help determine the best coastal management approaches.

With respect to the recognition of gender importance in coastal mangement, significant strides have been made in this area at the Nariva Swamp in Trinidad. The Gender Studies Department of the University of the West Indies, St. Augustine has been working with the communities here towards the empowerment of women and sustainable development of the swamp resources.

3.10 Institutional Frameworks

Trinidad and Tobago is currently in the process of modernizing it's legal and regulatory framework in relation to environmental protection, land and natural resources management and administration, and agricultural development. Integrated watershed-coastal area management has already been identified as an approach to address watershed and coastal and there are already various relevant laws to enforce compliance to achieve it. Many of the legal and regulatory requirements are at this stage pending approval and promulgation; these are discussed here.

Environmental Management Act of 1995 and Supplemental Legislation

The Environmental Management Act of 1995 established an autonomous agency called the Environmental Management Authority (EMA) under the Ministry of Planning and Development. The act reflects the commitment of the Government of Trinidad and Tobago towards achieving economic growth in accordance with sound environmental practices. The objectives of the act include: integration of environmental concerns into private and public decision making; establishment of an integrated environment management system and regulatory framework to protect, enhance and conserve the environment; and development and implementation laws, policies and programs that foster conservation and wise use of the environment. Almost all these aspects are of direct relevance to the integration of watershed/coastal area management.

In this respect, the Environmental Code was developed by reviewing all legislation pertinent to environmental protection, standards and practices and sought to rationalise (and modernise) the legal and institutional framework for environmental management. The Authority may prescribe in accordance with section 26e the designation of a defined portion of the environment within Trinidad and Tobago as an enironmentally sensitive area, or of any species of living plant or animal as an environmentally sensitive species, requiring special protection to achieve the objectives of this Act. The EMA will co-ordinate with the relevant government agencies (unit responsible for watershed/coastal areas management) having responsibility for planning and management in such areas or with respect to such species.

Planning and Development of Land Bill (pending)

The Planning and Development Bill (PADL) is intended as a comprehensive land-use planning and development control instrument: to promote land development in a healthy natural environment; to maintain and improve the quality of the physical environment within which patterns of human settlement are situated; to assist in the orderly, efficient and equitable planning, allocation and development of resources; to ensure that the most efficient, equitable and environmentally sustainable use is made of land in the interests of all the people of Trinidad and Tobago. This new act will be carried out under the authority of the Ministry of Housing and Settlement, will replace the Town and Country Planning Act. The act will also establish the National Physical Planning Commission as the new national planning authority which will designate development control to local authorities. In this respect, the local authorities (together with Drainage Division) will be empowered to execute all required works inclusive of removing unauthorised structures. These will include development plans, issuance of development permits and in the designation and application of restrictions to development in environmentally sensitive areas-including those posing human health and safety risks or in relation to priorities of environmental health and safety protection and natural resources conservation.

Forest Resources Bill (pending)

This Bill (which will replace the Forests Act, 1915) ensures a mandate to conserve, manage and develop Trinidad and Tobago's natural and artificial forest resources, under the authority of the Ministry of Agriculture Land and Marine Resources (MALMR). The Bill establishes the authority to declare forest reserves and conservation areas for reasons including: proper watershed management practices, sustainable timber production, control of quarrying, development of recreational facilities and protection of flora and fauna.

The Institute of Marine Affairs Act

The Institute of Marine Affairs Act of 1975 (amended 1990) sets a mandate for the IMA to carry out research and monitoring in the marine environment. The IMA also functions as a technical support organisation to the Government of Trinidad and Tobago and plays a key role in the development of standards with respect to the marine environment.

National Parks and Other Protected Areas Bill (pending)

This Bill intends to provide the legal basis for the preservation, protection and management of designated national parks and other protected areas. The Bill provides for the establishment of the National Parks and Wildlife Authority under the general authority of the MALMR (responsible for application of the Bill's provisions). The Authority will co-ordinate functions with the EMA.

The Environmental Management Authority (EMA) is now charged with the responsibility of development towards safeguarding the environment of Trinidad and Tobago. The EMA can co-ordinate the various pieces of

legislation (which already exist) under the aegis of several government agencies. The Government of Trinidad and Tobago already has the legal instruments (as detailed above) to effectively control water pollution, landuse, coastal deterioration to the extent of effectively controlling the incidence and impact of destruction of these two (2) major areas within which the country's major resources fall. The EMA will effectively be the Government's arm towards implementing it.

The policies described above are quite adequate to guide the management of watershed and coastal areas. This however only happens in a very limited sense, in that there is much non-compliance by individuals, companies, factories. There also continues to be lack of co-operation between the responsible sectoral agencies, ministries, divisions and units. This unsatisfactory scenario will continue as long as there is continued neglect of compliance with the relevant legislation. Much environmental misuse and abuse takes place in Trinidad and Tobago without consideration for the legislation.

The Interim National Physical Planning Commission (INPPC) of the Town and Country Planning Division continues to exercise planning at the national level related to coastal areas. The INPPC is expected to be succeeded by the National Physical Planning Commission (NPPC) that is proposed by the Development of Land Act-2000 (a Bill, now before Parliament). If the Bill is accepted in its present form, physical planning will become the responsibility of the NPPC at the National level and the local planning authorities at local levels.

The NPPC as proposed will be a relatively independent stakeholder-commission with the tasks of:

- Advising the Minister responsible for Physical Planning with formulating National Physical Planning policy.
- Implementing physical planning policy that has been accepted by Parliament at arms length from the Minister. (The Minister will not be involved with day to day implementation and will only be able to adjust accepted policy through gazetted policy directives).
- Stimulating the institutional development of the planning and development control capability of local authorities.
- Overseeing the local planning authorities and ensuring coordination between local area plans and the national physical development plan.

All coastal planning matters will be incorporated/reflected by stipulations of this Act.

In Trinidad and Tobago, a Reclamation Committee (RC) was disbanded some time ago and reconstituted as the West Coast Masterplan Committee. The Chairman of the (Interim) National Physical Planning Committee (INPPC) now chairs the new Committee. The Reclamation Committee in the past advised the Commissioner of State Lands with respect to the granting of reclamation

licenses. The West Coast Masterplan Committee continues to do so but is also responsible for developing an integrated coastal development plan for the west coast of Trinidad and for development control along all the coastal waters of Trinidad and Tobago.

4.0 INTEGRATING WATERSHED AND COASTAL AREA MANAGEMENT

Coastal Zone Management (CZM) is the process of preparation and implementation of a *Coastal Zone Management Plan*. Its integration with the coastal watershed management brings about a complete unified approach of the two systems that interact, at the level of the shoreline.

Although the definition of the *Plan* may vary, it is usually taken to mean a non-statutory plan, prepared for a group of interested organisations that have management responsibilities at the coast. Government could have the leading role in this preparation process. The integrated *Watershed-CZM Plan* provides a unified framework to help resolve competing pressures on the coast and takes cognizance of the coastal and watershed inter-dependency. It generally covers the following main issues:

- Watershed Control
- Coastal Development
- Recreation
- Landscape
- Natural Environment
- River and Coastal Water Quality
- Navigation
- Fisheries
- Coastal Defence
- Institutional Capacity

The extents of CZM Plans vary, but normally they focus on a specific but large area such as a watershed and its related length of coastal zone. Administrative factors such as the marine territorial limit or a regional or development boundary on the landward side may condition the boundaries of the integrated watershed and coastal zone region. Alternatively, those boundaries may be conditioned by physical boundaries such as the location of sediment build up supplied by the river or on the origin of sediments located along the coast. Nevertheless, the underlying implications for the CZM Plan remain the same in that it is required to consider all the pressures (physical, social, quality, quantity)

and issues (economic, development, protection) concerning the watershed-coast system in an integrated way, hence the often used qualification "*Integrated Coastal Zone Management*".

A CZM Plan may be prepared in order to support a development plan (e.g. local or regional statutory plans), which has been more generally prepared with terrestrial planning interests in mind. It could take the form of a broad strategic framework or a detailed action plan for those charged with day-to-day management of the watershed and the related coast. However, whichever form it takes, it will almost certainly encompass most or all of the following considerations:

- *Watershed Control:* streamflows, sediment loads, pollution and impacts on ecology

- *Development:* asset identification; land use; regulations; zoning; access; coastal structures; flood control; hazard management; land use control (planning); agriculture management; development assets that are conditional on proximity/access to sea

- *Recreation:* tourism; beach use; demand/supply; leisure navigation; watersports; swimming (safety of); tourist industry/infrastructure; hotel and other holiday accommodation and coastal pathways

- *Landscape:* visual impact; visibility; heights and appearance of defences and influence on tourism

- *Natural Environment:* reefs and seagrass; other coastal habitats; marine ecosystem; terrestrial ecosystem; swamps and nature conservation

- *Water Quality:* surface flow; rainfall; subsurface flow; sewage; use of fertilizers and pesticides; hydrogeology; pollution; storm water management; fluvial discharge and salinity

- *Navigation:* port planning (inc. influence on infrastructure); port and harbours; navigation access channels; dredging and dredged channels; navigability; shipwash and interaction with coastal defence works

- *Fisheries:* water quality; navigation; salinity and saline intrusion (estuaries); landings; anchorages and fish processing

- *Coastal Defence:* coastal processes; wave regime; tidal regime; sediment budget; sand spits; sediment regime; shoreline evolution; shoreline response (to interference); coastal defence risks (flooding and erosion); assets at risk; the need to defend (or not); benefits of defence; costs of defence and impacts on other attributes

- *Institutional Capacity:* legislation; governmental administration; public participation; education; statutory planning; protocol between government departments and private sector and project funding and finance

The list given above is not exhaustive, but indicates the very broad range of attributes that might apply in the preparation and execution of an integrated *Watershed-Coastal Zone Management Plan.* The main purpose of CZM is to manage development so as not to harm environmental resources. This is achieved (or should be achieved) through a co-ordinated and integrated approach to resource management that is underpinned by a strategic framework (the CZM Plan). CZM can be undertaken through focussing on individual issues but these issues still need to be considered at the strategic level and in the context of other uses, activities and interests in the coastal zone.

In considering the coastal zone as one system of interacting resources, those charged with its management should be responsible for the development/ implementation of a comprehensive protection and control oriented policy, in order to preserve/conserve the existing values for future generations. The major systems which interact within the coastal zone are:

- Natural systems, such as watersheds, estuaries and coastal seas
- Socio-economic systems, such as agricultural production, urban settlements and industrial activities
- National valued systems, such as monuments, religious worship sites and historic relics
- Real estate systems, including the economic value of terrain that could be saved from destructive action originating from the sea.

The main issues to be considered include:

- Sectoral Planning
- Coastal Erosion Management (to include Coastline Erosion Control)
- Coastal Water Management
- Coastal Habitat Management
- Coastal Pollution Management
- Water Quality Control
- Coastal Land Management
- Protection and Maintenance of Coastal Sites of Special Significance (archaeological, religious, historic, other moral value)
- Special Areas Management

The amazing reality is that there is no Coastal Zone Management Plan in Trinidad and Tobago. This is in light of the fact that presently CZM Plans have

been elaborated by some 95% of island-nations worldwide. In some cases, those CZM Plans have evolved into their third (3rd) to eight (8th) updates, in island-countries like SriLanka, Cyprus and Taiwan. In the Caribbean region, countries as Martinique, Guadeloupe, Jamaica, Barbados and others have elaborated CZM plans since the early 1980's.

In principle, well-defined and implemented CZM plans provide a basis for long-term savings at the national level and for all integrated activities in the coastal zone and coastal watersheds. The correlated management of coastal hydrological basins and coastal zones should yield positive results in relation to a reduction of negative impacts on coastal regions.

With respect to coastal zone plans/policies in various stages of development, the NEDECO consultants report under the on-going Coastal Protection Project in Trinidad (Client - Drainage Division) reviews existing plans and policies that impact on the Coastal Zone of Trinidad and Tobago. This report is the first to address CZM issues within the country, with a formal recommendation that Government should initiate a CZM Study and elaborate the first version of a CZM Master Plan, as soon as possible. However, a number of concept plans and draft local area plans relating to coastal areas have recently been formulated under the aegis of the Ministry of Housing, Development and Planning. These include:

- The San Fernando Local Area Plan
- The Port of Spain Waterfront Concept Plan
- The Couva Draft Local Area Plan
- The Mayaro/Guayaguayare Concept Plan
- The Point Fortin Concept Plan
- The Chaguaramas Development Plan

It is critical that further development of these plans be informed by CZM considerations. It should be noted that in many cases, development and investment of private entrepreneurs in coastal areas are unfortunately and detrimentally held back by the absence of such national CZM Plans. Inexplicably, Trinidad and Tobago is one of the few countries worldwide that has not yet initiated such CZM studies and developed long-term Master Plans.

A number of potential issues are related to water management in the coastal zone, namely:

- water quantity and flood control
- water quality and drinking water supply
- water use in agriculture
- fisheries and salt water intrusion

- water use in transport
- water surfaces for recreational users (tourism), to include coastal sea waters

The water management should be carried out in an integrated way. That is it should be recognized that there is only one water system, comprising as its main components: water, the bed/bottom and the banks/shores. In the broadest sense system interactions should be recognized at the levels of the physical, chemical and biological.

The water management concept should incorporate everyone. It should encourage participation of both local authorities and public users, since they are called to be the main financial contributors to plans and projects on the basis of the "polluter pays" principle.

To facilitate appropriate and sustainable development in the future, a long-term approach must be adopted. Further, legislation on water quality standards, regulation and strong means of enforcement are needed.

One of the major challenges in the management of coastal zones is to relate the CZM Plan with the existing planning programmes. These may include the following interests:

- Planning of coastal land use and of coastal recovered lands from the sea through reclamation actions
- Registration of lands and regulation
- Taxation
- Provision of development and land use conditions

Land use planning and its implementation at national level is easier when the Government owns and controls coastal land. Where it does not have such control, it may be advisable to acquire such lands by compulsory purchases. Other specific Government oriented measures could be implemented meanwhile, such as restrictions on private purchase and development, zoning, rights of access, protection of natural habitats, limits of infrastructure build-ups and setbacks.

Land use management is characterised by relatively complex planning procedures that seek to establish a formal plan that should be acceptable to all relevant sectors of the community. It should also have a strong legislative base. Land use management generally uses a range of instruments to achieve its goals. These include zoning, a permit-based system and a regulation mechanism that involves penalties and enforcement provisions.

Many island nations practice four types of planning that will directly influence the shape and direction of CZM planning, namely:

- National economic planning involving given goals for each sector of the economy and calling for allocation of labour, investment capital and land use
- Sectoral Planning
- Coast-wide or island-wide land use planning/regulation
- Planning related to special areas or regions

5.0 NATIONAL ACTION PLAN TO IMPROVE INTEGRATED MANAGEMENT OF WATERSHEDS AND COASTAL ZONES

There are many benefits of putting into place a framework for coastal zone management, integrated with coastal watershed management, leading ultimately to the production and execution of an integrated Coastal Zone Management Plan for Trinidad and Tobago. The following list is not exhaustive but serves to indicate some of the principal advantages of national significance:

- The very process of planning and integrating the management of the coastal zone together with coastal watersheds provides a more favourable outlook on the future for such regions. This generates increased confidence for commercial investments e.g. hotels for the tourism industry, both local and foreign, and provides a well-balanced long-term policy favouring and encouraging private investments within the coastal zone

- By making more sustainable and efficient use of the natural resources, there will be increased opportunities to enhance the coastal environment from many different perspectives including the conservation of ecology

- Several of these improvements will be visible and realised within time scales such that benefits to the community can be perceived

- Such benefits are by no means superficial. On the contrary, by making strategic use of the coastal resources, the benefits should be quantifiable in terms of a long-term economic advantage to the nation

- As well as providing a better framework for the involvement of private enterprise, the adoption of a plan for joint watershed and coastal management will facilitate more efficient use of governmental and other public sector resources, thus making for more cost effective administration

- Having a publicly available plan for development should reduce the potential for conflict between parties with competing interests in the coastal zone

All the factors mentioned above, if achieved through adoption of integrated watershed-CZM, and ultimately a CZM Plan, would position Trinidad and

Tobago properly in the pursuit of sustainable development and integrated management of its coastal zones.

The strategy for CZM implementation should include sectoral and cross-sectoral sub-strategies including:

- Pollution Control Standards for coastal waters (fresh, brackish and salt) have to be accepted and adopted.
- Land Use Planning
- Environmental Assessment and Environmental Audits
- Conservation actions (limiting the degradation of and preserving the coastal environment is a strategy element that is made effective by creation of special management area status).

The following components should be put together in effecting the implementation of a CZM Plan:

- The work plan has to be broken down in accordance with the major CZM tasks. The agencies responsible and the schedule of tasks are key elements to be outlined
- Requirement for the evaluation of the performance level of the CZM plan. Normally, this would be incorporated within the accompanying legislation
- Verification procedures
- Re-evaluation procedures, to allow for re-evaluation of the CZM Plan, in case changes occur in the national policies relating to land use planning, physical planning, economic planning etc.
- Training, to be carried out at various levels of involvement in CZM: top management, related agencies, policy makers, executive personnel responsible for CZM tasks (fisheries, water quality, pollution control, coastal processes), technical support staff, coastal professionals, marine police, law enforcement officers, etc
- Raising the level of awareness of both the larger public and specific target groups of users
- Contingency planning, such as for rapid response to crisis situations like oil spills, hurricane, flood, earthquake, etc
- Monitoring procedures
- Enforcement procedures and requirements, which is a very sensitive area since the interaction between CZM plan managers and various user groups could shift negatively.

Sourcing external funding for a CZM Plan is a key step in its implementation. Negotiations and arrangements are necessary even if extended possibly over many years. The establishment of good contacts and well-oriented discussions

should begin before the CZM implementation. A bridging plan should be elaborated, in order to re-establish order of actions under scenarios with non-financed long time lags, before funding arrangements are finalized and funds allocated, prior to implementation of the Plan.

Any original CZM Plan should outline a strategy that is expected to be effective within the context of a set of conditions, valid for a certain period considered and envisaged by the Plan makers. The original CZM Plan would generally target the mitigation of adverse impacts of development activities or the effects of the occurrences of natural hazard events on coastal areas. However, increased economic and social activities in the coastal zone would produce changes of data and priorities that had been considered for an initial version of the Plan. These would require an adaptation of the CZM Plan to cater for new conditions.

The scope of revised CZM Plans would include not only direct control and mitigating actions, but also educational and enforcement programmes to effectively address problems. The CZM Plan should also incorporate a process of Stakeholder Identification and Participation and identify Research and Development initiatives. The initial CZM Plan should also specify the period for periodic revision of the Plan.

Planning and preparation are required in relation to the number of natural hazards which are expected to impact on the coastal watersheds and coastal zones. Such preparation would relate to:

Hydrology Hazards

Main coastal hydrological basins must be assessed with respect to ***flood-generated hazards***, under normal and extraordinary conditions. Mapping of flooding risk of various return periods should be produced along with their physical extent within the watershed. Besides, such studies should identify the risk of generating mudflows within a particular coastal watershed and evaluate the associated potential damage. Such hazard mapping of coastal basins will be extremely useful in planning, designing and providing risk insurance for various assets within the basin.

Coastal Hazards

The categorization of the intensity of sea storm should be incorporated with the framework of Coastal Hazards assessment. In accordance with coastal physical details, particular local/regional features and geological consistency, erosion and sea flooding hazards mapping should be developed for the entire coastline/coast zone of Trinidad and Tobago. Such hazard mapping of coastal areas will be extremely useful in planning, designing and providing for risk insurance of various assets within the coastal zone, particularly along the coastline (beaches, resorts, coastal protections, coastal structures, coastal roads, lagoons, cremation sites, mosques, monuments etc).

Seismic Hazards

Seismic hazards represent a real threat within the Trinidad's environment. Normally, the existing Seismic Codes are associated with the civil building industry and civil land-based infrastructure works. However, no design and construction provisions exist for Trinidad and Tobago relating to the industry and engineering practice for hydraulic works. Thus, for those structures that are located in water (sea, artificial reservoir, lakes, lagoons, rivers, harbours) like port wharves/piers, coastal protection structures, breakwaters, dams, submarine pipelines or which normally function in connection with a water related body (e.g. water tanks, water conveying systems, culverts, bridges, diversion structures, slope protections, revetments, coastal roads) a specific code of design and maintenance has to be established, based on existing international experience. It is necessary that such codes be implemented at the earliest to minimize the risks of failure of future hydraulic works when subjected to seismic hazards.

Various planning and implementation mechanisms exist for managing coastal and hydrological hazards. Government should recognise and allocate proper financing for a number of hazards, which are considered critical. Hazard management is mostly a planning process consisting of the following actions:

- preparing the nation and disaster management agencies for a hazardous event before it occurs. A high degree of public education and involvement is required.
- preparing for a rapid response when the event occurs. This action particularly requires good and reliable knowledge of the extent of the event and dependent factors. Usually, it requires suitable and specific institutional arrangements.
- monitoring and assessing the consequences, after the event. This requires reliable forecasting and accurate information mechanisms.
- providing feedback of results for refinement of the planning process.

Direct requirements in the process of integrating the management of watersheds and coastal zones include:

- the extension of the coastal zone upstream along the coastal rivers or estuaries for minimum distances of two (2) to three (3) kilometres rather than the currently accepted coastal zone width of one hundred (100) to three hundred (300), metres for normal shore conditons.
- river sediments – volumes and quality – must be continuously monitored and controlled
- the water quality of the river should be monitored and controlled, even if the river is not a source for drinking water or used for other purposes

- the entire river lower stretch should be the subject of a detailed hydraulic assessment considering various scenarios of hydrological conditions upstream within the basin, combined with various sea conditions along the coastal stretch which interacts with the river inlet/estuary

Monitoring

The scope of the monitoring studies will clearly depend on the findings of a Report on the Baseline of the Existing Environment (highly recommended). Monitoring is only useful if it is maintained over a timescale that matches (is much greater than) the timescale of change of the phenomenon which is being observed (eg. beach evolution would typically require ten (10) to fifteen (15) years observation to be valuable). With this in mind, it would be prudent to initiate monitoring programmes at the earliest opportunity.

For Trinidad and Tobago, the parameters to be observed could include: beach levels and sediment distributions; nearshore, foreshore and terrestrial ecology; sea level, waves and currents. In essence, monitoring is applied to those parameters which are nature driven rather than human driven; the latter more normally being monitored through the keeping of records of that which has been affected by man. There will, however, be areas where new surveys of the human environment are warranted, depending on the suitability of existing data; this might entail, for instance, surveys of land use and fisheries.

Integrated Watershed-CZM Forums

Trinidad and Tobago, is still a long way from the introduction of CZM in the true sense and its integration with watershed management. However, there is the scope, and certainly a need, to establish a CZM Forum. This would consist of an advisory panel (or CZM Unit) comprising government officers and experts selected according to their specific expertise or through their intimate understanding of local issues. From time to time the specialist panel would be expanded to a wider affiliation of members, drawn together to discuss issues at general or targeted workshops.

The role of the CZM Forum would include a number of duties:

- to provide expert advice and guidance to the existing planning authorities in matters concerning the coastal zone. This would be an interim measure to provide assistance whilst the formal CZM planning framework is under preparation;
- to initiate a monitoring campaign based on the recommendations of a Report on Baseline of the Existing Environment;
- to administer specific studies.

Specific Studies

Specific topics will require more detailed study than that derived from the baseline investigations. The report on the Baseline Environment will identify the particular fields in which such studies are required. For Trinidad and Tobago, it is anticipated that specific studies will be required in some detail in the following areas:

- coastal watershed management issues, with view to integrate these with the coastal zone management issues
- shoreline management (particularly erosion control and management)
- fisheries management
- hydrocarbon exploitation
- coastal navigation
- other industries affecting the coastal zone
- socio-economics including heritage interests
- tourism and recreational interests

Primarily, the studies could focus on those aspects that are mostly influenced by human initiative and which are driven by commercial or economic interests, representing controllable pressures at the coast. It is important, in executing such studies, to consider future growth trends and the likely coastal pressures arising. In some ways, this part of the development of integrated watershed-CZM can be regarded as a "bottoms up" approach, providing the building blocks from which an integrated plan for development in the coastal zone can be derived.

National Action Plan

Based on the present situation with respect to the watersheds and coastal zones, concrete issues can be identified to facilitate integrating management of watersheds and coastal areas in Trinidad and Tobago. A matrix outlining the broad initiatives is shown in Table 5.1

Table 5.1: National Action Plan Matrix

No.	Proposed Activity	Significance to National Community	Funding Mechanism	Timeframe	External Expertise
1	Develop policies for coastal zone, watershed and water resources management	Provide basic principles and objectives to facilitate sustainable management and development of the nations natural resources	External Support Required	Short Term	Minimum
2	Develop Coastal Zone Management Strategy and Plan (including disaster management)	as above	External Support Required	Medium Term	External Support Required
3	Develop Plan for the integration of watersheds and coastal zones	as above	External Support Required	Medium Term	External Support Required
4	Establish financially autonomous Water Resources Management Authority with Watershed and Coastal Units	Provide framework for integrated management, reduce financial burden on the national purse	External Support Required	Medium to Long Term	External Support Required
5	Draft Water Resources , Watershed , and Coastal Zone Management Acts and present for enactment	Provide the institutional and regulatory framework for integrated and sustainable management of the country's resources	External Support Required	Medium Term	External Support Required
6	Prepare Coastal Zone and Watershed Hazards/Vulnerability maps for Hydrologic, Seismic and Chemical Hazards	Facilitate the protection of human life, property and ecosystems	External Support Required	Medium Term	Minimum
7	Establish Coastal Zone and Watershed Monitoring and Assessment Programme	To assess the state of the natural resources and provide information for the planning process	External Support Required	Short to Medium Term	Minimum
8	Establish Formal and informal mechanisms for Stakeholder Participation	To enhance the decision making process, promote collective ownership of the resources and shared vision	Minimum External Support Required	Short to Medium Term	Minimum

9	Establish Coastal Zones , upstream and seaward extensions and supporting watersheds as legal entities	Provide framework for effective integrated management	External Support Required	Medium Term	Minimum
10	Develop database and information systems, and decision support systems	Provide for efficient storage, retrieval and presentation of data. To also support decision making	External Support Required	Short to Medium Term	Minimum
11	Develop and implement Public Awareness/Education Programme	To promote shared vision, and resource protection and conservation	External Support Required	Short Term	Minimum
12	Establish Training and Scholarship Programmes	To facilitate capacity building and institutional development	External Support Required	Short to Long Term	External Support Required

Short Term: Within one (1) year
Medium Term: Within three (3) years
Long Term: Within three (3) to five (5) years

Issue 1: The implementation of the concept of resource management to attain sustainable development of the nation's watersheds and coastal zones.

The present approach to watershed and coastal zone management has contributed to inefficiencies in resource utilization, degradation and destruction of ecosystems, deterioration in water quantity and quality, conflicts in resource allocation, and threats to the health and livelihood of significant portions of the population. Continuation of this approach could only lead to serious negative impacts on the country's efforts to achieve sustainable development. It is therefore imperative that the development and management of coastal areas and their supporting watersheds are carried out under the guidance of a comprehensive framework. This framework must include:

- Development of Policies for water resources, watershed and coastal zone management
- Establishment of Water Resources Management Act, Watershed Management Act, National parks and Wildlife Act and Coastal Zone Management Act.
- Demarcation of coastal zones and their supporting watersheds as well as environmentally sensitive areas.
- Establishment of formal and informal mechanisms for stakeholder participation
- Establishment of Public awareness/education programme to promote shared vision, partnership and shared ownership of the resources.

Issue 2: The need to establish an effective and financially autonomous institutional framework that facilitates proper watershed and coastal zone management

Effective management of watersheds, coastal zones and water resources is hampered by the highly fragmented management system, which presently exist. Management responsibilities are dispersed among numerous agencies whose priorities do not necessarily include these areas of interest. In addition, existing agencies are ill-equipped to meet the modern day challenges of integrating management of water resources, watersheds and coastal zones. Lack of suitable staff, inadequate financial resources, outdated and unenforceable laws and lack of reliable data bases all contribute to poor management of these areas and their resources. It is therefore important to establish a financially autonomous organization such as the proposed Water Resources Management Authority with added units for coastal zone management and watershed management (this unit could also be placed in the Forestry Division). This Authority should have clear responsibility for resource assessments, policy and strategy development, master planning, resource allocation, resource exploitation licenses, and enforcement.

Issue 3: The protection of the environmental quality and ecological systems

The current state of the watersheds and coastal areas in Trinidad and Tobago, clearly indicate an urgent need for environment conservation and protection. The following activities are proposed for the protection of the environmental quality of watersheds and coastal areas;

- Implementation of in-stream water requirements
- Establishment of a water quality programme to include pollution identification, monitoring and control.
- Establishment and implementation of ecological flow requirements
- Development of watershed management plans, and the implementation of soil and water conservation measures and reforestation activities.

Issue 4:The development of capacity and tools within a suitable institution to support decision making

Capacity building and the acquisition of appropriate tools are vital to provide the needed information to promote proper decision-making. The required components are:

- Establishment of comprehensive data and information management systems and linked decision support systems (computer models)
- Acquisition, installation and maintenance of monitoring and computational equipment

- Training of staff in hydrology, geology, resource modeling, hydrodynamic modeling, resource planning and dispute resolution.
- Establish funds for training, research and development and emergency response
- Establish mechanism for cost recovery such as user fees, exploitation fees and penalties

6.0 RECOMMENDED INPUTS TO REGIONAL ACTION PROGRAMME

Based on a consideration of the National Action Programme presented above, Items 6, 7 , 10 and 12 which may be more effectively executed at the regional level are recommended for inclusion in the Regional Action Programme.

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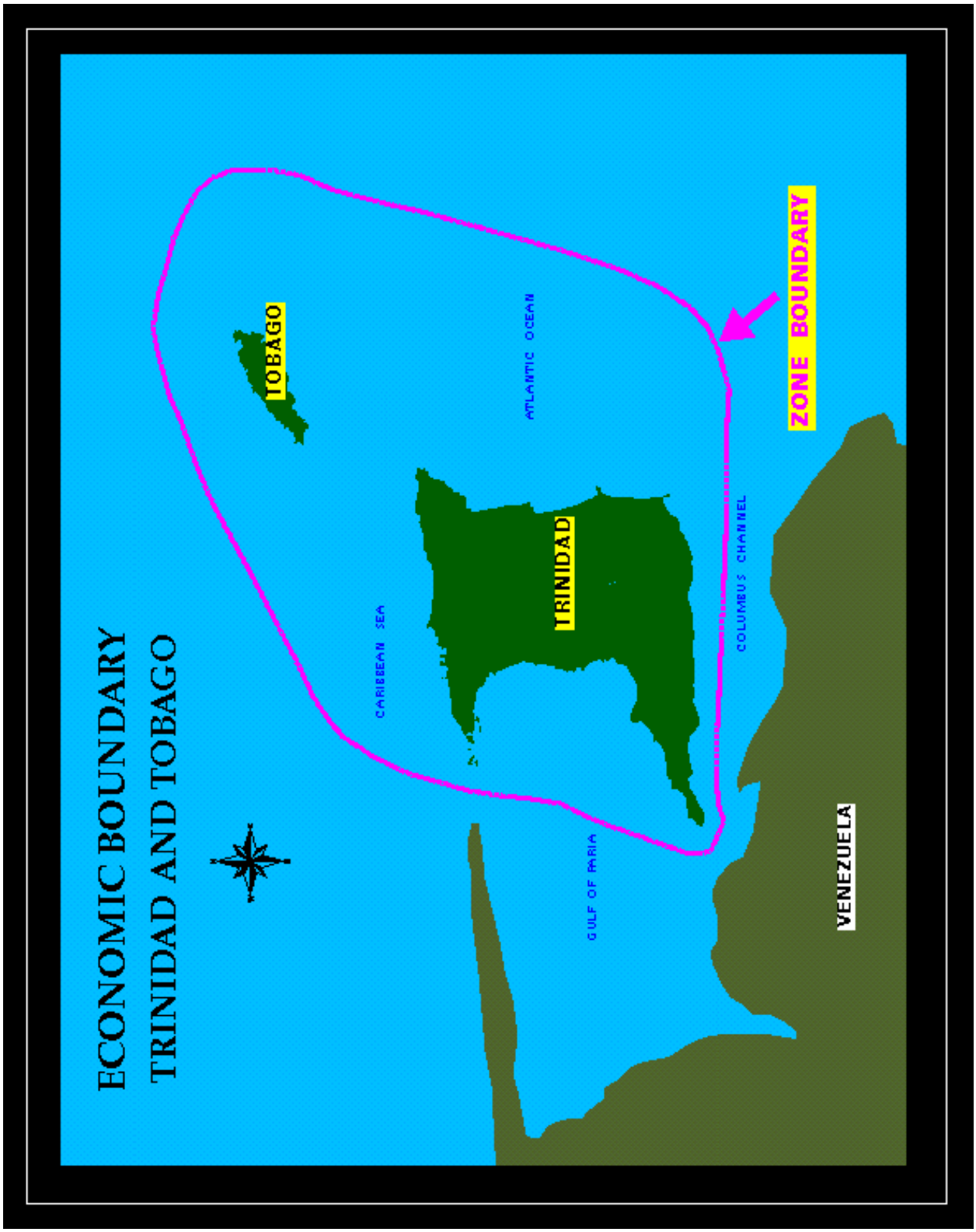
Appendix 1.0


ECONOMIC BOUNDARY
TRINIDAD AND TOBAGO
TOBAGO
ATLANTIC OCEAN
ZONE BOUNDARY
CARIBBEAN SEA
TRINIDAD
COLUMBUS CHANNEL
GULF OF PARIA
VENEZUELA