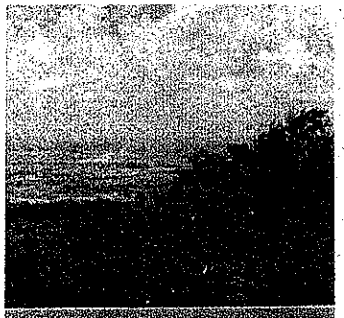

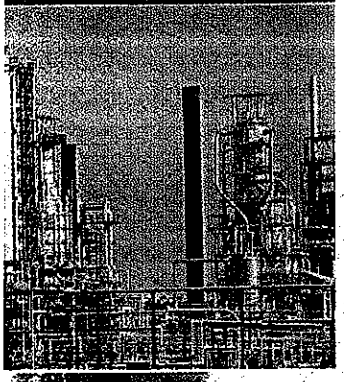

Initial National Communication of the Republic of Trinidad and Tobago

under the

United Nations Framework Convention on Climate Change

EMA
environmental
management
authority

1NC-TTO02

REPUBLIC OF TRINIDAD AND TOBAGO

INITIAL NATIONAL COMMUNICATION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

ENVIRONMENTAL MANAGEMENT AUTHORITY

FEBRUARY 2001

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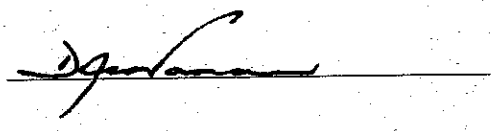
FOREWORD

The United Nations Framework Convention on Climate Change (UNFCCC) provides a template for addressing the threat of global climate change. The Republic of Trinidad and Tobago signed and ratified the United Nations Framework Convention on Climate Change in 1994 and is committed to play an integrated role in helping to achieve, within a reasonable timeframe, the ultimate objective of the Convention, namely the stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

In accordance with Article 4 of the Convention, Trinidad and Tobago has prepared its Initial National Communication. This report details the national greenhouse gas inventory, statements on vulnerability and adaptation, as well as identification of technology needs, capacity building and research.

Trinidad and Tobago, as a Small Island Developing State, faces critical challenges in grappling with environmental problems while striving to achieve our economic goals. The severe limitations of, and pressures on, our land and other resource bases compound these challenges. While accounting for a minuscule fraction of global greenhouse gas emissions, it is expected that our emissions will grow to meet our economic development objectives as recognised by the Convention. Nonetheless, Trinidad and Tobago will seek ways in which to maximise its energy use. Presently, more than 99% of our power generation is achieved by the use of natural gas and we will be pursuing feasible renewable energy programmes and policies. However, adapting to global climate change remains our major concern.



The Honourable Dr. Adesh Nanan
Minister of the Environment

INSTITUTIONAL ARRANGEMENTS AND ACKNOWLEDGEMENTS

The Project was executed by the Environmental Management Authority, Ministry of the Environment, under the supervision of the Cabinet-appointed Working Group to Determine the Implications of Global Warming, Climate Change and Sea Level Rise. This Committee comprises representatives from the following agencies and institutions:

Environmental Management Authority (Chair)
Environmental Unit and Drainage Division of the Ministry of Works and Transport
Ministry of Foreign Affairs
Ministry of Health
Meteorological Services, Ministry of Public Utilities
University of the West Indies
Ministry of Energy and Energy Industries
Ministry of the Attorney General and Legal Affairs
Institute of Marine Affairs
The Tobago House of Assembly
Ministry of the Environment
Caribbean Industrial Research Institute
Non-Governmental Organisations representative
South Chamber of Commerce
Hydrographic Unit
Ministry of Agriculture, Land & Marine Resources

A core group of experts from the University of the West Indies conducted the necessary research with the assistance of international experts.

The Government of the Republic of Trinidad and Tobago wishes to acknowledge the contribution of the members of the Working Group as well as all others who have contributed to the completion of the Initial National Communication.

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LIST OF ABBREVIATIONS

CBD	Convention on Biological Diversity
CBO	Community-Based Organisations
CFCs	Chlorofluorocarbons
CH_4	Methane
CNG	Compressed Natural Gas
CO	Carbon monoxide
CO_2	Carbon dioxide
COP	Conference of Parties
CSO	Central Statistical Office
EMA	Environmental Management Authority
GCM	General Circulation Model
GDP	Gross Domestic Product
Gg	Gigagrammes
GHG(s)	Greenhouse Gas(es)
GNP	Gross National Product
GORTT	Government of the Republic of Trinidad and Tobago
Gt. C	Gigatonnes of Carbon
GWP	Global Warming Potential
ha	Hectares
HFCs	Hydrofluorocarbons
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
LPG	Liquid Petroleum Gas
Mscfd	Million standard cubic feet per day
Mtoe	Megatonnes of oil equivalent
N	Nitrogen
NBSAP	National Biodiversity Strategy and Action Plan
NEMA	National Emergency Management Authority
NGO	Non-Governmental Organisation
NMVOCs	Non-methane volatile organic compounds

N_2O	Nitrous oxide
NO_x	Nitrogen oxides
OECD	Organisation for Economic Cooperation and Development
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride
SIDS	Small Island Developing States
SO_2	Sulphur dioxide
Tcf	Trillion cubic feet
TJ	Terajoule
TT$	Trinidad and Tobago dollars
UASB	Up-flow Anaerobic Sludge Blanket
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UWI	University of the West Indies
WASA	Water and Sewerage Authority

Executive Summary

Trinidad and Tobago, being a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), is committed to playing an integral role in helping to achieve, within a reasonable timeframe, the ultimate objective of the Convention, namely the stabilisation of Greenhouse Gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. This would enable ecosystems to adapt naturally to climate changes, ensure a stable food supply and enable sustained economic development.

Under Article 4 of the Convention, Trinidad and Tobago is required to publish, update periodically and make available to the Conference of Parties (COP) its National Inventory of GHGs and its national programmes to mitigate and adapt to climate change. In this regard, Trinidad and Tobago will be required to take climate change scenarios into account, to the greatest extent possible, in relevant future social economic and environmental policies and actions.

This Initial National Communication contains information (1990 baseline) under four major headings:

(i) The National Circumstances
(ii) The National Inventory of GHGs
(iii) Statements on Vulnerability and Adaptation
(iv) Technology Needs and Capacity Building and Research

Chapter 1: National Circumstances

Trinidad and Tobago, situated in the Caribbean Sea between 10°–11.5° N latitude and 60°– 62° W longitude, has a total land area of 5,126 km^2. Its exclusive economic zone covers approximately 104,000 nautical km^2. It experiences two relatively distinct seasonal types, tropical maritime and modified moist equatorial, resulting in two distinct seasons — a dry season (January to May) and a wet season (June to December). There is a perennial problem of heavy flooding, especially in the major river basins. The average minimum and maximum temperatures range between 22–25°C and 29–31°C, respectively. The total population in 1990 was 1.2 million with an overall population density of 237 persons/km^2. The annual birth rate has been increasing at less than 1% over the last eight years. Approximately 40% of the population live in urban areas.

Trinidad and Tobago is classified as a Small Island Developing State (SIDS) with a relatively significant industrial sector, based principally on the petroleum and petrochemical industries. This includes petroleum refining, natural gas liquification, methanol and ammonia/urea production as well as steel and cement plants.

Government revenues from the petrochemical sector in 1990 were $2.3 billion, representing 30% of Gross Domestic Product (GDP) and 41% of Government's revenue. While oil production has been declining, natural gas production has been increasing (estimated reserves for 1998 were 30.7 trillion cubic feet). The manufacturing sector accounted for 9.0% of GDP whereas agriculture accounted for 2.0% (but 10% of employment). Tourism plays a much smaller role than in other Caribbean nations, representing only about 1% of GDP. While tourism is currently concentrated in Tobago, it is targeted for rapid expansion in both islands. Diversification of the economy into areas other than the petrochemical sector is also being actively pursued.

In Trinidad and Tobago, climate change matters at the international level are the responsibility of the Ministry of the Environment. Domestically, responsibility is vested in the Environmental Management Authority (EMA), under the Ministry of the Environment.

A number of policy programmes have recently been enacted and initiatives undertaken which have implications for climate change. These include environmental management policies to cover all major solid, liquid and gaseous emissions to air, land and water; public information programmes; a review of national water management strategies and a biodiversity and forestry strategy.

Chapter 2: National GHG Inventory

This Initial National Communication provides Trinidad and Tobago's first inventory under Article 12 of the UNFCCC, for the base year 1990, following guidelines developed by the Intergovernmental Panel on Climate Change (IPCC) as recommended by the UNFCCC in 1995. The greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have been inventoried. The three other direct-acting GHGs – hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) – have not been, due to lack of data. The report also estimates emissions of the indirect-acting GHGs – nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2).

Inventorying was carried out following the IPCC 1996 Revised Guidelines according to the prescribed sectors: Energy, Industrial Activity (other than Energy), Agriculture, Land-Use Change and Forestry, Waste and International Bunkers. International bunkers are fuels for boats and aeroplanes that travel internationally. These are estimated and reported as memo items, according to the IPCC 1996 Revised Guidelines, and are not included in the inventory accordingly.

Total GHG emissions were estimated to be 15,000 Gg (CO_2 equivalent). Of this, CO_2 contributed 95% of global warming potential (GWP), followed by CH_4 with 4.5% and N_2O <1%. With respect to sectoral contribution, the combustion of fossil fuel for the production of energy contributed 66% of the total anthropogenic CO_2 emissions, with industrial processes contributing the remaining 34%. Within the energy sector, the energy industries

contributed 44% of the total emissions, manufacturing and construction industries 38%, transportation 15%, and other activities 3%. Methane emissions were 71% (24 Gg) from waste, 18% (6.25Gg) from agriculture and the remaining 11% distributed among the other categories. With respect to N_2O emissions, 62% (.68Gg) came from agriculture and 34% (.36Gg) from the waste sector with a 4% contribution from industry, energy production and transportation.

The Land Use Change and Forestry Sector served as a sink for CO_2, removing 10.2% of the total national anthropogenic emissions. The bulk of this was as a result of abandonment of agricultural holdings and plantations and not necessarily from active reforestation activities.

This inventory was prepared from data already documented in public institutions and private industries. Important data gaps were found, especially with respect to industrial processes emissions from private firms. There was also a difference in the energy-related CO_2 emissions estimated by the sectoral approach used in this report when compared to the emissions estimated by the reference approach. The latter accounts for emissions based on the primary fuel and net quantity of secondary fuels used in the country. Inventory data are summarised in Figures I and II.

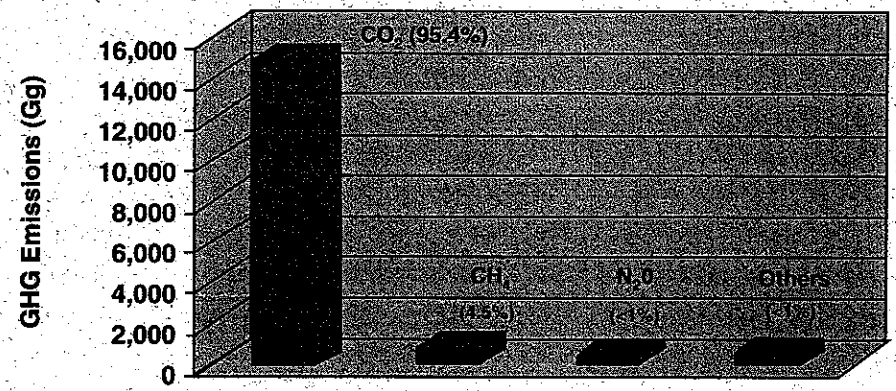


Figure I: Total National GHG Emissions For 1990
Others (NO_x, CO, NMVOC, SO_2). Concentrations of CH_4 and N_2O are given in Gg of CO_2 equivalent.

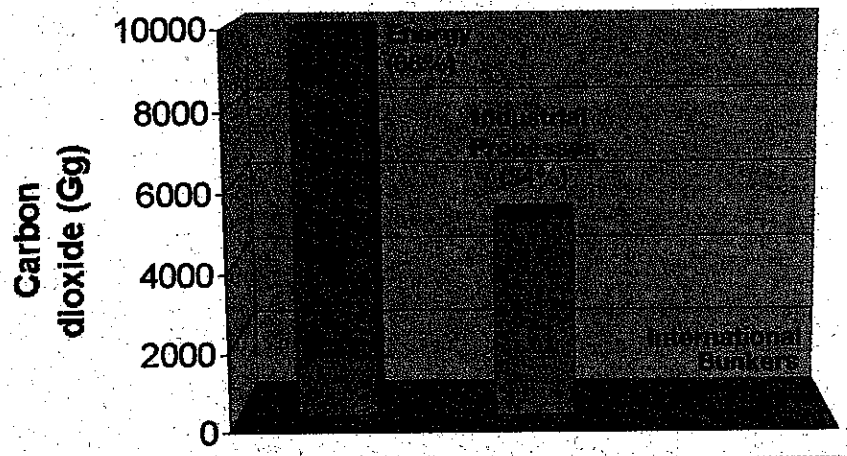


Figure II: The CO_2 Emissions By Sector For 1990

Chapter 3 – Statements on Vulnerability and Adaptation

This chapter assesses the vulnerability of various sectors of Trinidad and Tobago to projected climate change and sea-level rise and the possible adaptation measures that can be implemented. It also addresses areas for capacity building and improvements in the impacted sectors.

Future climate scenarios focus on four main areas – temperature, rainfall, sea-level rise and extreme events. In this context, projections released by the IPCC and other General Climate Models (GCMs) set the following scenario to the year 2100 for Trinidad and Tobago – a temperature rise of between 1°C and 3.5°C; a sea-level rise of 15 to 95 cm and a rainfall deficit of about 15%. It is on this basis and assumptions about future socio-economic scenarios that the vulnerability statements were formulated.

Actual temperature and humidity changes recorded over the last 50 years at Piarco International Airport are consistent with climate change projections for the region – maximum and minimum temperatures have increased by about 1°C in 30 years with accompanying increases in relative humidity. No trends, however, were observed for rainfall, sunshine or windspeed data.

Vulnerability assessment of the sugar industry, based on an historic analogue, suggests that the continuation of current trends in temperature rise could result in reduced sugar yields.

Water planning and management analyses that do not take climate changes into account indicate that average supplies are adequate to meet the country's needs to 2050. The dependence on several watersheds on runoff from rainfall, together with model prediction

of declining rainfall and increased evaporation, identifies the need for climatic change to be factored into water management strategies, as well as attention to drought management and flood damage reduction programmes. The latter speaks to the real possibilities of increased frequency of extreme events such as storms and hurricanes as a result of climate change. Other vulnerable sectors for which adaptation measures will be required are the coastal areas (eastern, north-eastern, south and south-western coasts of Trinidad and the south-western coast of Tobago) and the related impact on tourism, given factors such as sea-level rise; energy supply for greater cooling use given temperature rise; health problems associated with heat stress and the indirect effects of potable water availability and food security.

Proposals for the implementation of adaptation options must be linked to other sustainable development objectives and strategies for Trinidad and Tobago, including economic growth, poverty alleviation, health and employment. In this regard, Trinidad and Tobago must give attention to adaptation measures needed to respond to climate change as well as the vulnerability of its economic development objectives. The availability and use of funds for mitigation and adaptation measures must therefore be taken in the context of the whole government budgetary process.

Furthermore, benefits from potential adaptation measures will occur in a setting in which the effects being adapted to have some inherent uncertainty. In some cases, benefits from adaptation-related measures will occur even in the absence of climate change, while in other cases they are uniquely related to a climate effect. Inherent in such a scenario is the costly risk of maladaptation. This also complicates any priority sequencing of measures that involve allocation of scarce financial resources.

Chapter 4 – Technology Needs, Capacity Building and Research and Development

Adequate undertaking of climate-change impact assessments, planning for adaptation and implementing mitigation strategies require the assembling and harmonisation of almost every discipline. Several aspects of institutional and capacity weaknesses were identified in preparing Trinidad and Tobago's Initial National Communication. This chapter describes the identified weaknesses as well as the necessary measures required in addressing these lacunae. Measures focused on, *inter alia*, appropriate research in formulating emission factors for the scale of tropical small islands, appropriate training and building of endogenous capacity as well as establishing centres of excellence, perhaps on a regional basis, that will serve to meet the national needs. Additionally, specific constraints, such as inadequate funding required to implement appropriate measures, are identified.

Chapter 1

National Circumstances

The Republic of Trinidad and Tobago is a two-island state located at the south-eastern end of the Caribbean archipelago (Figure 1.1). Trinidad and Tobago, classified as a non-Annex I country[1], signed the UNFCCC on the 11th June, 1992 and ratified the Convention on 24th June, 1994.

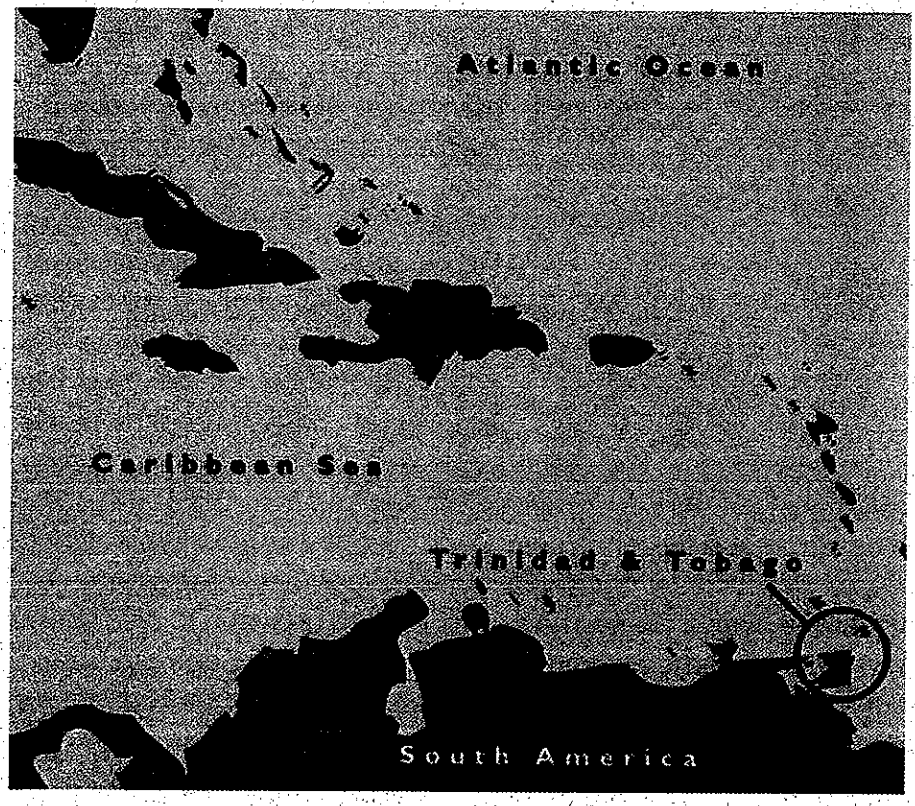


Figure 1.1: Location Map of Trinidad and Tobago

[1] Annex I countries are countries listed as developed countries under the UNFCCC. Non-Annex I countries are developing or least developed countries.

Physiography

Trinidad and Tobago together comprise a total land area of 5,126 km², with the island of Trinidad having an area of 4,826 km² and Tobago, the smaller of the two, an area of 300 km² (CSO, 1997). Trinidad and Tobago are both situated on the continental shelf of South America, from which they became separated in geologically recent times. Notwithstanding this, they both have marked differences.

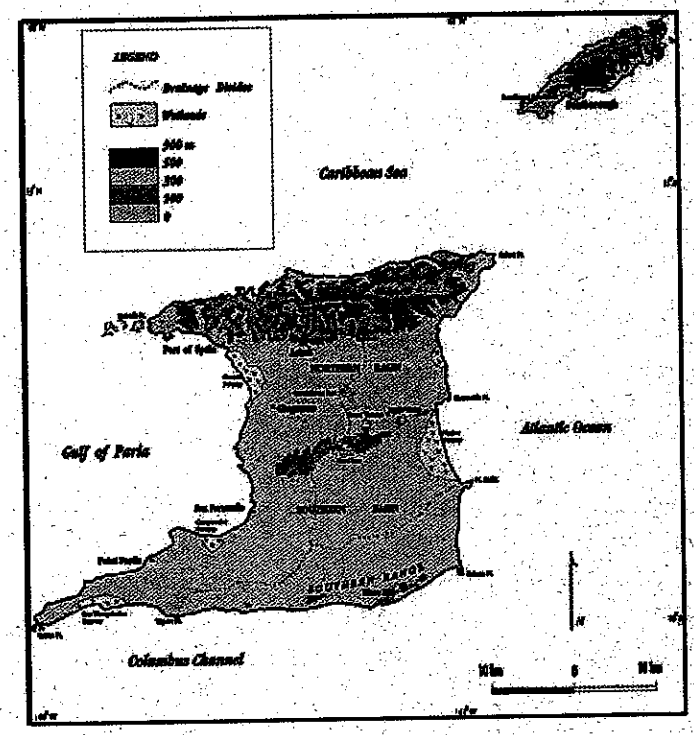


Figure 1.2: Physical Features

Trinidad features three mountain ranges. Figure 1.2 shows the main physical features of Trinidad and Tobago. The Northern Range, running east to west across the northern boundary of the island and having an elevation of over 900 metres, represents the easternmost extension of the Andean Mountain System. The Central Range is an area of rolling hills of maximum elevation of about 300 metres, oriented north-east to south-west across the centre of the island and characterised by many limestone peaks. The Southern Range, located in the extreme south-eastern part of the island, comprises a series of anticlinal folds separated by complicated fault systems which have resulted in low hills. These three mountain ranges are interspersed by two fertile plains, the Northern Basin, lying between the Northern and Central Ranges, and the low-lying rolling Southern Basin with a shallow, inland freshwater lagoon, known as the Nariva Swamp, separated from the sea by a 25-km-long sand bar.

Tobago's physical features include the Main Ridge, that occupies the north-eastern two thirds of the island and reaches a height of 576 metres, and the Southern Lowlands that comprise a coastal plain of coral terraces, terminating in a coral reef.

Trinidad and Tobago's exclusive economic zone is estimated to be 15 times greater than the landmass, covering approximately 104,000 nautical km².

Climate

The islands of Trinidad and Tobago lie roughly between 10° N and 11.5° N latitude and between 60° W and 62° W longitude and 14 kilometres (at its closest point) off the eastern coast of Venezuela. These are the two most southerly islands in the Eastern Caribbean archipelago. As a result of their southerly location, Trinidad and Tobago experience two relatively distinct seasonal climatic types:

(i) Tropical Maritime — warm days and cool nights with rainfall mostly in the form of showers due to daytime convection. This typifies the early- to mid-dry season months of January to April.
(ii) Modified Moist Equatorial — low wind speeds with hot, humid days and nights and a marked increase in rainfall that is not always convective. During this period, the area repeatedly comes under the influence of equatorial weather systems.

The two climate types described above result in two distinct seasons — a dry season from January to May and a wet or rainy season from June to December. Tobago, the more northerly of the two islands, experiences a drier dry season and Trinidad a wetter wet season (Pollonais, 1998).

Climatic determinants

The main climatic determinants affecting Trinidad and Tobago are:

(i) the latitudinal position and strength of the subtropical ridge of high pressure (the Azores-Bermuda High) — a semi-permanent hemispheric feature;
(ii) the Intertropical Convergence Zone (ITCZ) — the major rainfall/cloud-producing system that is largely responsible for our wet or rainy season;
(iii) the Mid-Atlantic Trough of low pressure — an upper tropospheric feature that assumes increased prominence mainly during the fall and early winter months of the Northern Hemisphere (September to November); and
(iv) daytime convection, orography and land size.

The controls that have minor effects on the climate are:

(i) the occasional intrusion of polar fronts into our latitudes, mainly during the dry season as shear lines, bringing with them some rainfall;

(ii) tropical waves and cloud clusters in the easterly wind current – this feature is noticeable only during the hurricane season from June to November;

(iii) tropical cyclones, i.e. depressions, tropical storms and hurricanes – even though these systems cause severe damage and bring phenomenal rainfall, they cannot be given major status owing to their low frequency of occurrence; and

(iv) the sea-breeze or cooling effect.

Rainfall

The rainfall that affects Trinidad and Tobago annually is bi-modal in distribution (Figure 1.3). The first and major peak is around June or July and is associated with the northward movement of the ITCZ. The other peak is in November. The windward (eastern) halves of the islands receive more rainfall than the western halves. Maximum rainfall occurs in the north-east of Trinidad where orography contributes to the enhancement of the already high rainfall (Figure 1.4).

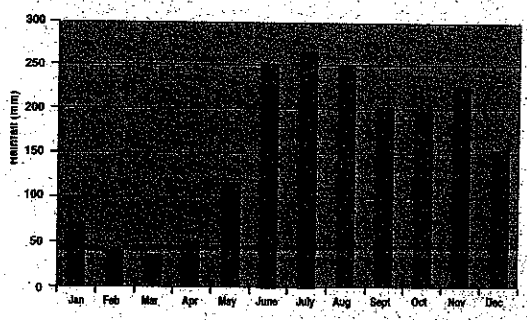
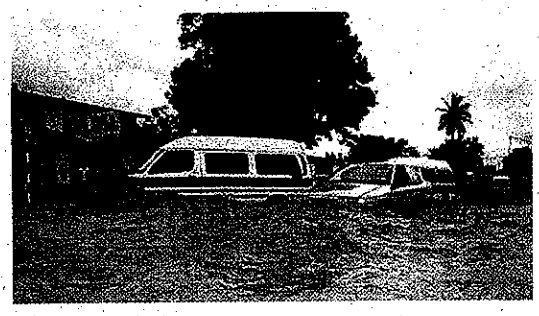


Figure 1.3: 30-year Average (1961 - 1990) of Rainfall at Piarco International Airport, Trinidad (T&T Meteorological Service)

The prevailing easterly trade winds come from off the tropical Atlantic Ocean and are responsible for the enhanced precipitation experienced on the eastern halves of both islands. This pattern is extended eastward along mountain ranges that are oriented east/west in Trinidad and north-east/south-west in Tobago (Figure 1.4).

Flooding

This is a perennial problem in Trinidad where heavy rains can cause flooding in major river basins. The Caroni River Basin is the most notable in this respect, with flooding occurring at least once per year, during the period October to December (Henry, 1987). Also notable is the common incidence of flash flooding along the foothills of the Northern Range during and after heavy showers in small catchment basins, which lead to the overflowing of low-volume water-courses. Port of Spain is particularly susceptible to this form of flooding as it is nestled at the base of the Northern Range. This type of flooding is largely a result of urban run-off.



Flooding event
Photo courtesy *Daily Express*

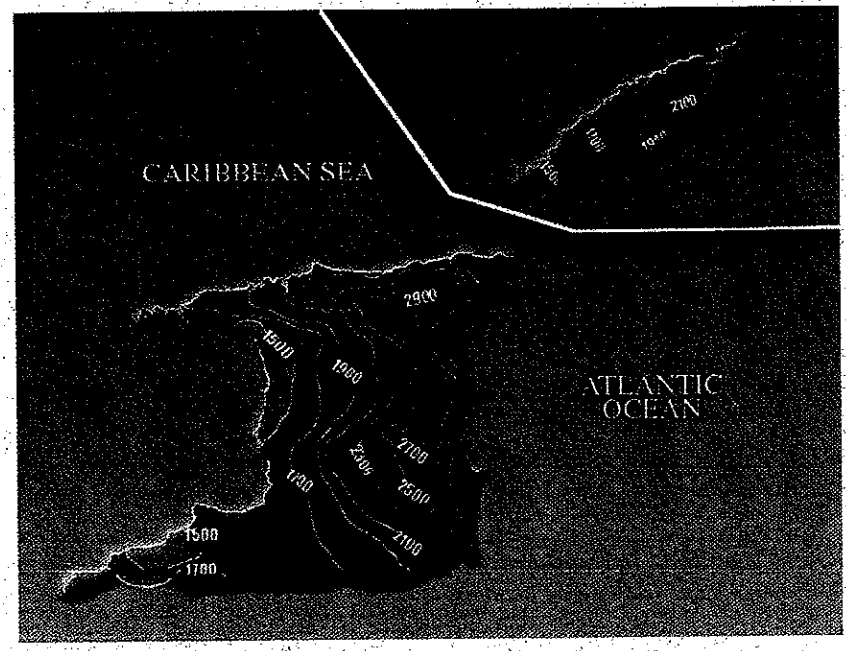


Figure 1.4: Mean Isohyetal Map (areas of equal rainfall) of Trinidad and Tobago (T&T Meteorological Service)

Temperature

The average annual temperature in Trinidad is 25.7°C. Temperatures are for the most part mild, with the average (rural Trinidad) between 24.5°C in January and 26.7°C in May. In Tobago, on the other hand, diurnal fluctuations of temperature are less pronounced as a result of the mitigating influence of the sea and the smaller size of the island. Average minimum temperatures vary between 22°C and 25°C, with average maximum temperatures between 29°C and 31°C (Figure 1.5). In mountain valleys, temperatures tend to be approximately 2°C lower at night as a result of cool air drainage.

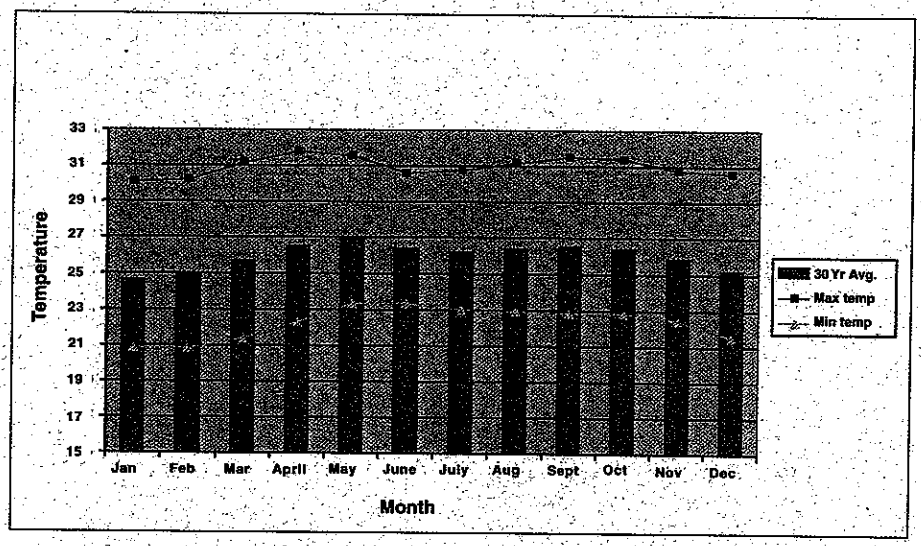


Figure 1.5: 30-Year Averages (1961-1990) of Mean, Maximum and Minimum Temperatures at Piarco Airport, Trinidad (T&T Meteorological Service).

Winds

Winds are easterly with either a weak northerly component during the dry season or an even weaker southerly component during the wet season. The directional persistence is high (>95%) with speeds averaging 11 to 30 km h^{-1} during the day. Gusts of over 65 km h^{-1} are rare and are usually associated with heavy showers and thunderstorms. At night, windspeeds generally fall below 7 km h^{-1} inland with mostly calm conditions in areas close to sea level.

El Niño

The Caribbean, including Trinidad and Tobago, has experienced significant El Niño teleconnections. It is now well established that during El Niño years tropical cyclone activity in the Caribbean is markedly suppressed. During intense El Niños, deficit rainfall affects the southern Caribbean, including Trinidad and Tobago. The reverse is true of La Niña years. However, annual rainfall totals do not fully reflect the effects of El Niño conditions, since a typical onset time for El Niño conditions is the middle of one year with the typical end being in the middle of the following year (Table 1.1).

The abnormally dry periods with El Niño typically run from July through to the following June, occasionally followed by heavy rains.

Table 1.1: El Niño Years Rainfall Classification

Piarco, Trinidad Average Annual Rainfall = 1847mm					Crown Point, Tobago Average Annual Rainfall = 1511mm				
– –	–	0	+	++	– –	–	0	+	++
1957	1953		1948	1969	1957	1983		1963	1958
1951									
1963	1972		1958	1986	1986	1991		1965	1973
1982									
1995	1992		1973	1993	1993			1969	
1983									
		1976			1994			1972	
		1991			1995			1976	
		1994							

Relationship to Annual Average Precipitation Legend

– –	Below 85%
–	86% to 95%
0	96% to 105%
+	106% to 115%
++	Above 115%

Political structure

Trinidad and Tobago became an independent state in 1962 under the British monarchical system. This changed in 1976 when the republican system of government was adopted. The Constitution now provides for a President as head of state who acts in accordance with the advice of the Prime Minister or Cabinet. The Constitution also provides for a Prime Minister whose duties, as head of the executive arm of Government, include informing the President about the general conduct of Government.

The Parliament of the Republic of Trinidad and Tobago consists of the President, the Senate and the House of Representatives. Under the Constitution, the Cabinet is responsible for the general direction and control of the Government and is collectively responsible to Parliament. The Cabinet consists of the Prime Minister (who chairs) and other Ministers, one of whom is the Attorney General, chosen from among members of the House of Representatives and the Senate as appropriate and in accordance with the advice of the Prime Minister.

The Judiciary is headed by the Chief Justice who is appointed by the President after consultation with the Prime Minister and the Leader of the Opposition. The President, acting in accordance with the advice of the Judicial and Legal Service Commission, appoints Supreme Court Judges. The Tobago House of Assembly is responsible for public administration in Tobago.

In Trinidad and Tobago, climate change matters at the international level are the responsibility of the Ministry of the Environment. Domestically, this responsibility is vested in the Environmental Management Authority (EMA), a statutory body under the Ministry of the Environment.

This mandate is embodied in the Environmental Management Act (Environmental Management Act No. 3, 2000) which undertakes the following:

(i) the establishment of an Environmental Management Authority to coordinate, facilitate and oversee execution of the national environmental strategies and programmes;
(ii) the promotion of public awareness of environmental concerns; and

(iii) the establishment of an effective regulatory regime which will protect, enhance and conserve the environment.

Provisions for relevant legislation include:

(i) A Vehicle Emissions Act
(ii) National Environmental Policy and Code
(iii) Air and Noise Pollution Management
(iv) Water Pollution Management
(v) Waste Management
(vi) Management of Hazardous Substances
(vii) Designation of Environmentally Sensitive Areas and Species
(viii) Certificate of Environmental Clearance Rules

Demographics

Population and population growth

The total population of Trinidad and Tobago (1990 census) was 1,215,187 persons (Table 1.2). Of this, 607,998 (50.03%) were male and 607,189 (49.97%) female. Tobago showed a population of 48,656 persons, representing 4% of the national population. Further subdivision revealed 24,455 males (50.26%) and 24,201 females (49.74%). The overall population density was given at 237 persons/km^2 with densities per island given for Trinidad at 242 persons/km^2 and Tobago at 162 persons/km^2.

Table 1.2: Total Population Statistics for Trinidad and Tobago (1990 Census), 1990-1998 (CSO, 1982-1996).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Population	1,215,220	1,225,100	1,239,908	1,246,877	1,249,738	1,259,971	1,263,614	1,273,900	1,282,600
Population Increase(%)	–	0.8	1.2	0.6	0.2	0.8	0.3	0.8	0.7

Crude Birth Rate declined from 19.7 per thousand to 14.2 per thousand for the period 1990 to 1996. This decline is attributed to increasingly effective family planning programmes along with increased education and job opportunities among females. Mortality rates, on the other hand, show a slight increase over the

same period. This is particularly evident in the rates of infant mortality, which increased from 12.7 per thousand to 16.2 per thousand.

Average life expectancy is given for males at 68.4 years and females at 73.2 years. For males over the age of 70 years, further life expectancy is forecast at 10.8 years on average and, in the case of females, 12.9 years.

Approximately 44% of the total population live in urban areas, with the urban to rural population ratio estimated at 0.8.

Agriculture

Agriculture, though contributing an average of only 2% to overall GDP, remains climate-sensitive and employs about 10% of the labour force. Major crops are sugar, cocoa, coffee, citrus, vegetables, rice, some grains and pulses, and root crops (Table 1.3).

Table 1.3: Agricultural Performance - Production ((Selected Crops ('000 units)) (Central Bank of T&T, 1989 - 1996)

Agricultural Commodity	1989	1990	1991	1992	1993	1994	1995	1996
Sugar (tonnes)	97.0	118.2	100.4	110.4	104.9	131.1	117.1	92.0
Cocoa (kg)	1.437	2.127	0.855	1.140	1.556	1.188	1.649	2.540
Coffee (kg)	1.209	1.935	0.917	0.706	0.859	0.980	0.831	0.353
Citrus (kg)	4.112	2.223	2.520	2.788	7.088	10.418	10.258	11.069

Forests and land use

Existing forests in Trinidad and Tobago occupy a total of 248,000 ha (235,093 ha in Trinidad and 12,907 ha in Tobago (Table 1.4)). The Forestry Division is responsible for the establishment and maintenance of plantation forests (Table 1.5). For the period 1990 to 1998, there has been an 11.6% net loss of forested areas.

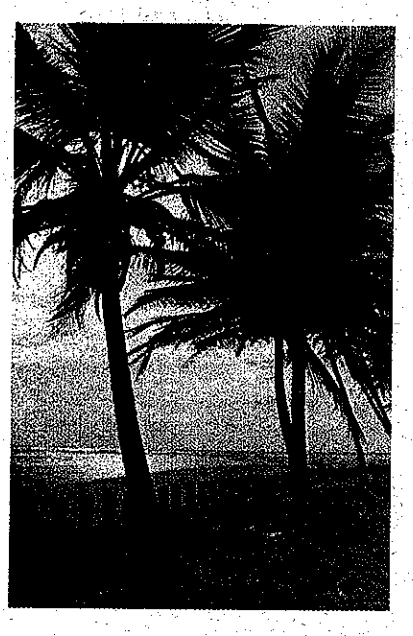
Table 1.4: Trinidad and Tobago's Forest Cover and Ownership of Forested Areas (ha) (GORTT, Forestry Division, 1998)

	Trinidad	Tobago	Total	%
Proclaimed Forest Reserves	127,474	3,958	131,432	25.6
Unproclaimed Forest Reserves	11,652	-	11,652	2.3
Private Forests	56,000	-	56,000	10.9
Other Forested State Lands	36,967	8,949	48,916	9.5
Total Forested Area	235,093	12,907	248,000	48.4
Total Land Area	482,500	30,300	512,800	

Table 1.5: Area Under Plantation Forests In Trinidad and Tobago (ha) (GORTT, Forestry Division, 1998)

Species	Trinidad	Tobago	Total
	1998	1998	
Teak	9,035.5	—	9,035.5
Pine	3,637.5	646	4,283.5
Other Species	2,177.6		2,177.6
Total	14,850.6	646	15,496.6

Contribution of forest products to the overall economy has been small, with the aggregate National GDP for Agriculture, Fisheries and Forestry being a minuscule 2% (1995-1997). There has been no significant change since. In terms of the forestry contribution, i.e. wood and wood-related products, licences and punitive charges, the output to GDP was a negative TT$113,500 in 1994 and TT$210,000 in 1995 due mainly to poorly structured royalty policies. In later years (1996, 1997 and 1998), there was significant improvement, with annual revenues totalling TT$750,808.19, TT$3,851,507.39 and TT$2,490,684.83 respectively (GORTT, Forestry Division, 1998).



Coconut palms and coastal defences at Manzanilla.

Biodiversity

Trinidad and Tobago sit on the continental shelf of South America, and are therefore geologically part of the mainland, with evidence indicating that Trinidad was only separated about 11-15,000 years ago. Disconnection on such a short geological timescale has not allowed for the evolution of separate species and therefore island endemism is not a critical factor. However, it is believed that there are a number of sub-species of different plant varieties and endemic plant species. Of special note are some of the palms and reptile species found in Tobago but not in Trinidad.

The small distance between the islands and the South American mainland does not present a barrier to flying animals, nor to many terrestrial plants and animals, with the consequence that our flora and fauna are natural extensions of South American populations, the species being identical. The biodiversity of Trinidad and Tobago is the most varied of the islands in the Caribbean archipelago, due to the continental origin of our islands. Our marine biota, though, is characteristic of the Caribbean bio-geographical province.

The terrestrial ecosystems are a result of the interplay of the environmental factors of climate, topography and soil. Climatic factors such as moisture, temperature or elevation and wind are important for our ecosystems. While there is no comprehensive listing of how many species of plants and animals there are in Trinidad and Tobago, some groups have been extensively studied. Table 1.6 gives a rough estimate of our present knowledge of the number of species.

Table 1.6: Species Diversity in Trinidad and Tobago
Source: NBSAP, 2001

Major Groups	Number of Species
Vascular Plants	2160
Birds	450
Mammals	95
Reptiles	85
Snakes	55
Amphibians	30
Freshwater fishes	45
Marine fishes	354
Butterflies	600
Nematodes	200-300

Economic profile

Unlike most Caribbean countries, Trinidad and Tobago has a relatively significant industrial base with 27% of its GDP derived from the petroleum and petrochemical sector. Agricultural production, on the other hand, primarily comprises 2% of GDP, while manufacturing contributes between 8% and 9%. Tourism in Trinidad and Tobago is by comparison very small and centred mainly in Tobago. Its contribution to GDP is a marginal 1% (Table 1.7)(Central Bank of Trinidad and Tobago, Annual Economic Survey, 1997).

An eight-year period of economic decline reached its turning point in 1990 with what could be described as a year of mixed domestic economic performance. Real GDP contracted by a marginal 0.4 % in 1990, the smallest decline since 1983. The period 1983-1990 saw an average rate of decline of 3.3%. This reversal was marked by a turnaround in the petroleum sector as the factor most responsible. The resurgence of activity in both the exploration and production, and refining sub-sectors became the driver with growths measuring 0.9% and 21.2% respectively. In support of this trend, there was a robust performance of the goods-producing sectors of the economy, which collectively posted a growth rate of 3.7% in 1990. Unemployment, which stood at 22% in 1988, gradually declined to 16.3% in 1996.

Table 1.7: Trinidad and Tobago 1987-1996
GDP at Market Prices (Current) By Sector of Origin. (Values in $ Million).
(Numbers in parentheses reflect sectoral contribution to GDP in percent)

SECTOR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Agriculture	478.1 (2.8)	469.5 (2.7)	450.2 (2.1)	547.2 (2.5)	558.2 (2.5)	585.4 (2.5)	628.4 (2.5)	684.6 (2.4)	627.2 (2.1)	688.1 (2.1)
Petroleum	4,353.4 (25.2)	4173.9 (24.3)	4999.4 (26.3)	6595.2 (29.6)	5691.6 (26.2)	5283.3 (23.6)	5815.4 (23.3)	7548.2 (26.6)	8325.4 (27.3)	8747.1 (26.7)
Manufacturing	1,424.9 (8.2)	1505.3 (8.8)	1807.7 (9.7)	1860.0 (8.7)	1992.3 (9.1)	2072.1 (9.2)	2273.3 (9.1)	2461.2 (8.7)	2623.3 (8.6)	2697.9 (8.2)
Electricity & Water	254.1 (1.5)	293.6 (1.7)	258.8 (1.5)	268.7 (1.2)	258.4 (1.9)	371.5 (1.5)	481.6 (1.9)	522.0 (1.8)	393.0 (1.3)	544.7 (1.7)
Construction	1,546.3 (8.9)	1609.0 (9.3)	1,633.5 (9.1)	1,730.5 (8.0)	1851.5 (8.6)	1934.8 (8.4)	1892.6 (7.6)	2121.9 (7.5)	2497.7 (8.2)	2762.3 (8.4)
Transport, Storage & Communication	1,729.2 (10.0)	1,706.9 (9.8)	1,701.9 (9.8)	1,753.5 (8.1)	1980.5 (8.6)	2028.7 (9.6)	2202.2 (8.8)	2536.5 (8.9)	2546.0 (8.3)	2760.0 (8.4)
Distribution	2,395.0 (13.8)	2,553.7 (14.7)	2,697.7 (14.7)	2,716.1 (12.6)	3228.2 (13.1)	3529.5 (13.4)	3720.3 (14.9)	4058.0 (14.3)	4382.3 (14.3)	4979.1 (15.2)
Finance, Insurance & Real Estate	2,058.7 (11.9)	1,950.1 (11.3)	1,883.9 (11.6)	2,294.9 (10.6)	2525.8 (11.9)	2765.6 (13.7)	3314.5 (13.3)	3582.8 (12.6)	3811.2 (12.5)	3882.0 (11.8)
Government	2,552.2 (14.8)	2,441.3 (14.1)	2,194.4 (12.6)	2,297.5 (10.7)	2481.7 (11.1)	2756.7 (11.8)	2764.6 (11.1)	2865.9 (10.1)	3095.4 (10.1)	3263.7 (9.9)
Other Services*	1,196.1 (6.9)	1,233.3 (7.1)	1,282.9 (6.4)	1,339.1 (6.2)	1454.6 (6.3)	1516.2 (6.5)	1591.0 (6.4)	1693.0 (6.5)	1802.1 (5.9)	1916.7 (5.8)
Correction Factor	-686.7 (-4.0)	-652.0 (-3.8)	-679.9 (-3.8)	-563.6 (-2.6)	-640.2 (-3.0)	-859.3 (-4.5)	-977.8 (-3.9)	-1004.4 (-3.5)	810.5 (-2.7)	852.1 (-2.6)
Value-Added Tax	—	—	—	926.6 (4.3)	1051.7 (4.7)	1144.5 (4.2)	1280.8 (5.1)	1320.0 (4.6)	1249.7 (4.1)	1421.0 (4.3)
GDP (mp)	17,301.3	17,284.6	18,372.9	21,765.7	22,434.3	23,129.0	24,490.5	28,008.2	30,542.0	32,810.0

**Includes Hotels, Guest Houses, Education and Community Services and Personal Services.*
(Source: T&T Central Bank)

On the negative side, declines in the service sector, which includes Government and other sectors, induced deterioration in the overall performance of the non-oil economy. The productivity of a new value-added tax, which supported an increase of 12.1% in government non-oil revenues, was responsible in large measure for the progress from a fiscal deficit of over 4% of GDP in 1989 to 0.4% in 1990. In addition, the increased oil prices in 1990 contributed to a rise in total recurrent revenues. Prudent government fiscal management also maintained total expenditure at 1989 levels (T&T Central Bank, Annual Economic Survey, 1990 - 1997).

The external performance of the economy deteriorated in 1990, with the external payments deficit widening to 3.5% of GDP, from 3% in 1989. This was largely due to the increase in external debt-servicing. Merchandise trade showed a surplus of TT$3,374.4 million in 1990 compared with TT$1,411.2 million in 1989, a figure which included the growth of manufacturing exports (CSO, 1990 – 1996).

Energy profile

The energy sector is here operationally defined as the country's hydrocarbon-based institutions, industries, resources and new and renewable energy sources. Primary energy production in Trinidad and Tobago comprises mainly crude oil and natural gas with a small additional component from bagasse. Approximately 48% of crude oil produced is exported and the remainder refined locally, along with some imported oil to maintain optimum production levels at the refinery (GORTT, Ministry of Energy, 1998).

The oil and gas sector continues to be the mainstay of the country's economy with significant contributions to GDP. In terms of Government's revenues, the oil sector in 1990 contributed some TT$2,317.5 million, with the non-oil sector contributing TT$3,345.3 million.

The prominent position of oil sector contributions was maintained over the period 1986 to 1990; however, the period 1991 to 1996 saw some erosion of that position which has reflected a lessening dependence on oil as the economic mainstay. Natural-gas production, by nature, is driven by demand and therefore the development of this sub-sector is crucial to the development of downstream industries.

As subsequent activities dictated, the fertiliser industries (ammonia and urea), along with methanol production, became prominent in the post-1990 years, paralleling significant natural-gas discoveries. This has led to the gas industry being used as a provider of fuel or feedstock. The fact that levels of domestic consumption have been well below those of available domestic supplies is largely because demand management and energy efficiency were not major concerns in Trinidad and Tobago. Product prices were comparatively low and, in many cases, subsidised. This situation is, however, changing.

Since 1990, oil production has been declining at an average annual rate of 2.7%. This is partly due to the natural decline in field production and also to insignificant oil finds since the late 1970s. Gas production, on the other hand, has increased steadily over the past decade from 643 MMscfd[1] in 1990 to 927 MMscfd in 1998. Further to this, gas reserves have increased steadily. By the end of 1997, estimated proven and probable reserves for oil stood at 2.6 billion barrels while those of gas (end of 1998) were 30.70 Tcf[2] (Ministry of Energy, 1998a).

Renewable energy

Government's policy is to develop renewable sources of energy where feasible. Areas of renewable energy which are applicable to Trinidad and Tobago are solar energy (thermal and photovoltaic), wind energy, wave energy and, to a lesser extent, biomass. Solar energy carries with it the greatest potential for development due to its abundant supply and the fact that it can utilise technology, which can be competitive. The Government is prepared to support, by fiscal and other incentives, all viable opportunities that may seek to exploit this sector. However, this non-conven-

[1] MMscfd - Million standard cubic ft. per day

[2] Tcf - Trillion cubic ft.

tional energy sub-sector is in its embryonic stages. In the case of biomass, agricultural supplies to sustain large biomass energy plants are not available. Additionally, the high methane content of natural gas produced locally, as well as security of supplies of natural gas, have made it unfeasible to produce methane gas from agricultural waste at this time. (Ministry of Energy, Renewable Energy, 1998b).

Transport

Energy demand in the transportation sector rose by 4% and 3% between 1990 and 1991, and 1991 and 1992 respectively. During the following two years, 1993 and 1994, transportation energy demand recorded falls of 11% and 3% respectively. Of interest in this trend, however, was the steady decline over the period 1990 - 1994 of gasoline energy consumption from 15,804 TJ to 12,828 TJ, representing an average decline rate of 5.25% over the period. Diesel fuel, on the other hand, showed an increase in 1994 over its 1990 consumption level.

One feature to note is the marked preference shown by the travelling public for individual private transportation (cars) to the use of the public system (buses). The majority of persons transported by buses came from the lower income brackets and from the school population. Notwithstanding this feature, customer levels for the Public Transport Service Corporation (PTSC) — the government-owned and operated bus service — decreased from 16.3 million passengers in 1990 to 6.4 million passengers in 1998 (Table 1.8). This trend is explained only by noting a general decrease in buses available, an increased reliance on private, personal transportation, along with increased vibrancy in the private commercial transport sector (taxis and maxi-taxis).

As anticipated, privately-owned cars showed an increase in absolute numbers over the period 1990-1998, rising from a registered total of 105,584 vehicles to 137,119. The percentage of private vehicles to the total number of vehicles registered fell from 38% to 28% over the period 1990-1998 (Table 1.9) (CSO, 1985-1992; Ministry of Works and Transport, 1999).

Table 1.8: Number of PTSC Passengers (1990-1998) ('000 units)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Passengers Carried	16,323.3	15,650.9	17,412.2	15,605.7	11,183.7	9,378.8	9,690.5	8,097.5	6,438.6

Table 1.9: Number of Vehicles Registered by Type and Year (1990-1998) (CSO, PTSC, 1985-1992)

Type	1990	1991	1992	1993	1994	1995	1996	1997	1998
Motorcycle	2,714	2,185	2,223	2,144	2,227	2,350	2,435	2,490	2,653
Private	171,870	139,310	142,359	135,397	137,209	141,047	148,693	157,199	168,336
Hired	26,663	21,454	21,757	20,492	20,523	20,689	20,866	21,107	22,107
Rented	782	1,399	2,240	2,755	4,004	4,638	5,333	5,669	5,900
Goods	43,453	35,943	37,232	35,815	36,769	38,625	40,223	41,855	43,656
Omnibus	267	288	291	271	271	271	271	271	272
Tractors	3,886	3,175	3,259	3,103	3,147	3,263	3,331	3,368	3,404
Trailers	5,029	4,182	4,358	4,295	4,465	4,612	4,793	4,892	5,047
Industrial	361	386	393	377	384	400	435	448	454
TOTAL	**255,025**	**208,322**	**214,112**	**204,650**	**208,999**	**215,895**	**226,380**	**237,299**	**251,829**

Institutional arrangements, national environmental policy and related natural resources policies

The Government, cognisant of climate change and its impacts, established in 1990 a Cabinet-appointed Working Group to Determine the Implications of Global Warming, Climate Change and Sea Level Rise. The Working Group is presently Chaired by the Environmental Management Authority and, *inter alia*, advises Government on climate-related policies. The Working Group has representation from relevant government ministries, NGOs and the private sector.

The National Environmental Policy (GORTT, National Environmental Policy, 1998) aims at the constructive use and conservation of the environment for the promotion of economic and social development, in order to maintain and improve the quality of life to which all citizens are entitled. The goal of the policy, therefore, is the conservation and wise use of the environment of Trinidad and Tobago in order to provide adequately for meeting the needs of present and future generations and enhancing the quality of life.

Specifically, the following policy approaches are utilised.

Air pollution

(i) Adopting ambient air quality standards consistent with the World Health Organisation (WHO);
(ii) Product standards (e.g. lead in petrol, vehicle exhaust emissions);
(iii) Emission limit values (stationary industrial plants);
(iv) Setting upper limits on total emissions (more stringent in heavily industrialised areas);
(v) Uniform reduction in production or use of polluting products.

Noise pollution

(i) Codes of conduct;
(ii) Emission standards;
(iii) Listing of noise-emitting activities.

Motor vehicle emissions

(i) Inspection and certification programmes;
(ii) Emission standards and emission fees;
(iii) Improved gasoline and diesel standards with the aim of a complete phase-out of leaded fuel by the year 2005;
(iv) Fuel pricing to encourage the use of compressed natural gas (CNG) as an alternative fuel;
(v) Traffic management measures (speed limits);
(vi) Promotion of staggered work hours, mass transport services and non-motorised transport.

Greenhouse gases

(i) Conduct regular inventories of GHGs;
(ii) Implementation of technologies that will reduce, prevent or control man-made GHG emissions;
(iii) Conserve and enhance natural ecosystems that serve as sinks or reservoirs of greenhouse gases (forests, coastal and marine ecosystems).

Waste

Waste management to be based on the principles of reduction, reuse and recycle.

Other areas of focus

The other areas of focus include:
(i) Hazardous waste;
(ii) Hazardous substances;
(iii) Ozone-depleting substances;
(iv) Spills;
(v) Contaminated land and environmental emergencies (disasters both natural and man-made).

Approaches and achievements to date

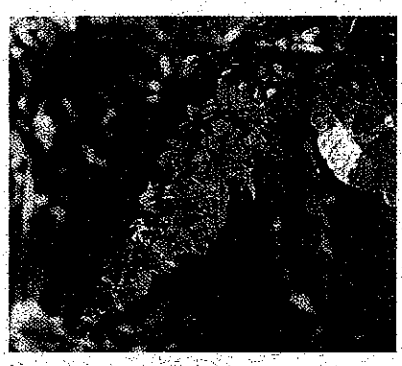
Water resources management strategy

A Water Resources Management Strategy has been developed for Trinidad and Tobago, focusing strongly on improving institutional arrangements to ensure better management of the resource. Among issues identified which link closely with climate change are the potential for more severe droughts and better flood-damage and flood-reduction policies and programmes. (Ministry of Planning and Development, June 1999).

Biodiversity strategy

The international community has shown a growing interest and commitment to sustainable development. This interest has translated itself in part into:

(i) the conservation of biological diversity;
(ii) the sustainable use of its components; and
(iii) the fair and equitable sharing of benefits arising from the use of genetic resources.



The Chaconia, National Flower of Trinidad and Tobago

Trinidad and Tobago is a signatory to the Convention on Biological Diversity (CBD). Under Article 6 of the Convention, Trinidad and Tobago is required to:

(i) develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes which shall reflect, *inter alia*, the relevant measures set out in this convention; and
(ii) integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes or policies.

Trinidad and Tobago is continuing to implement its obligations under the CBD. Accordingly, the Government of Trinidad and Tobago, in planning for the conservation and sustainable use of the country's biodiversity within the context of its socio-economic development, has formulated a National Biodiversity Strategy and Action Plan (NBSAP, 2001).

Trinidad and Tobago's NBSAP is people-focused, i.e. involving people from all walks of life and stakeholders in biodiversity conservation. Information has been collected in the following sectors:

(i) agriculture;
(ii) flora and fauna;
(iii) coastal and marine biodiversity and fisheries;
(iv) industry and environmental management; and
(v) tourism.

Based on its recommendations, the NBSAP will develop projects aimed at the involvement of NGOs and CBOs, utilising the services of the University of the West Indies (UWI).

Additionally, Trinidad and Tobago has had a long history of adapting to the management of its natural biodiversity resources. The following landmarks are of note:

1765: The Main Ridge in Tobago set aside as "Woods for the protection of the rains", a first in watershed management in the Western Hemisphere.

1922-1960: A system of 43 Forest Reserves declared for managing timber resources.

1934-1968: A system of 11 Wildlife or Game Sanctuaries declared for the protection of wild animal species.

1970: Marine Preservation and Enhancement Act used to declare Buccoo Reef in Tobago a Protected Area.

1972: Chaguaramas Development Act, for the protection of the Chaguaramas peninsula.

1987-1999: Prohibited Areas declared under the Forests Act, to prevent entry into sensitive areas at specific times of the year. Increasingly used to protect nesting animals and Forest Reserves from fires. Forest Reserves in the north of Trinidad and Wildlife Sanctuaries are now under this classification.

Source: NBSAP 2001

Public awareness and outreach programme

The Government of Trinidad and Tobago, as part of its continuing efforts to develop public awareness on matters pertaining to climate change, has embarked on a studied programme of information dissemination for the purpose of sensitising the population towards responsible behaviour through education.

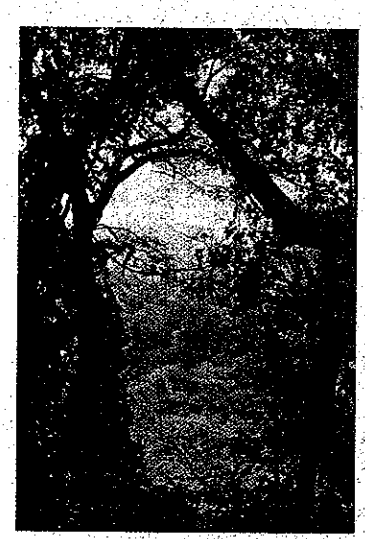
Prime targets in the drive towards creating an enlightened public are the country's school children. It is felt that this approach has the potential for rich rewards, as children can be effective conduits to parents. Programmes directed at the youth take the form of pamphlets, television infomercials, posters and poster competitions, musical jingles, lectures to schools by climate change project staff, and essay-writing competitions. In addition to the focus on young people, television documentaries, newspaper articles and lecture-discussions are strategies used from time to time to sensitise their older counterparts. A three-year public awareness strategy and action plan has been formulated by the Sub-committee on Public Awareness of the Cabinet-appointed Working Group to Determine the Implications of Global Warming, Climate Change and Sea Level Rise presently being implemented through the public awareness programme of the EMA. A significant part of this strategy is the cooperation with NGOs and CBOs in reaching out to coastal communities and stakeholders.

The EMA, the agency charged with this particular responsibility, has also launched a website on the Internet for access by all interested persons. Repeating our strategy on the Web, there is a focus on the children with climate change quizzes and answers. The URL for the website is http://www.ema.co.tt/climatechange.

The Arena Shelterwood system, a first in sustainable forestry.

Forest management policies and achievements

A Forest Policy has been developed for Trinidad and Tobago. Strategies in support of this policy include periodic forest inventories and an interdisciplinary planning approach, along with the implementation of management plans at the national, sub-sectoral, regional and unit levels. Implementation of the policy is to be monitored and evaluated from time to time to ensure effectiveness. In addition, plans are to be periodically revised to take into account results of research, as well as social, economic, technological and other relevant changes. Forest production policy is geared to optimise the quality and quantity of forest produce by managing the production forests intensively with a view to obtaining sustained yield in perpetuity (GORTT. Forest Policy of T&T, 1998).



Trinity Hill Wildlife Sanctuary

Wildlife and wetland management

The protection of wildlife species necessitates the protection of their natural habitat, sustainable harvesting of exploitable species, and the protection from extinction of native wild species, especially the rare ones. To this end, relevant legislation, namely the Designation of Environmentally Sensitive Species and Areas Rules, under the Environmental Management Act 2000, is being drafted. When implemented, the law will provide for adequate protection of species and areas so designated.

In terms of wetland management, the Forestry Division of the Ministry of Food Production and Marine Resources presently chairs a Cabinet-appointed National Wetlands Committee, one of whose mandates is the development of a National Wetlands Policy to include the development and implementation of programmes for sustainable use of wetlands. Additionally, the Ministry is the Focal Point for the Ramsar Convention and is responsible for implementing the Convention. The Nariva Swamp, located on the east coast of Trinidad, is designated as a wetland of international importance under the Ramsar Convention.

Watershed management

The policy here is the adoption of appropriate land-use practices that will permit regulated stream flows, improved water quality and quantity, flood and erosion reduction and the maintenance of aesthetic values of watersheds. Strategies for the realisation of this objective include the identification of major watersheds and sub-watersheds in the country. These are to be evaluated along with the establishment of a priority system for their rehabilitation. Co-operation with other agencies in watershed protection is under way to prepare, implement, monitor and evaluate watershed management strategies.

Chapter 2

National Greenhouse Gas Inventory

Introduction

Since the birth of the UNFCCC at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, its governing bodies have enunciated measures for achieving the stabilisation of GHGs' atmospheric concentrations at levels that would not interfere with climate systems. Article 4.1 (a) of the Convention commits all parties to "develop, periodically update, publish and make available to the Conference of Parties, ... national inventories of anthropogenic emissions and removals by sinks of greenhouse gases". The Conference of the Parties also recommended in 1995 that all countries adopt the IPCC 1996 Revised Guidelines for National GHG Inventory. The Trinidad and Tobago National Inventory for Greenhouse Gases was compiled and reported here using the IPCC 1996 Revised Guidelines methodology. Following the requirements of Article 12.1 (a) of the Convention, the GHG inventory contains information on the following direct-acting GHGs: CO_2, CH_4 and N_2O. HFCs, PFCs and SF_6 are not covered in this Initial Communication. The indirect-acting GHGs covered in this report, as defined by the IPCC Guidelines, are NO_x, CO, NMVOCs and SO_2.

Greenhouse gases relevant to Trinidad and Tobago

Using the IPCC Common Reporting Framework 1 guidelines (IPCC 1997a-c), total national emissions and removals by source and sink categories were computed for CO_2, CH_4, N_2O, NO_x, NMVOCs and SO_2 for the base year of 1990. This GHG inventory is presented on a gas-by-gas basis with the emissions and removals separated only for CO_2. For the compilation of the GHG inventory, the sectoral categories covered are Energy, Industrial Processes, Agriculture, Land Use Change and Forestry, Waste

and International Bunkers. The emissions and removals from international bunkers were not included in the national totals for each gas and included only as memo items as per the IPCC reporting guidelines. The CO_2 equivalents of the aggregate GHG emissions and removals are reported for the other two direct GHGs (CH_4 and N_2O) covered in this inventory. The 1995 IPCC GWP values for a 100-year time horizon were used for calculating CO_2 equivalent of the reported GHGs.

Sources of data

Various data sources were used for the estimation of emissions by sources and removal by sinks of the greenhouse gases for Trinidad and Tobago. Government departments and agencies including the Ministry of Energy and Energy Industries, the Ministry of Food Production and Marine Resources, and the Ministry of Works and Transport provided most of the data used in this study. Others were the Central Bank, Central Statistical Office (CSO), Water and Sewerage Authority (WASA), EMA and the Petroleum Company of Trinidad and Tobago Limited (Petrotrin). Data were also sourced directly from manufacturing and agro-based industries. Except in the case of Agriculture and Land Use Change and Forestry, the GHG inventory was prepared for a one-calendar-year time period. The time periods used for the compilation of GHG inventory for the Agriculture and Land Use Change/Forestry for the base year of 1990 were those recommended in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories Volume 1: Reporting Instructions. Emission factors used for computations in this study were the default values given in the IPCC Guidelines for National GHG Inventories. A greenhouse gas inventory was not prepared for the solvent and other product use category due to the lack of data in this area for the year 1990.

National GHG emissions

GHG inventories for the base year are presented for Energy, Industrial Processes, Agriculture, Land Use Change and Forestry and Waste sectors. The national GHG inventory is summarised in Table 2.1. The individual greenhouse gas contribution to the national total is shown in Figure 2.1 for the CO_2, CH_4 and N_2O (the direct GHGs covered in this inventory). The figure shows

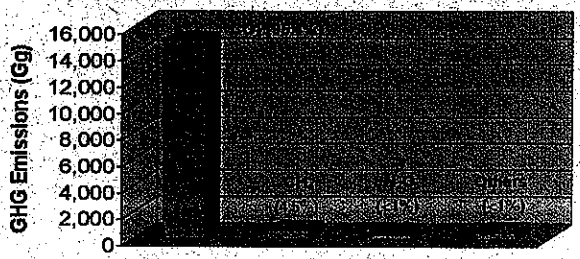


Figure 2.1: Total national GHG emissions for 1990. (Others: NO_x, CO, NMVOC, SO_2). CH_4 and N_2O are given in Gg of CO_2 equivalents.

that CO_2 contributes 95.4% (14,988 Gg of CO_2 GWP) of the GWP followed by CH_4 with 4.5% (714 Gg of CO_2 GWP). N_2O contributes less than 1% (12 Gg of CO_2 GWP). Figure 2.2 shows the contributions of the various sectoral activities to the total CO_2 emissions. As shown in this figure, the combustion of fossil fuel for the production of energy contributes 66% of the total anthropogenic CO_2 emissions. Industrial processes contribute the remaining 34%. The Land Use Change and Forestry Sector has a net removal effect as forests serve as sinks for CO_2 with the Forestry Sector removing 10.2% of the total national anthropogenic CO_2 emissions.

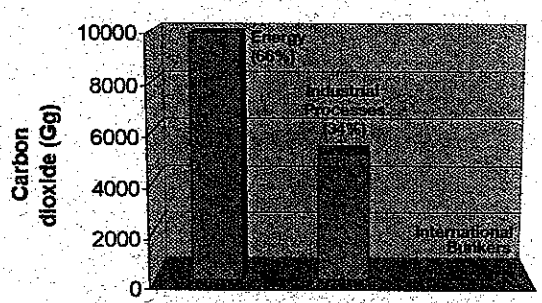


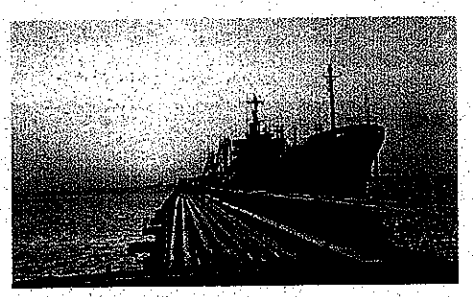
Figure 2.2: CO_2 emissions by sector 1990.

Energy Sector

The inventory for the Energy Sector was prepared with data obtained from the Trinidad and Tobago Consolidated Energy Balance data sheets supplied by the Ministry of Energy and Energy Based Industries, Petrotrin, and those obtained from Trinidad and Tobago National Petroleum Marketing Company Limited. The national GHG inventory report for the Energy Sector includes fuel combustion activities and fugitive emissions from fuels as computed using the sectoral approach. Fuel combustion activities considered are those

of the Energy Industries, Manufacturing Industries and Construction, Transport and other sectors.

The fugitive emissions from oil and gas exploration, production, transport, refining, storage and distribution were estimated. Also included in fugitive emissions were the products of the venting and flaring of oil and gas. Figure 2.3 depicts the total national emissions of all greenhouse gases for the energy sector. The figure shows that CO_2 is the main GHG emitted from the energy sector.



Bunkering facility, Petroleum Company of Trinidad and Tobago (Petrotrin).
Courtesy Petrotrin

CO_2 from the Energy Sector

In Table 2.1, the total national emissions and removal of CO_2 from energy sources are presented in two forms: Reference Approach and Sectoral Approach. The Reference Approach accounts for the emissions of CO_2 based on the primary fuel and net quantity of secondary fuels available in the country. The Sectoral Approach accounts for all of the GHG emissions associated with fuel combustion activities and fugitive emissions from fuels. It is expected that national emissions values calculated with the Reference Approach should agree with that estimated from the Sectoral Approach. The inventory data shows that, for 1990, the CO_2 emissions estimated by the Reference (16,454 Gg) and Sectoral Approaches (9,887 Gg) differ by about 40%. The discrepancy between the national emission estimates obtained with the two approaches can be explained as mainly a result of the variety of sources of the original data used for the preparation of the inventory. The CO_2 emission was also compared with values reported by the International Energy Agency (IEA) for CO_2 emissions from fuel combustion. IEA reported values of 12,310 Gg for 1990 (IEA 1999a) compared to the 9,887 Gg estimated in this national inventory. The IEA estimation used the Reference Approach and included contributions from international aviation (IEA, 1999b).

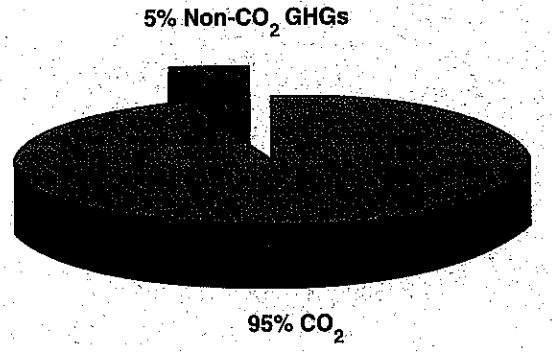


Figure 2.3: GHG emissions from the Energy Sector in 1990. Total CO_2 from fuel combustion is 9,887 Gg. Non-CO_2 GHGs from fuel combustion total 520 Gg (CO_2 equivalents of CH_4 and N_2O were used).

Table 2.1: Summary Report for National Greenhouse Gas Inventory For 1990

Greenhouse Gas Source And Sink Category	GREENHOUSE GAS INVENTORY (Gg)							
	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emissions and Removals	14,988	1,524	33.871	1.073	36.858	405.468	93.128	8.750
1. Energy Reference Approach	16,454							
Sectoral Approach	9,887		1.428	0.037	36.093	372.906	61.089	8.505
A. Fuel Combustion	9,887		1.382	0.037	35.055	151.855	27.879	
B. Fugitive Emissions From Fuels			0.047		1.038	221.051	33.210	8.505
2. Industrial Processes	5,100		0.805	0.000	0.052	14.692	32.039	0.246
3. Solvent and Other Product Use	NE[1]			NE			NE	
4. Agriculture			6.255	0.668	0.413	7.303		
5. Land Use Change and Forestry		1,524	1.208	0.008	0.300	10.566		
6. Waste			24.174	0.367				
Memo Items:								
International Bunkers	60.608		0.027	0.000	0.137	0.733	0.177	0.010
Aviation	30.863		0.027	0.000	0.137	0.733	0.177	0.010
Marine	29.744		0.000	0.000	0.000	0.000	0.000	0.000
CO_2 Emissions From Biomass	0.000							

[1]NE refers to "Not Estimated"

The CO_2 emissions from the Energy Sector consist of contributions from the Energy Industries (43.5%), Manufacturing Industries and Construction (38.2%), Transport (14.9%), and other sectors that combust fuel for energy production and utilisation (3.4%). Non-CO_2 GHGs emitted from the energy sector are summarised in Figure 2.4.

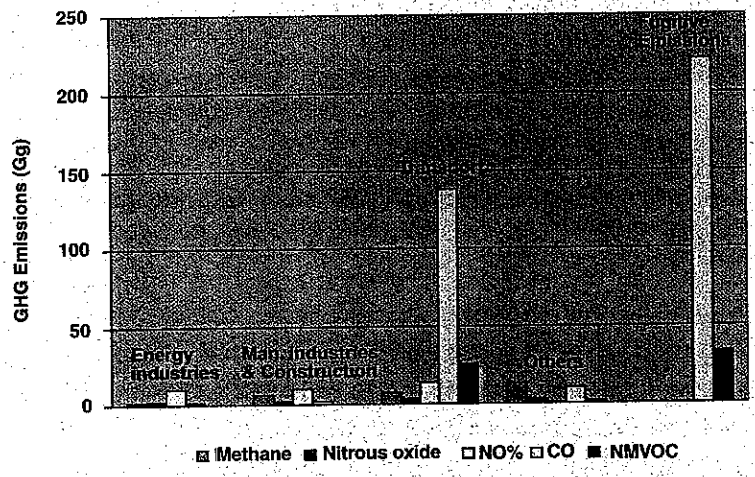


Figure 2.4: Non CO_2 GHG emissions from the Energy Sector 1990. CO_2 equivalents of N_2O and CH_4 were used.

Industrial Processes Sector

The major industrial processes in Trinidad and Tobago that contribute to GHG emissions are the Mineral Products Industries (Cement), and Chemical Industries that produce ammonia. Industrial processes involving iron and steel production, and other products (e.g. food and drink), were also considered in the inventory preparation. Table 2.1 shows that CO_2 is the main GHG produced by industrial activities, and this constitutes 34% of the total national emissions of CO_2 in 1990. Figure 2.5 shows the contribution of the various industries to the overall CO_2 emissions of the Industrial Process Sector. The production of ammonia is the main source of CO_2 emissions in the Chemical Industry. However, much of the CO_2 produced during ammonia production is recovered and used as feedstock in the manufacture of methanol.

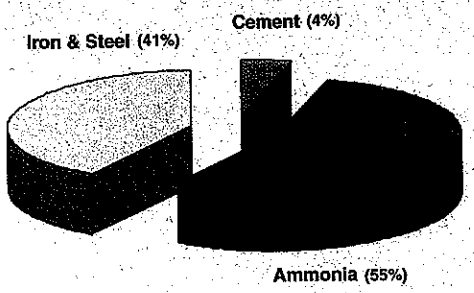


Figure 2.5: CO_2 emissions from Industrial Processes 1990

Agriculture Sector

Introduction

While agriculture accounted for just about 3.4% of GDP in 1990, within this sector sugar production accounted for about 32% of the GDP. However, from a social perspective, agriculture is much more important than indicated by only a reference to its contribution to the GDP. Other important agricultural commodities include, on the crops side, cocoa, coffee, citrus and vegetables; on the livestock side, poultry, milk, eggs, beef, pork and some other meats.

The main activities in the agricultural sector (in 1990) that were responsible for GHG emissions can be categorised as domestic livestock farming and rice cultivation. Figure 2.6 shows the contributions these activities make towards the emissions of GHGs in Trinidad and Tobago. The main contributor to methane emissions is enteric fermentation from livestock; for N_2O, it is from the addition of nitrogen to soils; and for both CO and NO_x, it comes from the burning of agricultural residues.

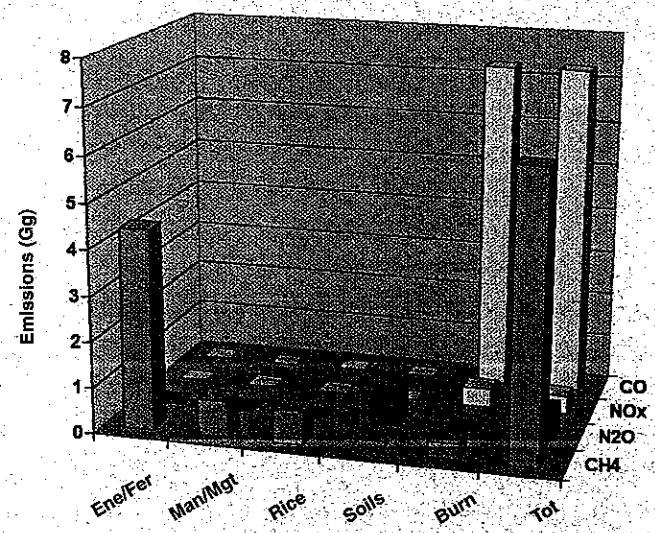


Figure 2.6: GHG emissions from the Agricultural Sector.

GHG emissions

Enteric fermentation and manure management

Figure 2.7 shows the proportion of methane emissions from various livestock species reared in Trinidad and Tobago although the total emissions are practically insignificant. The two most important factors determining the volume of emissions were stomach design characteristics of the animal (ruminant or not), the size of the animal, the population of the species, and the amount of feed intake. The graph shows that emissions from cattle (including both beef and dairy herds) were the predominant source of methane, although accounting for a mere 3 Gg. The other emissions were from poultry and other livestock such as swine, sheep and equines.

The management of livestock waste, specifically manure, is also a factor contributing to methane emissions amounting to just 0.794 Gg, with contributions to nitrous oxide being 0.012 Gg.

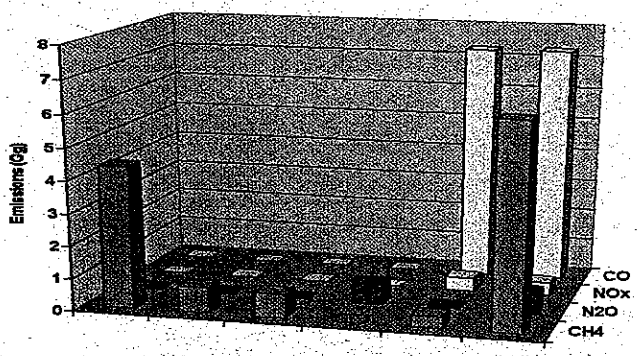


Figure 2.7: Proportion of methane emissions from Enteric Fermentation by Livestock

Field burning of agricultural residues

Burning of sugar cane prior to harvesting is the normal process employed in the sugar industry, and the reported GHG emissions from this sector are those other than carbon dioxide as per IPCC instructions. Emissions from all other crops combined represent only about 2% of the production from sugar cane.

Agricultural soils

The addition of nitrogen to agricultural lands/soils can occur through the direct application of fertilisers, through additions of crop residues and animal waste (inclusive of that which is added by grazing livestock), and by additions from the atmosphere. Nitrous oxide emissions from agricultural soils account for 0.641Gg.

Land Use Change and Forestry Sector

The forest resources of Trinidad and Tobago account for about 42% of the 512,600 ha total land area of the country. The most important forest product at present is lumber. However, the additional roles of producing and maintaining good quality water associated with the watersheds and a level of biodiversity for sustainable developments in biological resource management are sometimes greatly under-emphasised. Eco-tourism is also fast becoming an important product that could generate both economic gains as well as greater awareness for the preservation of this resource. Implementation of Trinidad and Tobago's forestry policy should accommodate all of these in a cohesive and sustainable manner. The following activities were analysed to calculate the CO_2 balance for the baseline year (1990): changes in forest and other woody biomass; forest and grassland conversion; and abandonment of managed lands.

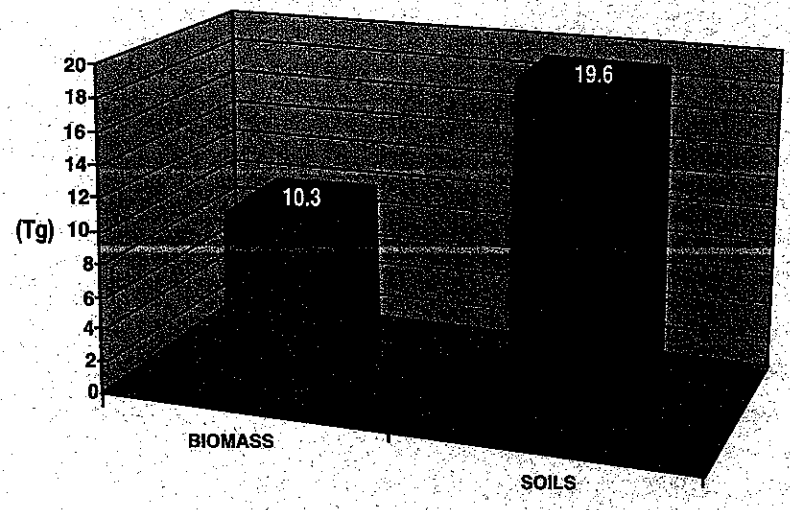


Figure 2.8: Approximate Carbon Store in Biomass and Soils in Trinidad and Tobago in 1990.

The forests and soil resources of Trinidad and Tobago are significant sinks/reservoirs of carbon as shown in Figure 2.8. The management of these resources ultimately determines to what extent their carbon reserves may be converted into CO_2 emissions. The net effect has shown that, for 1990, the forest resources of Trinidad and Tobago have positively contributed to abating GHG levels in the atmosphere through the removal of approximately 1,524 Gg CO_2. While the forest biomass itself serves as a significant sink for CO_2, the harvesting of forest species for lumber, the clearing of forest for agriculture and otherwise, along with improper soil management, particularly of land converted out of forest, have all somewhat hindered the full CO_2 trapping capacity of the forests. However, better soil management and conservation practices on agricultural lands in the future should result in increasing the soil sinks of carbon.

Waste

The emission of GHGs in this sector pertained to CH_4 and N_2O from the management of solid waste, domestic and commercial wastewater, and industrial wastewater. As shown in Table 2.1, the waste sector contributes 24.2 Gg of methane. Solid waste disposal on land and wastewater handling generate about 16 Gg and 8.5 Gg respectively of methane while wastewater handling is responsible for the emission of 0.124 Gg of nitrous oxide (333 Gg of CO_2 GWP).

Data gaps and uncertainties

The GHG inventory was prepared with data already documented in public institutions and in private industries. However, some of the data, particularly in the Industrial Processes Sector, were based on surveys or information from major private sector companies involved in the manufacture of a particular product. Data gaps do definitely exist in terms of taking proper inventory of such companies and their output. Moreover, in cases where either governmental agencies or the companies provided data directly, the uncertainties associated with the estimates of production output were not provided. This makes it difficult to estimate the uncertainties in the GHG inventory. No direct measurements or surveys were carried out for the purpose of the compilation or verification of this inventory.

A significant amount of uncertainty was incurred as a result of the use of default emission factors provided in the IPCC 1996 Revised Guidelines as well as other factors such as fraction of carbon oxidised. In the absence of factors specific to Small Island Developing States, use of these default factors resulted in emission over-estimates and therefore may not reflect the best estimate.

Relevant research is needed in order to reduce the uncertainty for future inventories. Accordingly, the following approaches can be used:

(i) Evaluation of the fuel efficiency and greenhouse gas emission rates of the various automobile populations used in Trinidad and Tobago, with a view to implementing appropriate policy measures and the establishment of technological standards for pollution minimisation;
(ii) Determination of the percentage of forest cover of young versus old forests and absorptive capacity for carbon dioxide;
(iii) Determination of the absorptive capacity of coastal ecosystems within the Exclusive Economic Zone;
(iv) Development of emission factors that are suitable and relevant to the scale of activities of Small Island Developing States.

Chapter 3

Statements on Vulnerability and Adaptation Strategies

Introduction

There is strong scientific evidence to suggest that the already observed climate changes being experienced worldwide are linked to anthropogenic activities (IPCC 1997d) and that the effects will continue to increase. The quantification of Trinidad and Tobago's contribution to greenhouse gas (GHG) emissions, albeit insignificant compared to the global emissions, is nevertheless relevant in this context. The effect of Trinidad and Tobago's emissions on climate change globally is inconsequential when compared to the actual impacts that climate change is likely to have on us. This is particularly true not only because of our small land size, but also as a result of our high population density, reliance on our narrow natural resources such as forest reserves, agriculture and domestic supply of natural fresh-water, and the generally fragile nature of our economy. Climate change is no longer something of the future. Indeed, action must be taken now to guarantee our future.

It is therefore very important that Trinidad and Tobago prepares itself, like most other developing small-island states, for the changes in climate that we are already committed to as a result of past GHG emissions, as our survival depends on it. In order to even begin to respond to these challenges, comprehensive assessments of climate change impacts across all sectors are required. Understanding all the complexities and likely impacts of climate change on the physical, biological and human resources of Trinidad and Tobago will involve an ongoing, long-term and detailed technical assessment. Such an assessment would possibly incorporate, to a large extent, the use of models, this being the most reliable technique in conducting these types of studies, despite the inherent uncertainties. The lack of relevant technologies and institutional and human technical capacity to conduct the necessary research is a significant handicap in this respect and is a glaring lacuna.

A climate change impact assessment would largely be designed to investigate what effects future changes in climate could have on human activities and natural, biophysical resources. These studies are effectively conjectural in nature with likely impacts not being able to be confirmed experimentally. However, there are several approaches that can be employed to forecast the likely impacts of climate change:

(i) palaeontological, archaeological, or historical studies of how climate changes and climate variations in the past have affected human and/or natural systems;
(ii) forecasting by analogy;
(iii) studies of impact of present-day climate and climate variability;
(iv) use of models; and
(v) expert judgment.

At this stage, we can only produce a statement that accommodates, through a series of consultations and workshops with key stakeholders, expert judgments of our level of vulnerability and adaptive capacity. It is by no means a quantitative or comprehensive assessment. However, an analogy of the sugar industry over a 30-year period provides some more specific information that is also presented here.

As a first step in alerting the public to the possible effects of a changing climate, this Initial National Communication is geared towards highlighting the areas in which we are most vulnerable and the ways in which we can adapt. Climate change is no longer something of the future; it is of the present and that reality must be appreciated.

It is noteworthy that while this Communication looks at what is believed to be the level of vulnerability of Trinidad and Tobago to climate and sea-level change and the ways that adaptation can take place, it also addresses concerns, obscurities and areas for capacity building and improvements in understanding the systems being impacted on.

Chapter 1 of this Communication details the national circumstances of Trinidad and Tobago with respect to its climatology, geography, economy and socio-political ideology. As a small, humid-tropical, fairly well-populated country with a diverse physiography and a relatively significant industrial sector, Trinidad and Tobago possesses a certain socio-economic dimension that makes

it unique. These circumstances therefore influence the level of vulnerability to climate change and sea-level rise in a number of ways. The two islands are somewhat sheltered from extreme events due to their close proximity to the South American mainland. Our major concern, however, lies with the watersheds of both islands — the fact that there exists a large, low-lying flood-plain area in Trinidad — as well as with the beach and marine resources of Tobago.

Flooding and land reform issues

Perennial problems of flooding exist particularly in Trinidad within the flood plains of the island, which are fairly extensive. Many of these areas are just a few feet above sea level and communities are placing a lot of pressure on the Central Government to compensate for economic losses and possible relocation. The simultaneous occurrence of high tide and an extreme rainfall event would always serve to exacerbate the problem, which would be worsened in a scenario of sea-level rise. This reality therefore has to be addressed with some sense of urgency. In the defence of the flood-plain communities, however, stricter control of activities such as logging in the watersheds, particularly in the Northern Range, should yield beneficial results in alleviating some of the flooding problems. Nevertheless, there is an urgent need to relocate some communities and to engage in stricter land control and land reform activities. The country possesses sufficient data including an inventory of all the soils of both islands (Brown and Bally, 1968), as well as land-use capability reports (Hardy, 1974), some GIS technology and technical expertise, all of which can be merged to produce good policy positions on land reform for Trinidad and Tobago. Notwithstanding this, assistance may be needed in this area.

Population and food security

Population growth for Trinidad and Tobago has been at an average of less than 1% annually over the last decade (CSO, 1999) and should continue in this trend, with a possible decline over the next century. Education and the improved status of women have contributed to some level of control over the population growth and should continue to do so. While Trinidad and Tobago does not rely much on domestic agriculture to meet its food demand,

about 10% of the labour force and a significantly greater percentage of the population actually live (directly or indirectly) off domestic agriculture, especially in the rural communities, and off the sugar cane industry in particular (CSO, 1999). Although most of the food consumed is imported, any negative impact on this section of the population could reduce their capacity to obtain food and maintain adequate nutrition. Rural communities presently account for as much as 56% of the total population. The country enjoys a very diverse food group and would not want this to be compromised.

Deforestation and land degradation

Although there is a clear governmental policy on land, there are significant challenges to implementation and enforcement which result in continued illegal activities. Slash-and-burn agriculture is still quite prevalent, and the nature of the soils, particularly in the Northern Range of Trinidad, is such that they degrade and erode quite easily, forcing the planting/cultivation cycle to be quite short. The result of this, coupled with the incidence of forest fires which are mostly difficult to control, is that many areas of open, denuded land exist, which contribute to the severity of flooding, the quality of life in the flood plains and the availability of good-quality drinking water.

Housing, property and insurance

The practice of using reinforced walls in home construction was not popular in the past because of the great additional costs. It has, however, been adopted particularly by the wealthier homeowners and developers, which makes for safer and more resilient houses. Most of the higher-income-bracket families insure their houses as well, but this is not a mandatory activity. The price of property is continually increasing and in Trinidad and Tobago, as well as throughout the Caribbean, generally, extended families are becoming the norm, even in middle-class and high-income homes.

Climate, disaster and response

Trinidad and Tobago suffers very few extreme events, particularly in relation to storms and hurricanes. This is rather fortunate since the damage from flooding and devastating high winds would be catastrophic because of our poor history of building codes and design. The largest population densities occur just at the foothills of the Northern Range in Trinidad and the combination of a highly erodible soil (Brown and Bally, 1968) and inadequately constructed homes would make these areas quite vulnerable in extreme storm activity. Special Units, however, have been set up to plan for and respond to these extreme events if they were to occur. One example is the National Emergency Management Authority (NEMA) which has developed disaster management plans. It is hard to say, though, how effective these facilities are since, especially in the recent past, there have been very few extreme climate events to test their preparedness.

Future trends in climate, sea level and socio-economics

The future is unpredictable and, while it is necessary to plan for anticipated changes in climate and sea level within the context of changing socio-economic circumstances for Trinidad and Tobago, these scenarios must be plausible and must also be recognised as being a projection of what the future is likely to be and not a definition of the future before it unfolds. No one can predict the future, but it would be unwise not to acknowledge trends and changes that are taking place, and instead react in a manner that would minimise or mitigate against the negative impacts.

Climate and sea-level scenarios

Fundamental to the study of climate-change impacts is an appreciation of what are likely to be the general climate circumstances in a projected period into the future, and what are expected to be the dynamics of change over that period. While being very relevant to the development of an impact assessment for any given

sector, it is sometimes the most uncertain. These future climate circumstances are referred to as a climate scenario; a scenario, by definition, being... "a coherent, internally consistent and plausible description of a possible future state of the world". Many climate scenarios examine the climate associated with a doubling of carbon dioxide levels in the atmosphere.

According to Smith and Hume (1988), four (4) conditions must be met in the climate-change scenario selected:

(i) The scenario should be consistent with the broad range of global warming projections based on increased atmospheric concentrations of greenhouse gases;
(ii) The scenario should be physically plausible;
(iii) The scenario should estimate a sufficient number of variables on a spatial and temporal scale that allows for impact assessment;
(iv) The scenarios should, to a reasonable extent, reflect the potential range of future regional climate change.

Many Global Circulation Models (GCMs) exist that can give some indication of the likely future climate changes for Trinidad and Tobago with some degree of uncertainty. Many of these GCMs cannot project over the scale of regions such as the Caribbean, and so projections for small islands such as Trinidad and Tobago result in even greater uncertainty.

The climatic future focuses on four main determinants: temperature, rainfall, sea-level rise and extreme events. Based on the premise of increased atmospheric concentrations of GHGs, the following scenarios are set for Trinidad and Tobago (Houghton *et al.*, 1996; IPCC, 1990):

(i) A temperature rise of 1.0 to 3.5°C by 2100;
(ii) A sea-level rise of 15 cm to 95 cm higher than the 1990 figure with a mean sea-level rise of 30 cm by 2050;
(iii) A rainfall deficit of 15% by 2100.

Approximately 40-50 years of data from the Meteorological Office at Piarco, Trinidad, have shown some clear evidence of climate change. Figures 3.1 and 3.2 show the mean monthly maximum temperature and the mean annual minimum and maximum temperature respectively for Trinidad and Tobago over a specified period in its history. The major trends observed were that both the minimum and maximum temperatures increased at about the same rate of approximately 1°C rise in 30 years. Generally, there were no trends observed for rainfall, sunshine, or wind speed, but there was an increase in the relative humidity over the same period.

The occurrence of extreme events like the El Niño phenomenon and storms and hurricanes is uncertain. However, one investigation (Singh, 1997) suggests that these may intensify for Trinidad and Tobago.

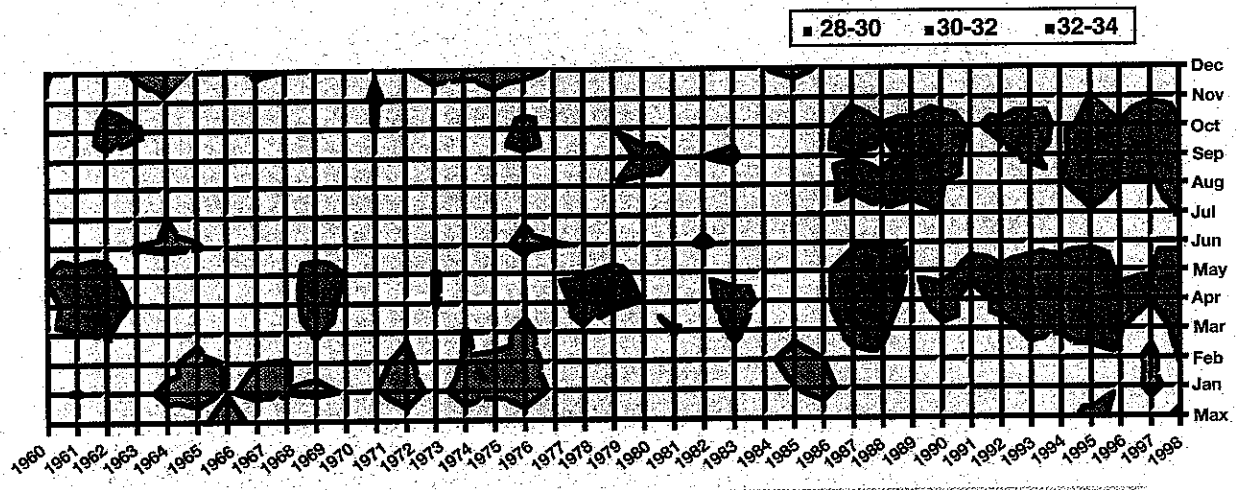


Figure 3.1: Mean Monthly Maximum Temperature (°C) in Trinidad and Tobago (1960-1998)

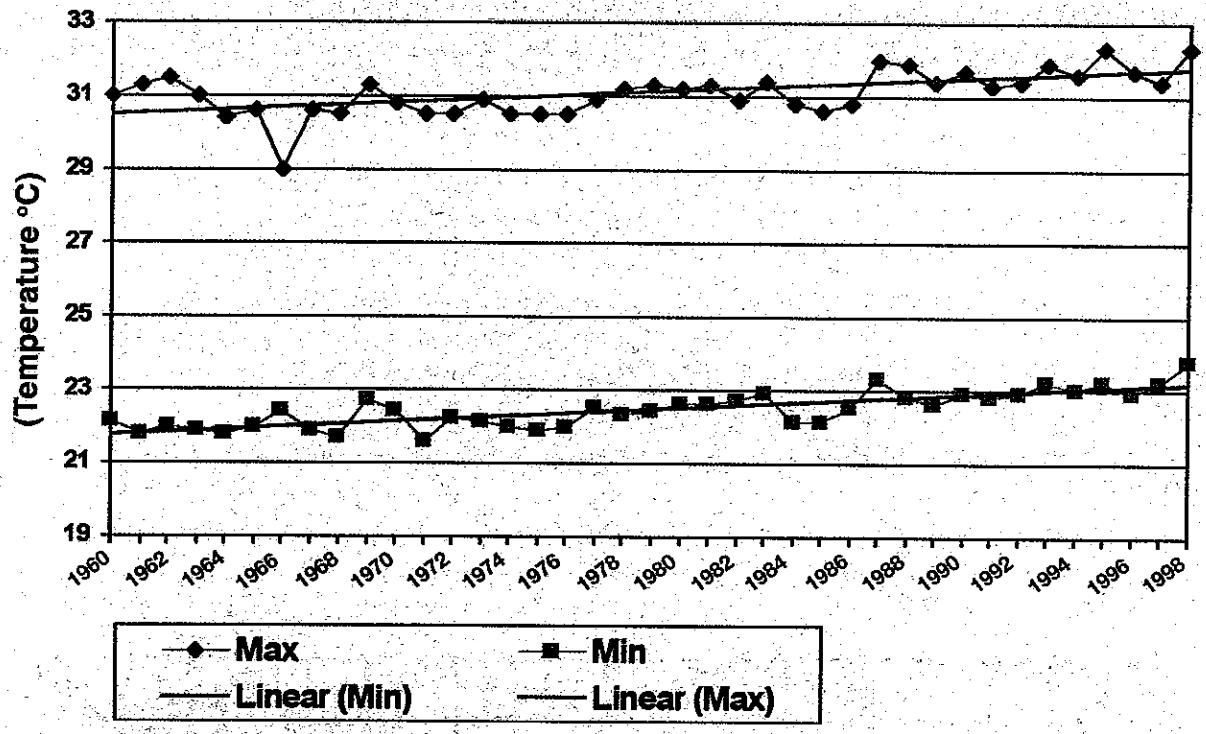


Figure 3.2: Mean Minimum And Maximum Temperature For Trinidad and Tobago (1960-1998)

Environmental and socio-economic scenarios

The world in which climate change will have its impact will not be the same as the world today. Many things will change, some even faster than climate, with populations and economies figuring prominently in this scenario of events. Like climate change, scenarios of socio-economic conditions to the future are necessary in order to conduct a thorough assessment of the likely impacts of changing climate on our society. A socio-economic baseline situation for Trinidad and Tobago is necessary in developing scenarios of how the society is likely to be in the projected period. The concept of climate change impacts therefore can be viewed in a number of combinations between climate and socio-economic scenarios as demonstrated in Figure 3.3 (adapted from Tol, 1998). The upper left box shows the situation at present, with current climate and a current society. As we move into the future, this and three other broad possibilities exist:

(i) future climate with current society
(ii) current climate with future society
(iii) future climate with future society

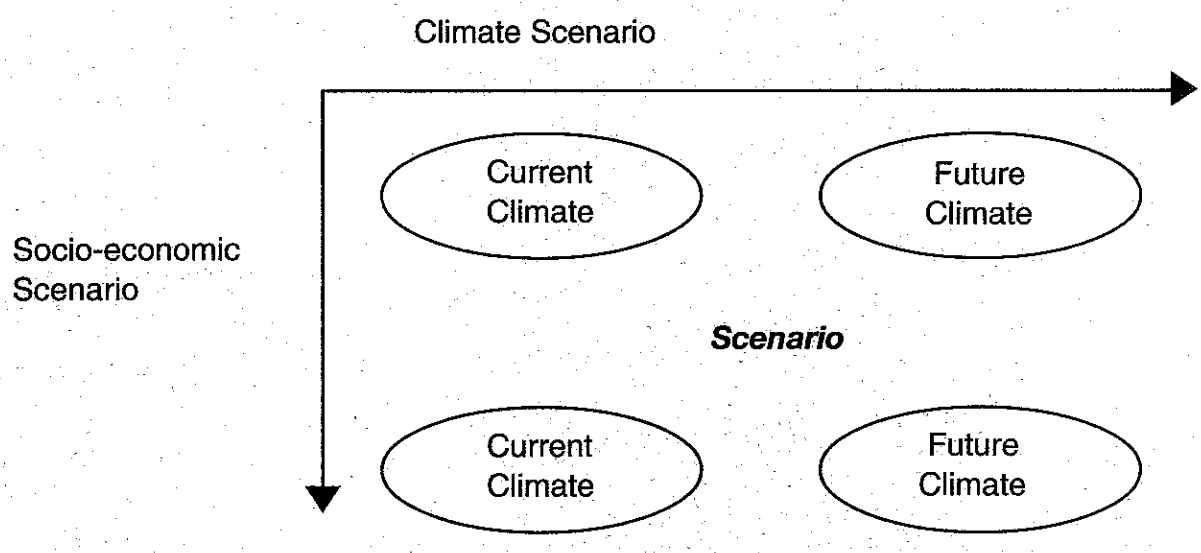


Figure 3.3: Climatic and Socio-economic Scenario Combinations

Of all scenarios, the most plausible is that there will be a future climate and society, both of which will be significantly different from what exists today. A thorough analysis, however, would favour a look at all possibilities to fully understand the range of impacts and vulnerabilities that may exist in any particular section of the economy. The focus is therefore to determine how that future society is going to deal with the effects of climate at that projected period. This is the basis for impact assessment.

Whilst the present society may be able to cope, and is therefore not necessarily vulnerable to future climate conditions, the future society may not and vice versa. This is the essence of vulnerability assessment studies and it determines the policy decisions and financial planning that are necessary to deal with, or adapt to, the impacts of climate change on future societies.

The population projection for Trinidad and Tobago is expected to be around 2.1 million by 2050 and 3.0 million by 2100. There is expected to be a strong urban drift into the interior of Trinidad, particularly into established rural towns and villages. This will be associated with a likely decentralisation by government outside of the main capital of Port of Spain, causing increased economic activity in these once marginalised areas.

Major industrial and agricultural water demands are expected to develop which will create conflict with other users of water whose numbers and demand are also expected to increase significantly (Fletcher, WASA, personal communication). The economic buffer of an expanding non-oil sector will continue to reduce the reliance of the economy on the fairly fragile and volatile oil sector, and stabilise the local economy even further. However, the economy is expected to marginalise certain groups already in the low-income bracket because of significant demand and supply trends favouring increasing prices for services.

Article 2 of the United Nations Framework Convention on Climate Change explicitly acknowledges the importance of natural ecosystems, food production and sustainable economic development. The vulnerability of human health, socio-economic and ecological systems depends upon economic circumstances and institutional infrastructure. The vulnerable sectors in Trinidad and Tobago are the terrestrial and aquatic ecosystems, hydrology and water resources management, food and fibre production, human infrastructure and human health. The terrestrial and aquatic eco-

systems in Trinidad and Tobago that are susceptible to the impacts of climate change include the hills and mountains, rivers, streams, coastal systems and oceans. Since a significant proportion of the rural population in Trinidad and Tobago depends on the surrounding environment for its livelihood, the climatic effects on agriculture, forest products and fisheries is likely to affect the production of food and fibre.

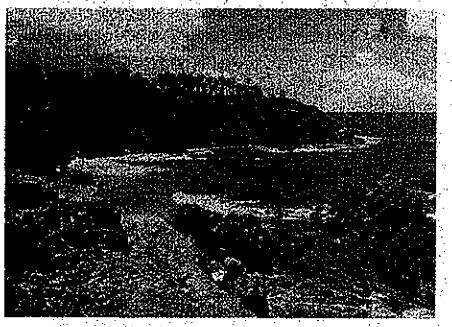
The key areas/sectors that are likely to be most vulnerable include the Caroni Basin, coastal and other marine resources, water resources, forestry and land use and biodiversity.

Caroni Basin

This is an area located between the Northern Range and the Central Range of Trinidad and is considered to be most vulnerable to the impacts of projected climate change and sea-level rise for the following reasons:

(i) 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 to supply most of the present needs of the island of Trinidad.

(ii) 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 siltation arising out of upstream deforestation as well as pollution from a multitude of small-scale industries, particularly poultry rearing and quarrying, despite efforts to control and regulate such activities. The situation is exacerbated by the increasing use of pesticides and fertilisers in agricultural holdings.



Toco Point, north-east coast.

Coastal and other marine resources

Coral reefs

The coral reefs of Tobago are under serious threat from both sea-level and ocean-temperature rise due to climate changes. The results of studies in the Caribbean have documented quite extensive bleaching resulting from a 1°C rise in ocean temperature (Goreau *et al.,* 1993; Goreau and Hayes, 1994). At the Culloden Reef in Tobago, though not very extensive at all, Singh (1997) found conclusive evidence of bleaching with a strong varietal influence. These reports point to the potentially disastrous effects of climate change on the health of our coral reefs and on the downstream industries that can be affected.

The impacts of climate change and sea-level rise on the island of Tobago would have to be carefully considered, particularly in relation to the tourist industry and the coral resources of the island, critical elements contributing to its socio-economic development. There have been some preliminary analyses of satellite-derived sea-surface temperature in relation to El Niño episodes (Della Harripaul, M.Sc. Thesis, UWI, unpublished). This study revealed the occurrence of higher average sea-surface temperatures around Trinidad and Tobago in El Niño years and coincided with incidences of coral bleaching in Tobago. Higher sea surface temperatures can therefore be expected to have significant deleterious effects on coral communities and, indirectly, on coastal vulnerability.

Coastal erosion

Coastal erosion at Manzanilla on the east coast of Trinidad.

The dynamics of coastal erosion are quite complex and predictions can be difficult, but definitely any rise in sea level will ultimately intrude on coastal communities. Several coastal regions are also susceptible, particularly to sea-level rise, and include communities along the east, north-west and south-west coasts of Trinidad and the south-west coast of Tobago. Evidence of encroachment, based on observations made during 1990-1996 (Singh, 1997), already exists, particularly along the Trinidad coastline on the south-east (Guayaguayare; ≈ 2.5 m/yr.), south (Los Iros; ≈ 3 m/yr.) and south-west (Coral Pt., Icacos; ≈ 2 m/yr.). In the latter, accretion is being observed close by at Punta del Arenal at a rate of 2.3 m/yr. Such encroachment has often been accompanied by severe denudation of the coastal communities. Limited encroachment and erosion continue to be experienced in some coastal areas of Tobago, particularly the south-west area, from Scarborough to Lambeau, where there is evidence of erosion. Loss of coral reefs in these areas as a result of increased bleaching will result in enhanced coastal vulnerability and the impacts of sea-level rise. Consequently, increased erosion is likely to be expected.

The Point Lisas Industrial Estate on the west coast of Trinidad had been developed on some portion of reclaimed land and is now one of the country's major GDP providers. This estate is just above sea level and very vulnerable to sea-level rise and extreme tidal variations. In addition to the vulnerability of physical infrastructure, there are indirect economic implications. Protection of this area by means of sea walls or other types of barriers and protective options may be considered. However, the particular option would have to be assessed to avoid costly maladaptation. Relocation inland and/or to higher ground is an option that may have to be considered. The feasibility of this option will depend on impacts on land use as well as the cost of physical relocation. Additionally, this will result in increased population density with the attendant problems of resource allocation and use. Trinidad and Tobago, already a small-island state with limited land and other resources, may find difficulty in pursuing this path. In some circumstances the use of sea walls can be an option, but this is extremely expensive and not always very effective.

Toco Fish Depot, north coast of Trinidad

Fisheries

In addition to the vulnerability of coral reefs to the impacts of increased sea-surface temperature, the marine stocks of fish, shrimps etc. are dependent on water within a particular temperature and nutrient range for their proper growth and development. Siltation of the rivers and pollution of the coastal marine resources also create sub-optimal conditions for aquatic life. With the expected increase in human population, the likely impacts of climate change on marine resources, such as a reduction in marine fishery stock, could put serious strain on the local food supply, a significant part of which is derived from fishing activities. For example, over the period 1992 to 1995, the country's total annual shrimp landings ranged from approximately 1,000 to 2,000 metric tonnes, with total annual revenue ranging from approximately TT$15 million to TT$33 million (Fisheries Information Series No. 9). Of this, exports ranged from 288 metric tonnes in 1992 to 500 metric tonnes in 1995. Impacts on marine fisheries will also have socio-economic impacts in terms of employment in this sector. Protection of this rich food resource would therefore depend partly on the success of the mitigation of indiscriminate activities inland which cause pollution and siltation of the marine environments.

Wetlands

The fresh-water Nariva Swamp is the largest and most diverse wetland ecosystem in Trinidad and Tobago. It is located on the east coast of Trinidad and covers an area of approximately 6,000 ha. There are numerous varieties of plants and animals within this system as the area is environmentally diverse and ecologically complex. It is the habitat of a number of highly sensitive species of plants and animals. Economically, direct consumption of the swamp resources occurs mainly through the harvesting of fish, conch and oysters. The area is also utilised for agricultural purposes — rice farming and fruit and vegetable cultivation. More than 90% of the swamp is less than 5m in elevation and it is protected from the Atlantic Ocean by the Cocal Sand Bar. The Nariva Swamp has been shown to be susceptible to salt-water intrusion (Bacon *et al.*, 1979) and is therefore likely to be extremely vulnerable to sea-level rise.

Agricultural Sector

While agriculture is not a major economic component of the local economy (3.4% of GDP; CSO, 1999), a fairly large proportion of the population depends in some way on the successful production of major commodities such as sugar and to a lesser extent coconuts, citrus, cocoa, poultry, cattle and vegetable crops. While a more detailed assessment of the level of vulnerability within these industries is required, the fact that agricultural production depends on the water supply and the atmospheric temperature regime would imply that this industry could be susceptible and vulnerable to any changes that may occur in the climate. Sea-level rise is more likely to affect the production of coconuts, which tends to be concentrated along the eastern and south-western coasts of Trinidad. Higher temperatures, compounded by lower rainfall or less effective rainfall, could significantly reduce yields throughout the industry. Implementation of suitable land reform measures so that agriculture can be practised on more suitable, less fragile lands, where accessibility to water and other inputs is greater, should allow farmers to adjust and deal with extreme environmental circumstances in a more effective way. Encouragement of soil management practices that preserve soil quality to the extent that soils remain at a reasonably high level of fertility and productivity, with improved capacity to conserve moisture, should also yield the desired results and benefits. Practices can include minimum tillage and integrated plant nutrition, along with other sustainable soil management practices that conserve soil quality in the long term, allowing the soil's responsive capacity and tolerance capabilities to adverse weather conditions to be maintained and or improved (Brady and Weil, 1999).

Sugar cane production is a significant agricultural activity in Trinidad and Tobago. The performance of sugar cane in Trinidad for the period 1970 to 1995 was measured in relation to climatic circumstances for the same period. Sugar cane performance was taken as the mean yield of cane per acre for all the cane varieties that had been grown and for all the sites on which they had been grown. Additional data from the sugar industry were also utilised in the investigation, including the TC/TS ratio (tonnes of cane to produce a tonne of sugar), the number of cane farmers and the amount of cane produced by the farmers and by Caroni (1975) Limited (the single, state-

owned sugar cane grower). The meteorological data for that period covered rainfall, temperature, humidity and sunshine as monthly and annual means.

The following non-meteorological variables were also considered for their effect on sugar performance:

(i) Percentage of farmers' cane in relation to total cane ground
(ii) Number of farmers providing cane
(iii Tonnes of cane per tonne of sugar
(iv) Year of cane production

Figure 3.4 shows the performance of sugar cane for the period 1970 to 1995. In the 1970s, production was usually over 25 tonnes per acre. After a sharp dip in the early 1980s, there was some recovery by the 1990s but performance was still usually below levels of the early 1970s. Correlation between yield of sugar cane per acre and 96 independent variables was calculated. The independent variables represented climatic conditions and other relevant factors over the period.

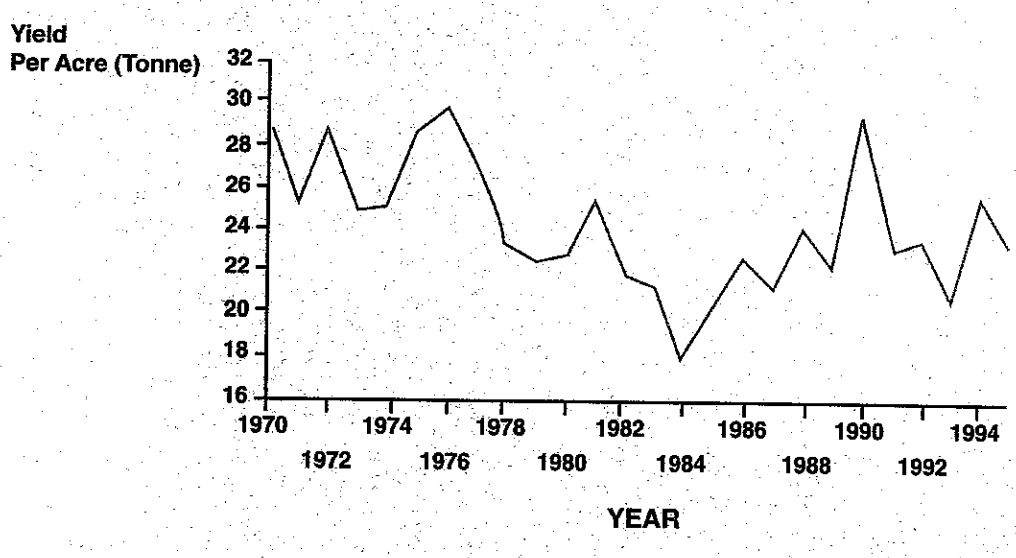


Figure 3.4: Trinidad Sugar Cane Performance for 1970 - 1995

The major conclusions to be drawn from these findings are that good sugar cane production was related to:

(i) years with higher numbers of farmers
(ii) when the TC/TS ratio was high
(iii) lower rainfall with June being a particularly crucial month
(iv) cooler minimum temperatures, particularly in the months of April and May in the previous year
(v) lower humidity, especially during the wet months from May to August

The sugar performance data also indicate a general decline in performance over the 26-year period. It should be noted that most Global Circulation Models of the world's climate suggest that with enhanced global warming Trinidad and Tobago should experience higher temperatures but, on average, lower rainfall. Outside of management factors, strong relationships were observed between climate and this decline. In another study (Singh and El Maayar, 1998), sugar cane yields were also found to be likely to decrease with climate change in the future but were shown to be related more so to increasing soil moisture stress in a warmer climate.

A number of notable findings were the negative relationships existing between sugar cane yield and mean minimum temperature and mean relative humidity in the year just prior to harvest. The most important finding was the increase in mean minimum temperatures, whereby for every 1°C rise the yield has reduced by about 3 tonnes per acre. There is clearly a strong suggestion of diminishing sugar cane yields in a climate-change scenario where it is projected that there will be an increase in temperature and humidity. Adaptation to a changing climate may therefore involve the consideration of exploring options of diversifying out of sugar to varying degrees or introducing temperature-tolerant cultivars. Given that sugar cane showed a negative relationship to these features, there are limited options for the industry, which may include:

(i) continuing with sugar production, in the absence of vulnerability assessments for other crops;
(ii) focusing on expanding the acreage under the more resistant varieties and in the least susceptible sections of the industry;

(iii) diversifying partially out of sugar in the areas showing the greatest sensitivity to these increases in temperature and humidity;
(iv) diversifying completely out of sugar into other crops and agricultural activities which, though they may be more sensitive, may not be as vulnerable.

These options offer a significant challenge to the existing agriculture and socio-economic framework. A thorough vulnerability analysis of the sugar industry to climate change and the diversification options available, including appropriate cost-benefit analyses, would be critical to guide the decision-making process in this context.

Water resources

A major concern is that there are still many communities without a regular supply of pipe-borne water despite efforts to overcome this problem. The main sources of potable water are ground water (coastal aquifers of north-west Trinidad and south-west Tobago) and the surface water systems of Caroni, Matura, South Oropouche and Courland in Tobago (Trinidad and Tobago Water Services Limited, 1998). The main demands are from domestic and industrial users with limited supply going towards agriculture and other activities. Essentially, the problem is not really one of supply; rather it is one of access. Management improvements can result in an improved supply, even in extreme drought periods, by utilising more of the ground-water reserves and reducing on wastage/loss in lines, which at present is around 50% or more (Fletcher, WASA, personal communication).

In general, average water supplies in Trinidad and Tobago are adequate for projected uses to 2025, and in the driest month in 1997 (taken as a base year) the supplies for Trinidad as a whole slightly exceed (by 27%) projected demands, assuming no impact of climate change. (Ministry of Planning and Development, Water Resource Management Strategy, June 1999.)

However, some recent projections of future climate change (e.g. Hadley Centre, UK Meteorological Office model output) suggest that, on average, Trinidad and Tobago could have significantly less rainfall in a warmer world by 2050. Evaporation will increase as the temperature increases already experienced in Trinidad and

Tobago continue and as climate projections indicate. The increased drought projected may be associated with more El Niño-like conditions in a greenhouse-forced world. From past El Niño experience, this would suggest that drier-than-normal conditions might occur, especially in the typical El Niño period of mid-year one year to mid-year the next. In addition, salt-water intrusion into coastal aquifers as a result of sea-level rise may provide increased pressure on potable supplies.

These projections indicate the need to build more resilience into water management systems. In particular, the incorporation of plausible climate scenarios into the Water Resources Management Strategy and the analysis of future needs and supplies can provide an assessment of the runoff relationship to rainfall for the four major watersheds of Trinidad and Tobago (Caroni, Courland, Matura and South Oropouche). This should give an initial indication of changes in yield that could occur with rainfall changes, associated with the impacts of climate change.

More stringent compliance by users of water, use of controlled-metering devices in homes and public places, and the adoption of watershed management practices that minimise erosion and conserve rainfall are also ways of adapting to the impacts of climate change on water resources. Presently, the Government is seeking to meet the present and anticipated increases in industrial demand by using desalinated water. It is proposed that the potable water presently used in industry will be diverted to other domestic uses.

In addition, it is recognised that improved drought management and response capability, making use of El Niño predictions now available, can result in the reduction of flood damage.

Forestry and land

The forest resources are also vulnerable because of unsuitable and unsustainable practices, along with the inherent fragility of the forest ecosystems. This is especially so since the forest soils are highly erodible and susceptible to land slippage. Land demand for habitat and agriculture places further pressures on the forestry sector. As a result, unplanned practices that expose bare soil, such as slash-and-burn agriculture, squatting, excessive logging and natural and set fires, cause severe damage to the forest ecosys-

tems, affecting flora and fauna and ultimately the watershed as a whole, which further impacts on the water resource sector. The frequent occurrences of forest fires in the dry season — which are not easily controlled — destroy vegetative cover, rendering the land highly vulnerable to erosion during heavy rainfall events. As a result, silting and flooding in low-lying areas become more problematic. Control of these activities could go a long way to coping with future climate changes. It is envisaged that implementation and enforcement of the present forestry policy should provide an adequate set of protocols for sustained use and conservation of the forest and watershed resources of the islands.

Biodiversity

The biodiversity of Trinidad and Tobago, being characterised largely as a result of the climatic regime, is therefore most likely to be adversely affected by any change in the climate. The projected changes in climatic factors such as moisture, temperature and precipitation, all of which are important to the terrestrial ecosystems of Trinidad and Tobago, may result in changes such as forest cover and species diversity. Much of the attractions within the tourism industry depend on the diversity of the biological resources of both islands, but more so of Trinidad. Changing climate and sea-level rise can also alter the wetland areas, particularly in Trinidad, through salt-water intrusion. The coral reefs of Tobago are susceptible to both increasing sea temperature and tidal modifications. Adverse effects on biodiversity are likely to have indirect impacts on other sectors such as agriculture and, by extension, human health and associated socio-economic impacts. Controlled activities in the natural ecosystems, assessments of eco-tourism activities and loading pressures in these environments may guide the development of better management systems to conserve biodiversity and sustain wildlife. However, conservation efforts are expected to be effective only to a limited extent in adapting to climate change and it will be largely left to global mitigation of climate change to avoid or minimise impacts on biodiversity.

Human health

The health implications of climate change for Trinidad and Tobago are related to Balbus *et al*'s (1998) description of the diverse patterns of negative effects that are likely due to a changing climate

tending towards higher temperatures and more erratic rainfall regimes, as are expected in the Caribbean. Increased heat stress may become evident with more high-temperature episodes in future. In addition, with atmospheric humidity expected to increase, the stress of heatwaves on humans will be augmented. This is particularly a concern for the elderly and infirm citizens and for outdoor workers. A further factor is that hot spells are usually accompanied by increased concentration of air pollution in urban areas, causing problems (respiratory, allergic and physiological disorders) especially for children and asthmatics.

It is not clear how indirect effects of climate change, such as increases in the potential transmission of vector-borne diseases as a result of extension of geographical range and season of vector organisms, may affect Trinidad and Tobago. While the country is potentially vulnerable to an increase in dengue fever transmitted by the vector *Aedes aegypti,* the mosquito can already be found in all parts of the country.

Apart from the direct effects on the prevalence of the diseases already given, there are many indirect effects resulting from a contaminated and limited water supply and more polluted atmosphere that encourage ill-health in a number of ways. Also, the negative effects of climate change on agricultural production and maintenance of the watersheds will lead to nutritional deficiencies and limited access to basic needs by an expanding proportion of the population, which will have deleterious health consequences. Additionally, the risks of drowning and other accidents related to flooding in low-lying areas and near the coastline are real in a scenario of rising sea levels and more frequent storm events.

It is expected that proper management of the water resources sector would buffer health impacts due to impacts on the potable water supply. Adaptive options to reduce health impacts of climate change may include the improvement of primary health. This of course will also have indirect socio-economic effects, which cannot be quantified at this time.

Urban development and housing

Housing and urban sprawls where human densities are large suggest greater risk and vulnerability to climate changes. Due to the actual nature of these developments, where roads, buildings and large paved/concrete areas exist, the infiltration of rainfall is restricted. This results in large runoff volumes occurring which can be compounded by rising sea levels causing severe flooding, particularly in flat and low-lying areas. While Trinidad and Tobago is geographically slightly south of the hurricane belt, enforcement of existing building codes should enable structures to withstand strong winds from storms and hurricanes.

Vulnerability of the Energy Sector

The energy-related sub-sectors and activities most sensitive to climate change include:

(i) agro-industry
(ii) energy demand

Agro-industry

As indicated, the major agro-industry in Trinidad and Tobago is the sugar-cane industry which occupies a large portion of the landmass of Trinidad and utilises energy for farm activities and electricity generation. Electricity is generated from bagasse, the cane-sugar biomass, for providing power to the refineries. Any climatic changes that affect the production of biomass may increase the total cost of production, as the industry will depend more on an externally generated power supply.

Energy demand

Climatic changes leading to increased temperatures and humidity in Trinidad and Tobago are likely to result in the increased use of air-conditioning and fans and an increase in energy demand.

Tourism

One of the notable impacts of climate change will be on the growing philosophy of a tourism-oriented culture being seeded and nursed in Trinidad and Tobago. Stress, in any way, within the islands, will hinder significant developments and strides to be made in this area, since tourists are not likely to travel to places where diseases are prevalent, where water quality is poor and where beaches and other tourist sites are affected negatively. The concept of product development and product variability, when applied properly, can result in a product that can guarantee a sustained tourist industry. While there are some areas that will be unavoidably more likely to be affected by the changing climate, particularly due to sea-level rise, effective management of those that are more resilient can be developed and promoted.

Relative vulnerabilities and priorities

There exists a web of interactions among the sectors of the economy that makes it highly unrealistic to consider the impacts of climate and sea-level change on any sector of the economy in isolation from the rest. At the same time there are key sectors that are most vulnerable for a number of reasons, some biophysical, others socio-economical and even political. Either way, priorities will have to be set to target those areas that are identified as being most vulnerable. Table 3.1 attempts to represent the relative vulnerabilities of the most sensitive sectors in Trinidad and Tobago informed by expert judgment and through consultations.

Table 3.1: The Intra- and Inter-Active Effects Within/Of Climate and Sea-Level Rise with Socio-Economic Situations for Trinidad and Tobago

Effects	Water	Agriculture	Forestry	Health	Tourism	Bio-Diversity	Coastal	Marine	Industries	Urban Dev
Temp	**	* to ***	**	**	*	** to ***	* to ***	***	*	*
Rain	***	***	***	**	**	* to ***	**	**	*	**
SLR	**	**	*	*	***	**	***	***	***	* to **
Inter-Climate	** to ***	***	**	**	***	**	***	**	*	**
Population	***	**	** to ***	***	*	**	***	**	*	***
Economics	***	***	* to **	***	** to ***	*	*	*	** to ***	***
Socio-Econ	***	***	**	***	**	**	**	*	**	***
Total Interaction	***	***	**	***	**	**	**	**	*	**

LEGEND	
*	LOW
**	MID
***	HIGH

The most vulnerable sectors, as evidenced by the largest numbers in the final row, are likely to be water resources and agriculture and, to a lesser extent, the coastal and marine resources, forestry, health and tourism sectors. The main findings and measures are as follows:

(i) Impacts on the industrial and urban developments are not so severe.

(ii) As far as the water resources sector is concerned, adaptation opportunities may exist in the implementation of integrated water resources planning and management measures. This is expected to address the water allocation principles in relation to the agricultural, industrial and tourism sectors, under the climate-change and sea-level-rise scenarios, while taking into consideration the environmental and socio-economic projections.

(iii) The Government, along with industrial agencies, is already taking on board issues such as water reuse efficiencies and clean and efficient technologies with accompanying incentives/rewards and penalties for conformance and non-conformance respectively. This extends into the transport sector where emphasis is now being placed on the use of natural gas as a less carbon-intensive fuel to replace the heavier, more polluting fuels that are presently in use. Such efforts will also serve to reduce greenhouse gas emissions from this sector and to obviate the need for sudden and direct interventions and controls on the industrial sector in the medium to long terms.

(iv) The necessary regulations and laws are being introduced in order to minimise the impacts on the land, air and water environments arising from the disposal of pollutants. In this way, the impacts of climate change and sea-level rise should not exacerbate these environmental problems.

(v) A watershed management programme is already under way within both Trinidad and Tobago, which should see the adoption of more sustainable agricultural practices as well as re- and afforestation.

(vi) Possible measures to be implemented may include an intensive ongoing research programme to investigate the issues of crop suitability, diversification and resiliency in the face of

the projected rises in temperature and sea levels. The same would apply to the areas of protection of the biodiversity and coastal fringes and marine resources.

Benefit-cost analyses should inform the efficacy of the possible adaptation measures outlined above, particularly from a technological perspective and risk of implementing maladaptation options. However, the required human capacity and funding to conduct such research and studies will have to be enhanced where available and sourced as necessary. Additionally, a comprehensive public awareness and education programme, implemented to facilitate an appreciation of and buy-in in relation to the issues of climate change and sea-level rise and their appurtenant impacts, will engender the cooperative spirit in finding more efficient ways to adapt to climate-change impacts.

Socio-economic impacts of vulnerability and adaptation to climatic change

In the short to medium term, the economy of Trinidad and Tobago is likely to continue to be dominated by the development of the industrial sector in order to meet the objectives of economic development and increasing the quality of life of its citizens. Despite the identified adaptation opportunities, it is recognised that implementation of any such option is likely to be challenged by the non-availability of the suitable and relevant technology, financing and human technical capacity. Such efforts may result in the compromise of the country's economic and social development, which, at this time, cannot be afforded.

The foregoing sections explored the impacts of climate change in terms of the most vulnerable areas, namely water resources, agriculture, and housing and urban developments. It was noted that the society and economy of Trinidad and Tobago would be different in 2050, relative to socio-economic realities in 1999. To adequately assess the socio-economic impacts of vulnerability and adaptation to climate change, there is a need to assess the likely exogenous economic trends that will impact on the current, dominant socio-economic modes; the impact of the endogenous behaviour of micro-economic and social actors and of socio-economic policy undertaken both in response to, but also independent of, these exogenous economic trends; and the influence of climate change on this socio-economic scenario and how these

can be accommodated or adapted to. This is a significant challenge and only some limited inferences can be made at this time. The likely socio-economic impacts are given for the sugar industry and the water resources sector.

Sugar cane

It may be that exogenous economic trends will impact earlier than climate change on the sugar industry. Notwithstanding, three main adaptation options are considered for the sugar industry in terms of the assessed vulnerability of the sugar industry.

There is an obvious need for an analysis of the economic vulnerability of the sugar industry relative to diversification options before any adaptation option can be considered, particularly in the context of the employment figures in this sector. Table 3.2 below shows that the sugar industry is a direct employer of some 13,000 people. This number is likely to be at least double when indirect employment is taken into account. Socio-economic impacts as a result of climate change on the sugar industry are therefore likely to be significant.

Table 3.2: Basic Statistics on Sugar Industry

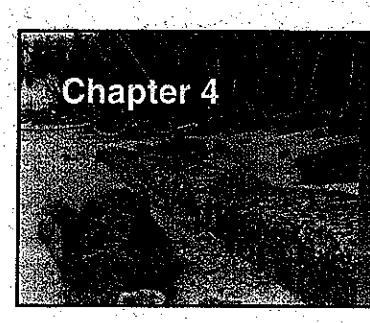
YEAR	NO. OF FARMERS	STAFF EMPLOYEES	FIELD EMPLOYEES	TOTAL LABOUR FOURCE	WAGES	MAN-DAYS	TT$ DAILY $	TT$ ANNUAL $
	1	2	3	4				
1986	4771	1100	5911	11782	78	1040412	75	13194
1988	5112	1052	5799	11963	85	1018207	85	15002
1990	5185	1015	5988	12188	86	1008739	86	14697
1994	5522	1029	5807	12358	107	1133210	107	21007
1995	5631	1092	5825	12548	108	1111735	108	20771

Source: Caroni 1975 Limited, unpublished data.

Water resources

The issue of water resources is of fundamental importance to the socio-economics of Trinidad and Tobago, given that all of the population depends on water while many industries have substantial water utilisation. However, as with the sugar industry, there is need for more detailed analysis to ascertain the relative vulnerabilities of major watersheds in Trinidad and Tobago to climate change (including alternative water sources from groundwater and desalination).

There is a substantial dependence on water resources from the Northern Range. The socio-economic impacts of climate change on water resources are likely to be more widespread, given the overlaps in potable water supply and secondary health impacts.



Chapter 4

Technology Needs, Capacity Building and Research and Development

As a party to the United Nations Framework Convention on Climate Change (UNFCCC) Trinidad and Tobago is committed to working towards the achievement of the ultimate objective of the Convention. Trinidad and Tobago has only recently started to put in place the preconditions for grappling with environmental pollution control. The steps taken so far include the setting up of the Environmental Management Authority, and establishment of the Ministry of Environment, along with the promulgation of relevant environmental management legislation. Despite the Government's effort to deal with the challenges inherent in achieving a state of sustainable growth and development, there are major challenges to be faced in advancing toward this goal.

A wide range of environmentally sound technologies that have been developed internationally are available, and it is possible in principle to formulate approaches by which environmental pollution can be addressed. However, the identification of existing barriers in gaining access to, adapting and applying such technology at an affordable cost will be one of the major challenges for the future if Trinidad and Tobago is to play a responsible role in furthering efforts to achieve the ultimate objective of the Convention.

Trinidad and Tobago, while accounting for a minuscule fraction of global greenhouse gas emissions, recognises adaptation options as a priority compared to GHG emissions abatement at this time. The country is therefore now faced with the task of addressing, on a prioritised basis, adaptation to the myriad impacts of climate change, taking into consideration its sectoral vulnerability assessment to date.

Already faced with the attendant challenges that have come to characterise Small Island Developing States, including severe limitations of and pressures on its land and other resource bases, Trinidad and Tobago must now seek ways to mitigate and adapt

to climate change in addition to fulfilling its economic development objectives toward the improvement of the quality of life of its citizens. It is now necessary that approaches incorporate adaptation and mitigation planning in development objectives, a consequence of which will certainly be additional financial burdens on implementing such programmes.

One of the most critical aspects of adaptation planning to climate change is the ability to continuously assess the vulnerability and adaptation options in the various sectors with a high degree of certainty. This is especially essential when planning for climate change, the impacts of which are likely to vary as the science becomes clearer. This will also avoid the implementation of costly maladaptation options to a significant extent. As part of the regional project Caribbean: Planning for Adaptation to Global Climate Change (CPACC), Trinidad and Tobago has already begun to assess various approaches toward planning for adaptation under this project. However, there are national issues and priorities that have to be addressed in order to make adaptation planning a comprehensive and ongoing activity.

Presently, there are recognised lacunae in the institutional and intellectual capacity required to fully comprehend, on an ongoing basis, required technology needs as well as assessment of those needs, to adequately address the impacts of climate change. This is the case across all sectors. Accordingly, and in keeping with the commitments of all parties under Article 4 of the UNFCCC, the following sections seek to identify approaches to assist in implementing the Convention. Specifically, the capacity and technological needs to be addressed for the adequate and comprehensive approaches to mitigating the impacts of climate change and assessing the most cost-effective adaptation options are highlighted.

Institutional strengthening, training and education

The enhancement of endogenous competence for effective participation in climate-change matters cannot be over-stressed. Training and education are critical components towards this end. Consistent with the provisions of Article 6 of the UNFCCC, the following approaches may be pursued:

(i) Training of local personnel in predictive computer modelling and interpretation of models for Global Change Scenarios as well as training and "know-how" in conducting integrated climate change impact assessment;

(ii) Training in conducting technology and capacity needs-assessment relevant to climate change;

(iii) Development of a programme of action for data collection using Geographic Information Systems in order to help planners update their databases periodically;

(iv) Evaluation of the indirect effects of climate change on the various socio-economic sectors;

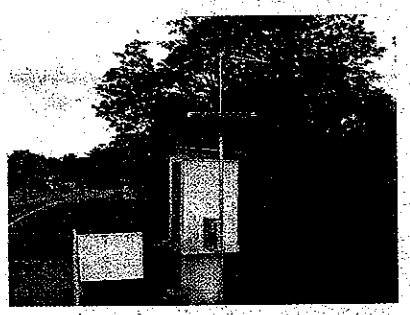
(v) Enhancement of the physical and human infrastructure in key governmental departments for data collection.

In this regard, a regional approach may achieve the desired benefits. Thus, the establishment of a regional centre of excellence can fulfil the role of providing and facilitating research on climate science, training and keeping all stakeholders up to date on the impact, adaptation and mitigation of climate change specific to Small Island Developing States. The centre may also assume the role of a clearinghouse on climate-change issues, including adaptation technologies, as well as the suitability and adaptability of these technologies. Further, networking the centre with other institutions, regionally and internationally, will allow a pooling of resources, thus enabling the exchange of information and technical personnel as well as undertaking collaborative research.

National Greenhouse Gas Inventory

Most of the data used for the compilation of the 1990 National Greenhouse Gas Inventory were based on surveys or information provided by the Central Statistical Office, the Central Bank or the private sector. These estimates were not corroborated by direct measurements. In other cases such as in the Agriculture, Land Use Change and Forestry, and Waste Sectors there were obvious data gaps. In those sectors where data was available, the uncertainties associated with the figure could not be addressed. A serious concern in this area is the wide application of default emission factors in the various sectors in estimating GHG emissions. The uncertainty in the generated values could not be addressed. As such, final emission estimates could be overestimated. Accordingly, emission factors that reflect the local or regional scenario would have to be developed in the future.

For the sake of continuity and ease of compiling future GHG inventories, the Government will seek support in developing suitable databases or in adapting and applying existing databases that can accommodate the data requirements of the IPCC reporting format.



Solar-powered data collection station.

Energy and Industrial Processes Sectors

Trinidad and Tobago has a relatively significant industrial sector based principally on the petroleum and petrochemical industries. Consequently, industrial activities in the country include petroleum refining, natural gas liquefaction, methanol and ammonia/urea production, as well as the production of steel and cement. All these industrial activities depend heavily on natural gas consumption, already a clean fuel and less carbon-intensive, either for the generation of energy or as a source of raw material. Government policy is to pursue the use of renewable sources of energy where feasible. In this regard, Government will seek the necessary support required for continuing research and development of potential renewable energy sources as well as encourage investment to promote environmentally sound technologies in these areas.

The Transport Sector

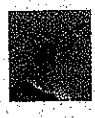
As explained in Chapter 2, the energy utilisation rate from the Transportation Sector in Trinidad and Tobago increased, as expected, between 1990 and 1994. Reliance on the importation of used vehicles to afford the average citizen some level of relief would have to be managed in the context of minimising any future pollution problems arising therefrom. In order to achieve such management objectives, the Government will seek the required support for the research to evaluate the fuel efficiency and greenhouse gas emission rates of the various automobile populations used in Trinidad and Tobago. A major component of this initiative will be the development of the necessary technology in maximising the use of natural gas as an alternative fuel for vehicles or the development of alternative fuels such as alcohol.

Agricultural Sector

Although not a substantial contributor to GDP, the Government is pursuing an agriculture policy that aims to, *inter alia*,

- Increase agricultural production while sustaining the renewable natural resources and ecosystems;
- Increase incomes using strategies that are sustainable and consistent with international trade and environmental agreements and market-oriented agricultural systems;
- Promote development of agro-industries and the sustainable utilisation and conservation of ecosystems and species as sources of employment;
- Reduce the imbalance on the balance of payments (foreign exchange) account for food, i.e. towards food self-sufficiency;
- Promote private investment in agriculture;
- Foster development and application of cost-effective technologies that meet the needs of stakeholders;
- Conserve and sustainably manage the marine resources, agricultural land, forests, ecosystems and biological heritage of the country for the benefit of present and future generations.

To effectively implement these policy options, planning in the context of the impacts of climate change has to be adopted.



Accordingly, Government will seek the necessary assistance to, *inter alia*, build capacity for the:

(i) Conduct of research in order to document and make recommendations as necessary for the various soil management practices in order to arrive at the best sustainable option;
(ii) Investigation of crop suitability, diversification and resiliency in the face of projected rises in temperature and sea levels;
(iii) Modelling of crops' and animals' climate interactions together with their economic implications;
(iv) Application of the most suitable environmentally sound technologies.

Land Use Change and Forestry

ogging activities, Northern ange, Trinidad

High uncertainties were observed in the Land Use Change and Forestry Sector during the compilation of the greenhouse gas inventory. This was due to the continuously changing pattern of land management and the uncertainties surrounding changes in woody biomass stocks, forest and grassland conversion, abandonment of managed lands and land-use change. A large part of the uncertainties resulted from the absence of ground-truth data. The Government will therefore examine options towards providing this ground-truth data by seeking the necessary funding and technical assistance. Part of this approach will be to determine the land-use and forestry types and sizes and their propensity to act as sources or sinks of greenhouse gases.

Waste Sector

The main issue identified in this sector is the inadequacy of information on the quantity of solid waste generated. The development of suitable emission factors for this sector is critical for the proper reporting of GHG emissions. In addition, pertinent data were lacking on the biodegradable content of solid wastes, the fraction of wastewater that undergoes treatment, the quantity of sludge formed during wastewater treatment, and the types of treatment plants and their efficiencies. This is largely as a result of insufficient capacity to address these problems. Accordingly,

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