TRINIDAD AND TOBAGO

NATIONAL REPORT
ON

CURRENT STATE OF DISASTER MITIGATION PROGRAMMES AIMED AT REDUCING THE VULNERABILITY OF HEALTH FACILITIES

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1. GENERAL INFORMATION

1.1 BACKGROUND

Trinidad and Tobago is a twin island state situated at the southern end of the Caribbean chain of islands. It is a democratic republic within the British Commonwealth. It attained Independence in 1962 and became a Republic in 1976.

Unlike the volcanic and coral origin of the neighbouring islands to the north, the islands of Trinidad and Tobago were formed by a gradual breach of a small region on the North East coast of South America. As a result, the geography, flora and fauna are as multiform as that of the continent.

The island of Trinidad lies 10.5 degrees north of the Equator and 61.5 degrees west longitude and has a land mass of 4,828 square kilometres. At the nearest point, it is 11 kilometres from the coast of Venezuela from which it is separated by the Gulf of Paria and the narrow channels of the Bocas. Tobago lies 35 kilometres north-east of Trinidad, 11 degrees north of the Equator and 60 degrees west longitude (Figure 1). Both islands feature beaches, flat lands, rolling hills, tropical rain forests and a rugged hilly topography consisting of chains of peaks, the highest being 940 metres in Trinidad and 549 metres in Tobago. Several rivers and small streams flow from the hills to the Gulf of Paria, the Caribbean Sea and the Atlantic Ocean.

Historically, the economy of Trinidad and Tobago was based on agriculture and trade. However, the discovery of petroleum in Trinidad in the middle of the nineteenth century caused a gradual shift to a petroleum based economy. Since World War II, successful exploration has resulted in the discovery of reserves of petroleum and natural gas. The oil boom of the latter 1970s resulted in further expansion of the petroleum sector. At present, petroleum and petroleum based industries play, by far, the most important roles in the economy.

Trinidad and Tobago has a population of approximately 1.26 million (35,000 of whom reside in Tobago). The current (1995) increase in annual population is estimated to be 1.7%. The population is concentrated in the two main cities of Port of Spain in the North and San Fernando in the South, and in a number of small towns throughout the country. Over the past 25 years a major process of urban sprawl has extended east and west from the capital city of Port of Spain, and particularly along the base of the Northern Range there have been major encroachments into the foothill.

For the purpose of Health Administration, Trinidad and Tobago is divided into five (5) Regions. Each Region is administered by an autonomous Regional Health Authority, in keeping with the policy of decentralization of Health Services by the Government of Trinidad and Tobago. The services in each region are centred around one major hospital, with a number of satellite health centres/facilities.

There is a total of one hundred and four (104) Health Centres well distributed throughout Trinidad and Tobago. There are five (5) major hospitals located in Port of Spain, San Fernando, Mount Hope, Sangre Grande and Scarborough, Tobago (Figure 2). There are also specialized hospitals for geriatric, psychiatric and chest disorders. Bulk storage of drugs and supplies is done at Chaguaramas, in the north-western peninsula of Trinidad. There is some storage at the major hospitals and, to a lesser extent, at the district hospitals and some health centres.

In addition to Government Health facilities, there are many private physicians, and several private hospitals and clinics in areas of high population density.

1.2 RISK ASSESSMENT

Available records show that Trinidad and Tobago has never suffered large numbers of lost lives or severe economic damage from any catastrophic event. However, due to the small size of the islands, and the geographic location, the country continues to be vulnerable to natural disasters.

(a) **Meteorology**

Tropical Cyclones: The official North Atlantic/Caribbean basin Hurricane Season runs from June 1 to November 30, with Trinidad and Tobago being situated on the southern fringes of the Atlantic Tropical Cyclone Tracks. Although less vulnerable than other Caribbean Islands, it can be hit by tropical cyclones. Tobago is much more vulnerable even though it is only 35 km northeast of Trinidad.

As reported by the Meteorological Office, of the twenty-nine (29) cyclones which affected the country during the periods 1725 to 1847 and 1878 to 1993, twenty-one (21) cyclonic disturbances affected Tobago, and thirteen (13) Trinidad. The most significant cyclonic event in Trinidad and Tobago was Hurricane Flora in 1963. Of the 7,500 houses in the island of Tobago, 2,750 were destroyed and 3,500 damaged. There was no significant damage to the healthcare facilities. Total damage in the two islands amounted to TT $30.1 million.

The most recent cyclonic disturbance was Tropical Storm Bret which occurred on August 6 - 7, 1993. Losses were minimal because the storm's centre passed through the channel separating both islands.

Tornadoes: Prior to 1988 there was doubt that Tornadoes could occur in Trinidad, although there were previous reports of damage done by strong whirlwinds. Over the past six years damage due to whirlwinds was reported in the south of Trinidad. The first recorded tornado occurred in October of 1988, in Central Trinidad causing an estimated damage of TT $600,000 to 24 buildings.

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

Floods: The severity of flooding in the country has been on the rise, especially in Trinidad. This is as a direct result of increased runoff and siltation of watercourses due to accelerating urbanization, quarrying and agricultural activities.

Most floods in Trinidad and Tobago occur during the period of October to December, when the soil has been saturated from earlier rains. Flooding is an annual event in Trinidad. Among the most significant floods in Trinidad were:-

i. that in 1985 which severed the major road linkages between the northern and southern region of Trinidad; and

ii that in Port of Spain of 1993 which resulted in six deaths and millions of dollars in damage to buildings and their contents.

(b) **Seismology**

Earthquakes: Trinidad and Tobago is located close to the south-east corner of the tectonically active circum - Caribbean belt, and consequently has been subjected to earthquakes. This is a well defined arcuate seismic belt occurring parallel to the Lesser Antilles arc with the shallowest earthquakes occurring about 100-150 km to the east of the arc platform. In general, this belt exhibits a variable density of epicentres, with the northern region (north of about 14° N) being more active than the southern region.

Damage may occur to structures from ground acceleration, liquefaction in poorly consolidated sediments and reclaimed ground.

Table 1 shows the statistics of earthquakes of intensities VI and greater on the Modified Mercalli (MM) scale felt in Port of Spain between 1800 and 1991.

Three earthquakes which occurred on September 20, 1825, February 24, 1918, and December 4, 1954, produced heavy damage in Port of Spain, while 27 others caused slight to moderate damage.

Ambeh (1992) indicated that a maximum probable earthquake for the Trinidad and Tobago area can be assumed to be of approximate intensity MM VII. If such an earthquake were to occur within a 100 km radius centred on Trinidad, MM intensities of VIII or higher could result throughout Trinidad and Tobago. A conservative damage estimate for this scenario is an 80 % damage to buildings. Such an earthquake has never occurred in the history of Trinidad, but

has occurred in many areas in the Caribbean stretching from Venezuela to Jamaica and Puerto Rico.

The most recent earthquake in the Trinidad and Tobago area occurred on January 1, 1996. The epicentre was located at approximately 55 km North of Port of Spain, magnitude 5.0 on the Richter Scale and MM intensities II - VI. Only minor isolated damage was reported.

Table 1. Statistics of Earthquake Intensities (MM≥VI) felt in P.O.S. 1800-1991 (192 years)

MM Intensity, I	**VI**	**VII**	**VIII**
Frequency	23	4	3
Annual rate of occurrence	0.120	0.021	0.015
Return Period, R (Years)	8.3	48.0	64.0
* 50-Year Probability (%)	99.7	64.7	54.2
+ Peak Horiz. accn. a(cm/s/s)	31.3	66.6	143.1

* 50 - year probability calculated using the formula P(t) = 100 (1-excp(-t/R), where t is the time interval (50 years) (Gumbel, 1956).

+ Peak horizontal acceleration, a, in cm/s/s estimated from the empirical Gutenberg and Richter (1956) relationship log a = (I/3-0.5.

Tsunamis: Since 1530, about 10 Tsunamis with wave heights between 2 and 20m have occurred in the Caribbean (Ambeh 1992). There are no recorded effects on Trinidad and Tobago. However, the potential for Tsunamic hazards exists due to:-

i. Earthquake in the Caribbean Sea and

ii. Explosive submarine volcanic eruptions, such as those which can occur from Kick-em Jenny, located approximately 10 km north of Grenada.

The coastal cities of Port of Spain and San Fernando are not thought to be at great risk because of their location bordering the Gulf of Paria which is relatively isolated from the Caribbean Sea (Ambeh 1992).

1.3 RECENT DISASTERS AND THE HEALTH SECTOR

In Trinidad and Tobago, during the period of the last ten (10) years, the health sector and its physical facilities have not been significantly affected by natural disasters (floods, earthquakes or tropical storms/hurricanes).

1.4 SOCIAL AND ECONOMIC IMPACT OF DISASTERS

Trinidad and Tobago has a well developed social structure. A large variety of groups exist. These include religious organizations, village and community councils, public service groups and, environmental, organisations, cultural and social change committees. The groups, however, need to be motivated to become involved in natural disaster reduction.

The potential for strong ground motion generated by earthquakes places buildings, public utilities and industry at risk. Vulnerability assessment for certain structures in Trinidad and Tobago was carried out by Chin (1991). However, detailed inventories of buildings and structures still need to be compiled.

Recurrent flooding results in significant disruption of economic activities and damage to personal and commercial property. Roads and bridges sustain annual damage from flooding. Landslides and coastal erosion are also potential threats to facilities and infrastructure (Figures 3 and 4). Unplanned building practices along the coast and on steep hillsides, and other acts of deforestation, exacerbate these natural processes. Electrical, water and telephone services and roadways are often interrupted by landslides.

All sectors of the economy are vulnerable to the natural hazards identified above. The petroleum sector is particularly vulnerable to cyclonic events and earthquakes. The Agricultural sector suffers annual losses from flooding and is also vulnerable to tropical cyclones while the industrial sector also suffers from annual flooding and is also potentially vulnerable to earthquakes and cyclones. A public health hazard is also created by the flooding annually.

1.5 MITIGATION ACTIVITIES

A programme for the mitigation of natural hazards has not yet been developed for the country. However, mitigation strategies and measures which include land use planning, water and forest management, a national flood protection and prevention programme and building codes practices, are being implemented.

Land use planning is guided by the National Physical Development Plan which was prepared in 1989. This plan is at present being updated, with more recent land capability and land use data, and with the incorporation of quantitative hazard risk assessment data. In the interim, a qualitative approach is used for major land activities.

Water and forest management centres around the identification of critical watersheds and the reafforestation of those which have been denuded. The objective is to reduce flooding, soil loss, and enhance water quality and quantity. The reafforestation activities have been affected by shortage of funds, unplanned housing, indiscriminate quarrying, slash and burn agriculture and wildfires. Other mitigative measures which are applied to sloping lands include integrated watershed planning, agroforestry and soil and water conservation.

The national flood protection and flood prevention programme is funded by the Inter American Development Bank (approx. US $100 m) and includes desilting and re-routing of major watercourses, the rebuilding of embankments etc.
Building codes and practices are being guided by the **Caribbean Uniform Building Code (CUBiC)** which was prepared to ensure that buildings are constructed according to specific engineering standards suitable for the Caribbean Area. The use of the CUBiC code, however, has been diminished due to delays in updating of the code. Use of the American code (**UBC - Uniform Building Code**), the Canadian code (**NBCC - National Building Code of Canada**) and the British code (**BS - British Standards**) has been more prevalent and accepted. These codes together with the CUBiC code incorporate earthquake risk factors and must conform to minimum requirements set by the **structural regulatory Agency, the Ministry of Works.**

In this regard whilst high rise offices, commercial and institutional buildings in Trinidad are normally properly designed and constructed, the same cannot generally be said for low rise buildings with pitched roofs. Generally in the design of Health facilities reinforced concrete flat roofs are quite resistant to damage against hurricane winds. Health facilities with pitched roofs are, however, more susceptible to damage by hurricane winds.

Generally the level of public awareness of natural hazards in Trinidad and Tobago is not satisfactory. The public and governmental agencies must be made aware of the dangers of natural hazards, vulnerable areas, expected damage and the measures available to respond to the hazard. Efforts have been made to educate the population through publications and the media. However, the infrequent occurrence of natural disasters in the country has resulted in a high level of complacency by the population.

2. HEALTH AND HOSPITAL FACILITIES

2.1 CODES AND STANDARDS

Hospital facilities are regarded as **specialist structures** and are designed and built in accordance with the prevailing codes of practice used in the country.

The Ministry of Works and Transport is the Agency which is responsible for ensuring that all new structures, especially public, commercial and institutional buildings, are designed in accordance with the following codes of practice -:

VERTICAL LOADS	-	**BS6399**
REINFORCED CONCRETE	-	**BS 8110 or ACI 318**
STRUCTURAL STEEL	-	**BS5950 or BS449**
WIND	-	**Code of Practice for Wind Loads for Structural Design (Barbados Assoc. of Professional Engineers - BAPE) 1981**
EARTHQUAKE	-	**Structural Engineers Association of California (SEAOC 1990)**

All structures are designed to accommodate the effects of the following loading combinations with the appropriate load factors-

1. **Dead + Live + Earthquake**
2. **Dead + Live**
3. **Dead + Wind**
4. **Dead + Live + Wind**

The above CODES OF PRACTICE have been enforced by the **Ministry of Works and Transport** and accepted by the **Board of Engineering (BOE) of Trinidad and Tobago** as the minimum requirement. However, a Structural Engineering Firm may use any acceptable code of practice with which it is familiar, e.g American (UBC - Uniform Building Code), Canadian (NBCC - National Building Code of Canada) or Caribbean (CUBiC - Caribbean Uniform Building Code), but the designs are always checked to ensure that the minimum requirements (strength, ductility and detailing) set by the Ministry of Works are met. **Although the application of the seismic codes is not legally enforceable, it is a requirement of the regulatory body, the Ministry of Works**. Approval of structural designs must be obtained before commencement of construction. This authority is obtained from the Public Health Ordinance (1950). The effect of this is that the enforcement of the codes is beginning to have the status as accepted practice and therefore the onus is now on practising engineers to apply them.

Special consideration is given to **Hospitals** in their structural design since they are critical public institutions, and are deemed to be **'essential structures'.** The **importance factor is increased by 25%** in the assessment of the earthquake forces that can impact on the building which is therefore designed to resist increased seismic lateral loads.

In the provision of earthquake resistant design for essential facilities the general objectives are for the structures to be able to -:

1. Resist minor earthquakes without damage.

2. Resist moderate earthquakes without structural damage but with some non-structural damage.

3. Resist major earthquakes without collapse but with some structural as well as non-structural damage.

The practical application of the philosophy is that design is generally carried out at an **elastic level (no damage)** so that earthquake forces are treated in a similar manner to that in which gravity, wind and other loads are treated.
In order to deal with the second requirement for **non-structural damage** in moderate earthquakes, requirements for limiting displacements are included in seismic design codes.
In order to deal with the **'no collapse' requirements**, ductility requirements are stipulated so that the structure is capable of yielding without collapse. Yielding is inevitably accompanied by damage.

The majority of earthquake resistant buildings are designed using **equivalent static lateral forces** to represent the effects of ground motion on the building. In general terms, static forces can be used to represent the effects of an earthquake by producing the same structural displacements as the peak earthquake displacement response. The use of this method is limited to **reasonably regular structures.**

The principal seismic lateral forces are derived by determining the base shear - V in accordance with SEAOC 1990.

V = Z I C W / Rw

Z = Seismic Zone Factor (Zone 3 = 0.3)

Trinidad and Tobago is ranked in **ZONE 3** in accordance with **SEAOC 1990** ; that is a zone of **relatively high seismicity** based on a seismic risk map of the country and region.

I = Importance Factor (I = 1.25 for Essential facilities)

W = Total seismic dead load

Rw = Factor based on the Lateral Force Resisting Structural System (4 to 12)

Ç = Numerical coefficient based on acceleration response spectrum and soil characteristics.

Although the analysis done is primarily a **static analysis** for regular buildings with two storeys and above, a **dynamic analysis is** insisted on for buildings above two storeys.

The **detailing** of buildings of reinforced concrete or structural steel must conform to the requirements of **SEAOC 1990.** The significance of this is greatly increased by the necessity for controlling ductility and avoiding the possibility of any non-ductile form of failure.

The effectiveness of seismic codes though can only be ascertained by the feedback of earthquake damage studies on the design practice.

In the case of **hurricane winds**, the code used is the '**CODE OF PRACTICE FOR WIND LOADS FOR STRUCTURAL DESIGN'** by The Barbados Association of Professional Engineers (BAPE). Buildings in **Trinidad** (being the most southerly Caribbean island) are designed for a basic wind speed of 45 metres per second (**100 miles per hour**). Buildings in **Tobago**, which is more northerly, are designed using a wind speed of 50 metres per second (**112 miles per hour**) taking into account the **shape, height, exposure conditions, cladding, height above sea level and location of the building**.

The basic wind speed is the **3-second gust speed** at a **height of 10 metres above ground in an open situation**, estimated to be exceeded on the average only **once in 50 years**. This speed has been assessed for a number of Commonwealth Caribbean countries.

These analyses are applied to regularly shaped structures. However, with buildings of unusual shapes, special investigations are necessary to determine the loads and their effects. Conformance to the design codes and contract documents is **mandatory**. However, in terms of structural design, there are no specific regulatic-- applicable to hospital buildings.

In the case of the design of services, there are no Codes of Practice applicable in the country. However, the stipulations of the national governing bodies for these are met, but there are no specific requirements for hospitals. These bodies include:

- Government Electrical Inspectorate .
- Government Factory Inspectorate (high pressure vessels, boilers, elevators, compressors etc.)
- Ministry of Energy (installation and maintenance of fuel storage facilities)
- Fire Services Department (fire detection, alarm and suppression system)
- Water and Sewerage Authority
  For medical gases, the recommendations of the supplier are met.

The **Ministry of Health** and the **Ministry of Works and Transport** are the agencies responsible for the physical planning and design of hospital buildings. **Financial approval** is normally sought by the client Ministry, in this case, the Ministry of Health, through the Ministry of Finance. Construction is normally performed by reputable local contractors and supervised by local consultants, with the Ministry of Works and Transport acting as Executing Agency and providing a project managment function to ensure that the works are completed in accordance with the drawings and specifications.

Physical maintenance is usually done through a contracting maintenance firm whereas **maintenance of plant and equipment** is normally done by in-house labour with specialist works done by contract.

2.2 CLASSIFICATION

Hospital facilities in Trinidad and Tobago can be categorized into the following types of Institutions based on the type of services which they provide -:

Secondary and Tertiary Care Institutions
Secondary Care Institutions
Specialist Care Institutions
Health Centres

The **Secondary and Tertiary Care Institutions** are facilities providing the full secondary and tertiary services, i.e. **accident and emergency, bedspace, operating theatres, specialist care etc.**

The **Secondary and Tertiary Care Institutions** are strategically located throughout Trinidad and Tobago in the following areas:-

Northern Area	-	Port of Spain General Hospital **(POSGH)**
Southern Area	-	San Fernando General Hospital **(SFGH)**
Central Area	-	Eric Williams Medical Sciences Complex **(EWMSC)**

These are ***essential facilities*** which must remain structurally safe and totally functional after a disaster, be it as a result of a hurricane or an earthquake. These buildings must be able to withstand the earthquake and hurricane with minor damage to structural and non-structural elements.

The **Secondary Care Institutions** are Hospitals with limited secondary and no tertiary care services. Specifically the role of these facilities will be to ***resuscitate, stabilize and transfer*** patients to a **Secondary and Tertiary Care Institution** as soon as possible after a disaster. These facilities provide **bed space, accident and emergency service but no specialist care,** and include the following -:

Tobago	-	Scarborough County Hospital
Sangre Grande	-	Sangre Grande County Hospital

The **Specialist Care Institutions** are facilities with no secondary and tertiary care services but some specialist care service e.g. ***psychiatry, geriatric and chest care services*** and include **bed space but no accident and emergency services.**

These Institutions will play a minor role after a disaster and include the following -:

St. James, P.O.S	-	St. James Medical Complex (Geriatric)
St. Anns, P.O.S	-	St. Anns Hospital (Psychiatric)
Caura, Tunapuna	-	Caura Hospital (Chronic Chest)

The **Health Centres** are facilities which provide ***primary health care services*** only, i.e. **units without operating theatres and bed space.**
These **Health Centres** are located strategically throughout the country and are expected to play an important role after a disaster and are categorized into the following types based on the range of services provided:-

Type A	-	400 sq. m.
Type B	-	300 sq. m.
Type C	-	180 sq. m.

From an examination of the facilities, a classification (see Table 2) was arrived at based on the probability of physical and functional safety during and after a hurricane or earthquake.

The classification has been based on the following -:

(A) Physical Safety

- Analysis of the structural designs and drawings
- Physical examination of the building (for cracks etc.)
- Age of the structure
- Type of construction materials and methods
- Type of roof system
- Type of structural framing system
- Location of structure (flat or sloping land)
- Height of structure

(B) Functional Safety

- Water Supply
- Standby Power Supply
- Medical Gases
- Pharmacy / Storage (bulk)
- General Stores
- Communication
- Sewerage System
- Information network of the facility (records)
- Chemicals

The following rating was used in *Table 2* to prioritise the importance of the facility and its structural and functional safety -:

V.H	-	very high)	
H	-	high)	Importance
L	-	low)	
v.g	-	very good)	
g	-	good)	Safety
f	-	fair)	

Table 2 SAFETY CLASSIFICATION-HEALTH FACILITIES

No	Health Facilities	Priority	Physical Safety		Functional Safety	
			H	EQ	H	EQ
	SECONDARY & TERTIARY CARE INSTITUTION					
1	Port of Spain General Hospital	V.H.	g	g	g	g
2	Eric Williams Medical Sciences Complex	V.H.	vg	vg	vg	vg
3	San Fernando General Hospital	V.H.	vg	vg	vg	vg
	SECONDARY CARE INSTITUTION					
1	Sangre Grande County Hospital	VH	g	vg	g	vg
2	Scarborough County Hospital	V.H.	f	f	f	f
	SPECIALIST CARE CENTRES					
1	St. James Medical Complex (Geriatric)	L	g	g	g	g
2	St. Anns Hospital (Psychiatric)	L	g	g	g	g
3	Caura Hospital (Chronic Chest)	L	g	g	g	g
	HEALTH CENTRES					
	Type A - (400 sq m)	VH	vg	vg	vg	vg
	Type B - (300 sq m)	H	f	g	f	g
	Type C - (180 sq m)	H	f	g	f	g

3. CURRENT STATE OF HOSPITALS WITH REGARD TO MITIGATION OF DISASTERS

3.1 STUDIES OF STRUCTURAL AND/OR NON-STRUCTURAL VULNERABILITY IN CERTAIN FACILITIES IN THE COUNTRY.

The Engineers and Support Technical Staff of the Planning Unit of the Ministry of Health as well as the Plant Engineers assigned to the hospitals and Engineers from the Ministry of Works and Transport, as necessary, carry out periodic inspections of the buildings, plant and equipment at each hospital. These inspections are made with one of the primary objectives being to determine what types of work are necessary for upgrade of the facilities, and to mitigate against natural disasters.

The most recent major studies performed were done during the period 1993 to 1995. These studies included the country's major hospitals as follows.

Secondary and Tertiary Care Institutions

Port of Spain General Hospital	-	923 beds
San Fernando General Hospital	-	751 beds
Eric Williams Medical Sciences Complex	-	536 beds

Secondary Care Institutions

Sangre Grande County Hospital	-	161 beds
Scarborough County Hospital	-	146 beds

These studies were promoted by the Ministry of Health, Government of the Republic of Trinidad and Tobago and the International Consulting Firm, Health and Life Sciences Partnership. They were undertaken by Health and Life Sciences Partnership with Pre-Investment funds from an Inter-American Development Bank Loan to be used for the country's Health Sector Reform Programme.

Analysis of the facilities has resulted in provision being made for the necessary funds for upgrade works to be included in the Loan Application Document which is at present being negotiated between the Government of the Republic of Trinidad and Tobago and the Inter-American Development Bank.

No special difficulties were encountered in performing these studies.

3.2 METHODOLOGY USED TO ASSESS STRUCTURAL AND NON-STRUCTURAL VULNERABILITY

There is no established methodology in this country to assess structural or nonstructural vulnerability to natural disasters in hospitals. As stated at Section 3.1 herein periodic inspections of the buildings and the equipment and plant are carried out by the Ministry of Health's engineers and support staff as well as the technical representatives of the Ministry of Works and Transport. From these inspections, decisions are made on the types of works necessary.

In the case of the recent studies undertaken by Health and Life Sciences Partnership, the methodology employed included the following:-

- Study of drawings (architectural and engineering) of the hospitals where these were available.

- Review of previous studies and documentation on the condition of the hospital buildings and the engineering services

- Physical examination of the state of the facilities, equipment and related services

- Production of a wide range of working papers and studies that have informed proposals for future upgrade and retrofitting of the hospitals

The above procedure was followed in relation to every health facility in the country.

3.3 INTERDISCIPLINARY ORGANISATION THAT MANAGES PROGRAMMES TO MITIGATE DISASTERS IN THE HOSPITALS

In this country, the main organisation that manages programs to mitigate disasters in hospitals is the National Emergency Management Agency (NEMA). NEMA has established as one of this country's activities for the International Decade of National Disaster Reduction a Critical Facilities Sub-Committee which comprises of representatives from the following :-

Directors and Co-ordinators of NEMA
Trinidad and Tobago Electricity Commission
Ministry of Works and Transport
Water and Sewerage Authority
Telecommunications Services of Trinidad and Tobago
National Housing Authority
Faculty of Engineering, University of the West Indies
Ministry of Health

This multi-disciplinary committee includes representatives of all the critical services in the country and reports to the Minister of National Security.

3.4 PROGRAMMES TO STRENGTHEN MEASURES TO PROVIDE PROTECTION FROM NATURAL PHENOMENA

Within the last five (5) years, this country has undertaken programs to provide protection from natural phenomena in its hospitals as well as other physical measures to mitigate the risk in existing hospitals. The main hospitals which have benefited from such upgrade works are :-

Port of Spain General Hospital	-	Structural repairs to Specialist block and other buildings.
	-	Removal of extensive panels of glass louvres and replacement by ventilation blocks
	-	Relocation and upgrade of oxygen storage system

	-	Renovation and upgrade of kitchen
San Fernando General Hospital	-	Structural repairs to existing hospital buildings and Nurses' Hostel.
Sangre Grande County Hospital	-	Structural repairs to existing hospital buildings including wards, and accident and emergency department.
	-	Installation of new standby generator
	-	Construction and commissioning of new operating theatre
	-	Upgrade of sewage treatment facilities
St Anns Hospital	-	Structural repairs to buildings (wards and other buildings)
	-	Renovation and upgrade of kitchen
St. James Medical Complex	-	Structural repairs to buildings
	-	Construction of new ward buildings

In addition to the above, a new four-storey wing was added to the San Fernando General Hospital and the ground floor of the existing main building refurbished to create additional wards, under a separate contract.

The foregoing projects were identified and developed by the engineers and support technical staff of the Planning Unit of the Ministry of Health, the resident engineering staff at the hospitals and the engineers from the Designs Section of the Ministry of Works and Transport. The Ministry of Health made the decisions to carry out the projects.

In the case of the upgrade to the hospitals, the works were undertaken by a State Agency under a Project Management Contract with the Ministry of Health and were monitored by the Planning Unit of the Ministry of Health. This Programme was worth TT $69.0m and was locally financed.

The extension of the San Fernando General Hospital was designed and supervised by a multi-disciplinary Team of local consultants and the construction was undertaken by a leading local building contractor under traditional contract arrangements. The Ministry of Works and Transport was the Executing Agency for the Project which was locally financed to the tune of TT $94.8m.

The limitations of the budget dictated the extent of works performed at each institution. However, more extensive works are programmed to be undertaken in the near future at these institutions with funding from an Inter-American Development Bank loan to be obtained under the Health Sector Reform Programme.

3.5 HEALTH SECTOR POLICIES TO ASSESS THE RISKS FROM NATURAL PHENOMENA IN THE CONSTRUCTION AND MAINTENANCE OF HEALTH FACILITIES

The Ministry of Health is not directly involved in the construction of new health facilities. The Ministry of Works and Transport plays a key role in this. There is, however, a national policy which is guided by the Town and Country Planning Ordinance.

Before any new construction project is implemented, it must be approved by the Town and Country Planning Division, the Ministry of Works and Transport (Structure and Drainage), the Fire Services Department, the Ministry of Health and the Water and Sewerage Authority.

For any major development programme in the country, the Town and Country Planning Division, which is a department within the Ministry of Planning and Development, requires that an Environmental Impact Assessment (EIA) be done for the project, as a pre-requisite for consideration for approval. Included in that EIA would be measures to mitigate against risks associated with natural hazards. The costs associated with the preparation of the EIA and the requirements to facilitate the approval process are borne by the developer.

3.6 PARAMETERS USED TO DETERMINE THE PHYSICAL SAFETY OF THE HOSPITAL SYSTEM

(a) General

The Ministry of Health is now in the process of producing a Specimen Health and Safety Policy for release as a standard for adoption by all health care facilities. Each institution will be responsible for producing a Fire Policy and Procedure in consultation with the Fire Services Department. A Planned Preventive Maintenance System is being introduced within the Health Care Sector with particular emphasis on vulnerable equipment such as electrical items. There is also on-going general awareness training on Health and Safety Policy.

(b) Specific

Buildings: The physical safety of the hospital system can be determined by consideration of the following parameters -:

1 History of seismic, hurricane and flood risk
2 Study of the geology and tectonics of the area
3 Design characteristics for EQ, hurricane and floods
4 Site conditions - type, topography and the environment
5 Choice of architectural and structural form (framing)
6 Choice of materials
7 Choice of roof shape
8 Height of building
9 Construction considerations
- supervision
- workmanship
- buildability
- components

10 Cost considerations
11 Analysis
12 Detailing

Infrastructure: Some specific items used to determine the physical safety of the hospital infrastructure include:

- design and construction/installation of electrical system
- location of electrical panels
- routes of medical gas systems (away form hazardous areas)
- location of central storage system of medical gases
- location of central fuel storage system and adequacy of bond
- protection and jointing of gas systems
- water storage capacity and supply system
- safe location of boilers, standby generator, central air-conditioning units
- risk of flooding in technical tunnels
- design, construction and protection of sewage system

3.7 TEACHING PROGRAMMES AT THE FACULTY OF ENGINEERING (UWI - TRINIDAD) AND COLLEGE OF ARTS SCIENCE AND TECHNOLOGY (ARCHITECTURE) (CAST, JAMAICA)

In the civil engineering programme of the Faculty of Enginering (UWI - Trinidad) structural engineering and design is compulsory at the undergraduate level. Emphasis is placed on the application of engineering science and technology in the design of structures to resist the forces of nature, which include dead and live loads, wind loads and seismic loads.

Specific emphasis is not placed on the design of specialised structures such as hospitals at the undergraduate level. However, this may be the subject of post-graduate studies. Most Codes of Practice as well as practicing engineers recognise hospitals as essential structures and appropriate importance factors are incorporated into the engineering designs. These include adopting lateral load resisting systems that should be as regular as possible or should not deviate significantly from a recommended lateral load resisting system.

In the Architectural programme the same problem arises where the design of hospitals is not a formal part of the curriculum at the undergraduate level. The problem, however, is that few architects pursue post-graduate studies in hospital design but most architects are likely to be influenced by their natural inclination to produce a design that projects their own personal touch or mark, resulting at times in irregular structural framing systems.

It must also be stated here that the seismic design of a hospital is a responsibility that is shared between architectural form and resistant structural systems, and that it would be ideal if these shared relations could be understood by every designer who works in hazard-prone areas. Unfortunately, at the international level, educational methods and practice have tended to limit the opportunities for promoting this kind of understanding in the minds of designers, since the instruction that new architects receive is separate from that of new engineers, and in many cases remains separated even in practice. Some architects have an intuitive understanding of structure, but they are very few, and this felicitous understanding tends to occur despite their training and practice, and not as a result of them.

4.0 CONCLUSION AND RECOMMENDATIONS

The Caribbean region has been the site of major natural disasters in the past. Although Trinidad and Tobago has been fortunate to have infrequent occurrences of natural disasters, the risk of seismic and meteorological disasters is ever present.

As a consequence, Trinidad and Tobago must develop and implement strategic plans and activities to mitigate the effects of natural disasters in the event of such an occurrence.

In this regard, the following recommendations are made: -

- the establishment of a Committee to consider adopting an existing international Building Code as the National Building Code of Trinidad and Tobago

- the introduction of legislation to make the design and construction of all public buildings conform to the National Building Code

- the formation of a disaster mitigation unit within the Ministry of Works and Transport, with appropriately trained staff and a dedicated budget, to manage and establish a national disaster mitigation plan

- the establishment of a disaster management research centre within the Faculty of Engineering, UWI. This Centre can be developed to serve the needs of the region.

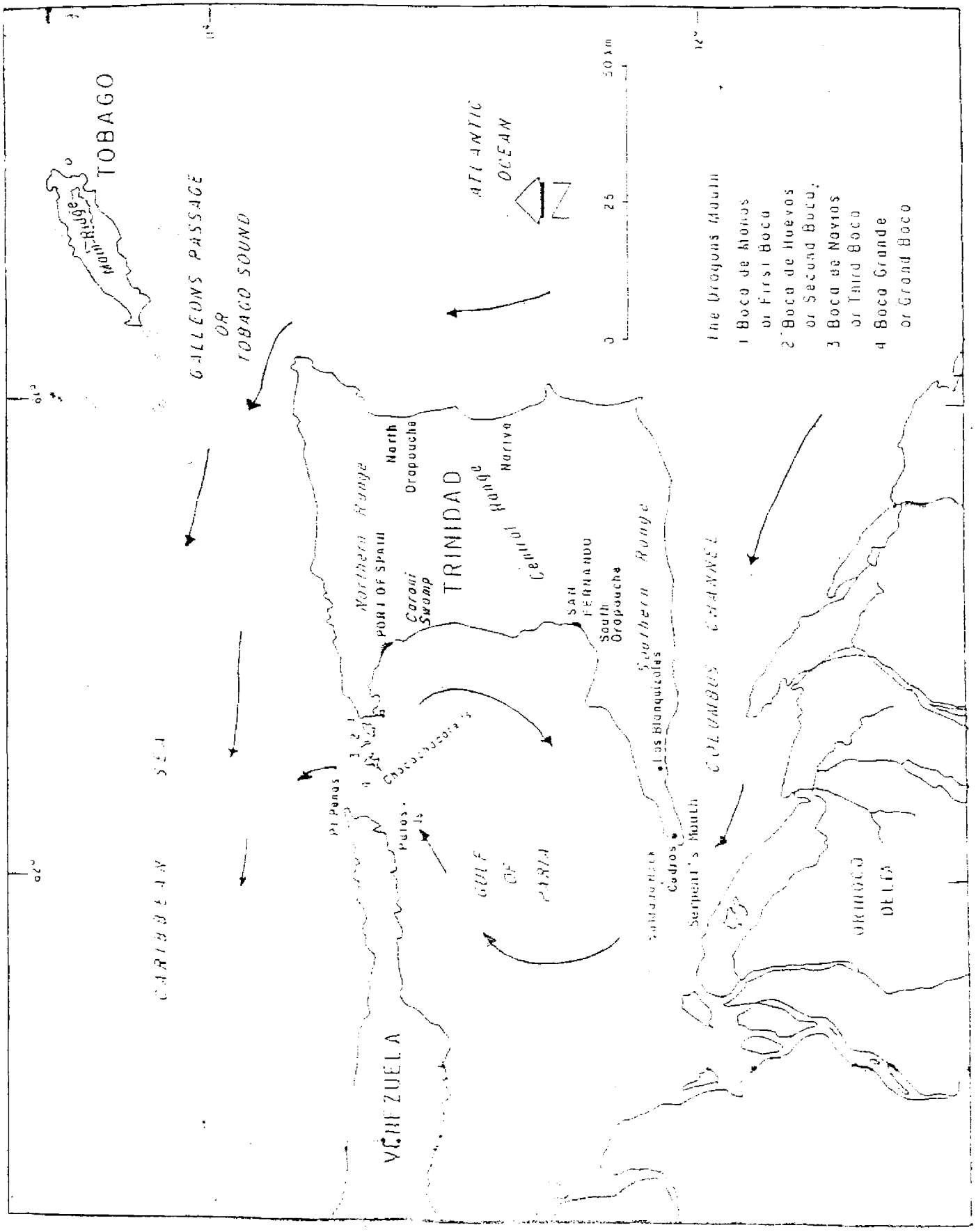

Figure 1 Location Map of Trinidad & Tobago

TRINIDAD

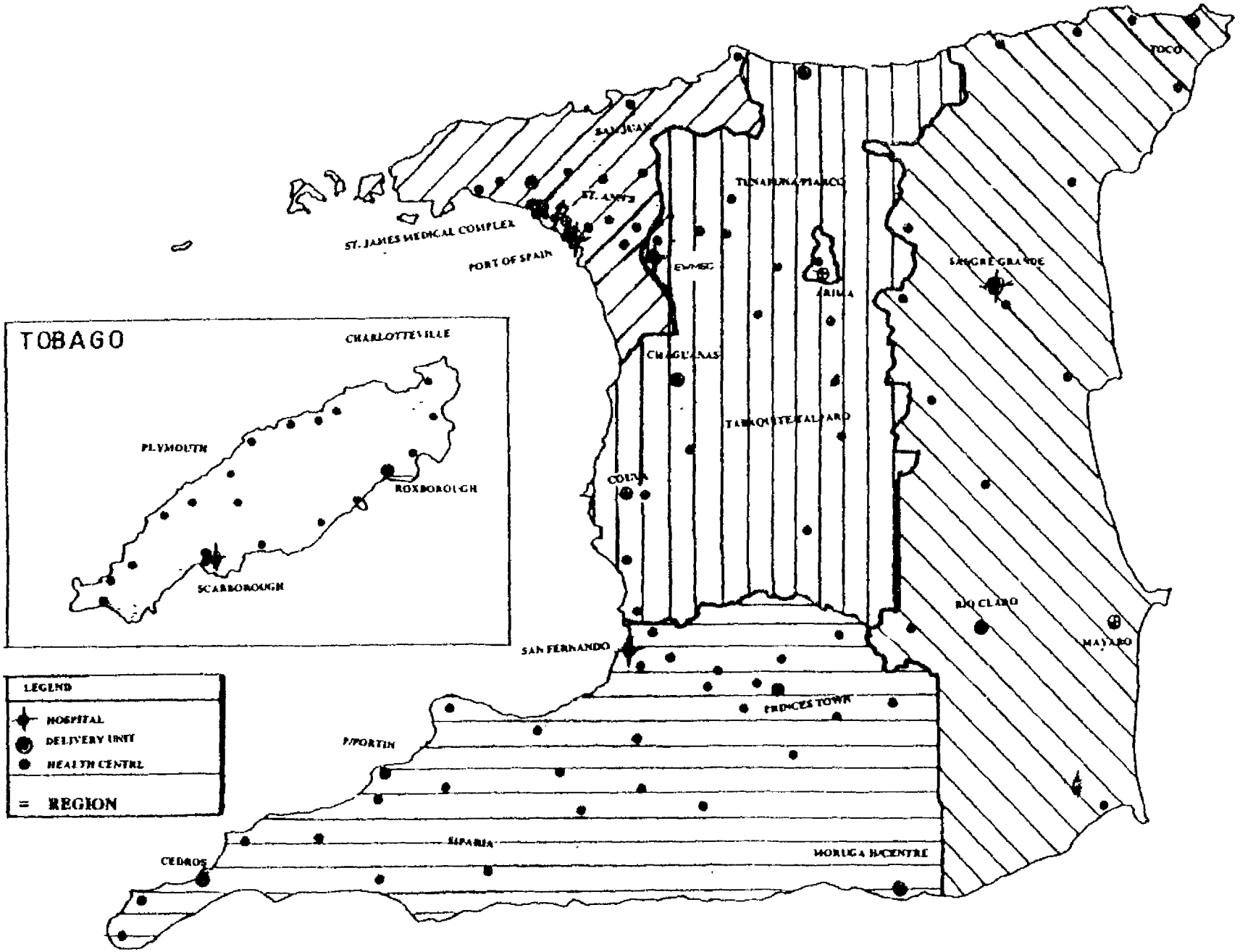

Figure 2 Distribution of Health Facilities in Trinidad & Tobago

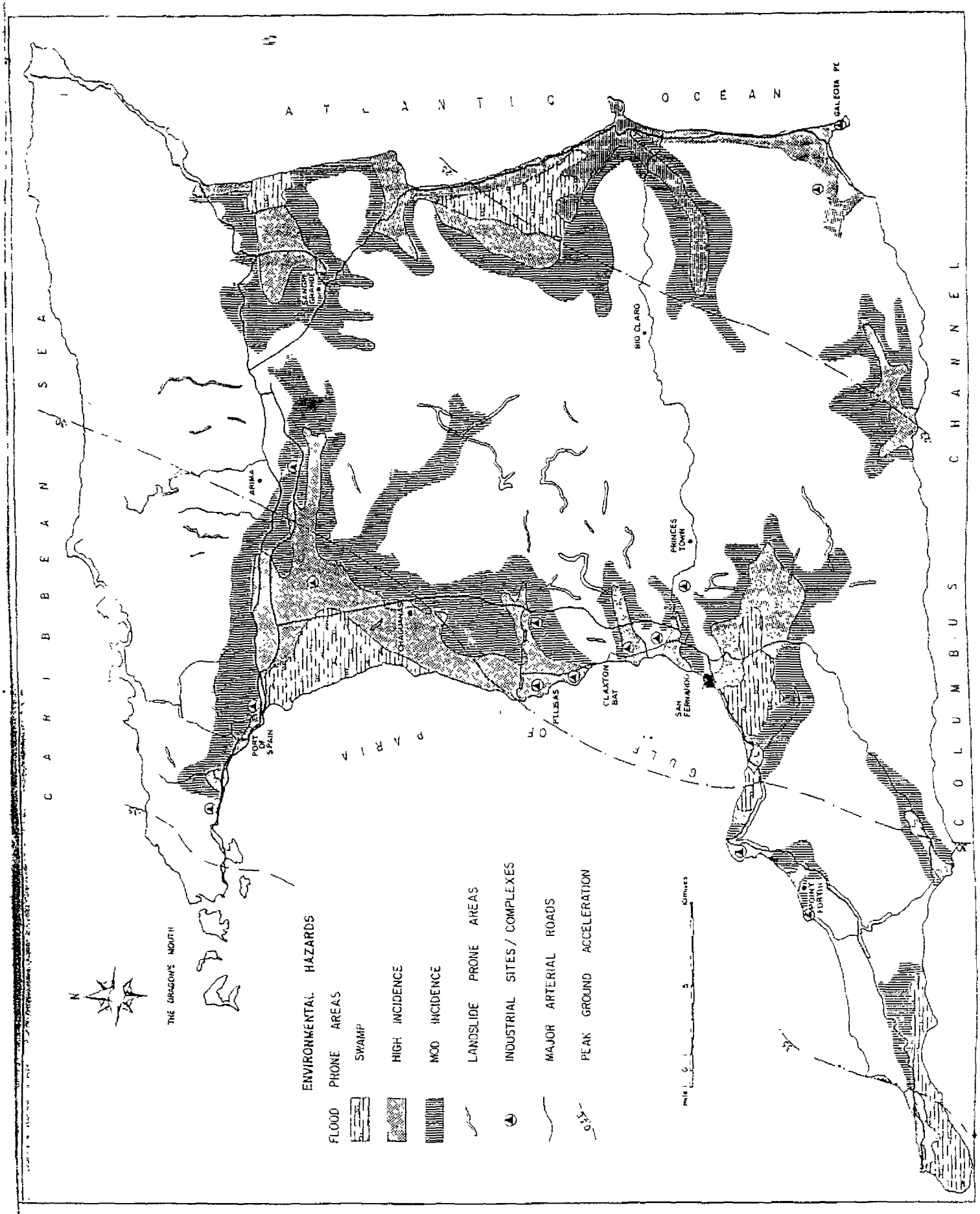

Figure 3 Hazard Map of Trinidad

Figure 4 Hazard Map of Tobago