Climate Resilience, Innovation & Partnership
for Sustainable Water and Waste Development

PLANNING FOR CLIMATE VARIABILITY AND CHANGE

VULNERABILITY OF THE NORTH COAST OF TRINIDAD AGAINST NATURAL AND MAN-MADE THREATS

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ABSTRACT

One major consideration for the sustainable development of a country is climate change, climate variations and their likely impacts. Natural disasters are associated with climate variability and climate change and drive the alterations observed with natural and human systems. To adequately address these issues, vulnerability assessments can be carried out to identify the hazards and threats in the system and the policies and strategies to deal with them. In this way, the resources necessary to deal with the social and economic impacts of threats could be identified proactively and the valuable assets of a country such as the fishing, agricultural and tourism sectors could be protected.

For Trinidad & Tobago and the wider Caribbean, these natural threats include flooding, hurricanes, storm surges, sea level rise, earthquakes & tsunamis and landslides. The impacts of these hazards include loss of life, economic losses, property damage, destruction of buildings & other structures and threats to floral and faunal species.

The northern coastline of Trinidad, the southernmost island in the Caribbean archipelago is exposed to the range of threats affecting the region. The vulnerability assessment of the north coast of Trinidad identified the threats and their impacts to the coastal zone. The study area was delineated into individual grids and the characteristics of the area were identified. The main susceptible assets in the coastal zone were detailed including population settlements, land usages for agriculture, tourism and recreation, fisheries, critical lifeline structures and the natural environment. The key vulnerability issues were identified as low income clustered settlement patterns near the coast, poor housing construction, poor land use planning and inferior construction of critical infrastructure.

Thus, the project report revealed that the north coast of Trinidad is indeed vulnerable to natural threats and addressing proper enforcement of policies, technical strategies and regulations are necessary to reduce future vulnerability of the coastline that is due to worsening impacts and economic losses of valuable coastal assets.

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CHAPTER 1

BACKGROUND OF STUDY

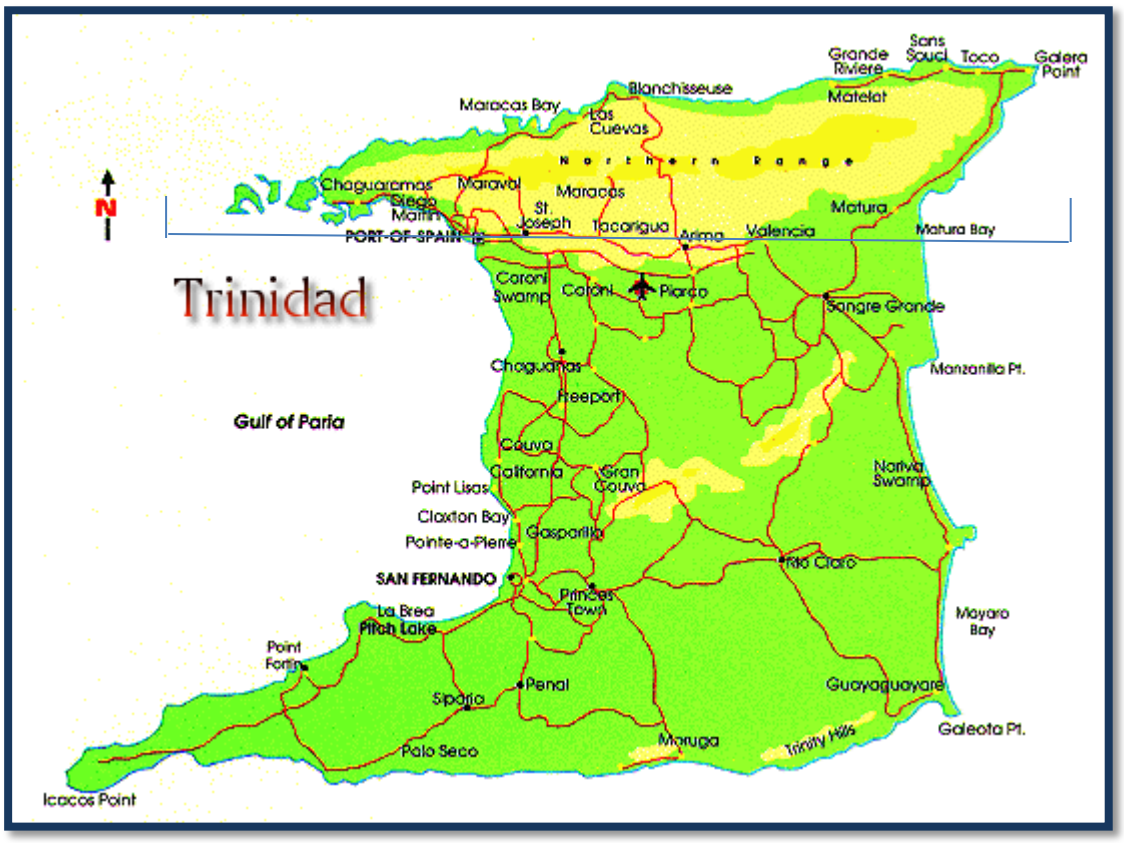
Vulnerability assessment includes the susceptibility of the coastal zone to physical changes resulting from climate change, the anticipated impacts on socioeconomic and ecological systems and available adaptation options (HARVEY et al., 1999).

Small island developing states (SIDS) shaped by their remoteness and insularity develop ecologies and cultures that are usually unique to their location. These developing states tend to have very fragile environments and economies and are highly vulnerable to some of the most devastating meteorological and geological phenomena. They incur the highest proportional impact of disasters which threaten their very survival thus creating escalating demands on rapidly diminishing international resources which are used for aid and relief efforts.

Thus, it was in this regard that the vulnerability of the North Coast of Trinidad against Natural and Man-made Threats was examined. The major threats that would be considered include: Flooding, Hurricanes, Earthquakes, Storm Surges and Coastal Erosion. These can impact the coast of Trinidad due to the susceptibility of the following industries:

- Fishing; Agriculture; Forestry; Tourism; Cottage industries (small shops and trades); Wildlife Sanctuary; Housing and Infrastructure;

This study will focus on the Northern coastline of Trinidad from the Chaguaramas peninsula at Teteron Bay in the West up to Galera Point, Toco in the East. See **Figure 1.1** below for the Map of Trinidad showing the North Coast and the Northern Range.



(Source: UWI, 2010)

Figure 1.1: Map of Trinidad showing the North Coast and the Northern Range.

CHAPTER 2

METHODOLOGY

This study area is a very narrow coastal strip that has been subjected to increasingly more development over the last decade. The environmental impacts and the susceptibility of the coastline to natural hazards must be examined as a direct consequence of this encroachment. Historical data on the north coast of Trinidad from a social, geological and environmental background was obtained and an extensive study was conducted to examine the geological and topographic features as well as land use patterns along the north coast of Trinidad. The methodological approach was the key in outlining the following stages:

- Project Planning – to examine the northern coastline, coastal zonation was performed which demarcated points of major interest into grids. These grids were then further subdivided (micro-zonation) and their general and individual characteristics were examined. These grids were of non-standard sizes but contour lines ranging from 5 metres to 100 metres above sea level provided the boundaries of each individual grid and its study area;
- Literature Review - international, regional and local points of view were extracted to drive the issues surrounding the vulnerability of the north coast;
- Data Collection – site visits to every major coastal village and areas of importance were undertaken; photographs were obtained; interviews with locals including villagers and entrepreneurs were also done. Visits to major utilities, government offices, tourism agencies and research institutions were also done to accumulate data on the various aspects of the north coast;
- Data Organization and Presentation – extensive reviews of maps, bathymetry studies, tabular data and historical data was compiled into this report;
- Analysis of Data – the vulnerability assessment was detailed by examination of the general and individual characteristics of each grid along the coastline and the impacts of natural and man-made threats to them;
- Recommendations and Conclusion – mitigation measures were highlighted in order to alleviate the problem and further induce the importance of the study

CHAPTER 3

DELINEATION OF THE STUDY AREA

The north coast of Trinidad, the larger of the two islands that form the Republic of Trinidad and Tobago, is defined from Teteron Bay, Chaguaramas in the west up to Galera Point, Toco in the east. This area lies between 60° 55' - 61° 40' West Longitude and 10° 45' - 10° 55' North Latitude. This stretch of land is approximately 102 kilometres in distance and investigations of the northern coastline were carried out at a distance of 200 metres inland from the high water mark on the shoreline. Thus the area under study is approximately 20.4 square kilometres (20.4 km^2).

Sub division of the study area led to the following grids being examined:

- Teteron Bay to Entrada Point;
- Entrada Point to Macqueripe Bay;
- Macqueripe Bay to Maracas Bay;
- Maracas Bay to Las Cuevas Bay;
- Las Cuevas Bay to Blanchisseuse Bay;
- Blanchisseuse Bay to Matelot Bay and;
- Matelot Bay to Galera Point, Toco.

A detailed analysis of the general characteristics and individual grid characteristics was undertaken. Features that were examined included: Bathymetry studies; Water circulation and Tidal currents; Salinity and temperature; Weather and climate; Geology and Pedology; Topography; Land use; Infrastructure; Population and settlement patterns; Fisheries and Tourism & recreation.

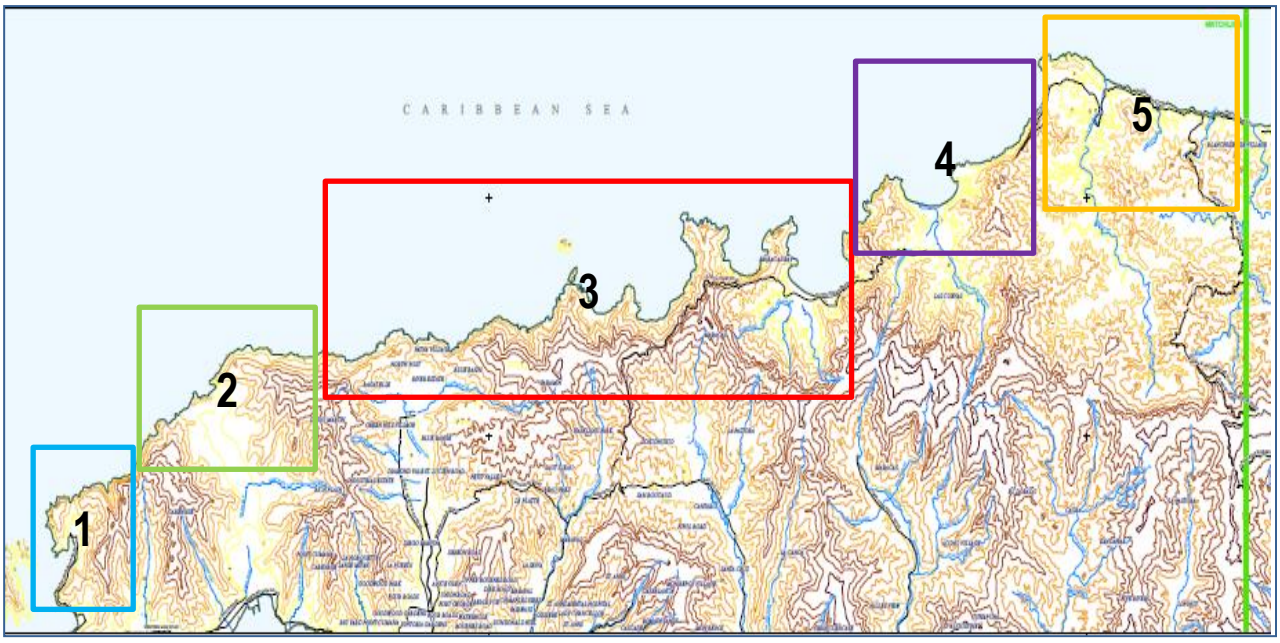
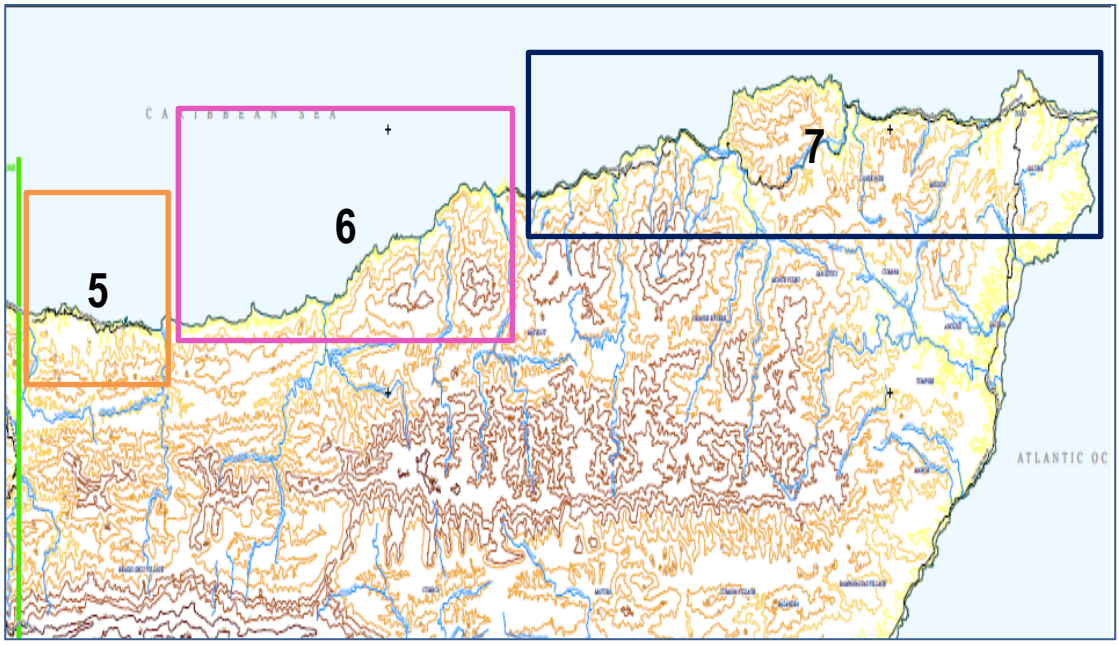


Figure 3.1



(Source: Central Statistical Office, 2010)

Figures 3.1 & 3.2: General Grid Framework II for the Northern Region of Trinidad.

KEY:

GRID 1 – Teteron Bay to Entrada Point;

GRID 2 – Entrada Point to Macqueripe Bay;

GRID 3 – Macqueripe Bay to Maracas Bay;

GRID 4 – Maracas Bay to Las Cuevas Bay;

GRID 5 – Las Cuevas Bay to Blanchisseuse Bay;

GRID 6 – Blanchisseuse Bay to Matelot Bay;

GRID 7 – Matelot Bay to Galera Point, Toco.

CHAPTER 4

VULNERABILITY ASSESSMENT OF THE STUDY AREA

4.1 Teteron Bay to Entrada Point

The two (2) most vulnerable sites within this grid include the Teteron Bay Barracks and Scotland Bay. The strip of land within this grid is relatively low lying within 10 metres above sea level. Due to the free internal drainage of the soils in this area into the open sea, the susceptibility to flooding is low. If a hurricane approaches in the future, the Teteron Bay Barracks would experience loss in terms of damage to buildings, damage to sea vessels and their equipment; fallen trees in the vicinity and the accumulation of sediment and debris from higher elevations in the nearby terrain. Extreme wave events and storm surges would also result leading to further loss of assets by salt water intrusion on land. The conditions would also be unfavourable for coastal navigation and monitoring duties to be executed. Critical lifeline structures for electricity and communication would be non-functional. The likelihood of an earthquake of magnitude greater than 6.5 in the near future is fairly high. Impacts to the area would include loss of life and destruction to the built environment. Coastal erosion can be associated with storm surges, hurricanes, earthquakes and sea level rise and effects would be similar to those previously mentioned.

4.2 Entrada Point to Macqueripe Bay

The pocket bay areas of Mahout Bay, Grande Ravine, Trou Tazar Bay, Tete Boeuf and Macqueripe Bay are the vulnerable sites within this grid. Hurricanes, earthquakes and storm surges within this grid would result in fallen trees in dense forest areas and loss of wildlife & their habitats. Heavy sediments and debris would be accumulated on land and lead to the open sea, resulting in murky waters, loss of marine life and alterations to the ocean PH and temperature. In the Macqueripe Bay area, critical lifeline structures for electricity and communication would be non-functional. The beach resort facilities would incur damages to the building structures, signage, fencing and roadways. The likelihood of an earthquake of large magnitude in the near future

is fairly high. Most of the coastal strip within this grid being rocky terrain and rugged cliffs would not be as susceptible to erosion. The beaches would experience movement of sediments, dips in the beach floor and alterations to the shoreline by removal of trees, shrubs and other vegetation.

4.3 Macqueripe Bay to Maracas Bay

The pocket bay areas of Saut D'eau, Balata and Maracas are the vulnerable sites within this grid. Otherwise, the entire strip of coastline from Macqueripe to Maracas is featured by dense forests and rugged cliffs at elevations greater than 15 metres above sea level. This reduces the vulnerability of this strip drastically from slope instability as there is a natural coastal protection barrier against the elements.

The Maracas Bay area is the only vulnerable site that is fairly developed with a coastal population of 112 *(See Appendix 1 - CSO Population Data for Year 2000)*. This low lying area is very susceptible to flooding comprised of the dwelling homes in the area, the fishing village and the beach resort facilities such as the car park and nearby shops. The muddy waters reach the bay area and cause major siltation of the bay such that fishing and other recreational activities come to a halt. Apart from damage to property in the area, the small scale agriculture which takes place on the nearby hillsides is also affected. Food availability in the area would be compromised as farmers depend on their crops for a source of income by sale near roadsides and for their own consumption.

In addition, the primitive 'slash and burn' methods for farming result in soil erosion and landslips. Blockage of the North Coast Main Road is the result. Runoff from pesticides used in farming are harmful to the marine life in the nearby wetland. Fishing in these surface waters would be detrimental as fish obtained would contain these harmful chemicals that lead to poisoning of human systems. These chemicals that runoff due to erosion and flooding could find their way into ground water systems that are utilized by WASA. In addition, untreated wastewater can pollute the groundwater systems during flooding. Excessive treatment of the water would be required before distribution to the various areas. This would be an additional cost for WASA. Flood waters contain

microbes and harmful parasites which are the causative agents for flu viruses and diseases such as cholera and skin ailments. Proper sanitization of homes and environs would need to be implemented.

The effects of an earthquake and associated tsunami to the area would be similar to that of storm surges and hurricanes. Wave heights would increase and cause accumulation of heavy silt and debris in pocket bay areas. The major infrastructure that would be vulnerable include the Maracas beach resort facilities, the Maracas Bay Hotel, the food huts on the beach, the fishing depot and boats, the vending shops and the dwelling homes of the valley area.

Recreational and social activities of the Maracas Bay area would be halted. The areas of cliff and dense forest will be less affected except for fallen trees and loss of wildlife.

4.4 Maracas Bay to Las Cuevas Bay

The pockets bay areas of Tyrico Bay, Damian Bay and Las Cuevas Bay are the vulnerable sites within this grid. Otherwise, the entire strip of coastline from Maracas to Las Cuevas is featured by dense forests and rugged cliffs at elevations greater than 30 metres above sea level. This reduces the vulnerability of this strip drastically as there is a natural coastal protection barrier against the elements. In addition, the Las Cuevas village lies 600 metres approximately off the coast and is protected by this natural barrier. Effects of hurricanes, earthquakes and storm surges would be similar to that of the Maracas Bay area, resulting in compromised homes, schools, health care, beach resort and fishing facilities.

4.5 Las Cuevas Bay to Blanchisseuse Bay

The pockets bay areas of Chupara Bay & Blanchisseuse Bay and the La Filette community where the Yarra River flows, are the vulnerable sites within this grid. Otherwise, the entire strip of coastline from Las Cuevas to Blanchisseuse is featured by broken forests, some coconut tree vegetation and rugged cliffs at elevations greater than 30 metres above sea level. This reduces the vulnerability of this strip drastically as there is a natural coastal protection barrier against the

elements. In addition, the La Filette community lies 600 metres approximately off the coast and is protected by an array of coconut trees as the natural vegetation that acts as a coastal protection barrier. The Blanchisseuse community lies within 100 metres off the coastline and is more susceptible to natural events with results similar to that of the Las Cuevas area.

4.6 Blanchisseuse Bay to Matelot Bay

The strip of coastline from Blanchisseuse Bay to Matelot Bay is fairly uninhabited due to the lack of infrastructure and basic utilities along the coastal strip. This may be due to the rugged and hilly terrain.

4.7 Matelot Bay to Galera Point, Toco

Bacasa, Grande Riviere, Monte Video, Sans Souci, L'anse Noire, Mission and Toco are the vulnerable communities within this grid. Otherwise, the entire strip of coastline from Matelot to Toco is featured by dense forests on prominent mounts, some coconut tree vegetation and rugged cliffs at elevations greater than 30 metres above sea level. This reduces the vulnerability of this strip drastically as there is a natural coastal protection barrier against the elements.

Grande Riviere, Monte Video and Sans Souci are villages that lie to the south of the prominent mount that features the coastline. This mount protects these communities from the effects of many natural events including storm surges and hurricanes. Mission and Toco are the two more vulnerable communities due to their proximity to the coastline being within 100 metres and their elevations being less than 10 metres above sea level. Effects of these hazards in these communities are similar to those outlined for the other grids.

4.8 SUMMARY

Table 4.1 below summarizes the key vulnerabilities for each grid framework and their likely level of impact categorized under the headings of high, medium and low. This information would be useful in an assessment of the north coast of Trinidad, where prioritization of regions is necessary when dealing with issues of vulnerability and mitigation measures, in terms of urgent attention.

GRID / THREAT	1	2	3	4	5	6	7
Flooding	L	L	H	M	H	M	M
Hurricanes	H	M	H	H	H	H	H
Storm Surges	H	M	H	L	M	M	M
Sea Level Rise	M	L	H	L	M	M	M
Earthquakes & Tsunamis	H	M	H	H	H	H	H
Coastal Erosion	L	L	L	L	M	M	H

(Source: Author, 2010)

Table 4.1: Summary of Threats and Level of Impact for each Grid.

KEY:

Likely Level of Impact: High – **H**

Medium – **M**

Low – **L**

CHAPTER 5

DISCUSSION, RECOMMENDATIONS AND CONCLUSION

5.1 Discussion

Along the north coast of Trinidad, the areas of susceptibility to natural and man-made hazards and their impacts are mainly the pocket bays and clustered population centres. There are many key factors that contribute to these small areas along the coastline being vulnerable which are examined below.

The general characteristics of the coastal strip make them very vulnerable to flooding and sea level rise while the higher elevations & steep cliffs are prone to landslides and rock falls. This was highlighted in the report in such areas as Maracas and Matelot. The drainage of the areas also contributes to the flooding in the low areas due to lack of man-made drainage structures along the north coast or poor drainage construction and maintenance.

The population density and settlement patterns along the northern coastline also determine its vulnerability to natural threats. The clustered settlement patterns along the north coast are located near pocket bays and the majority of the settlers are within the lower income bracket and are located within hazard prone areas. Poor housing construction is another factor that contributes to the vulnerability of settlers. The lack of proper housing planning and coastal zone management along the northern coastal strip result in squatter homes and the structural integrity of most homes are compromised by the use of inferior building materials. Other infrastructure such as bridges, canals and roadways are also not built to withstand the impacts of natural threats. Flooding, tsunamis, storm surges and hurricanes all impact these settlements causing major destruction and damage to homes, agriculture and property. This is highlighted in the area of Toco where roads and bridges collapsed when the effects of Hurricane Tomas were felt near north-east Trinidad. Poorly engineered domestic wastewater treatment systems also exist as a result of unplanned settlements. Untreated wastewater can find its way to nearby watercourses leading to water pollution by way of eutrophication and ultimately fish kill and overgrowth of algae.

The dependency of the human population on transportation networks and infrastructure along the northern coastline also determines its vulnerability to natural threats. Any disruptions to transportation networks during a natural threat can make some areas inaccessible such as these roads are the only point of access. The North Coast Road being the only roadway along the Maracas and Las Cuevas areas is thus very vulnerable to natural threats and this poses a hazard to commuters in times of emergency. Electrical lines, communication lines and water supply systems are compromised during natural hazards leaving communities without basic amenities to function. Villagers are left in deplorable and unsanitary conditions and further losses are incurred as a result of the natural threats.

The presence of important floral and faunal species along the north coast must be considered and is highly vulnerable to natural threats. The loss of these ecosystems will result in fisheries depletion and extinction of keystone species. Such changes will result in an ecological imbalance throughout the study area. Most settlers are dependent on fishing as their main source of income and hence, will suffer the most from these losses. Other fauna such as birds which are dependent on the mudflats for food and mangrove for roosting will become extinct from the study area. The reduction or extinction of mangrove systems from along the coastal zone will make inland areas much more vulnerable natural threats. Also, a decrease in wildlife species alters the food chain in these areas causing an upset in the ecological balance of prey and predator species.

5.2 Recommendations

In order to mitigate the impacts of natural threats a wide range of approaches and steps can be adopted. These steps can involve creating mitigation plans for individual natural threats as well as, the development of overall strategies for disaster reduction. The Environmental Management Authority (EMA) developed the STATE OF ENVIRONMENTAL REPORT (SOE) Report 2004 which outlined many initiatives relevant to the north coast to sustain human life, ecosystems and amenities. The major points are listed below while the details of the SOE report are given in **Appendix I**:

- ***Enforcement of Policy and Regulations***
- ***Proper Allocation of Lands for Housing and Settlement***
- ***Joint Management of Resources***
- ***Public Responsibility and Public Education***
- ***Research and Documentation***
- ***Monitoring and Evaluation***

(EMA SOE Report, 2004).

A summary of the response options required for the north coast of Trinidad are also outlined in the SOE Report 2004. The major points are given below while the details of the responses are given in **Appendix I**:

- ***Biodiversity***
- ***Land Use Planning***
- ***Forest Resources***
- ***Coastal Resources***
- ***Agriculture***

(EMA SOE Report, 2004).

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APPENDIX I

ABSTRACT FROM THE 'STATE OF ENVIRONMENTAL REPORT' BY THE ENVIRONMENTAL MANAGEMENT AUTHORITY OF TRINIDAD AND TOBAGO

The EMA developed the SOE Report 2004 which outlined many initiatives relevant to the north coast to sustain human life, ecosystems and amenities. These are given below:

- ***Enforcement of Policy and Regulations*** – as part of a sustainable development plan, many policies and regulations on coastal zone management and housing planning must be enforced along the north coast of Trinidad. Political and technical expertise is required in decision making for single ecosystems and socioeconomic systems along the north coast. One method is the setting up of a Sustainable Development Council for the area to bring together all sectors and engage in activities geared toward social and infrastructural development which sustains the value of the coastal area. Local government arrangements could also be established to monitor and maintain the regulations enforced.
- ***Proper Allocation of Lands for Housing and Settlement*** – revision of housing plans for the north coast must be considered. Zoning regulations and review of construction on slopes and contours must be enforced.
- ***Joint Management of Resources*** – natural resources and assets must be co-managed by the State and the communities and should conform to stipulated standards, regulations and policies. Involvement of the private sector would be an additional asset as well in decision making. Funding of the resources must also be considered between the parties involved.
- ***Public Responsibility and Public Education*** – better understanding of the rationale of policies and regulations and transparency in public decision making could bring better awareness to the settlers resulting in a positive attitude and behavior towards change.
- ***Research and Documentation*** – data and information for the area is currently inadequate. Organizations such as the University of the West Indies should engage in actively developing sustainable development policies; designing projects for better public interests; utilizing state of the art equipment for data collection and monitoring of coastal zones and disseminating the information to the public.
- ***Monitoring and Evaluation*** – must be done for the impact of policies and decision making regarding the north coast. Better understanding of roles responsibilities and accountability would be obtained. A systematic approach

would provide the necessary feedback required to continuously assess the area. Monitoring and inspection of properties for possible relocation or retrofitting should also be included under this programme.

(EMA SOE Report, 2004).

A summary of the response options required for the north coast of Trinidad are also outlined in the SOE Report 2004 as provided below:

- ***Biodiversity***
    - "Accelerate the designation of the recommended Environmentally Sensitive Areas and Species;
    - Zone the eastern section principally for conservation including designation as a biosphere reserve; apply and enforce more rigorous standards for housing and agriculture where allowed than have been used for the western section;
    - Institute a moratorium on all hunting; when lifted, strictly enforce applicable regulations; increase penalties for violation; increase revenue from sale of licenses and invest into enforcement capacity;
    - Promote cultivation of selected species that are or could be commercially used, including floriculture; establish sustainable use basis for wild specimens and;
    - Provide the necessary resources to manage and protect Environmentally Sensitive Areas."

- ***Land Use***
    - "Develop and implement plans for the north coast in the context of zoning and within the local government framework;
    - Revise contour and slope regulations for housing construction and strictly enforce (including on private lands); increase penalties to be more effective as a deterrent;
    - Formulate regulations, where appropriate, that are specific to certain watersheds;

- Base land use on land capability;
- Reserve high-quality pockets of soil for high-priced niche commodities and;
- Revise the land capability classification system."

- ***Forest Resources***
  - "Revise, approve, and implement the Draft Forest Policy (1998);
  - Establish a moratorium on commercial forestry on State lands and on private lands until forest cover on exposed and vulnerable locations is recovered; thereafter manage through a policy of allowable cuts;
  - Support private landowners who are replanting on their properties by providing incentives such as waiving land taxes;
  - Involve communities, including unauthorized settlements, in reforestation activities and;
  - Establish incentives for their continued care and protection of the trees."

- ***Coastal Resources***
  - "Accelerate negotiations for assessing and managing the fisheries stock;
  - Develop appropriate coastal infrastructure: better facilities at beaches along with the implementation of user fees to maintain these facilities, including lifeguards;
  - Discourage use of the coastal strip for commercial purposes that are not coastal/marine related;
  - Revise the policy of no-net-loss for mangroves to one of no-further-loss;
  - Encourage communities to cultivate heavily used species (e.g., sea moss) to avoid overexploitation (and possible irreversible loss) of wild specimens and;

- Assess the specific needs of seaside amenity sites and make appropriate responses."

- ***Agriculture***
  - "Re-orient small farmers to growing high-priced niche-market crops; subsidize these where possible; offer competent advice through well-managed agricultural extension services;
  - Confine agriculture mainly to the remaining flat areas with medium-sized farms where possible; where allowed on sloping land apply strict soil-conservation requirements;
  - Re-orient existing cultivation of herbaceous crops on steep slopes to be more restorative and preventative, through appropriate agro-forestry; require use of modern techniques; offer incentives for appropriate agriculture and forestry; encourage terracing;
  - Develop a policy to make farming a better livelihood basis, taking into account size of farm, type of crop, and desirable technology and techniques;
  - Discourage further cultivation on hillsides of valleys; use flat lands where available;
  - Upgrade all established agricultural trails and traces;
  - Consider cocoa and coffee as the preferred agricultural tree crops given suitability and long history of cultivation;
  - Enforce the Agricultural Fires Act and;
  - Penalize slash-and-burn practice."

(EMA SOE Report, 2004)

APPENDIX II

CSO POPULATION DATA FOR YEAR 2000 ALONG NORTH COAST OF TRINIDAD

CSO POPULATION DATA FOR YEAR 2000 ALONG NORTH COAST OF TRINIDAD

		Sex		Total
		Male	Female	
Cross communities and old communities	CHAGUARAMAS	22	15	37
	GREEN HILL VILLAGE	835	877	1712
	BAGATELLE	2132	2024	4156
	PATNA VILLAGE	295	274	569
	BLUE BASIN	1013	1027	2040
	NORTH POST	153	135	288
	PARAMIN	1062	1000	2062
	CAMERON ROAD	387	358	745
	MARACAS BAY	62	50	112
	LAS CUEVAS	384	325	709
	GRAND RIVIERE	162	136	298
	LANSE NOIR'	186	152	338
	MATELOT	275	211	486
	MISSION	140	127	267
	MONTE VIDEO	75	65	140
	SAN SOUCI	273	199	472
	TOCO	537	498	1035
Total		7993	7473	15466

(Source: CSO, 2010)