

A FLOOD VULNERABILITY ASSESSMENT FOR THE
DOWNTOWN PORT-of-SPAIN AREA, TRINIDAD, W.I.

A Thesis

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Abstract

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In the Caribbean natural and anthropogenic hazards occur frequently with disastrous effects in some instances. Amongst these hazards, flooding is one of the most frequently occurring which greatly affects the small island developing states (SIDS) of the Caribbean, often resulting in millions of dollars in property and human losses. In Trinidad flooding is a perennial hazard. Flooding occurs widespread throughout the island with a greater number of flood events occurring in urban areas with increasing intensity in some instances.

The Port-of-Spain area is one such area which continues to be flooded on an annual basis. As the capital, Port-of-Spain functions as the seat of government, the headquarters for Ministries and multinational corporations as well as a major transportation and services centre. Port-of-Spain is therefore the main location of many of the nation's assets. These assets serve as critical facilities essential to the city's ability to conduct its many roles and functions as the capital city and financial capital of the country. Therefore the effects of an extreme flood event can have potential catastrophic effects for all aspects of the environment especially the economic sectors. Ensuring the resilience of such critical infrastructure is therefore imperative.

This research will seek to assess the vulnerability of Port-of-Spain to flooding with a focus on the commercial sector and the physically challenged. It is expected that through this analysis, a better understanding of flooding will result in identifying those elements which

contribute to increasing vulnerability within the city. This will assist in determining the most appropriate mitigation strategies to be employed in order to alleviate the risk of flooding in Port-of-Spain.

Key Words: Gerarda Ramcharansingh; Flooding, Port-of-Spain; Vulnerability Assessment; Commercial Sector; Physically Challenged.

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Dedication:

This effort is dedicated to my mother, Patricia Ramcharansingh. You have been a constant source of motivation, inspiration and support throughout the writing of this thesis and in my life. Thank you for believing in me. It could not have been accomplished without you.

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Glossary of Terms

Capacity - The combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals.

Critical Facilities - The primary physical structures, technical facilities and systems which are socially, economically or operationally essential to the functioning of a society or community, both in routine circumstances and in the extreme circumstances of an emergency.

Disaster - A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.

Disaster Risk - The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period.

Disaster Risk Management - The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster.

Disaster Risk Reduction -The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

Hazard - A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Exposure -People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses.

Mitigation -The lessening or limitation of the adverse impacts of hazards and related disasters.

Preparedness -The knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions.

Public Awareness - The extent of common knowledge about disaster risks, the factors that lead to disasters and the actions that can be taken individually and collectively to reduce exposure and vulnerability to hazards.

Resilience -The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.

Risk -The combination of the probability of an event and its negative consequences.

Risk Transfer -The process of formally or informally shifting the financial consequences of particular risks from one party to another whereby a household, community, enterprise or state authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party.

Vulnerability -The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.

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Chapter One- Literature Review

1.0 Vulnerability in Disaster Risk Management

The process of using administrative directives, organisations and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibilities of disasters is defined as disaster risk management (UNISDR 2009). As such, disaster risk management plays an integral part in the management of a country's resources and population, safe guarding it against the possible impacts of potentially damaging hazards. Hurricanes, earthquakes, landslides, volcanic eruptions and floods account for some of the most destructive and disastrous events to have impacted the Caribbean, resulting in loss of life and property. A category five hurricane such as Ivan in 2004 was responsible for \$3 billion in losses in the Caribbean and over 92 deaths in total (National Hurricane Centre 2005). The earthquakes in Haiti and Japan which occurred in 2010 and 2011 respectively resulted in millions of dollars in losses as demonstrated in Japan and almost 250,000 lives in Haiti. In 2011 alone, the United States of America recorded approximately eleven major natural disaster occurrences ranging from tornadoes, to drought to hurricanes (Huffington Post 2011). In Trinidad and Tobago the impact of flooding is a perennial issue which results in millions of dollars in lost revenue. Therefore, it is apparent that now more than ever strategies must be put applied to reduce the impact of such hazards. These strategies must seek to reduce the occurrence of the hazards, as well as reduce the vulnerability of populations so as to increase their capacity to withstand the impact of disastrous events.

Vulnerability is one of the central tenets of disaster management. Understanding vulnerability, its root causes, its effect on populations and how it can be reduced can assist in building resilient communities which are better able to cope with the onslaught of a natural disaster. Vulnerability is defined as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (UNISDR 2009). Therefore an area may be defined as being vulnerable based on its features such as socio-economic and physical characteristics. The age structure of the population, the economic status of the country and the lack of or presence of well-defined social structures and networks can determine the level of vulnerability which a country or community is exposed to. According to Wisner et al. p. 52 (2004) “The most important root causes that give rise to vulnerability (and which reproduce vulnerability over time) are economic, demographic and political processes. They affect the allocation and distribution of resources, among different groups of people”. Therefore, all these factors should be considered as far as possible when assessing vulnerability.

In recent times there has been growing appreciation for the value of sound disaster management strategies which seek to minimize the effects of the natural disasters. The World Conference for Disaster Reduction (WCDR) held in Hyogo, Japan in 2005 illustrated this. At this Conference representatives from over 148 countries agreed to integrate disaster management into their development programmes following guidelines outlined in the Hyogo Framework for Action (HFA). Within the HFA, Five Priorities for Action were developed as guiding pillars for the global advancement of disaster risk reduction. Amongst these, priority two aptly describes the importance of the vulnerability assessment process. Priority two seeks to address the need for identifying, assessing and

monitoring hazard risk and enhancing early warning (UNISDR 2005). Activities necessary to achieve this priority include hazard and vulnerability assessments, early warning enhancement and capacity building. According to priority two, “The promotion and reduction of disaster risk starts with the knowledge of hazards, the physical, social, economic and environmental vulnerabilities to disasters” (UNISDR 2005). The extent of hazards can only be assessed through proper data collection and analysis of the hazard and its effects on society. This priority therefore illustrates the necessity and enormous value of the vulnerability assessment in disaster management.

At the regional level, the relevance of the vulnerability assessment is also illustrated. The Caribbean Disaster and Emergency Management Agency (CDEMA) has developed guidelines for disaster risk reduction which regional disaster management organisations follow called the Comprehensive Disaster Management (CDM) strategy. The CDM provides direction for the national disaster management organisations of the region to encourage and guide disaster risk reduction in the Caribbean. In the 2001 CDM Framework (UNDP 2011), five results or outcomes were highlighted as desirable. Result five highlights the importance of the vulnerability assessment in disaster management. Result five states “Hazard information is incorporated into development planning and decision-making” (UNDP 2011). In order for hazard information to be incorporated into development strategies, good data collection must first be employed. This may be achieved by carrying out a hazard vulnerability assessment. Thus one may say that the hazard vulnerability assessment provides the basis for the best decisions to mitigate and reduce the effects of hazards.

1.1 Assessing Vulnerability

Assessing vulnerability is an essential tool necessary for designing comprehensive disaster risk management strategies. Recognizing the vulnerabilities within an area, assessing them and developing a plan to reduce these same vulnerabilities is key to achieving the overall aims and objectives of disaster risk reduction. As such, the first step to planning disaster risk management strategies should include a vulnerability assessment.

Vulnerability by itself does not result in disastrous impacts from natural hazards. It forms part of an equation which seeks to demonstrate those push and pull factors which result in a disaster. A disaster event consists of two elements working with or against each other to produce a catastrophic event. The equation is given as

$$\text{Disaster/ Risk} = \text{Hazard} \times \text{Vulnerability}$$

Here the hazard refers to the natural events that may affect different places singly or in combination (coastlines, hillsides, earthquake faults, savannahs etc.) at different times (season of the year, time of day, over return periods of varying duration) (Wisner et al. p. 49 2004). The risk or disaster is understood as a compound function of the natural hazard and the number of people, characterized by their varying degrees of vulnerability to that specific hazard within a given time and exposed space.

In this scenario, the disaster or risk is exacerbated by a combination of an increase in the hazard along with an increase in vulnerability. Therefore, when a significantly vulnerable population experiences a hazard and suffers damage and/or disruption in livelihoods in such a way that recovery is unlikely without external help; this is defined as a disaster. A

reduction in both or either will result in a reduced risk and therefore a lower chance of a disaster occurrence. In Wisner et al. (2004), this equation forms the basis for assessing the resulting impact of both factors interacting with each other.

Similarly, various models utilize this basic principle formula to explain how disasters occur due to the interaction between vulnerability and the hazard. For example, the Pressure and Release (PAR) model illustrates that interaction between hazards and the vulnerability with the intersection of the two creating a disaster. This model seeks to demonstrate that vulnerability does not just occur in isolation but results from a series of root causes which create pressure and dynamic changes on the population and environment. This leads to the creation of conditions which increase vulnerability in various sectors as previously mentioned, such as the economy and the physical environment. With the onslaught of a hazard, the high level of vulnerability is unable to withstand the hazard due to a lack of coping mechanisms and thus a disaster is produced. In other models such as the Access model, it is the lack of access to resources which leads to the increased vulnerability. This model differs from the PAR model in that it tries to understand the various complex social and environmental events which may be associated with a disaster event. Unlike the PAR model, the Access model seeks to address the roles and the responses of the various actors involved as the disaster situation unfolds. Both models seek to analyse in detail how vulnerability when combined by some triggering event such as a hazard result in disaster.

1.2 Vulnerability Assessments in the Caribbean

In the Caribbean region, disaster management has become an important focal point for development. The Caribbean faces a multitude of threats owing to natural and anthropogenic causes such as hurricanes, earthquakes, floods, chemical spills and the like. Additionally, the effects of climate change have increased the number of threats as well as exacerbate existing ones. Thus there is an urgent need for disaster management in the region.

As mentioned, the hazard vulnerability assessment is essential in deciding on the best plan to reduce the effects of hazards. An intimate understanding of the hazards which affect an area is therefore imperative. Ahmad (2007) in his report on the implementation of disaster risk management strategies in the Caribbean highlights that often the lack of proper understanding of the hazard leads to improper mitigation strategies. For example, he pointed out that the floods in 2004 and 2005 in Trinidad and other Caribbean countries were treated as common water floods in spite of the hazard exhibiting characteristics of debris floods. This information is useful in determining the most effective mitigation strategies such as in the construction of storm drains for the removal of flood water and debris.

However, in the Caribbean region hazard vulnerability assessments are few due to the lack of trained personnel as well as funding to execute thorough assessments. In some instances where assessments have been undertaken, the results of the assessments are not considered in the development of mitigation strategies to alleviate the effects of the hazards. This is similar in Trinidad and Tobago. In a CDEMA country report completed in 2003 it was found that hazard vulnerability assessments were lacking in Trinidad and Tobago. Findings

showed that only one hazard mapping project was done i.e. a seismic hazard mapping exercise conducted by the Seismic Research Centre. In the case of hazard vulnerability assessments none had been recently completed. Two initiatives were expected to come on stream; a flood assessment initiative for specific flood basins and landslide assessment. These assessments have been completed for the most part. However, due to funding and lack of technical expertise the results of these projects have not been beneficial in alleviating the threat of hazards. Thus, there have been few effective mitigation strategies to reduce hazard risk.

One may therefore surmise that the vulnerability assessment is crucial to developing strategies to alleviate the effects of hazards. The execution of these assessments can provide an in-depth analysis of the hazard and its effects on the natural and built. In turn, the results of the assessment aid in shaping the most effective strategies for disaster risk reduction that are most suited to the existing environment allowing society to cope and avoid such disasters. This study is therefore most relevant at this time as Port-of-Spain continues to be repeatedly affected by flooding with little success in the strategies employed to reduce the effects of flooding thus far.

Chapter 2- Introduction

2.0 Aim of Study

The Caribbean may be described as a multi-hazardous environment affected by a wide range of both natural and anthropogenic hazards. This is mainly due to geophysical and climatic conditions of the Caribbean. Among the various hazards, flooding is the most common and repeatedly affects the small island developing states (SIDS) of the Caribbean resulting in millions of dollars in property and human losses. The actions of physical development and environmental degradation as well as the effects of climate change continue to exacerbate the effects of flooding. It is therefore imperative that the effects of flooding be analysed with a view to propose sustainable and practical interventions to reduce the vulnerability of populations.

In Trinidad flooding is a perennial hazard. Flooding occurs widespread throughout the island with a greater number of flood events occurring in urban areas with increasing intensity in some instances. The Port-of-Spain area is one such area which continues to be flooded on an annual basis. As the capital, Port-of-Spain serves not only as the Central Business District (CBD), the hub for most ministries and multi-national corporations and transportation but also the seat of governance. Port-of-Spain is therefore the main location of many of the nation's assets. A nation's physical assets serve as the foundation for effective governance, economic vitality, and a resilient civil society. These critical facilities must therefore be protected against the effects of all hazards including flooding as they can potentially cripple the development strategies of a nation. Ensuring the resilience of such critical infrastructure is therefore imperative.

This study will seek to address specific questions as they relate to flooding in the downtown Port-of-Spain area. It is expected that this study will provide the relevant answers to these questions and therefore suggest recommendations to alleviate the problem of flooding in the study area. The main research questions to be answered include:

1. Flooding in Port-of-Spain
 - a. What is the nature of the flood events?
 - b. What are the main causes and contributing factors to flooding?
 - c. What have been the effects of flooding?
2. Vulnerability of the Commercial Sector/ Physically Challenged
 - a. What services are provided by these elements?
 - b. What is the level/ extent of vulnerability of the commercial sector and the Princess Elizabeth Centre to flooding?
3. Perception of Flood Vulnerability
 - a. To what extent are these sectors aware of the cause and effects of the hazard?
 - b. How do the sectors explain or perceive flooding in their area?
4. What are the possible solutions to flooding?

This study will examine the vulnerability of populations within Port-of-Spain, Trinidad to flood hazards. It will seek to examine the level, type and the root causes as far as possible, of the vulnerabilities experienced within the commercial sector as well as the issue of vulnerability of special populations i.e. the physically challenged. This will be done using various techniques such as questionnaires and interviews with the relevant target groups.

The commercial sector was chosen as Port-of-Spain is the commercial and financial ‘mecca’ of the country. Port-of-Spain serves as the centre for various types of economic activity; small and large scale retail and wholesale sales, banking and finance, transportation, service industries at varying scales, insurance and the headquarters for many multinational corporations. Additionally, persons of various nationalities converge on Port-of-Spain to conduct business or have established local businesses in the city. Therefore the importance and value of the economic transactions, assets and capital is high and as such building resilience is important. In order to achieve this, the existing vulnerabilities must be examined so that progress can be made in developing resolutions.

It should be re-iterated that certain characteristics of a population may increase its vulnerability. Within this study, the vulnerability of one of the many populations found within Port-of-Spain will be examined i.e. the physically challenged. The Princess Elizabeth Centre is located within the city of Port-of-Spain and is home to many young persons who suffer from orthopaedic disabilities including scoliosis of the spine; it also serves as a centre for orthopaedic surgeries. It is the only facility of its kind in Trinidad and Tobago as well as the Eastern Caribbean, making it one high in demand and of great importance. Since 2003, the Centre has experienced flooding of varying degrees which has often severely affected its physical structure as well as its community. Therefore the Princess Elizabeth Centre may be considered to represent a very vulnerable unit of the population in Port-of-Spain.

It is hoped that by observing as well interrogating the operations of these two sectors of the population a conclusion indicating Port-of-Spain’s vulnerability will be derived. This will

provide the basis for recommendations on the possible methods that can be utilised to mitigate the effects of flooding in the study area.

2.1 Description of the Study Area- Port-of-Spain

2.1.1 Physical Description

Port-of-Spain is the capital city of Trinidad. It is located to the north west of the island and like other Caribbean capital cities, is a coastal port. It was chosen as the capital mainly due to the flat coastal land and its sheltered harbour away from the North East Trade winds (See Fig 2.1).

Figure 2.1 Map of Trinidad and Tobago showing location of Port-of-Spain.

(Source:<http://www.ezilon.com/maps/north-america/trinidad-and-tobago-physical-maps.html>)



The city consists of flat land at the coastline which was formed by alluvium deposits and covers an area of approximately 13km^2 . The land gently rises approximately between 5ft to 15ft above sea level. This area was once protected by mangrove but has been cleared over a 40 year period to almost nothing. Now tall high rise buildings can be found on the near shore regions. Surrounding the flat land the topography changes and steeply rises into the Northern Range. Here, the land reaches heights greater than 1000ft above sea level. The

Northern Range is characterised by steep slopes with tropical vegetation and endemic species of fauna and flora of great importance. In recent times, urban encroachment along the slopes of the Northern Range has reduced the vegetation cover significantly. These actions have resulted in landslides and contributed to flooding.

Port-of-Spain is drained by two main rivers which originate in the Northern Range and flow in a southerly direction through the city. The St. Ann's River becomes the East Dry River when it enters Port-of-Spain at the eastern boundary where it drains into the Gulf of Paria. The Maraval River is found to the western boundary of the city and empties into the Gulf of Paria as well, near Woodbrook (See Figure 2.2). These two rivers topple their banks quite often resulting in flooding especially in the near shore areas of the city.

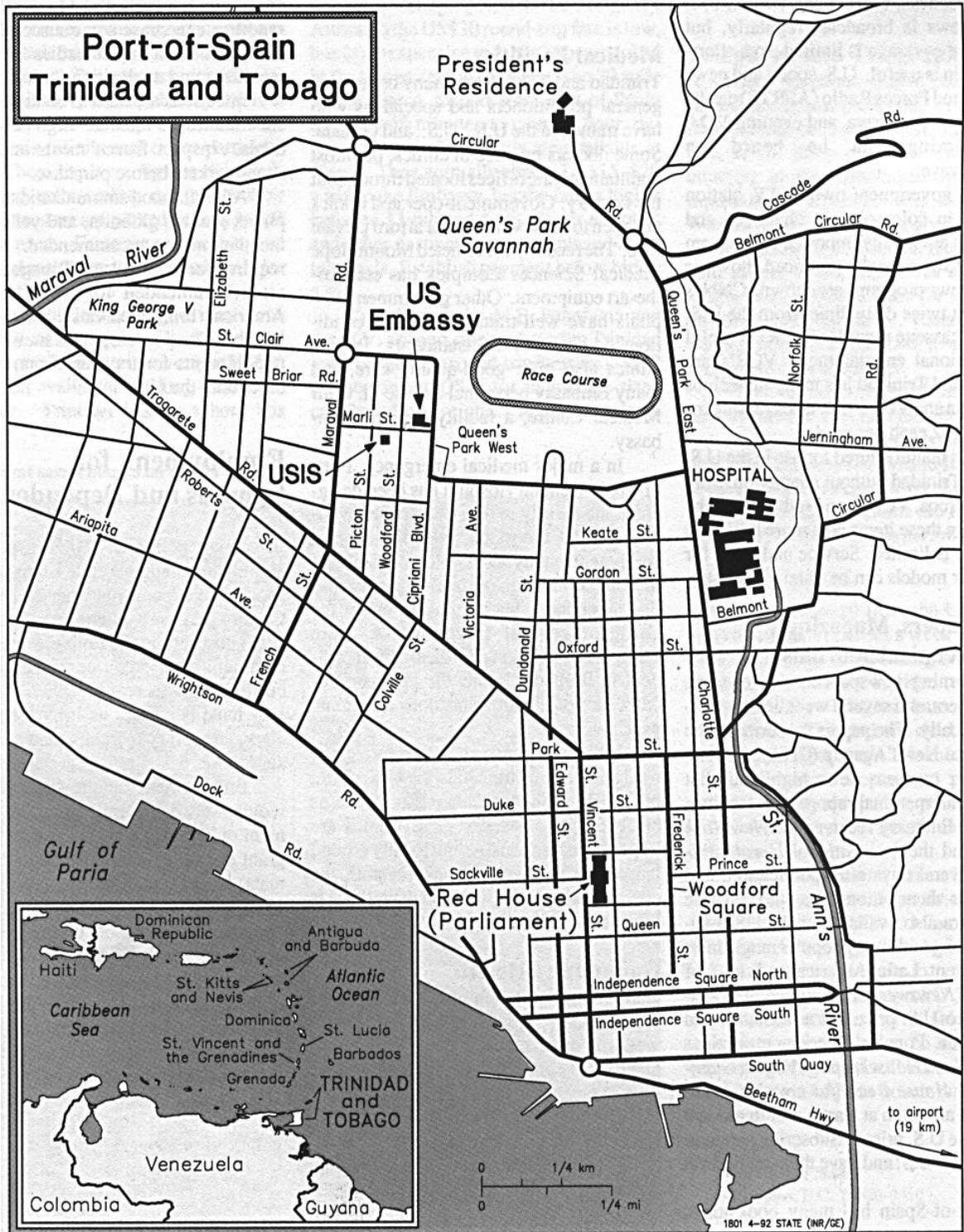


Figure 2.2 Map of Port-of-Spain Showing major landmarks and features.

(Source:http://images.nationmaster.com/images/motw/world_cities/port-of-spain.jpg)

2.1.2 Human and Social Description

The city of Port-of-Spain is home to approximately 49,031 persons (CSO 2002). Given that the city consists of an area of 13km² one can envision the high population density. Therefore it may be suggested that the dwelling population within the city faces greater vulnerability due to its high concentration of persons within the given area coupled with its being juxtaposition between two rivers as well as the Northern Range.

As the capital, Port-of-Spain may be described as the business and financial hub of the country. It serves as the headquarters of many multinational corporations especially oil and gas companies such as British Petroleum and British Gas companies. Other international agencies also have situated their headquarters here such as the United Nations Economic Commission for Latin America and the Caribbean (UNECLAC), the Association for Caribbean States (ACS) as well as the Caribbean Court of Justice. Additionally, Port-of-Spain houses the local judicial headquarters and seat of government for the country; both the Trinidad and Tobago High Court and the parliamentary buildings are housed here as well as various ministries. Thus, Port-of-Spain plays an important role as a prime location for well- established institutions.

Although Port-of-Spain holds no large industries, financial transactions are always occurring. The Central Bank of Trinidad and Tobago as well as the Trinidad and Tobago Stock Exchange can be found in the city centre. Port-of-Spain also serves as a vibrant commercial centre as it has many wholesale and retail outlets. According to the Central Statistical Office (CSO) Port-of-Spain had approximately 5,111 established business in 2009 (see Table 2.1). From Table 2.1 it is observed that of all the municipal corporations,

Port-of-Spain has the greatest number of established businesses. This therefore suggests that Port-of-Spain is the most favourable area to establish and conduct commercial activity. It also suggests that Port-of-Spain dominates the rest of the country in terms of commercial activity. Thus, prevention and mitigation of the impact of hazards such as flooding is essential if the city is to maintain its economic dominance. It also implies that a flood event of sizeable nature can cause devastating damage to the various commercial establishment found within the city.

Table 2.1 Number of Business Establishments by Municipal Corporation 2007-2009

Corporations	2007	2008	2009
City Corporations			
Port-of-Spain	5,284	5,312	5,111
San Fernando	2,025	2,132	2,028
Borough Corporations			
Arima	984	1,038	1,003
Chaguanas	1,563	1,660	1,571
Point Fortin	436	447	437
Municipal Corporations			
Diego Martin	2,210	2,269	2,175
San Juan/Laventille	2,906	2,992	2,948
Tunapuna/Piarco	3,178	3,262	3,164
Couva/ Tabaquite/ Talparo	3,063	3,186	3,158

Corporations	2007	2008	2009
Mayaro/ Rio Claro	650	670	653
Sangre Grande	907	940	922
Princes Town	1,169	1,210	1,201
Penal/Debe	1,528	1,602	1,561
Siparia	1,143	1,165	1,154
Total Trinidad	27,046	27,881	27,096
Tobago	2,451	2,476	2,397
Total Trinidad and Tobago	29,497	30,357	29,483

Source: Central Statistical Office - Business Surveys Establishments Register

This demonstrates the extent to which Port-of-Spain exerts urban primacy. In fact according to Udika (2010) Port-of-Spain has never relinquished its urban primacy mainly due to affordable lands located along the main roads leading to the city as well as the growth in automobile ownership. In 1997, 24 per cent of the total number of jobs was located in Port-of-Spain, while 79 per cent of persons working in the city resided outside of Port-of-Spain (Halcrow Group in Udika 2010). According to the report completed by the Halcrow Group Ltd (2000) approximately 20,000 person trips were made into Port-of-Spain via the eastern transport route (Churchill Roosevelt Highway) during the peak early morning period, translating to approximately 90,000 persons entering the city on a daily basis. In contrast a significant number approximately 12,000 persons leave the city on a daily basis as well. Thus, the city also functions as a transportation hub.

From Port-of-Spain, a range of transportation services can be accessed going in every direction of the island. The City Gate transportation hub managed by the Public Transportation Service Corporation is located on South Quay within the study area. City Gate is well located with the main access routes from across the island converging near to the transportation hub (Audrey Jeffers Highway in the west, Churchill Roosevelt Highway and the Priority Bus Route to the east and the Solomon Hochoy Highway to the south). Additionally, the South Quay area located near the port is the hub for sea transport. The Port of Port-of-Spain is located nearby and is the point of entry for cargo and passenger ships including the service to the sister isle of Tobago. Nearby, is located the ferry service which transports commuters from San Fernando the nation's second city in the south to Port-of-Spain each day. Therefore, the impact of a flood hazard can overwhelm the demand for these services as persons try to make their way in and out of the city. City Gate may therefore be viewed as a potentially vulnerable element to flooding based on its location at South Quay.

There are many groups or sectors of the population which may be identified within Port-of-Spain. These include migrants, the economically disabled and the physically challenged. Many persons have been encouraged to utilize Port-of-Spain as their main port of entry because of its many favourable pull factors. Port-of-Spain is often the first point of entry for many migrants, especially those coming from the smaller islands in the Eastern Caribbean and Guyana. For example, many persons from St. Vincent and Grenada have settled within the city usually in suburban dwelling units close to sources of labour within the city.

Port-of-Spain therefore presents a series of intricately connected services which when affected by a hazard such as a flood can negatively impact its activities such as business, transport, provision of services etc.

2.2 Nature of the Hazard

Flooding hazards continue to be one of the most common and disastrous hazards in the world. They are caused by the inundation of areas by water which previously were without. Flood events may be considered to be one of the most frequently occurring natural hazards in the Caribbean (Udika 2010). In the region, flooding exerts a substantial and consistent influence on the societies of Caribbean SIDS and can create disastrous situations (Ahmad 2007). In Trinidad, flooding over the past 20 years has caused damages to over 1,000 homes and businesses (Ramlal 2008). Within Port-of-Spain the situation is no different.

There are many types and causes of flooding. The main types of flooding include-

1. Riverine flooding. This is caused by rivers toppling their river banks. It is usually accompanied by heavy and intense rainfall occurring in the river catchment.
2. Flash flooding. This type of flooding is characterised by sudden increases in water levels with often equally quick run off periods. It is its suddenness which makes it hazardous and destructive.
3. Coastal flooding. Flooding occurs here as a result of powerful storm surges pushing water inward onto the coastal areas. It is often associated with hurricanes and tsunamis.

4. Urban flooding. The paving and concreting of surfaces retards interception and percolation of water into the ground allowing for pooling and eventual flooding in urbanised area.

The flooding experienced in Port-of-Spain for the most part may be described as flash flooding where the water often rises very quickly and dissipates within a matter of minutes. However, it is still disruptive to conducting business in the capital as almost all streets become conduits for this water. In some cases, the rainfall occurs over the Northern Range in the catchment areas and the rivers become swollen and both the Maraval and St. Ann's Rivers topple their banks as they enter the city, leading to flooding of the riverine type. Flooding has also occurred as a result of the passage of tropical waves and other weather phenomena across the island.

2.2.1 Weather Phenomenon

Much of the rainfall which occurs in the study area is as a result of convectional rainfall production. This occurs whereby heating of the ground causes warm air to rise and upon reaching the atmosphere leads to cloud formation; once dew point is reached rainfall occurs. However, a phenomenon called the westerly convergence has been identified by the Trinidad and Tobago Meteorological Service as being the main cause for rainfall in Port-of-Spain.

The westerly convergence phenomenon is attributed to the readily available heat sources located on the west coast. These heat sources are ideal for rainfall development due to the presence of high acreage of impermeable surfaces (asphalt and concrete) which have

smaller specific heat capacities and as a result heat to greater levels than dry earth or grass covered earth. This concentrated heating is facilitated by the breakdown of the easterly trade winds which usually occurs during the wet season months from August to November (wind speeds less than 7.6km/hr.). The presence of densely urbanised and paved surfaces found on the west coast of the country such as in Port-of-Spain, Point Lisas and San Fernando therefore are highly favourable for the development of the west coast convergence rainfall.

With the concentrated heating, the air close to the surface heats up and this rises, cools and condenses. Moist maritime air from the nearby Gulf of Paria then rushes in to take the place of the air which rose. This in turn heats up and rise, cools and condenses. This cycle continues allowing for large cloud development (cumulonimbus clouds or thunder clouds) over the city. The cycle also develops a reverse or westerly wind or wind coming from the Gulf of Paria. Sometimes this wind becomes strong and finds it way inland to significant distances. It may even move the thundercloud activity from its place of occurrence to locations further inland. This leads to intense yet limited rainfall events which dump large amounts of rainfall, resulting in flooding (*pers. comm.*)

2.2.2 Historical Flooding

Historically, Port-of-Spain has been affected by flooding over a long period of time. Although historical records have been discontinuous, the available records show that flooding has affected Port-of-Spain from as far back as in the 1960s. According to the

hazard database of the Office of Disaster Preparedness and Management (ODPM), flood events of varying degree have affected the capital city for more than 40 years.

In 1963, intense rainfall led to flooding in the capital city with approximately 11 persons including 7 children losing their homes after flood waters swept away their houses. Another example of the catastrophic effects of flooding is given by the case where in 1993 flooding in the city resulted in the deaths of five persons, eight homeless and approximately US\$70,000 in damages (ODPM Database 2011). In 2008, Port-of-Spain experienced some of the worst flooding it had seen in a long time with flood events occurring in September, November and December of that year. The lower portion of the city in the South Quay region was completely flooded after abnormally intense rainfall which occurred over a three day period culminating with flooding on November 18th 2008. One fatality was recorded and thousands of dollars in damages was recorded as well as traffic congestion and transportation issues (See Photographs 2.1, 2.2 & 2.3).



Photograph 2.1 Aerial view of South Quay, Port-of-Spain during Floods of November 2008.



Photograph 2.2 Debris and Flood water near the City Gate Transportation Hub at South Quay Port-of-Spain (November 2008)



Photograph 2.3 View of raging flood waters moving down the East Dry River/ St. Ann's River towards South Quay, Port-of-Spain (November 2008)

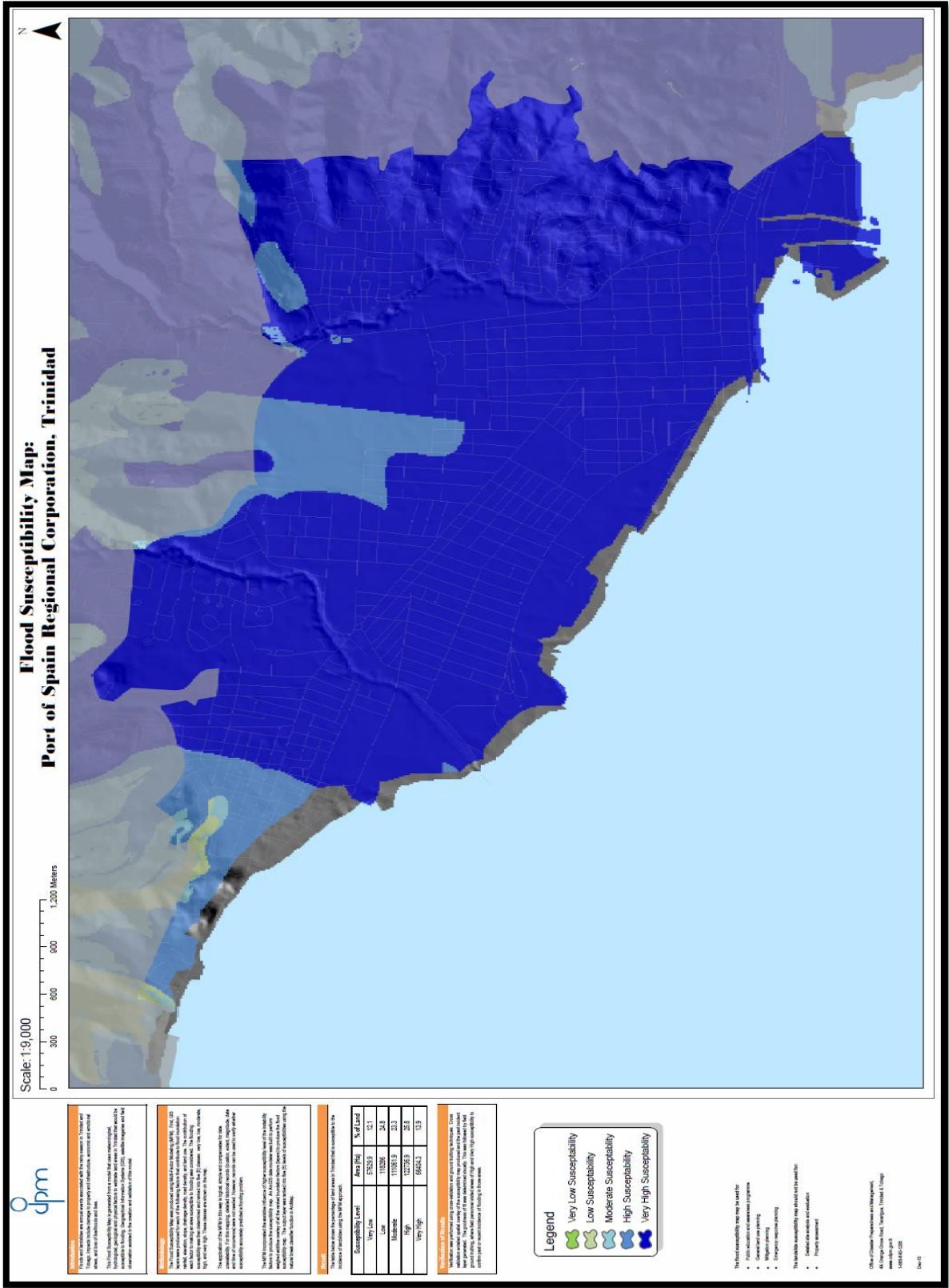


Photographs 2.4 and 2.5 Showing Flooding on November 19th 2011 at Princess Elizabeth Centre

In 2010, similar events occurred as well with persons being trapped in buildings. Most recently, in June and November 2011 (See Photographs 2.4 & 2.5) flooding occurred due to the tributaries of the Maraval River spilling onto the streets and homes of persons in Woodbrook. One such affected was the Princess Elizabeth Centre. Ten children and caretakers had to be rescued and relocated from the Centre after flood waters surrounded the home suddenly (Dowlath 2011). The flood also caused millions of dollars in damages as the operating theatre was also flooded and equipment was lost. Most recently, flooding has occurred in Port-of-Spain in October after more than three days of heavy rainfall over the island.

Given this information, it is apparent that the Port-of-Spain area is vulnerable to flooding. The ODPM through its Mitigation, Planning and Research Unit has compiled these events to develop a Flood Susceptibility Map for Trinidad inclusive of Port-of-Spain (See Figure 2.3). Figure 2.3 highlights the high susceptibility of the Port-of-Spain area and illustrates the high possibility of flood occurrence throughout the city.

Figure 2.3 Flood Susceptibility Map for Port-of-Spain¹



2.2.3 Causes of Flooding in Port-of-Spain

There are many contributing factors to flooding in Port-of-Spain. These factors have worked together to produce some spectacular flood events with debilitating impacts which have resulted in millions of dollars in losses and even deaths. The main factors which have contributed to flooding may be categorised into physical and human induced factors. These include

1. Physical

- a. Topography
- b. Intense rainfall and weather phenomena
- c. Tidal influences

2. Human Causes

- a. Poor Land Use Practices- these include subsistence farming, quarrying, private and public housing and squatter settlements especially in unsuitable lands. Recent land use trends have been dominated by an increase in inadequately managed urban growth patterns. It has been ascertained that the conversion of natural areas for residential purposes has been linked to an annual population growth rate of approximately 1.1%. This has resulted in urban development sprawled along the east west corridor and up the hill slopes of the Northern Range (EMA 2004)
- b. Poor Sanitation. Inadequate garbage collection within the city as well as antiquated drainage systems encourage flooding.
- c. Excessive Surface Runoff. This occurs as a result of clearing of the vegetation cover on the hillsides outside the city area. With denuded slopes,

there are greater quantities and rates of flow of surface runoff allowing for flooding to take place owing to insufficient water capture (overland flow is greater than infiltration and inadequate river systems). Rapid urbanization within the city is the root cause of this. There has been an increase in the number of paved surfaces in recent times both on the coast as well as within the city. This has created a unique situation whereby the increased paved areas in the city have contributed to increased surface runoff which naturally tends to flow towards the sea. However, building on the coastline has raised the coastline retarding the rate of run off into the sea, leading to ponding and flooding within certain areas such as Woodbrook.

- d. River Morphology. The river morphologies of both the St. Ann's River and the Maraval River have been altered naturally and through human intervention over the years. In order to accommodate land use developments and to alleviate some of the flooding issues, the river courses have been concreted and straightened to increase run off rates. Additionally, as with all rivers the morphologies have naturally changed within the flood plain. However, the presence of land developments on the flood plain has resulted in flooding and costly hazard impacts.

The natural factors which cause flooding are difficult to mitigate against. However the human induced causes of flooding can be reduced through both structural and non-structural mitigation measures. Port-of-Spain faces an all too familiar situation where it must seek that balance between competing land use developments and maintaining the physical environment so that it can adequately perform its functions with respect to runoff

and drainage. The increase in these human activities at alarming rates has resulted in the increased flood potential of the city of Port-of-Spain.

2.4 Conclusion

This chapter has set the scene for a better understanding as to the characteristics of the study area. Many of the vulnerable elements have been identified, highlighting the effects of flooding on them. The physical characteristics of the city's location and topography have influenced the growth of the city. The location has also allowed for the growth of the area as a commercial centre with paved areas and tall buildings where various types of commercial activity are carried out. This dense urbanisation has also influenced the type of weather phenomenon which affects Port-of-Spain resulting in heavy torrential downpours. Both physical and anthropogenic features work together to cause flooding to occur affecting the city's population. One may therefore suggest that there is a deeply intertwined connection amongst all the characters involved to produce an area that is vulnerable to flooding. Therefore it is worthwhile to understand those areas which are highly vulnerable to the impact of flooding in order to recommend possible measures which may reduce this vulnerability.

Chapter Three – Methodology: Conducting the Vulnerability Assessment

3.0 Popular Methodologies for Conducting a Vulnerability Assessment

Vulnerability assessments play a critical element in disaster risk management. As mentioned in the previous chapter, identifying those vulnerable elements within a community or population can assist in the formulation of proper disaster risk reduction strategies to reduce these vulnerabilities or provide coping mechanisms for at risk populations. According to Winrockⁱⁱ International India (2011) the primary objective of undertaking a vulnerability assessment is to anticipate the problems and possible solutions to save lives, protect assets, reduce impact and facilitate speedy recovery. Conducting a vulnerability assessment can achieve this in that it allows decision makers, governments and communities to make risk based choices to reduce vulnerability through mitigation against hazards and prepare effective response and recovery measures. Thus vulnerability assessments are essential in disaster risk reduction.

There are many types of vulnerability assessments and methodologies currently being employed. A wide range of organisations involved in security and environmental services have developed different assessment methodologies. Some assessments include matrices; some are dependent on spatial data while others use simpler tools. Overall, the main goal is to thoroughly understand the level of exposure, impact, the nature of the hazard event and sensitivity of the community to the hazard impact.

It has been found that understanding vulnerability cannot be done from a distance or based purely on statistical data and historical information; one must engage the populations or communities which are perceived to be at risk or vulnerable. In the 1990s when mainstream disaster risk reduction took off, many institutions became involved in conducting vulnerability assessments (HFA 2007). At first, before accepted methodologies evolved, information for the vulnerability assessments were based mainly on existing information such as statistics and historical information on hazard impacts etc. However, it was found that in many instances once gathered and analysed, the results did not prove fruitful and the ensuing mitigation strategies and coping mechanisms did not fit with the needs of the community and as such there was limited or no support for the projects. As a result, the projects failed or were abandoned. In order to bridge that gap and make the resilience building initiatives more relevant vulnerability assessments which worked with the communities were developed.

Two of the most popular types of vulnerability assessment tools are those utilized by the International Federation of Red Cross and Red Crescent Societies (IFRC) and the National Oceanic and Atmospheric Association (NOAA). The IFRC has developed a tool called the Vulnerability and Capacity Assessment (VCA) while NOAA has developed and utilizes the Community Vulnerability Assessment Tool (CVAT). These two are often combined or used solely by agencies and viewed as being successful in truly understanding and therefore assessing vulnerability at the community level.

According to the IFRC (2007), VCA is defined as a method used to investigate the risks that people face in their locality, their vulnerability to those risks and their capacity to cope with and recover from disasters. This tool is targeted for use by the National Societies to

assist communities in building resilience against disasters. The general methodology involves a twelve step process from planning to completion (IFRC 2007). The actual VCA is carried out in Phase Two; it follows the planning and training phase and precedes Phase Three, the action phase. It must be remembered that the outcome of such an exercise is to make recommendations aimed towards building capacity within the affected community. The main components of the Assessment phase include

1. Acquiring an understanding of the community/ study area. This supports the choice of community to carry out a VCA. Having an understanding of the community determines the priority level for the completion of the VCA as well as identifies the tools to be used.
2. Identification of the Assessment Tools. This includes identifying those processes which will yield best results based on the environment or community which the team will be going into. Some of the tools proposed include, secondary sources, questionnaires, direct observation, spatial maps, interviews, focus groups, historical timelines, transect walks and problem trees. The VCA handbook suggests utilizing a combination of these tools or all of them as possible in order to be very thorough in one's assessment.
3. Choosing the most appropriate tool. The choice of tools will be based on what is most appropriate to obtain the most relevant information from the community. This is often based on the characteristics of the community.
4. Field work. Once the tools have been chosen and preparation work has been completed the actual field work takes place to gather data.
5. Data analysis. This involves putting the data in the most relevant manner to be understood. It is considered the process whereby the data speaks to the individual. This

allows for the VCA team to formulate accurate conclusions and reflect what is occurring in the community. For example, prior knowledge shows that persons continue to build near a cliff prone to landslides. The perception may be that these people are ignorant of their vulnerability and the threats which they face. The data gathered and through its analysis may reveal that the people are aware of their situation but choose to stay there due to other factors such as lack of land tenure. Therefore the analysis of the data will provide answers to some of the behaviour of the community.

6. Presentation of results to the community. This involves providing the findings of the vulnerability assessment to the community for their approval and support. This allows for any wrong perceptions to be corrected.

7. Recommendations and Strategies. This phase allows for the building of resilience and the developing of coping mechanisms for the community's vulnerable elements.

It must be noted that, in many instances the recommendations have very little to do with disaster preparedness strategies. In many cases, those factors which promote or cause the vulnerability are outside the realm of disaster management and therefore the strategies which must be implemented require assistance from outside the National Society.

Similarly, the Community Vulnerability Assessment Tool (CVAT) seeks to address the vulnerability of communities, but does so based on assessments of various sectors within the community. This assessment is different in its methodology. The following describes the methodology for conducting the CVAT.

1. Hazard identification and prioritization

2. Hazard analysis
3. Critical facilities analysis
4. Social Analysis
5. Economic Analysis
6. Environmental Analysis
7. Mitigation and Opportunities Analysis

According to NOAA, this assessment owes its merits to the fact that it seeks to link the social, economic and environmental aspects or sectors of the community. The key to the success of this method is the adequate collection of data from each of the sectors. The analysis depends on data such as inventories of critical facilities, economic assets and environmental units. Included also, is the spatial extent of these elements such as the extent and location of the hazards, location of banks, commercial centres etc. The data to be collected requires great detail. The main outputs of the CVAT are a series of maps which are derived using Geographic Information Systems (GIS) software. These maps show the spatial interconnection between the various analyses. For example, it shows the relationship between the flood hazard and the economic sector. The intersection between the economic elements such as the location of the Central Bank and the location of the flood highlight the possibility of this and other buildings being affected by flooding. The attribute data will corroborate this analysis as buildings constructed according to strict codes or which conduct no business on their ground floors may not necessarily be affected by the hazard.

In comparing the CVAT and VCA methods it must be noted that both aim to assess vulnerability at the community levels. However, the approaches differ. The VCA methodology seeks to include the community by engaging them in discussion about their vulnerability. In contrast, the CVAT method is based on more data gathering especially where the data has some spatial aspect to it. The CVAT's tools are more sophisticated in the use of GIS mapping to highlight and illustrate vulnerabilities based on location and the attribute data related to that location i.e. it is data dependent. In developing countries that data is often inaccessible. An additional merit is that the spatial output provides users and decision makers with a visual from which the data can be manipulated to create scenarios and thus derive various outcomes and conclusions. This method is therefore advantageous in its ability to adapt to changes in the community.

The VCA method is truly community based and must have the support of the community. It allows the VCA team to get involved with the community and understand issues which may not have been identified in the CVAT method such as relational and social issues amongst the various groups. Behavioural attitudes towards disaster risk management are easily highlighted within the VCA method. The CVAT method because of its reliance on the use of GIS systems has not been able to integrate behavioural as well as other social observations into its analysis. Another advantage of the VCA methodology is the many tools available to conduct the analysis. However, within this there is the disadvantage of not choosing the appropriate tools to meet the specific needs of the study area. Overall, the CVAT method is ideal for a larger community and where data is readily available whereas the VCA works well in a smaller spatial area and provides a more intimate analysis.

3.1 Methodology used to collect data within the Study Area

In this study, aspects from both methodologies were drawn upon to conduct the assessment. The vulnerability assessment for the study area is based on prior knowledge of the hazard impact of flooding on the Port-of-Spain area. From the CVAT methodology, the aspect of a sectorial analysis was chosen. Given the vast and varying activities and functions of the city of Port-of-Spain as well as the limited time frame in which to complete the study, certain sectors were selected to be assessed. In order to choose the highest priority sectors historical data was collected and a time line of flood occurrences and impacts was sourced from various newspaper archives as well as the ODPM which has a database of flood events and some of the impacts. The sectors were chosen based on the priority which they play in the city's functioning, the impact of flooding based on location as well as income generation. Thus, the economic sector was chosen as an indicator of flood vulnerability. The category of special populations for the purpose of this study is defined as those persons who are physically challenged in that they are affected by orthopaedic or spinal injuries and attend the Princess Elizabeth Centre. This group was chosen because of the repeated effects of flooding which it has experienced. The CVAT method was therefore used in identifying the most relevant aspects of the community to be assessed based on priority.

One major limitation of this study was the time frame which was available for field work. The shortened period did not allow for a more thorough investigation of the factors affecting the vulnerability of the sectors. As a result a smaller subset of the entire downtown Port-of-Spain area was chosen. This area is perceived as the area which is perennially impacted by flooding. The area extends in an easterly direction towards the

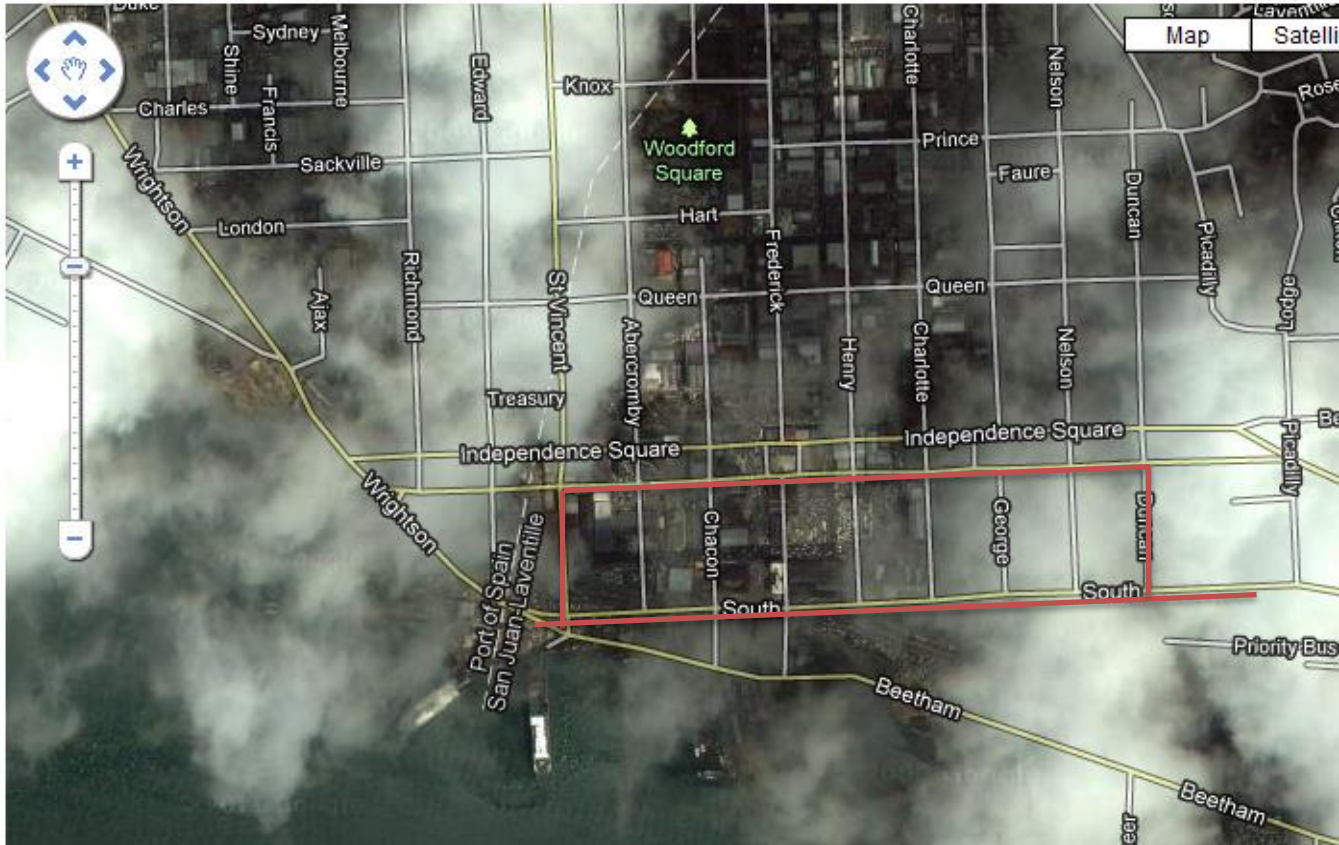
East Dry River and westerly towards the Maraval River. It is bound by Independence Square to the North and South Quay in the south (See Figures 3.1 & 3.2).

In order to acquire the necessary data for the vulnerability assessment a series of tools similar to those highlighted in the VCA methodology were utilised. Initially a transect walk was taken through the study area. This assisted in identifying the type of commercial activity that was taking place within the study area, the spatial layout and significant features of the area which might affect their vulnerability.

The transect walk also assisted in providing a background into the type of existing physical structures and infrastructure as well as some insight into the best approaches for data gathering. Along the transect walk, photographs of the study area were taken. Once the transect walk was completed, a questionnaire was developed to be administered to the businesses within the study area. The aim of this questionnaire (Appendix I) was to acquire information about the following:-

1. The nature of the businesses in the study area.
2. The impact of flooding on their business
3. The type and monetary value of losses due to flooding
4. The level of preparedness of the businesses
5. The perception of the businesses with respect to flooding and flood mitigation.

Figure 3.1 Satellite Imagery showing the section of Downtown Port-of-Spain where data was collected and transect walk done (highlighted in red)



The questionnaire consisted of twenty-two open and close ended questions. In order to achieve the best possible response, businesses which were located in the flood impact zone were administered the questionnaire. Not all businesses were sampled; the ones chosen were located along the main thoroughfare i.e. South Quay from St. Vincent Street to Duncan Street, as well as those which had permanent structures to carry out business. This resulted in twelve businesses of varying type of commercial activity; firm size and ownership being questioned. Therefore a wide range of answers were generated in response

to flood vulnerability. To support the questionnaire an interview with the President of the Downtown Owners and Merchants Association (DOMA) was conducted. This interview was done to obtain an overall view point of the business community on flooding and its impact on business within the Port-of-Spain area. The results of the questionnaire were interrogated using the SPSS software.

For the assessment on the vulnerability of the services provided to the physically challenged community, an interview and site visit was made to the Princess Elizabeth Centre. The impact which the Centre faces has been most costly in terms of the value of property damage as well as the delay in its ability to perform its functions. The interview was conducted with the Manager of the Centre, 'the Matron' as she is called. The aim of the interview was to gain a first-hand knowledge of how the Centre has been affected by flooding, the impact of the flood and the resulting losses. The interview also intended to identify the local coping mechanisms for assisting the Centre in its flood preparedness planning. The site visit yielded evidence of the impact of the last flood event which took place in June 2011.

The data collected from the interviews were analysed using qualitative methods. Qualitative methodologies aim to analyse various behavioural issues. It analyses the level of knowledge people have and how this knowledge affects their actions. It also looks at people's behaviour given various situations or circumstances as well as the effect of culture on the behavioural patterns. The method of content analysis was used whereby transcripts of the interviews were analysed for key phrases which pointed or suggested their levels of vulnerability. Content analysis is a research tool used to determine the presence of certain words and phrases within text. The researcher looks for relationships and trends within the

text amongst the chosen categories of words. This allows for inferences to be made about the messages found within the texts. It allows for relationships between cause and effect to be identified, for example.



Figure 3.2 Satellite Imagery showing Princess Elizabeth Centre (green star) in relation to the Maraval River (blue arrow). The red line denotes the transect walk

For this analysis the use of the Nvivo software was utilised. The software is a qualitative data management tool which allows the user to manage a wide range of data sources such as audio, literary and photography. The data is analysed through the use of nodes or themes related to the data under scrutiny. In this case the two aforementioned interviews were interrogated using this software. The transcript (See Appendix II) of each interview was

dissected under specific themes or nodes. This allowed for simple analyses of correlation between the themes as well as categorising of the interviewees responses under these themes. The main themes which were used to assess flood vulnerability were

- a. Perception- this included flood perception and causes of flooding
- b. Flood Awareness- this identified how aware the interviewees were aware of flooding as it related to their situation.
- c. Flood Preparedness- this looked at the actions or lack thereof taken to reduce flooding.
- d. Extent of Flooding- this identified the effects of flooding, both physical and monetary as far as possible.
- e. Flood Vulnerability – this looked at those issues which led to greater exposure to flooding. It included sub- nodes of Environmental Degradation, Infrastructure and Planning.
- f. Solutions to Flooding- this theme identified those recommendation or strategies which were interviewees were currently employing or have considered.

Therefore through a combination of mixed methodologies inclusive of quantitative and qualitative data conclusions about the vulnerability of the targeted sectors were derived. Appropriate recommendations could now be suggested based on the responses to the research questions.

Chapter Four- Presentation of Data and Analysis

4.0 Introduction

The data once collected was analysed using various techniques. These included the use of the Statistical Package for Social Sciences (SPSS) as well as Nvivo software. SPSS is a software package which assists in providing simple analyses of statistical data such as correlation, average as well as standard deviation of the data. Quantitative data yields information which points towards trends or indicators such as the number of businesses affected, the type of effects and the losses incurred. These can be used to infer the extent of vulnerability.

Qualitative data sets on the other hand do not lend themselves easily to statistical representation and must be analysed in a different manner. Therefore the other data sets such as the interviews and photographs were analysed using the Nvivo software and through a photographic analysis respectively. These tools allowed for the data to be processed into a format which could provide indicators or suggest answers to the main research questions regarding the vulnerability of the highlighted sectors in Port-of-Spain.

4.1 Quantitative Data Presentation – Results of the Questionnaire

As previously mentioned, the vulnerability of the commercial sector was assessed using a questionnaire directed at businesses located in frequently flooded areas. Twelve businesses were administered the questionnaire. The responses to each of the questions were put into a table where they were prepared for coding within the SPSS software as well as Microsoft

Excel spread sheets. The results of the questions were then depicted as graphs for analysis as well as provide visual answers to the questions asked. The following graphs illustrate the answers to the various questions posed to the business owners.

Figure 4.1 Gender of Business Persons

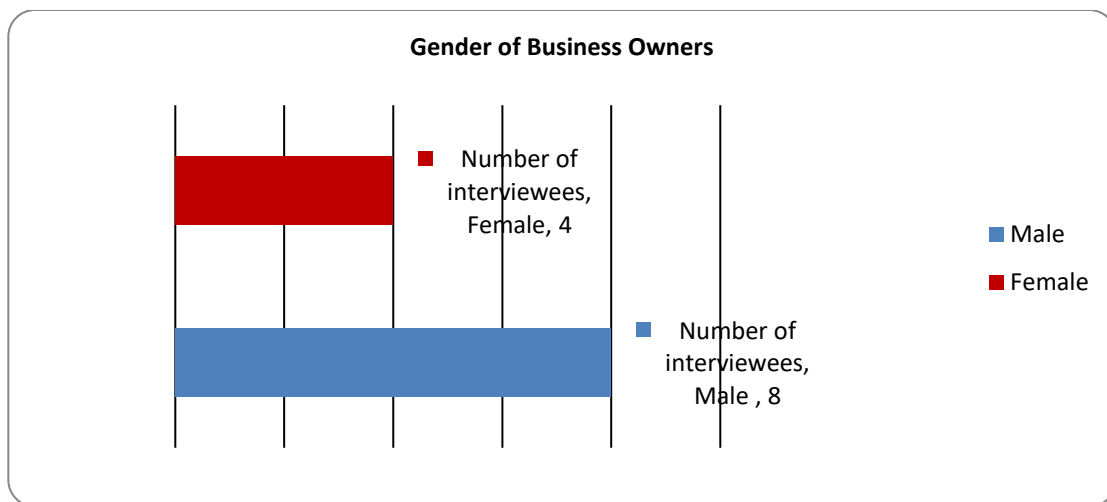


Figure 4.1 shows the gender of the participants of the questionnaire. Of the twelve participants the majority were male totalling 8 persons while the remaining were female. Figure 4.2 illustrates the longstanding involvement of the business owners in their various activities. Approximately 8 persons were involved in their respective businesses for more than 10 years. This demonstrates their commitment to the business activity in which they are involved. The twelve businesses that were questioned had been at their current location for varying periods of time. The majority of businesses were located within the study area for more than ten years. In Figure 4.3, the pie chart shows that three quarters of the

businesses had been at their present location for more than 10 years¹. This suggests a certain level of satisfaction with these present locations.

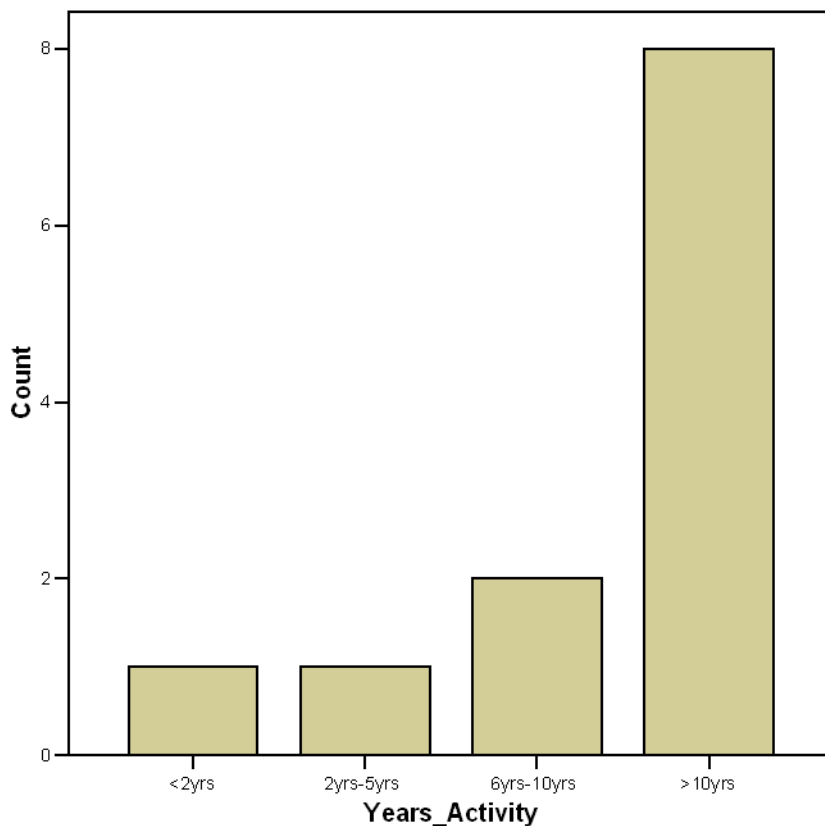


Figure 4.2 Number of years involved in business activity

¹ One business identified that they had been at that location conducting business in shipping since the early 1800s.

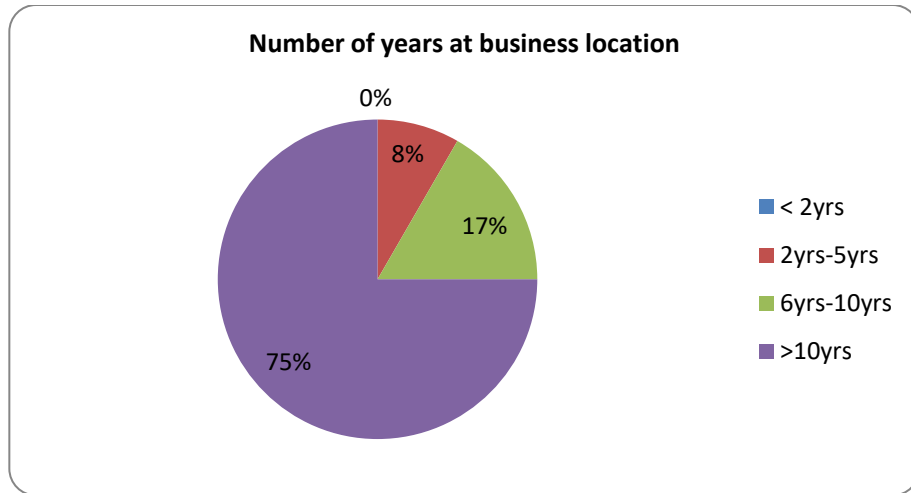


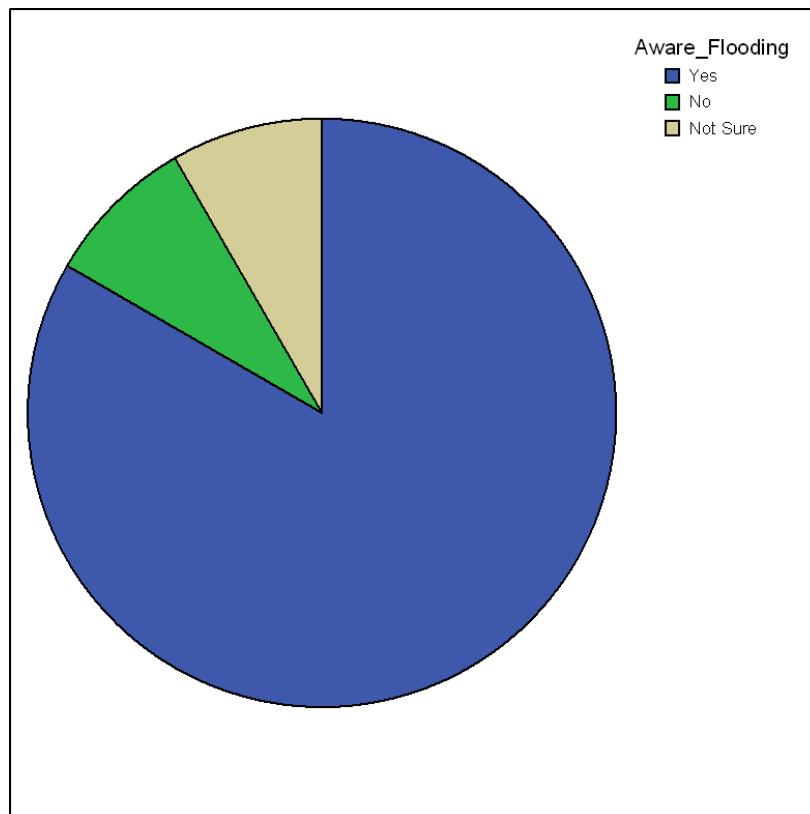
Figure 4.3 Number of years at current business location



Figure 4.4 Bar Graph showing reason for choosing business location

Many of the businesses cited a wide range of reasons for their present location as demonstrated in Figure 4.4. Amongst the most popular reasons was the greater accessibility to shoppers/ high pedestrian traffic by shoppers. Secondly business owners identified the close proximity to the main transportation hub at City Gate being one of the main reasons for them choosing this location. The availability of good rental agreements was also a favourable reason for the business owners' choice of location. Two businesses cited the close proximity to other facilities such as the port and major roads as a major deciding factor in choosing that location. Thus one may surmise that Port-of-Spain role as a major commercial centre holds true based on the responses of the participants.

Figure 4.5 Awareness of Flooding within the study area



From the pie chart in Figure 4.5, it was noted that almost all the respondents were aware of the flooding issues which existed within the area. One suggestion is that the location is highly favourable in spite of the possibility of flooding. Alternatively, businesses choice to locate in the flood prone areas is an indication of the shortage of commercial space for small and medium sized firms.

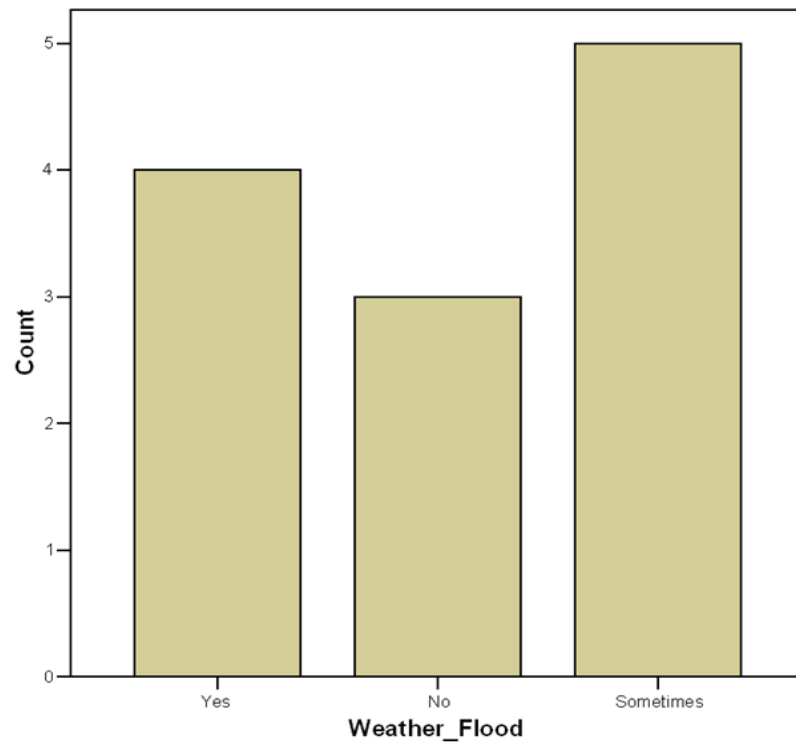


Figure 4.6 Persons who listen to weather report

The bar graph in Figure 4.6 highlights business owners' reaction to weather reports. Of the twelve businesses interviewed, the majority of them were not consistent in listening to the weather report in order to have early warning to prepare for possible flooding in the city. This therefore presents a situation whereby the business owners are more vulnerable to possible flooding due to a lack of awareness.

All the businesses interviewed have been affected by flooding in some manner as illustrated in Figure 4.7. This supports the view that flooding is a major problem within Port-of-Spain. When asked how they were affected, the businesses owners presented various combinations of effects. The pie chart in Figure 4.8 shows the various effects of flooding on commercial activity within the study area. Businesses cited the loss in sales as the most frequent effect of flooding. This was followed by loss of stock. Of the possible responses that could be given, a significant number of businesses cited all of the above as a response (all possible effects). In a few cases, business owners identified their building being affected as one of the effects of flooding.

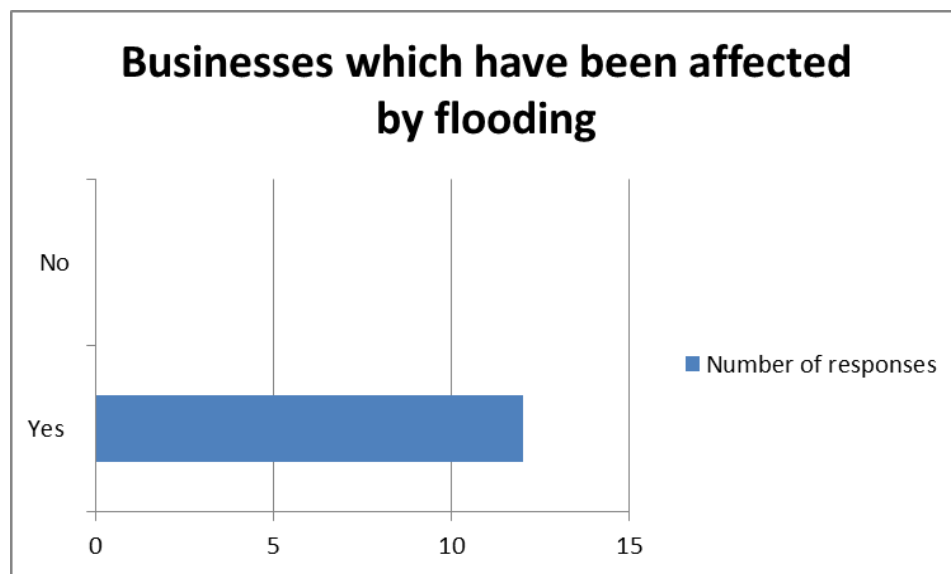
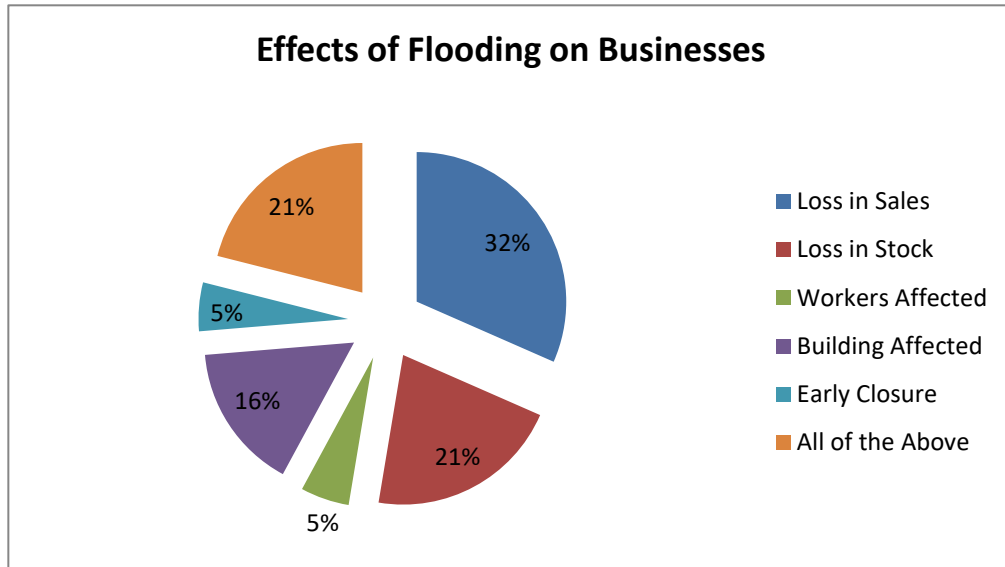


Figure 4.7 Businesses that have been affected by flooding

Figure 4.8 Effects of Flooding on businesses



These results demonstrate that flooding has impacted commercial activity to a significant degree in Port-of-Spain. This indicates that the businesses are highly susceptible to the effects of flooding.

Another indicator of the impact of flooding on the commercial sectors is the record of the actual losses which businesses incurred. The ability to quantify the losses sustained supports the view that flooding events adversely affect the business community. It also supports the importance of having effective flood mitigation measures in place. The extent of losses reflects the level vulnerability of the businesses and is directly related to recovery time. From Figure 4.9 it is noted that two thirds of the businesses actually recorded the losses which they incurred during various flood events. Many of the business owners identified their accounting sections and insurance as the bodies who recorded their losses.

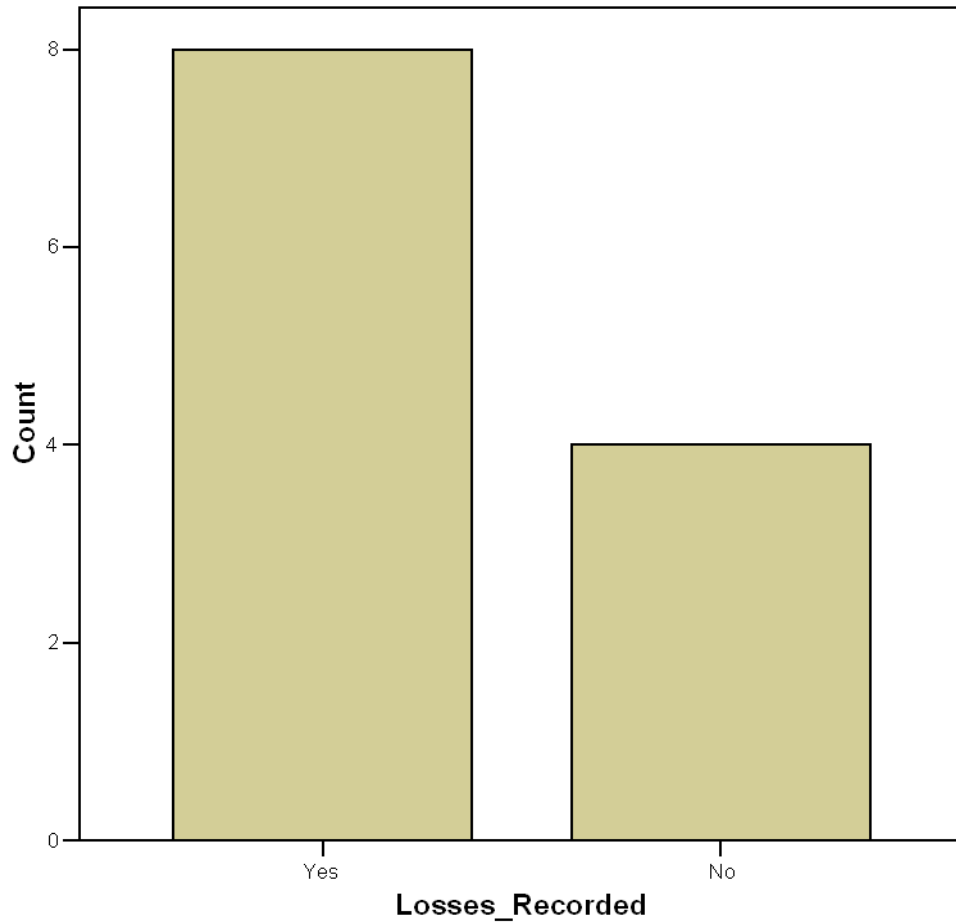
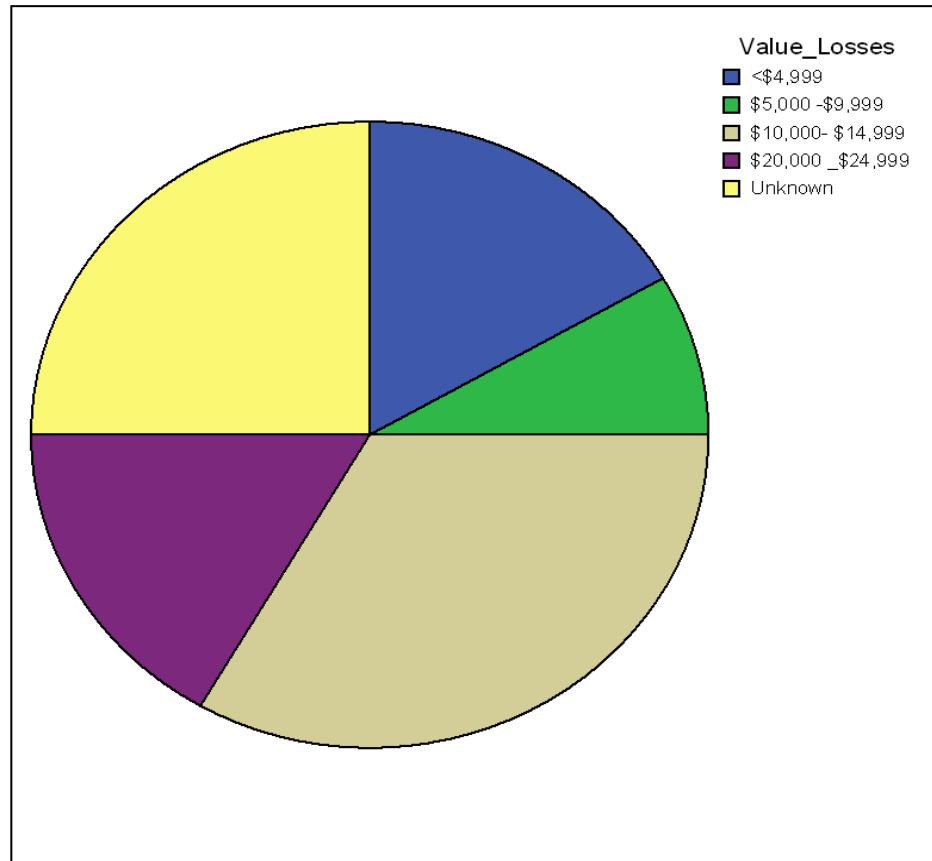


Figure 4.9 Number of Businesses who had their losses recorded

Figure 4.10 illustrates the monetary value of damages incurred by the businesses interviewed. Business owners were asked to approximate the value of losses based on the last major flood event which affected their business. One quarter of the businesses was unable to provide a monetary value of what they had lost due to flooding. The largest group of business owners estimated damages approximating between TT\$10,000 –TT\$14,999. Two businesses recorded losses between TT\$20,000 TT\$24,999 during a single flood event. Given the evidence provided by the pie chart it can be deduced that businesses in

Port-of-Spain incur significant damages during flooding. This suggests that the businesses are very vulnerable to flooding hazards.

Figure 4.10 Approximate losses in monetary terms of the last flood event which affected the business



Given the effects of flooding on businesses within the study area and the losses incurred, a preparedness plan or some action to prevent these recurring issues is important. Figure 4.11 shows the responses of the business owners when asked if there was a preparedness plan for flooding. Ten of the respondents identified that they had some plan in place or actions which they carried out when faced with flooding. One business said they had no plan and another was not sure if the business had a plan.

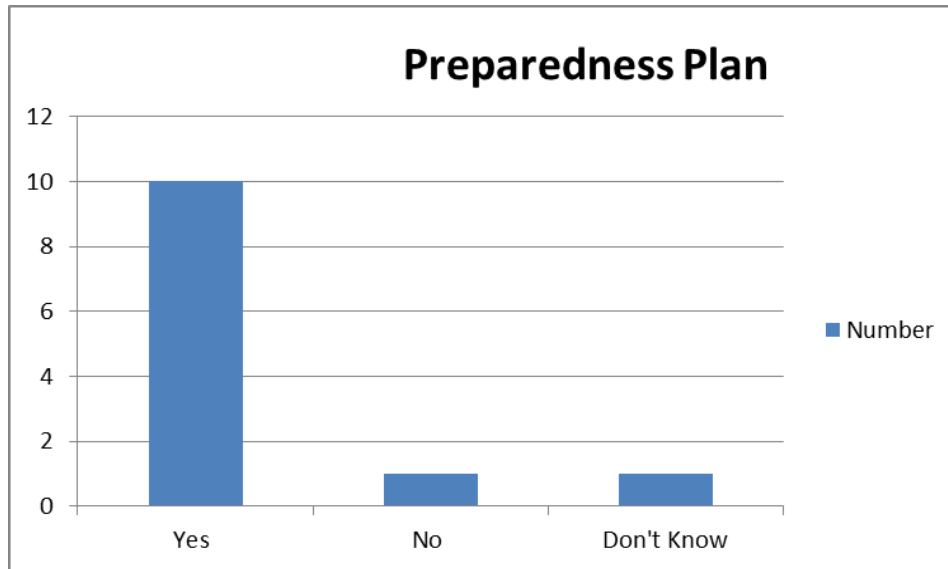


Figure 4.11 Business Owners who have Preparedness Actions

According to the businesses surveyed, the most favoured action was to move goods found on lower shelves to higher ground or spaces above flood waters (See Figure 4.12). Five businesses cited sandbags as their means of preparation against flooding. Some of the larger businesses had established structural measures within their buildings. Structural measures included altering of building construction such as raising floors, steps, rectifying drainage etc. Two businesses stated that they closed the doors of the business in order to block flood waters from entering. The remaining businesses had pumps to get water out in case of the business becoming flooded as well as did routine building maintenance such as roof repairs etc. Figure 4.12 indicates that many of the businesses were prepared in some manner. The measures taken demonstrate that it is imperative that preparedness measures are taken in order to safe guard against the impact of flooding on the businesses.

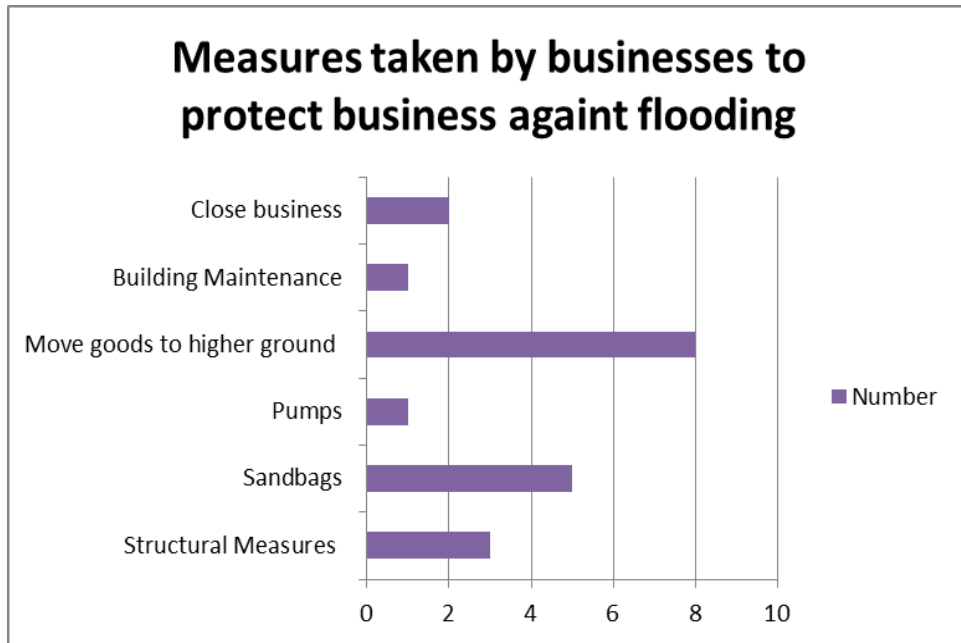


Figure 4.12 Measures taken by Business Owners during flooding

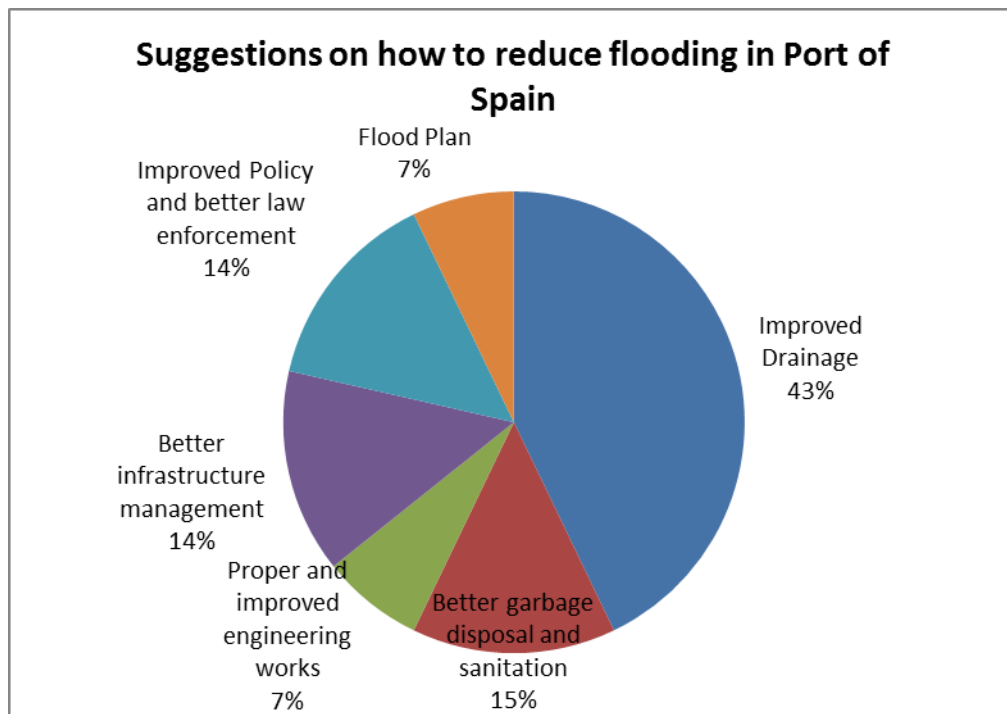


Figure 4.13 Pie Chart showing business owners' suggestions to reduce flooding in Port-of-Spain

When asked how flooding could be reduced in Port-of-Spain, businesses gave a wide variety of answers with improved drainage being the most popular method to reduce flooding. Better infrastructure management, improved garbage disposal as well as law enforcement were seen as equally good means of reducing the issues of flooding in the city. One person each highlighted the need for a flood plan and improved engineering works as possible solutions to reduce the problem of flooding. These answers suggest that the business owners, view flooding as a serious issue affecting Port-of-Spain. It also shows that there is the view that improvements can be made to reduce the vulnerability to flooding and therefore build capacity.

4.2 Photograph Analysis

4.2.1 Photographic Analysis of the Commercial Activity

Photographs were taken throughout the study area to illustrate the importance and wide variety of commercial activity in the city as well as illustrate the vulnerabilities of the city to flooding which affect the commercial sector. Photos, 4.1, 4.2, 4.3 and 4.4 show some of the businesses located along South Quay. From the photos it can be seen that there is a mixture of business located in the South Quay area. There are small businesses owned by immigrants selling mainly clothing and haberdashery goods. They are located opposite the main transportation hub - City Gate. As one walks westwards the businesses change with many well-known and well established businesses such as chain furniture and jewellery stores (See Photo 4.4). Pedestrian traffic is also high as persons move from City Gate to the Central Business District of the city.



Photograph 4.1 Businesses along South Quay (North) Port-of-Spain



Photograph 4.2 City Gate- Main Transportation Hub, South Quay (South) Port-of-Spain



Photograph 4.3 View of Henry Street and small businesses near South Quay



Photograph 4.4 Pedestrian traffic along South Quay



Photograph 4.5 Ponding of water along road way after short rainfall

Photograph 4.5 illustrates the inadequate or antiquated drainage which exists within the city. The picture represents what happens after a short period of rainfall i.e. ponding of water on roadways etc. as mentioned previously, some of the main issues causing flooding in the city of Port-of-Spain include inadequate drainage as well as poor sanitation. Photographs 4.6, 4.7 and 4.8 illustrate this.



Garbage filled drain which prevents water from draining off of roads.

Photograph 4.6 Storm drain filled with garbage

The photos show garbage clogged drains as well as overgrown storm grates which should allow water to pass from the roadway and pavements and into underground drains. These pictures support the views expressed by the businesses in Figure 4.12 in which business owners made suggestions as to how flooding can be reduced. The problem of poor drainage was highlighted as being one of main components which needs improvement. One may suggest that this problems stems from a lack of law enforcement for littering as well as poor sanitation collection and disposal of garbage in Port-of-Spain. These factors serve to increase the potential for flooding in the city.

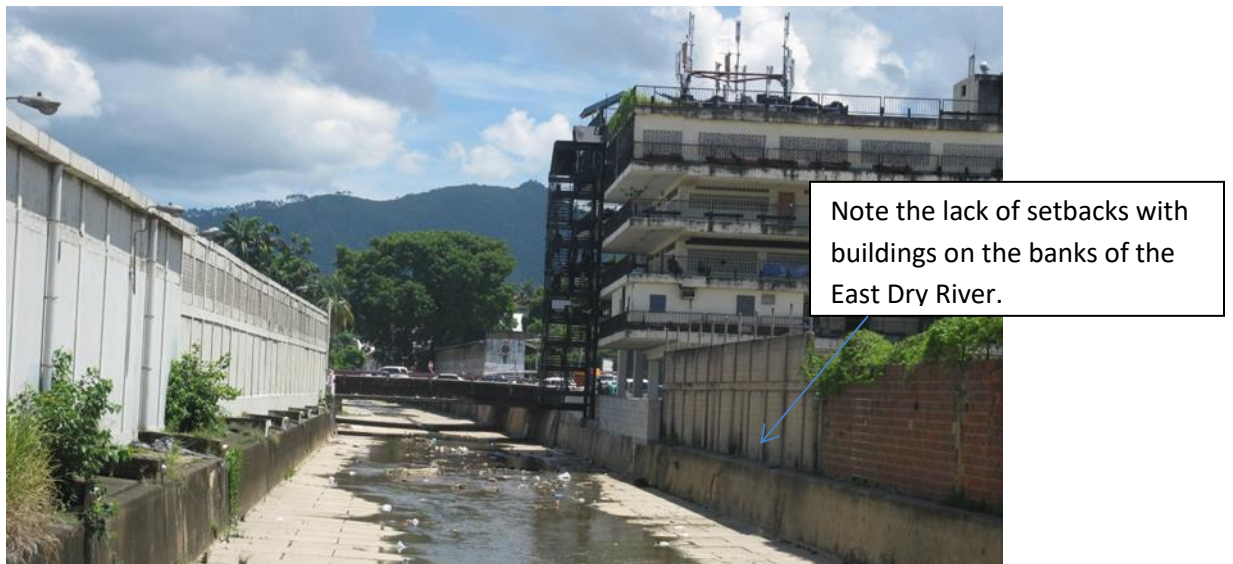


Photograph 4.7 Overgrown storm drain grate



Photograph 4.8 Storm drain filled with garbage

Another issue which has increased vulnerability is the close proximity of businesses to the banks of the rivers. In Photographs 4.9 and 4.10 it can be seen that certain buildings are located along the banks of the East Dry River. Additionally, roadways and bridges which form the main arterial roads of the city traverse the river. Thus when the river is in spate and topples its banks as it has been known to do, business places are flooded and transportation becomes difficult as the roadways become new waterways.



Photograph 4.9 Northwards View of the East Dry River. Note the presence of building on the river banks as well as low bridges across the river.

These photographs highlight the issue of unregulated planning within the city. Buildings are located adjacent to the East Dry River within the flood plain of the river. This location allows for the businesses as well as other activities to be more vulnerable due to their location. The low hanging bridges compromise use of the bridge when the river floods. This supports the views expressed by the business owners that better planning and management is necessary to reduce the problem of flooding in Port-of-Spain.



Photograph 4.10 Seaward view of East Dry River. Note the presence of buildings on either side of the river channel as well as low bridges across the waterways.

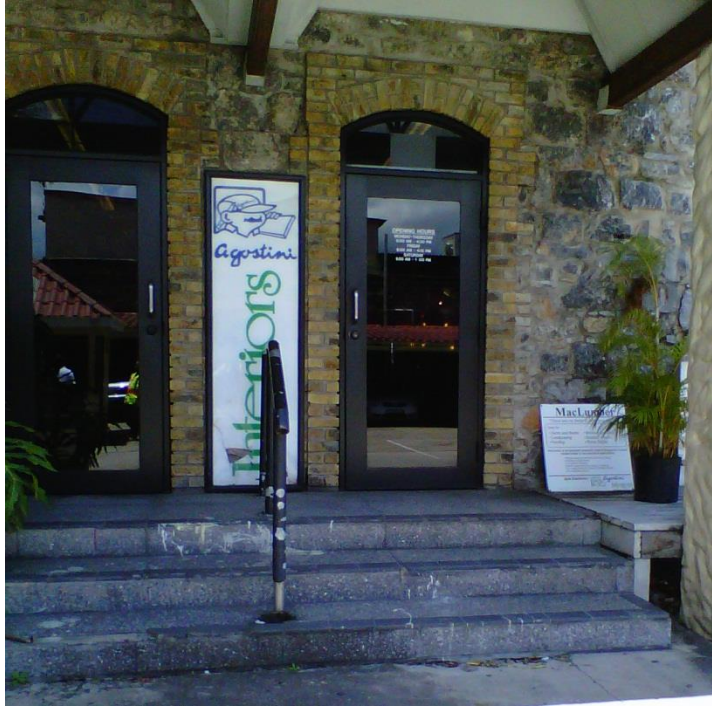


Photograph 4.11 Sandbags positioned at doorway at business on St. Vincent Street, Port-of-Spain

Photograph 4.12 Alternate view of sandbag positioned at doorway of business on St. Vincent Street

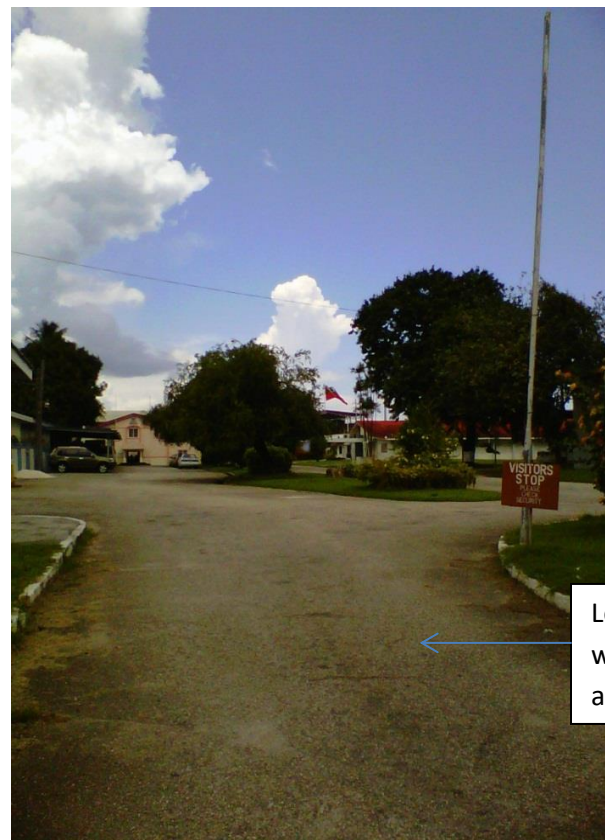


Photographs 4.11, 4.12 and 4.13 illustrate the measures which have been undertaken by business owners to protect their businesses from flooding. In Photograph 4.11. and 4.12, these buildings are located on lower St. Vincent Street. This business has permanently placed sandbags at the one of its entrances in preparation for possible flooding. In Photograph 4.13, this business has taken structural measures by raising its showroom approximately 3 feet above the road level so as to prevent flood waters from entering the showroom and causing damage to its stock of lighting fixtures etc. These photographs clearly suggest that flooding is a definite issue in Port-of-Spain. It also highlights the level vulnerability of the businesses which are unable to mitigate against the impact of flooding in the city.



Photograph 4.13 Business raised floors to prevent water from entering.

4.2.2 Photographic Analysis of Princess Elizabeth Centre, Woodbrook



Location provides flat land and wide expanse ideal for accommodating patients.

Photograph 4.14 Compound of Princess Elizabeth Centre

The Princess Elizabeth Centre (PEC) is a Centre for physical challenged persons. It was founded in 1953 and is the only one of its kind in the Eastern Caribbean. The Centre provides physiotherapy and conducts surgery for persons with orthopaedic related issues. The Centre has been affected by flooding perennially since 2003. The PEC is ideally located on flat land in what was previously a residential area called Woodbrook just outside downtown Port-of-Spain. The PEC caters to approximately one hundred and twenty children with accommodation for sixty persons. Therefore, the services which they provide are very much necessary and in demand.

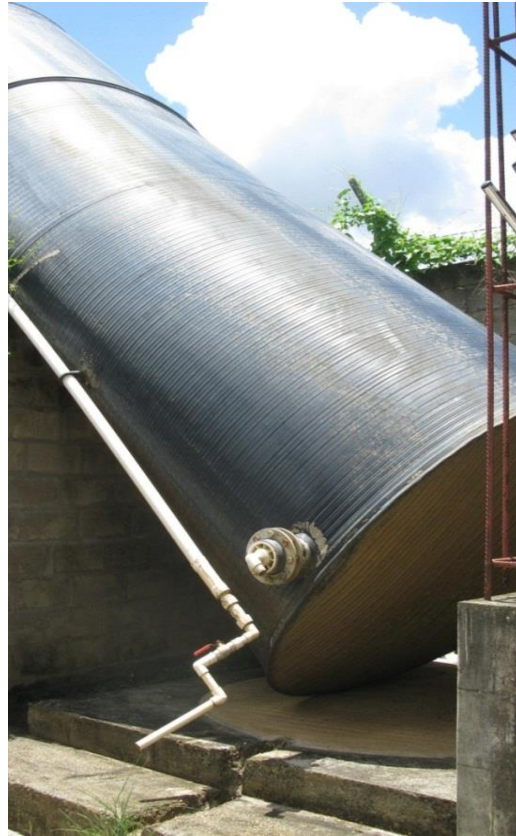
Photograph 4.15 Flood water mark of flood event in 2003



The Princess Elizabeth Centre has been affected by flooding almost on an annual basis causing significant destruction to the Centre. Photographs 4.15 and 4.16 show the still evident flood water mark from the major flood in 2003. This flood was unexpected and caused damage to the operating theatre and offices of the PEC.



Photograph 4.16 Illustrates the height of the flood in relation to the surroundings, showing the flood to be approximately two feet in some places.



Photograph 4.17 Empty water tank which was toppled by the force of flood waters in June 2011 flood event

Figure 4.17 illustrates the extent and strength of the flood. The flood in June 2011 was so powerful it was capable of toppling an empty water tank which was on the compound. These pictures demonstrate the effects of flooding on this special population which resides in the capital city. In the aftermath of the flood, the operating theatre was devastated with the entire area having to be specially sanitized and equipment worth thousands of dollars replaced. As a result the Centre has been unable to carry out surgery. Additionally, the lack of proper drainage exacerbates the issue of flooding resulting in catastrophic flood events like that of June 2011 as seen in Fig. 4.18.



Drain flows into a smaller outer drain reducing the flow of water out of the compound

Photograph 4.18 Inadequate drainage to remove flood waters

The Centre has developed its own coping mechanisms to deal with the flooding which affects them. One such measure has been the raising of equipment such as washing machines and dryers in the laundry (See Photograph 4.19). The Centre's accommodation of persons with physical disabilities makes it difficult to raise floors and install steps as these hamper patients in wheelchairs etc. from moving around the facility. In photograph 4.20, the Centre has invested in a flood dam to prevent water from entering the operating theatre where millions of dollars in equipment are stored and used in orthopaedic surgeries. This dam will prevent flood water from getting into the operating theatre in the future.



Photograph 4.19 Measures taken to reduce the impact of flood events



Photograph 4.20 Flood barrier placed at entrance to Orthopaedic surgery theatre to prevent flood waters from entering

Based on the data presented and the analysis one can surmise that Port-of-Spain is very much at risk from flood hazards. This is due to a high level of vulnerability as exhibited by the commercial sector as well as special populations such as the Princess Elizabeth Centre.

The graphs illustrate some of the views presented by the commercial sector and are supported by many of the photographs presented.

4.3 Analysis of Interviews

As part of the methodology, two interviews were conducted in order to obtain some more information about flood vulnerability in Port-of-Spain as it directly relates to the target groups chosen for analysis. As mentioned these interviews were analysed using Nvivo software package. The following is an analysis of the interviews under specific themes.

1. Perception. This theme was used to categorise how the interviewees perceived flooding and the causes of flooding in general. The general perception of flooding was fairly accurate by both interviewees. The DOMA president was able to describe in detail the causes of flooding in the city as well as the type of flooding which affected the city i.e. flash flooding. He was very knowledgeable about these details (See Appendix II). However, the perception that flooding was not a significant issue in Port-of-Spain stood out. The DOMA President is quoted as saying “We are more interested in earthquakes. A major earthquake during working hours can really affect the city”. “In this city centre we have not had the losses that the newspapers have reported”.

At the PEC, the matron was also able to identify and describe clearly the way in which flooding occurred, describing the extent of flooding, the history of flooding in the area and the extent of damage by floods.

2. Flood Awareness. This theme categorised those parts of the interview which illustrated the interviewees' knowledge of flooding. Both interviewees had a good awareness of flooding. For example, the DOMA president was able to identify those streets which frequently flood – “More than half an hour of rainfall results in about 10 inches of water on the main streets; Frederick, Charlotte, and Henry”. The Matron was able to illustrate similar awareness in her comment “Normally we expect floods in July and August”. “We’ve had flooding here which was not heavy, just ponding on the grass. But the worst to hit us was in 2003”.
3. Flood Preparedness. This theme reviewed the ways in which the interviewees and their members prepared for flood events. The DOMA president highlighted that businesses undertook precautions such as elevated entrances and sandbagging as the primary methods of flood preparation. However flood preparedness plans for the business sector were absent. At the PEC, there were a myriad of flood preparations. Electronic equipment such as the dryer was placed on higher ground; a flood barrier was installed to protect the operating theatre; drainage was altered to direct water into existing drains and away from buildings. The PEC also had a simple plan to evacuate residents to the school building when heavy flooding occurred. This demonstrates a higher level of preparedness as well as their ability to implement simple coping mechanisms for flooding.
4. Extent of Flooding. This theme illustrates how flooding affected the two sectors. In the case of the commercial sector, the DOMA president mentioned water collecting on the main streets in the Central Business District; shoppers being stranded on streets; losses in work hours but an overall low monetary loss with few claims made

by businesses. The PEC was better able to give more details about the extent of flooding over the years. For example, in 2003 they had to replace the x-ray machine which cost approximately \$500,000 after that flood event. The Matron highlighted damage to kitchen equipment, loss of children's books, shoes and clothing, operating theatre equipment as well as the closure of the facility for lengthy periods as the main damages which they sustained.

5. Causes of Vulnerability. Three main issues were apparent from the interviews; infrastructure, planning and environmental degradation. The most popular contributors to increased vulnerability were issues concerning infrastructure and environmental degradation. Both interviewees pointed out the state of drainage and the lack of changes to this, as being responsible for the flooding in Port-of-Spain. For example, the Matron at the PEC illustrated that when storm drains were constructed, the Centre they did not experience any flooding for a couple of years. She also pointed out that the drainage within the compound was now not adequate to hold the surface runoff received. The DOMA president highlighted that the drainage system inherited by the British some 40 years ago had not been added to while city had grown both in population and physical development, thus increasing vulnerability to flooding.
6. Solutions to Flooding. Both interviewees made some suggestions to alleviate flooding in Port-of-Spain. The president of DOMA in his interview suggested the ramping of bridges as the low hanging bridges prevented material from being removed from the river and led to flooding. The PEC made suggestions to their

situation which included the ramping of entrances to reduce flooding of the lower buildings.

The analysis of the interviews yielded results which supported much of what was said in the questionnaires as well as the photographs i.e. the commercial and special population sector is very much vulnerable to flooding. Similar issues of vulnerability were illustrated such as drainage, physical planning and environmental degradation; with each sector developing or utilising the most available coping mechanisms at hand to reduce their vulnerability.

Chapter 5 – Conclusion

5.0 Introduction

The data presentation and findings suggest a wide range of conclusions which answer the various research questions. The data presented demonstrated beyond a doubt that Port-of-Spain has been affected by flooding for a long period of time. Taking into consideration the equation which highlighted risk as being a function of the interaction between vulnerability and the hazard, it may be suggested that Port-of-Spain faces a high risk of flooding. Firstly, the hazard i.e. flooding is a frequent almost perennial occurrence, characterised by flash flooding as well as larger riverine floods. The most common type of flooding is flash flooding which happens very quickly as highlighted in the interviews and dissipates quickly as well.

The vulnerability of the various sectors has been highlighted in the data presentation. The data analysis shows that both the commercial sector and the physically challenged face varying levels of vulnerability to flooding. For example, it may be deduced that the Princess Elizabeth Centre faces a high level of vulnerability based on the evidence which shows that they have been repeatedly affected by floods, the high value of property losses and the often forced closure of the Centre. This therefore reduces its ability to carry out its main functions. In the case of the commercial sector, the value of property loss and losses in stock and sales indicates the level of vulnerability of this sector.

This leads one to ask the question of what are those factors which influence or make these two sectors sustain such losses and therefore more vulnerable than other sectors or persons

within Port-of-Spain. The following are the factors which make the commercial sector and physically challenged more vulnerable to flooding:-

1. Structural Vulnerability

- a. Issues with the existing drainage system
- b. Engineering works and maintenance
- c. Lack of proper garbage collection and disposal

2. Non Structural Vulnerability

- a. Poor or Ineffective Physical Development Plans
- b. Poor implementation of land use policy and legislation
- c. Lack of public awareness and education about disaster preparedness

5.1 Structural Vulnerability

The data analysis showed some recurring themes found across all the data sets. One of the most frequent recurring causes of flooding was issues with the drainage in the area. Within the questionnaires, the photos and the interviews, persons identified issues with drainage as the most significant problem facing persons in the city and which favoured flooding. Vulnerable elements of a structural nature were identified. These elements consist of certain physical factors that can be fixed through actions such as engineering and construction. The main issue identified was an old or antiquated drainage structure which has not grown at the same pace as development within the city. The drainage infrastructure was constructed in the early 1940s and since then very little has been done especially with

respect to the underground drainage that exists. Above ground, new buildings have been constructed and now more than ever the extent of paved areas has increased. As such, surface runoff has increased to the point where the present drainage system cannot adequately remove the water fast enough to prevent flooding from occurring. This has therefore increased the vulnerability of the city especially those in the commercial sector to flooding.

Another issue which was highlighted was the lack of effective engineering works and maintenance. For example, within the interview with the DOMA president, he highlighted how ineffective the existing infrastructure itself was encouraging flooding to occur. One such engineering issue was the low, flat bridges which crossed the East Dry River as well as the Maraval River. This type of bridge caused two problems allowing for increased vulnerability of the city. Firstly the low flat bridges made it easier for water to flow onto and over the bridge during heavy rainfall and flooding. Thus, cars were unable to use the bridge adequately during times of heavy flooding. Secondly, the low bridges helped trap material flowing within the river. Trees, bamboo and other large material became trapped when it reached the bridges and formed dams blocking the flow of water within the river from emptying into the sea. Another example was the observation of overgrown drains. These drains are therefore unable to hold the influx of surface runoff experienced when there is rainfall. Therefore improved engineering works and maintenance are needed in order to reduce flood vulnerability.

Throughout the city centre, many garbage bins could be seen. Some were overflowing, while others had been overturned by nearby homeless persons. Results of the questionnaires showed that business owners believed that a proper garbage disposal regime

was necessary. The interviews also revealed the view that the city was inundated by garbage. Photographs showed storm drains filled with plastic bottles and other garbage. Garbage which collects in the drainage system reduces the amount of water which can be removed from the city and thus contributes to flooding. Vulnerability is therefore increased due to an inadequate and compromised drainage system.

5.2 Non Structural Vulnerability

Non-structural vulnerability is attributed to those factors which cannot be remedied through physical changes but are more than often as a result of absent or poor policy and legislation as well as behavioural choices.

The flooding which occurs in Port-of-Spain is not only as a result of factors found within the city but outside as well. The city is flanked by the Northern Range as previously mentioned. In recent years there has been advancement up the steep slopes for the construction of houses, quarrying and agriculture. These activities have stripped the slopes of almost all the vegetation cover. Therefore when rain falls, the top soil is easily removed making its way into the rivers and drains reducing the capacity of the drains, resulting in overland flow onto streets. This view is supported by what was said in the interviews. Both interviewees identified or mentioned the destruction of the hillsides affecting the type of floods which occurred in Port-of-Spain. This was supported in their discussion about cleaning up silt and mud deposited by the flood waters. Therefore, the issue here is one of a lack of policies which seeks to regulate and protect the Northern Range from destruction as well as control and regulate development on the hillside. This is supported by the

Environmental Management Authority's State of the Environment Report (2004) on the Northern Range. This report suggests that a new strategy and updated policy is necessary to address the rampant and unregulated hillside development which is occurring. There is a need for adjustments to the policies that exist which change the way in which they are executed so as to improve monitoring and implement regulations.

Garbage disposal is not just an issue of collection and removal to landfills etc. but it also includes appealing to persons to change behavioural attitudes towards the way they dispose of their garbage. Garbage disposal begins with citizens conscientiously making the effort to properly dispose of their refuse in the right manner. The photos and questionnaire results illustrate the issue of the city of Port-of-Spain being inundated with more garbage than it can get rid of especially plastic bottles. This lack of willingness to dispose of garbage appropriately may be due to the improper enforcement of the relevant legislation such as the anti-dumping and littering laws. This indirectly adds to the level of vulnerability of the city to flooding.

Disaster preparedness through proper public awareness can assist in reducing the vulnerability of a society. A society which is prepared is less likely to be affected by that hazard. This is due to a better understanding of the hazard and the existing vulnerabilities which must be reduced where possible. From the results of the data, the information which is most apparent is the lack of preparedness by some persons. For example, very few persons listened to the weather report as a source of information to prepare for possible flooding in the city. There is also an apparent apathy towards flooding in the city. This is illustrated by the interesting fact that many of businesses have remained at their location for ten years or more in spite of enduring many flood events and the ensuing effects of

these events. It suggests that flooding is not taken into consideration when choosing a location or that in spite of the knowledge of possible flooding, businesses are willing to take that risk rather than locate somewhere outside the flood zone. Therefore a better understanding of disaster preparedness measures can help reduce the vulnerability of the sectors at risk.

Overall it can be surmised that flooding is a real and apparent threat to the various sectors in the Port-of-Spain area. Within recent times it has caused great damage for some sectors especially the commercial sector as well as special service centres such as the Princess Elizabeth Centre. These two sectors are at greater risk because of various factors such as their location as well as the nature of their operations. As such there is a great need for the relevant mitigation strategies both in the short and long term. These strategies can address the causes of flooding and thereby reduce the effects of flooding on both sectors. This in turn can result in a reduction of their vulnerability and by extension the city of Port-of-Spain.

Chapter 6- Recommendations to Reduce the Vulnerability to Flooding

6.0 Introduction

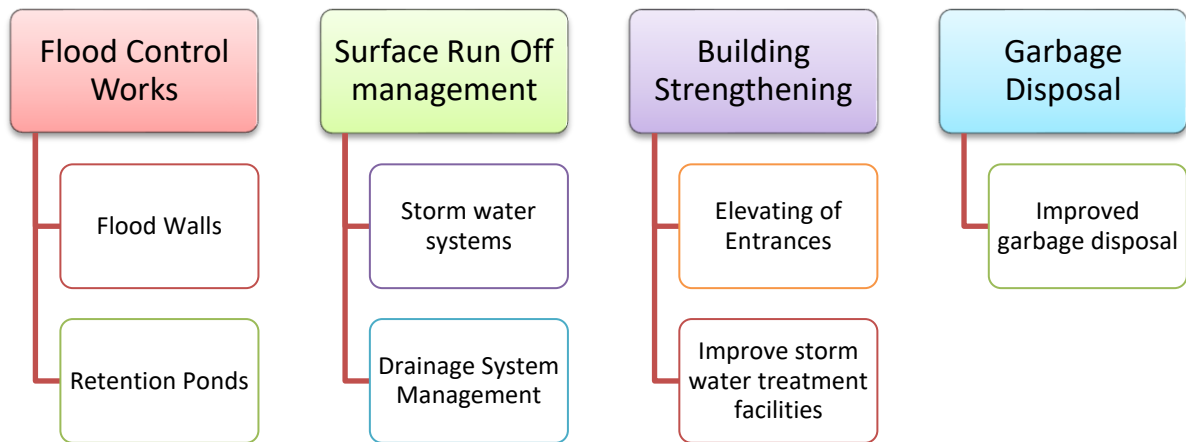
Over the last few years Port-of-Spain has endured repeated flood events. These events have become increasingly disastrous causing more damage with each successive event. These memorable events have been interspersed between frequent flash flood events. Flooding is therefore a hazard of potentially great magnitude and frequency in the city. Additionally, there are many factors which have increased the vulnerability of the city's citizens exposing them to the effects of flooding. The data presentation and findings pointed towards specific factors which heightened the vulnerability of the commercial sector as well as special populations. The alleviation of these conditions through the appropriate mitigation measures may allow for a reduction in vulnerability and as a result the risk of flooding which Port-of-Spain faces.

The literature has shown that many mitigation strategies exist which can alleviate flooding. These measures must be carefully considered and examined to ensure that the most appropriate measures are chosen to reduce the risk of flooding. The measures which are chosen should consist of not only physical measures but also include non-structural mitigation measures such as policy and legislation. The measures which can assist in reducing flood vulnerability cannot all be accomplished immediately and should be done in well planned out phases. Some measures are better accomplished in the short term while others in the long term. Given the discussion in the previous chapter the following are some of the mitigation measures deemed to be most appropriate for the reduction

6.1 Recommendations for Structural Measures

Short term recommendations usually consist of structural measures which can be easily executed once budgetary allocations and the technical and engineering knowledge are available (See Figure 6.1)

Figure 6.1 Structural Measures to Alleviate Flooding in Port-of-Spain



1. Flood Control Works. Flooding is unavoidable in Port-of-Spain due to its location and topography. As such, it is imperative that solutions which can control flooding to avoid the productive sectors such as the commercial sector are important.

- a. Flood Walls are simple inexpensive structures that consist of reinforced concrete that act as barriers against flood waters. These are built parallel to the river channel. This measure may be effective as there is not much available land along the floodplain of both the

Maraval and St. Ann's Rivers. This is due to extensive land development near the flood plain.

- b. Retention Ponds. These structures may be beneficial to alleviating flooding through the controlling of the amount of surface runoff which makes its way to the river channels. By doing this, water is released in such a way to prevent the overflowing of rivers and storm drains. These basins hold or retain water which provide a host of options for use, such as for irrigation and watering of lawns. This can be useful in Port-of-Spain as not only does it reduce flooding but the water can be used by farmers located outside the city or by homes in Woodbrook for lawns etc.

2. Surface Runoff Management has been highlighted as one to best perceived solutions to the flooding problem by almost all the respondents from both sectors.

- a. Storm water management consists of maintenance of urban storm systems as well as land based treatments. These land based treatments include maintenance and cultivating of shrubbery, grasses and trees as well as slope stabilization techniques. These measures will be especially helpful in the Northern Range where slopes are being denuded and large amounts of silt find their way into river courses contributing significantly to flooding. Therefore a programme which seeks to protect the vegetation of the Northern Range is important. This may involve the defining of buffers

consisting of major tracts of forest cover along the river banks within the Northern Range. For example, a buffer zone of 1km on either side of the St. Ann's river may be maintained with no development being allowed to take place. This can assist in reducing the rate and the quantity of inflow into the river system.

b. Drainage system management. This includes the maintenance and improvement of drainage infrastructure. Channels for the removal of water should be cleaned of over growth and garbage on a regular basis; aging drainage should be rebuilt to meet new carrying capacities of surface runoff and all peripherals such as culverts, storm grates, sewer pipes and back up valves should be maintained and checked on a regular basis to reduce flooding. This measure is imperative to reducing the effects of flooding especially near the Princess Elizabeth Centre where storm drains seem to have worked in previous years until recently.

3. Building Strengthening techniques provide structural measures aimed at strengthening or flood proofing of structures so as to avoid the effects of floods.

a. Elevation of entrances. In Port-of-Spain many of the commercial buildings and even the Princess Elizabeth Centre have been built on or very near the flood plain of the St. Ann's and Maraval Rivers. As such the elevation of these existing buildings provides a simple solution which is more cost effective than relocation and is easily

accomplished as it does not disrupt neighbours. It is achieved by physically building up of the lowest floors of the buildings above the average or high flood level mark. By doing this, businesses can still maintain their floor space but protect their property. This may be ideal for those commercial businesses which have low entrances such as Courts Ltd and have much to lose during flood events. However, due to the target audience of the Princess Elizabeth Centre the entrances will have to be raised via ramps which would allow for wheelchair access.

- b. Improving storm water treatment facilities can assist in reducing flooding in the city. This measure consists of the maintenance of existing facilities such as pump houses and storm water treatment facilities. In the case of Port-of-Spain, there is one pumping station which is used to remove water from the city during flooding. However, this water is removed into the East Dry River. This in itself poses a problem. It is believed that consideration of including the use of a second pump as well as the removal of the water in holding basins such as retention ponds be done. This will increase efficiency in flood water removal as well as provide alternatives for the use of this water.

- 4. Garbage Disposal. This was another significant issue highlighted by the respondents of the questionnaire as well as interviewees.

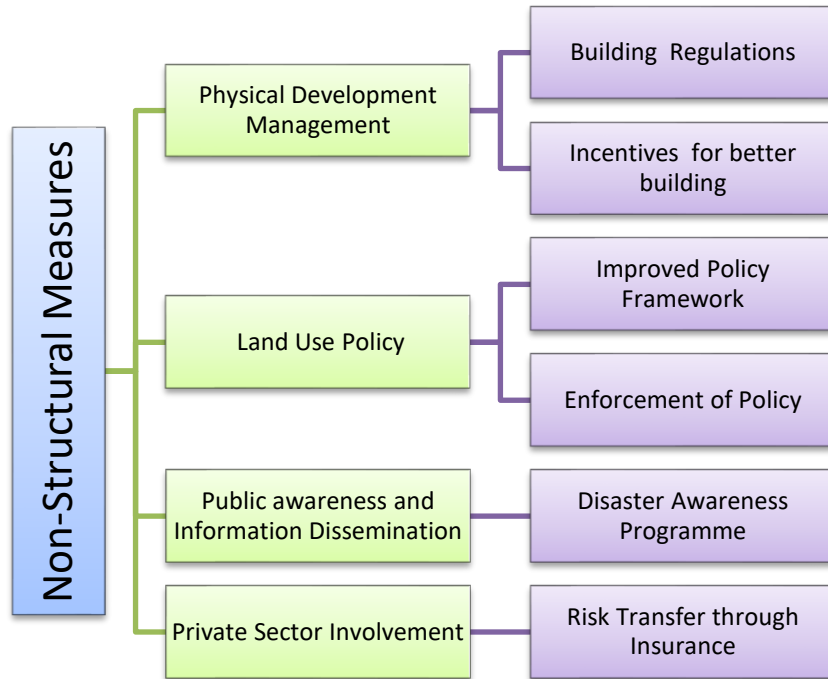
- a. A regular and well maintained garbage disposal system is necessary in the city. Bins should be visible on every street as well as skips be used for the removal of large amounts of garbage from businesses rather than placing them on the pavements or along drains. The removal of plastic bottles is a major problem and a long term solution to this may include development of a plastic bottle recycling programme which can also act as a means of livelihood for the less skilled in the city.

6.2 Non-Structural Measures to Alleviate Flooding in Port-of-Spain

Policy, information dissemination, training and awareness campaigns are examples of non-structural measures that can be utilised to alleviate the effects of flooding. These strategies seek to address the behaviours and attitudes of the citizens and as such may be considered long term measures. In many instances they are on-going and go beyond the extent of a government's term in office. Therefore budgetary allocations must be made to cover the extent of such measures. In Udika (2010) the Water Resources Agency (WRA) states that in order to alleviate flooding substantial capital investments which may not be available in the short term is necessary. Hamza and Zetter (1998) indicated that with the changing role of cities (such as Port-of-Spain which aims to change its economic status as being the financial 'mecca' for the Caribbean) they will have to facilitate access to capital as well as new technologies in order to carry on their expanding roles. This role includes disaster risk reduction through sustainable environmental management. Such roles can only be executed

through the appropriate policy implementation. The following illustrate some of the non-structural measures to reduce flood vulnerability (See Figure 6.2)

Figure 6.2 Non Structural Measures to Alleviate Flooding Vulnerability in Port-of-Spain



1. Physical Development Management involves the use of various strategies to manage and control physical development within a spatial area. In Port-of-Spain, this is sorely lacking. This is due to the inadequate and lack of enforcement of existing legislation. As a result, development has occurred unregulated to a point where relocation is almost impossible.
 - a. Building Regulations. In Port-of-Spain proper land use zonation which identifies areas which are best suited for specific types of land use can assist in reducing the vulnerability of flooding. This includes identifying the various hazard risk zones so that potential land owners and builders can be

aware of the proper building stipulations which must be adhered to. For example, businesses such as those interviewed that are located near the East Dry River/ South Quay must be constructed so that their ground floors are raised above the mean flood water mark so as to minimise property loss during floods. Additionally, the requirement of drainage in and around buildings which can adequately accommodate the surface runoff produced by that building's footprint should be compulsory and validated by the authorities such as the Town and Country Planning Division. Therefore criteria for building for different land use types within the city must be determined and made mandatory.

- b. Building Incentives. A variety of incentives to encourage better building practices especially by the commercial sector can help to reduce the vulnerability of this sector to flooding. One such incentive may be through special building tax concessions relevant to the cost of undertaking mitigative work to reduce flooding of their property for business and/or building owners. This would be effective for the larger businesses. For small businesses such as the ones on South Quay who may not have the collateral to make building renovations, small or micro- financed loans through credit unions at lower interest rates may be a viable option.

- 2. Effective land use policy is the basis for proper planning. The legislation of Trinidad and Tobago provides the instruments via which proper and guided land use development is allowed to occur. Legislation such as the Town and Country Planning Act (1969), the State Lands Act (1980), the Forestry Act (1980) and the

Draft National Hillside Policy of 1976 all provide for the regulation and control of land use development especially on the Northern Range. However, as demonstrated by the existing land use and incidents of flooding these policies have been ineffective in carrying out their mandates. Therefore measures are necessary to improve these laws.

- a. An improved policy framework is imperative in order for the effective working of the existing laws. At present there are many laws but the instruments are vested in various government ministries. Additionally, many of the laws do not reflect the reality with respect to land use in the country. Cropper (2008) recommends public policy that reflects understanding of sources of exposure and vulnerability which addresses the causal factors and the consequences of these actions and how they can be minimized. Therefore an improved policy framework which accurately reflects and addresses the existing land use issues is necessary.

Another issue facing the land use policy framework is the segmented way in which the law is being addressed. Many of the instruments of the existing legislation lie within the ambit of many ministries and as a result there is an overlap in the execution of the law as well as confusion in the roles and functions of government agencies. Udika (2010) describes it best in that this translates into a widely segmented approach to planning which is bounded in the various sectors i.e. each sector is trying to accomplish certain aspects of the law various. Therefore the legislation must be clear and succinct in its

aims. This may be best accomplished by one overarching physical development policy with the instruments existing within one single ministry.

b. Policy enforcement is sorely lacking in Trinidad and Tobago and by extension the capital city. Currently, there are limited resources to adequately ensure that land use development follows existing legislation. There are complaints of bureaucratic 'red tape' which slows down the process of development approval and as such developers and land owners continue to build with limited or no approval. Therefore more dedicated resources to efficiently review development and ensure the adherence to regulations can reduce flood vulnerability related to environmental degradation.

3. Public awareness is important in order to achieve a reduction in vulnerability. Citizens should be educated about those issues which increase their vulnerability to hazards as well as their role in reducing such. Within the assessment it was found that persons' awareness was limited. For example, many persons did not understand the value of the weather forecast as a means of early warning to safe guard their property. Currently, the Office of Disaster Preparedness and Management (ODPM), is engaged in various public awareness campaigns which target specific communities but not specific sectors such as the business community nor does the DOMA have any specific flood preparedness plans for its members. A public awareness programme which works with the commercial sector within Port-of-Spain is necessary. This programme should include educating the business community of their flood vulnerability, methods for reducing this vulnerability

through various initiatives as aforementioned as well as a flood preparedness plan inclusive of business continuity planning.

In the instance of the physically challenged special population, it is imperative that this sector be included in public awareness programmes. From the analysis, the Princess Elizabeth Centre is quite aware of its vulnerabilities and has developed its own coping mechanisms to safe guard against property and loss of life with some success. Their experiences can be shared with other similar organisations in order to encourage a better understanding of how to reduce their vulnerability. Therefore the PEC should be included in disaster management programmes and activities such as a flood preparedness plan for Port-of-Spain.

4. Private sector involvement is essential especially when talking about the commercial sector. The analysis shows that many businesses of varying type and firm size are affected by flooding and incur much monetary losses due to flooding in Port-of-Spain. One way of alleviating the vulnerability is to pass on the cost of the flooding or the risk associated with flooding to external parties through insurance. The transfer of risk is currently being encouraged for both small and large firms whereby firms are insuring their assets against the risk of hazards such as flooding based on yearly premiums. The interview with DOMA president and the results of the questionnaires showed that many of the businesses were insured but were unaware of their coverage. The PEC had limited coverage for some of the equipment owned but the coverage was insufficient to meet the costs of their losses. It is therefore recommended that stronger links be made within the private sector to play its role in educating as well as developing policies to meet the needs of the

commercial and special populations sector. The Association of Trinidad and Tobago Insurance Companies (ATTIC) should work closely with DOMA to ensure that members are adequately educated on the various policies available to them and ensure that the coverage which they have is relevant to their asset holdings.

In the case of small sized firms, who may be unable to access insurance for various reasons, the strategy of risk pools may be considered. Risk pooling is a means of transferring risk whereby the involved parties contribute to a central pooling system and those affected receive a disbursement related to the contributions made. These initiatives can only be successful where there is a closer relationship amongst agencies within the private sector working together to manage flood risk.

6.3 Summary

The vulnerability assessment provides an alternative view of the problem in a manner which allows for the interrogation of the various issues contributing to the vulnerability of the spatial area and the population that lives there. This study has highlighted some of the issues associated with the location of the commercial sector and the PEC such as their location on the flood plain of the two main rivers surrounding them. It also highlighted some of the inadequacies of the existing infrastructure such as the drainage system. The underpinning issues of land use policy and enforcement have also been illustrated throughout the study.

These issues come together to create an environment which has exposed Port-of-Spain and its citizens to flooding and its ensuing effects. Therefore in order to reduce this exposure and thereby reduce vulnerability these issues must be addressed through well-defined and relevant disaster mitigation strategies. These strategies must be formed in a holistic manner working synergistically; addressing the physical and anthropogenic causes of flooding and involving all relevant sectors of the population which depend on the services and functions provided by the city of Port-of-Spain. This is the best means by which vulnerability can be reduced.

As part of its economic development strategy, the government of Trinidad and Tobago envisions Port-of-Spain as the future financial ‘mecca’ of the Caribbean, making it the premier place to conduct business. If this is to become a reality, the vulnerability to flooding and by extension other physical and anthropogenic hazards must be reduced. This will ensure that Port-of-Spain is a more resilient city which is prepared for any eventuality and has the propensity to withstand future flood

events. If the appropriate recommendations are not employed, annual flood events can derail the development goals of the government. Thus not only will there be hesitation to conduct business and use the services found within in Port-of-Spain but the image of the city will be negatively affected.

Endnotes

ⁱ Map was produced as part of an Initiative carried out by the Department of Geomatics and Information, University of the West Indies, St. Augustine on behalf of the Office of Disaster Preparedness and Management. It utilized historical flood hazard data with topographical data to produce a Flood Susceptibility and Flood Occurrence Maps for Trinidad. The project was completed in 2010.

ⁱⁱ Winrock International is a research based organisation which conducts research in Asian countries in the field of environmental and sustainable management as well as disaster risk reduction. For the purposes of this study information was taken from an assessment of the various vulnerability assessment methodologies which highlighted their merits and appropriate situations for use.

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Appendices

Appendix I – Questionnaire used for businesses in the Downtown Port of Spain Area

Flood Vulnerability of the Commercial Sector in Port of Spain Trinidad

Questionnaire administered to businesses in the study area.

1. Name of Business
2. Sex – Male / Female
3. Address/ Location of Business:
4. Age:-
 - a. 16-25
 - b. 26-35
 - c. 36-45
 - d. 46-55
 - e. 56-64
 - f. 65 and over
5. Type of commercial activity conducted-
6. How long have you been involved in this type of activity?
 - a. Less than 2yrs
 - b. 2yrs- 5yrs
 - c. 6yrs-10 yrs
 - d. More than 10 yrs
7. How long have you been at this location?
 - a. Less than 2 yrs
 - b. 2yrs- 5yrs
 - c. 6yrs – 10 yrs
 - d. More than 10 yrs
8. What attracted you to this location?

9. Were you aware of flooding problems at this location?
- a. Yes b. No c. Not Sure
10. Do you believe that flooding is a major issue to business in Port of Spain?
- a. Yes b. No c. Not Sure
11. Do you listen to the weather report for flood bulletins and other weather related information?
- a. Yes b. No c. Sometimes
12. Has your business ever been affected by flooding in Port of Spain?
- a. Yes b. No
13. If Yes, how was it affected?
- a. Loss in sales b. Loss of stock
c. Workers were affected d. Building was affected
e. Early closure of business f. All of the above
14. Were these losses recorded or quantified in monetary terms?
- a. Yes b. No c. Not Sure
15. If yes, by whom?
16. How much did you lose in past flood events?
- a. <\$ 4,999 b. \$5,000 -\$9,999 c. \$10,000 -\$14,999

- d. \$15,000 - \$19,999
- e. \$20,000 - \$24,999
- f. >\$25,000
- g. Unknown

17. Do you have a plan in place to safe guard or take preventative measures to protect your business during a flood?

- a. Yes
- b. No
- c. Not Sure

18. If yes, what do you do when there is a flood?

19. Have you received any assistance for your business after a flood event?

- a. Yes
- b. No

20. If yes, what kind of assistance did you receive and from whom?

21. Do you think more can be done to reduce the impact of flooding in Port of Spain?

- a. Yes
- b. No
- c. Not Sure

22. What measures do you think can help to alleviate risk of flooding in Port of Spain?

Appendix II- Interview Transcripts

i. Transcript of Interview with Downtown Owners and Merchants Association of Port of Spain

	Timespan	Content
1	0:00.0 - 0:18.5	Would you say that Port of Spain's commercial Centre is vulnerable to flooding?
2	0:18.5 - 2:21.8	Yes, the commercial centre has been the scene of flooding in the form of flash flooding. This has been as a result of no additional drainage capacity in the last 30 to 40 yrs. More than half hour of rainfall causes approximately 10 inches of rainfall to cover the main streets i.e. Frederick, Henry and Charlotte street and collects at Independence Square. This is because of the water draining into the Gulf of Paria which silts up quickly. Sediment from the Northern Range and from the mainland causes siltation and the water is unable to drain properly. It is only recently that the current Minister of Works has accepted this and realises the need for repeated dredging of the Gulf of Paria
3	2:23.1 - 2:38.3	How would you say commercial activity has been affected? Such as the event in November 2008?
4	2:38.3 - 5:32.2	The cause of that event was that debris came down and displaced the water. It was as a result of overgrowth of trees and bamboo coming down into the rivers became trapped under bridges and causing water to come over. In 2008 these materials came down from as far as St. Ann's and Maraval rivers and got trapped causing flooding. This normally doesn't happen. The water was heavily laden with mud and made its way into City Gate and south quay clogging the drains there. It has a negative impact on lost man hours and loss in sales. Most significant impact is that it creates a negative image of the minds of the public. Consumers are mindful of possible rainfall and that the city can flood and shoppers can be trapped. If people perceive that rain is going to fall they will not come into the city.
5	6:06.7 - 6:15.2	Does DOMA assess any damages incurred by its members during floods?

6	6:15.2 - 7:15.4	Not really. We did have debris being getting stuck under the East Dry River in 1995 near Picadilly Street. That caused the water to come down Piccadilly Street onto Charlotte Street which did cause a lot of damage to businesses.
7	7:16.7 - 7:33.7	The reason I am mentioning this to you is because in other ‘‘societies and municipal authorities the bridges are ramped up over the bridges so that debris cannot get stuck and causes flooding.
8	7:33.7 - 7:43.1	Have any of the losses which you spoke about been quantified? Such as by insurance or even DOMA itself?
9	7:43.1 - 7:46.2	I do not have that information.
10	7:46.2 - 8:32.4	One of ways of ideally identifying vulnerability would be to quantify losses so as to point towards support for mitigation and prevention. It is very difficult to quantify losses when doing flood reports. By understanding or quantifying losses and understanding flooding it points towards what should be done to alleviate the problem. It has been found that governments are quick to respond but not proactive by putting measures in place.
11	8:33.4 - 8:42.1	Does DOMA have any strategies in place to deal with flooding for its members or otherwise?
12	8:42.1 - 9:47.6	Members of the association take the precautions which we have control over like sandbags and elevated entrances. In this city centre we have not had the losses that the newspapers have reported. It is more cost effective for the media houses to cover the rise in water level in the city than to look at what is happening elsewhere in the country.
13	9:47.6 - 10:02.6	In terms of insurance, such as flood insurance do businesses lean towards that? Is it available to businesses?
14	10:02.6 10:14.8	- I actually don't know if businesses are insured against flooding. I should get some more info on that. I would assume that for recovery that businesses do have that option of insurance
15	10:14.8 10:27.0	- That is because we have not had that many claims in the city centre. Remember what I said earlier, the water rises quickly and drops quickly.

16	10:27.1 11:00.1	- However, this year we have had a proactive minister who has completed short term measures. He has cleaned drains and dredged rivers. It cannot only be that however. This is just one part of the cycle. The persons who live on the Northern Range, who remove vegetation for agriculture and housing. Something should be done there.
17	11:00.1 12:40.1	- Well it has to do with capacity building. Since the British left Trinidad in 1962, very little has been done to build capacity in terms of drainage. The East Dry River was constructed in the 1940s and nothing much has been done since then. The city has expanded as well as the population of the city and the country has grown. That is why I mention the ramping of bridges. Debris comes down because of heavy and persistent rainfall from as far as Maraval causing the banks to collapse. It's not by the act of negligence of anyone. People do dispose of their garbage. Trinidad is inundated by garbage. To give you an idea people with yachts say they know when they are approaching Trinidad because they see plastic bottles floating.
18	12:40.6 13:15.2	- Are there any business continuity plans for flooding? In the aftermath of a flood as part of your recovery it is good to know that persons who are essential can report for duty or get into the city etc.
19	13:15.2 13:34.0	- I don't think that exists to any great extent because we have not had those types of flooding events.
20	13:34.0 13:45.1	- Would DOMA be interested in participating in disaster planning for its members if it were being offered?
21	13:45.1 14:27.3	- Absolutely we are interested but our interests are different. We are more interested in earthquakes. A major earthquake occurring during working hours can really affect the country and the city. There is no plan for such an event.
22	14:27.3 14:43.8	- Do you think a flood plan aimed at the commercial sector of Port of Spain would be useful?
23	14:43.8 15:22.5	- Yes if we could have the streets be clear of water when rain falls that would help with the image of the city. People would think the city is a safer place to visit and conduct business.
24	15:22.5 15:27.0	-

ii. Transcript of Interview with the Manager of the Princess Elizabeth Centre, Woodbrook.

	Timespan	Content
1	0:00.0 - 0:28.8	The government has suggested that we move altogether in the aftermath of the recent floods. It's the first time that the floods have come this early. - Matron
2	0:28.8 - 0:39.2	How long has the Princess Elizabeth centre been in operation and what are its main functions?-GR
3	0:39.2 - 2:09.6	Since 1953. The rehabilitation and education of the physically challenged child is what we are all about. This place was first a residential place which housed children who needed care after surgery. But we found that children needed not only care and rehabilitation but schooling as well. So there was a school down the corridor and then in 1976 the big school was built. The doctor at the time would take children to do surgery at Port of Spain or St. Clair and we found that that increased our surgery times so an operating theatre was added to the compound and we now do surgeries twice a week. -Matron
4	2:51.7 - 2:59.8	Ok I believe you have answered my next couple of questions. Has flooding been an issue prior to the last two events and how was the centre affected? GR
5	2:59.8 - 4:40.3	We've had flooding here which was not heavy just ponding on the grass. But the worse to hit us was October 2003. That really did lots of damage. We were out with the children and could not get out into the compound. I was the only person who could come out to the compound. That took us by storm. Since then we have flooding almost every year. They built storm drains a few years ago in front the compound and we did not have flooding for a couple of years. But in 2008, 2009 and this year we had big floods. When they cleaned out the drains after the flood in June you would be surprised at the amount of stuff that was removed.- Matron

6	4:37.8 - 5:03.5	That has been an issue highlighted. Maintenance of the structures seems to be a problem and where we are failing. The infrastructure exists but is not working as it should. In terms of damages what kind of damages did you receive after the floods? - GR
7	5:03.5 - 6:28.6	Nothing has been damaged in the office because I leave nothing on the floor. The children's books, shoes clothing etc. were lost in the last floods. The operating theatre, normally we expect floods in July August so we have built a wall to prevent water from getting in but these last floods caught us by surprise and theatre equipment was lost. The x- ray machine, electrical equipment, tables were tipped over. When they called me about the floods and I asked about blocking the theatre they said they couldn't move. They were sitting on tables. The kitchen suffered damage as well, refrigerators and freezers. In the laundry room we have put our dryers on higher ground but we can't with the washing machines because of the vibrations. So yes we had a lot of damages - Matron
8	6:26.1 - 6:28.9	Were the damages ever quantified? -GR
9	6:28.9 - 7:03.6	Financially I can't say so. The first year of flood in 2003 we had to buy another x-ray machine and that was over half a million dollars which we got from the insurance the first time. So I would imagine that the damages were greater than that in these last floods. - Matron
10	7:03.6 - 7:09.3	How did flooding affect operations?- GR
11	7:09.3 - 8:16.7	Yes, it did. After the water goes down there is silt. CEPEP always comes as well as the fire brigade to wash down. We cannot cook and the children are sent home and then we need to clean the theatre. This year a cleaning company came in to do a proper sanitization of the place after the silt was washed away. And of course we have to do swabs in all the nooks and crannies to make sure no bacteria are present within the operating theatre. This sets us back by about one month before we could resume classes etc. - Matron
12	8:16.4 - 8:26.7	Given that, what kind of measures has the home put in place to safe guard against flooding? GR

13	8:26.7 - 10:18.8	<p>We have put certain things higher above the ground. Some things we have been able to put higher within the Centre such as electrical equipment but not everything can do that. You will see when we walk around what we have done. This flood saw the water coming in higher than previously. In some places we have put in concrete to redirect water. We have tried to channel the water away from areas. There is a drain which empties into the Maraval river but what happens is that during a flood the water backs up and does not go down. When the Maraval river floods water backs up into the Centre. Sand bags have never seemed to work because we have to lug them around and with mainly women here putting them in place is difficult. We have had professional engineers come in to see what can be done but they are yet to provide any answers. You see when there is an emergency everybody is willing to help but nothing afterwards. We did have one gentleman who is going to come in and put in some ramps to assist with building up the area from the water. The water came in at tremendous speeds this time around. Something about the drainage has changed- Matron</p>
14	10:17.1 - 10:23.0	<p>It probably has change as well with new housing and buildings that has affected it -GR</p>
15	10:23.0 - 10:35.7	<p>Oh yes, the pulling down of the hills and you can see the amount of silt that comes in over the years. Matron</p>
16	10:35.7 - 10:40.8	<p>I think you mentions some of the people who you have received assistance from GR</p>
17	10:40.8 - 11:10.7	<p>Yes we cannot forget those who have helped us. There was a great outpouring of help from persons who donated boots, food stuff etc. Generally the business community has been good. Even people who live in the area. Matron</p>
18	11:10.7 - 11:17.9	<p>What do you think can be done to reduce the effects of flooding? GR</p>

19	11:17.9 - 12:46.8	<p>Well we are not the only ones who suffer others in the area. Others suffer because we are low lying. It has been suggested that we move but then so would the whole of Woodbrook. We are more vulnerable. It's got to be something with the drainage. In the first few years when the storm drains were constructed we didn't have flooding. But last year and this year when the rains fell we had water entering rapidly through the front of the building. We usually tell the children to go to the school. But we didn't have time or anywhere for the children to pass these last few floods. So I think it is the drainage. Matron</p>
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