ADAPTING TO FLOODING IN GEORGETOWN: AN INVESTIGATION OF CLIMATE CHANGE, SEA LEVEL RISE, STATE POLICY AND COMMUNITY PRACTICES

A Research Project

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ABSTRACT

Adapting To Flooding In Georgetown: An Investigation of Climate Change, Sea Level Rise, State Policy and Community Practices

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Climate change is being accompanied by rising sea levels and shifts in precipitation patterns worldwide. This phenomenon is increasing the frequency and severity of flooding events in Georgetown, which is already vulnerable due to its low elevation and history of land reclamation. Moreover, adaptive capacity is low due to limited financial resources and poor governance. The realization of a suitable adaptation plan for Georgetown through a more geographically-specific understanding of vulnerability and adaptation options is therefore critical.

Using case study wards differing by income level, land tenure, sewerage system, and garbage disposal method, the project examined how various wards were responding to the threat of flooding with the resources available to them. Sample wards were then used as an indication of how wards with similar characteristics are adapting.

As flooding is imposed upon a largely pre-existent urban structure, all social classes and urban environments were found to be potentially vulnerable to the impacts of flood events. Nevertheless, household experiences of flooding and its impacts were shown to be influenced by household asset profiles (income), which were in turn, linked to location (i.e. urban or semi-urban) and dwelling construction style.

Results suggest state intervention via enforcement of relevant building codes, drainage infrastructure maintenance, and secure housing programs, is likely to reduce Georgetown's vulnerability to the threat of flooding. Increased public awareness and disaster preparedness also stands to boost adaptive capacity.

Keywords: Sea level rise, climate change, flooding, vulnerability and adaptation.

ACKNOWLEDGEMENTS

For some years I have been concerned about the future of Georgetown as it faces many challenges associated with climate change and sea level rise. In March 2010, I came in contact with the ICURA funded "C-Change" Project which focuses on coastal climate adaptation strategies for communities in Canada and the Caribbean. Georgetown was one of the selected Caribbean case studies. I was therefore able to pursue this research interest under the supervision of Dr. Michelle Mycoo, whose encouragement and support from the initial to the final level enabled me to develop a better understanding of the subject. Without her expertise, editing and guidance, the product would not be the same. I also wish to thank the ICURA team, Professor Patrick Watson and Dr. Michael Sutherland in particular, as they were able to guide me regarding socio-economic and geographical issues respectively.

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Table of Contents

List of Figures

List of Tables

List of Acronyms

BAP	Bel Air Park
CARICOM	Caribbean Community
CBO	Community based organization
CC	Climate Change
CDB	Caribbean Development Bank
CH&PA	Central Housing and Planning Authority
ECAWG	Economics of Climate Change Working Group
ECLAC	Economic Commission for Latin America and the Caribbean
EDWC	East Demerara Water Conservancy
EPA	Environmental Protection Agency
EVN	Economic Value to the Nation
FP	Flood probability
GBOS	Guyana Bureau of Statistics
GCC	Georgetown City Council
GDP	Gross Domestic Product
GHG	Greenhouse gases
GNP	Gross National Product
GOG	Government of Guyana
GUYSUCO	Guyana Sugar Corporation
GVA	Global Vulnerability Assessment
ICZM	Integrated Coastal Zone Management
IPCC	Intergovernmental Panel on Climate Change
LACs	Latin American Countries
LCDS	Low Carbon Development Strategy
MoU	Memorandum of Understanding
NARI	National Agricultural Research Institute
NGO	Non-governmental organization
OCC	Office of Climate Change (of Guyana)
REDD	Reducing Emissions from Deforestation and Degradation
RBG	Roxanne Burnham Gardens
SCB	South Cummingsburg
SLR	Sea Level Rise
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program

NB: Unless otherwise noted, all photos were taken by Kira Lise Leung.

Chapter 1.0 Introduction

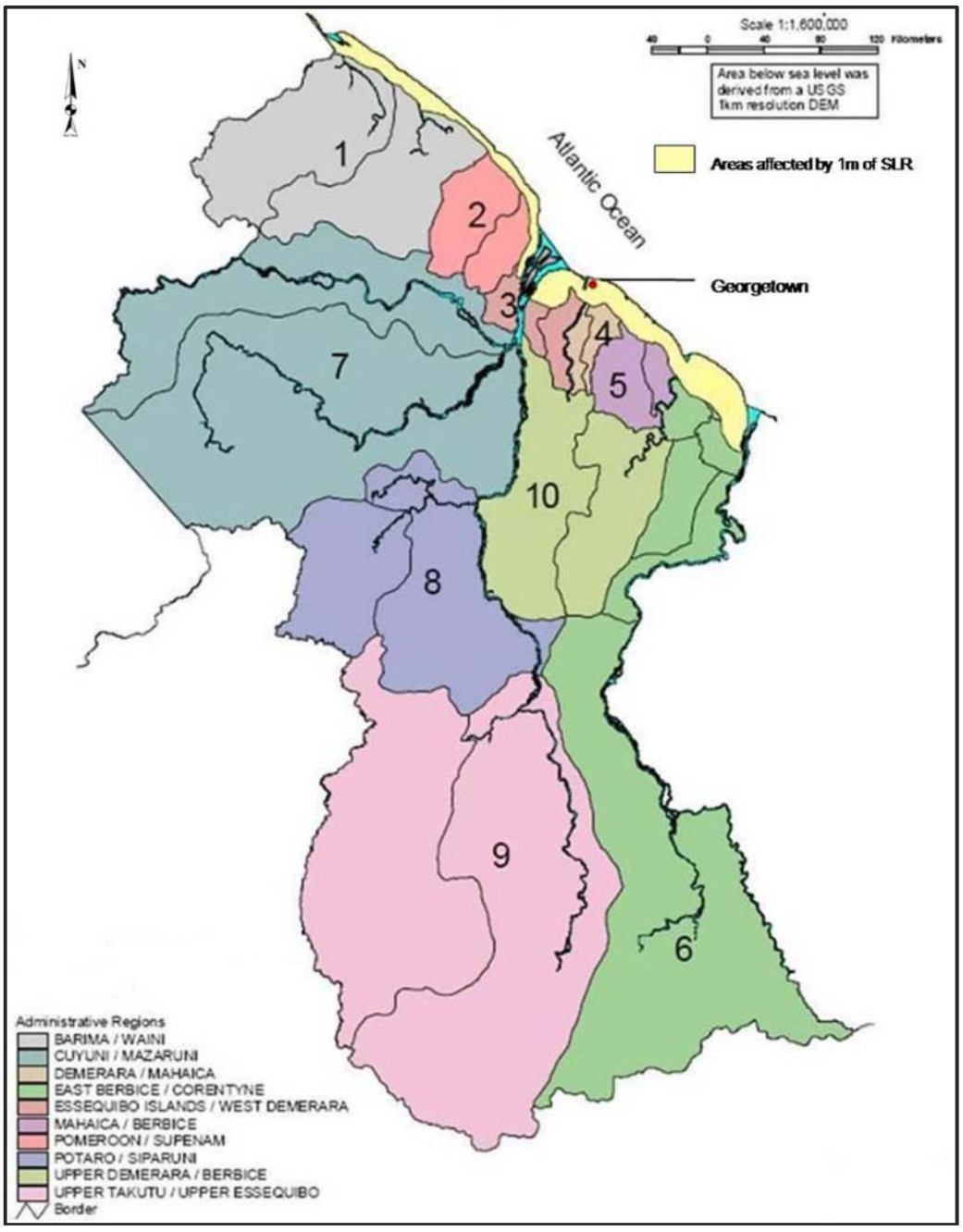
The International Panel on Climate Change (IPCC) confirmed that sea levels are rising globally as a result of climate change. Hydromet (Ministry of Agriculture, Government of Guyana) supports this claim adding that sea levels along Guyana's coast are rising at an accelerated rate. Data also suggests that climate variability (particularly changes in precipitation patterns) is accompanying SLR and CC in Guyana, and resulting in longer and more intense rainy seasons (see Figures 5 & 6). Georgetown has been subject to the negative impacts of flooding on numerous occasions as little is being done on the city scale to adapt to the threat of flooding. While this is rightly attributed to insufficient resources, an inadequate information base to guide action, dilapidated infrastructure, and poor quality governance systems (i.e. low adaptive capacity), it does not negate the fact that the people of Georgetown, like those of countless other low-income vulnerable coastal cities, must find a way to adapt, if future flooding events are to be prevented from becoming disasters. This thesis therefore seeks to further the goal of adaptation through a more locally specific understanding of past flood impacts, the communal and individual adaptation responses being employed, and their effectiveness.

The Guyana coast has long been vulnerable to changes in the adjacent Atlantic Ocean on daily, seasonal and annual time scales. The coast, which is below sea-level and supports 90% of the country's population, also experiences high intensity seasonal rainfall often associated with severe flooding. Global

projections on climate change (CC) are likely to exacerbate current flood vulnerability as accelerated sea level rise (SLR), and changing precipitation patterns (specifically more intense rainy seasons) are expected to accompany it. All of Guyana's coastal human settlements, ecosystems, and infrastructure are at risk (see Figure 1). However, Georgetown stands to lose the most if sea level rise and flooding persist unabated because:

- It is flat, below sea level, and surrounded by water bodies - the Demerara River on the north-west, the Atlantic Ocean on the north-east, and the East Demerara Water Conservancy (EDWC) on the south. It is therefore susceptible to storm surges from the Atlantic, breaches of the EDWC dam, and flooding via increased precipitation and prolonged high tides;
- It is where the highest concentration of people, jobs and infrastructure exist with 39% of the national population residing in Georgetown as of 2008 (Economics of Climate Adaptation Working Group (ECAWG) 2009); and
- It is the country's main economic centre housing several industries, agricultural farms (e.g. GUYSUCO) and businesses. Collectively, these account for 43% of Guyana's GDP (ECAWG 2009). Therefore, in the event of losses and damages to the capital, the rest of the country would consequentially be negatively impacted.

Figure 1: Administrative regions of Guyana & the areas affected by 1m of SLR.



Source: Environmental Protection Agency, 2002.

1.1 Research Aim

To further the realization of a suitable adaptation plan for Georgetown through a more geographically-specific understanding of vulnerability and adaptation options.

1.2 Objectives

I. To identify the factors shown to exacerbate the effects of flooding in Georgetown;

II. To determine the most vulnerable groups in Georgetown;

III. To ascertain the adaptation strategies currently employed in Georgetown, and determine which ones high-income, middle-income, lower-middle income, and low-income households are using respectively, and their effectiveness; and

IV. To suggest, at a conceptual level, achievable and effective adaptation strategies, keeping in mind the limited resources available to the government as well as communities.

1.3 Values and Assumptions

I. Climate change is indeed taking place and will be accompanied by sea level rise and shifts in traditional rainfall patterns. This will increase the likelihood of more frequent and severe floods in Georgetown.

II. Understanding the potential impacts of floods is necessary to be able to plan for the future and prescribe suitable adaptation strategies.

III. All city assets fall under one or more of the following dimensions:

- Economic e.g. loss of livelihoods, decreases in production;

- Environmental/ Ecological: e.g. soil and mangrove losses;
- Social e.g. loss of lives, displacement;
- Cultural e.g. loss of sites of cultural/ religious importance; or
- Physical i.e. in terms of the built environment – housing and infrastructure.

Since impacts infer the loss or damage of an asset, impacts will also be classified according to the above dimensions.

IV. Implementing suitable adaptation measures will not necessarily reduce the frequency of flooding events. However, they are likely to minimize the negative impacts of flooding events.

Chapter 2.0 Literature Review

2.1 Climate Change and Sea Level Rise

The International Panel on Climate Change (IPCC) declared in 2007 that "warming of the climate system is unequivocal". It also concluded with 95% certainty that the main drivers of climate change are anthropogenic increases in greenhouse gases (GHG), in particular carbon dioxide (CO_2) (Torre, Fajnzylber and Nash 2009). While changes in temperature present vast challenges worldwide, it is the consequential sea level rise (leading to flooding and shoreline retreat) and changes in precipitation patterns (i.e. more intense rainfall and consecutive dry days) that pose the greatest challenges for Latin American countries (LACs) such as Guyana (Bicknell, Dodman and Satterthwaithe 2009). Temperatures in LACs increased by about 1°C during the 20th century, almost the same as the worldwide average. This has triggered a sea level rise of 2-3mm/yr since 1980, in comparison with 1mm/yr in other parts of the world. Moreover, the IPCC's Fourth Assessment Report predicts that under a business as usual scenario, temperature increases are likely to range from 0.4°C to 1.8°C by 2020, and 1°C to 4°C by 2050 (Torre, Fajnzylber and Nash 2009). Experts agree this will result in the rate of sea level rise increasing, but debate exists regarding the extent. The IPCC forecasts that sea level will rise by 18 to 59 centimetres in the current century from thermal expansion. However, there remains considerable scientific uncertainty over the Greenland Ice Sheet which holds water sufficient to raise sea level by 7 metres.

While climate prediction studies are rightly the subject of much scepticism, Risbey, Lu and Dessai (2005) stress that many coastal cities will be vulnerable to the impacts of climate change and sea level rise even under best-case scenarios.

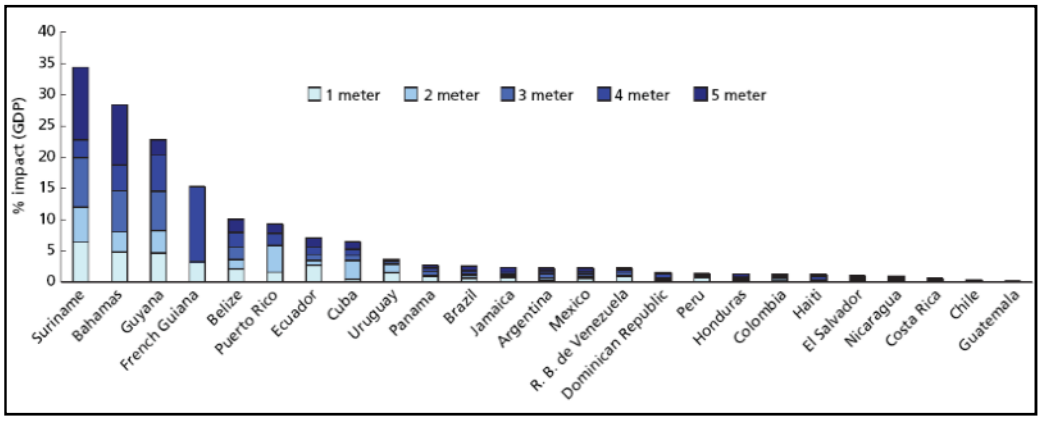
2.1.0 The costs of CC and the mitigation vs. adaptation debate

To date, many governments, municipalities and civil society groups have favoured climate change mitigation by implementing low carbon development strategies aimed at curbing greenhouse gas emissions. While this has the potential to restrain climate change escalation, Dessai, et al. (2009) stress that success is dependent on global cooperation. They also anticipate that the impacts of climate change will be felt well into the 21st century even if the concentration of atmospheric greenhouse gases is stabilized. As such, Bicknell, Dodman and Satterthwaithe (2009) make the case for relevant decision-making bodies to redirect resources into adaptation efforts which reduce urban residents' vulnerability to the many direct and indirect impacts of climate change. This is of particular importance in less-developed coastal cities which contribute minimally to the buildup of greenhouse gases in the atmosphere, yet face the highest risks from the negative effects of climate change.

Torre, Fajnzylber and Nash (2009) estimate that the annual economic damage from climate change in CARICOM countries (Guyana included) will amount to US$11 billion by 2080 (11% of their total GDP), with about 17% of the losses due to the specific effects of sea level rise – loss of land, tourism

infrastructure, housing, buildings and other infrastructure. LACs also stand to bear significant economic losses, as shown in Figure 1. Dasgupta, et al. (2007) encourage the development of implementable adaptation strategies, but note that they are only possible in the aftermath of reliable local vulnerability assessments.

Figure 2: Projected impact of sea-level rise on GDP in Latin American Countries.



Source: Dasgupta, et al. 2007.

2.1.1 Vulnerability to CC in Georgetown

The IPCC (2007) defines *vulnerability* as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes." It also adds that it "is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity."

Similarly, Bicknell, Dodman and Satterthwaithe (2009, 19) define *vulnerability* as "the potential of people to be killed, injured or otherwise harmed by the direct or indirect impacts of climate change." They put forward

that urban settings are particularly vulnerable to the impacts of climate related events as they concentrate people, homes, impermeable surfaces, infrastructure, physical capital, industries and waste. Higher levels of risk are also evident among those who inhabit dangerous sites, and lack the resources to modify their vulnerability. Latin America is particularly susceptible to the impacts of climate change and sea level rise as 75% of the population live in urban areas and as of 2006, 36.5% (194 million people) were 'living in poverty', while another 13.4% (71 million people) were in 'extreme poverty' (Torre, Fajnzylber and Nash 2009). It is therefore in the interest of these countries with coastal cities to identify the most vulnerable groups and determine potential local losses in the face of a variety of plausible future climate change scenarios, in order to be able to plan and adapt to the future.

Like most other coastal Latin American capitals, Georgetown is inherently vulnerable to the impacts of climate change and sea level rise. Pelling (1999) argues that flooding is the climate related hazard which Georgetown is most vulnerable to, as it lies 2.5m to 3.5 m below sea level, predominantly on reclaimed land. In support of this stance is the fact that 21 floods occurred between 1990 and 1996, severely inhibiting development. The January 2005 flood also substantiated this view as it paralyzed most of the population and cost the equivalent of 59% of the GDP for 2004 (Economic Commission for Latin America and the Caribbean 2005). Lakhan (1994) as well Wu, Mensah and Edwards (2005) highlight the fact that from the inception of the city, flooding was a threat which the Dutch addressed by 'poldering' off

land and engineering a gravity drainage and irrigation system consisting of canals, kokers and sea walls (see Figures 3 & 4). As such, climate change and sea level rise cannot be credited as the sole cause of flooding, but rather, a phenomenon likely to increase the frequency and severity of flooding events.

Figure 3: Photographs from the East Demerara Region showing elements of the drainage system.

Sea Wall
Source: M. Jaikarran, 2007.

Koker/Sluice
Source: Brian Max, 2005.

Canal
Source: M. Jaikarran, 2007.

Figure 4: Illustration of the East Demerara Region showing the drainage system.

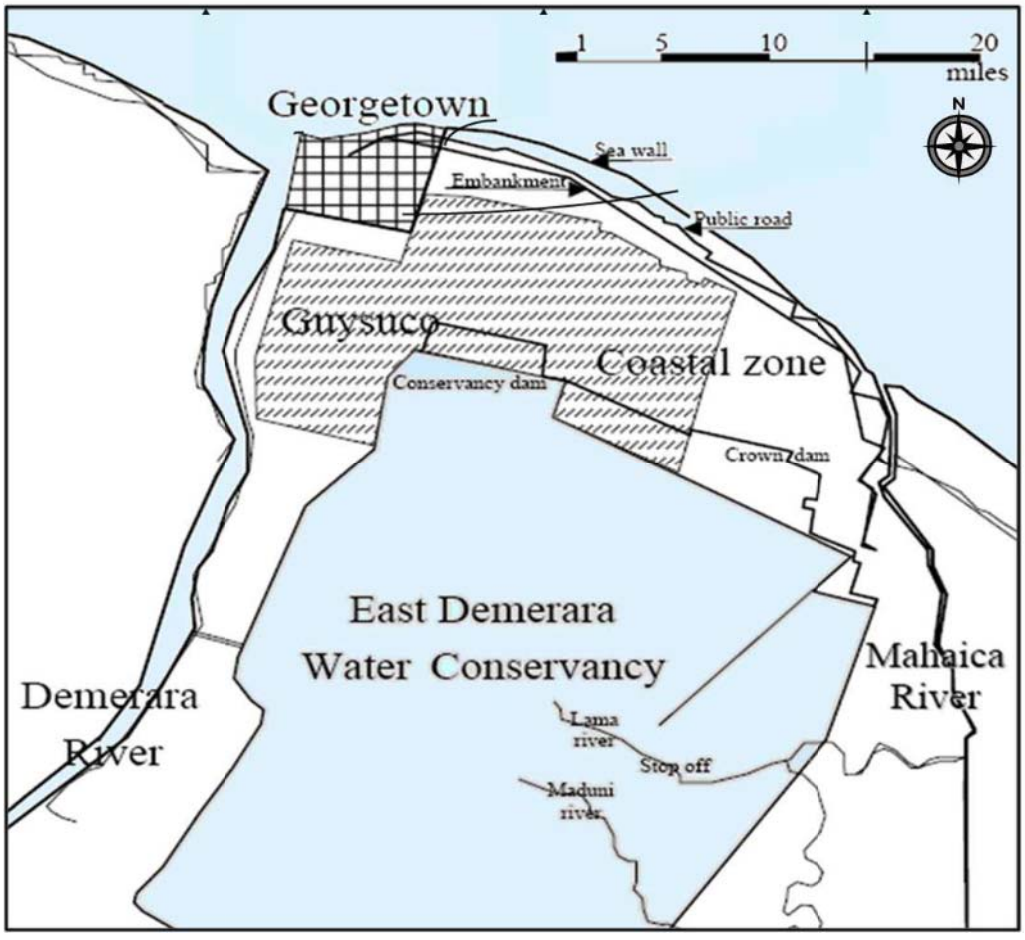
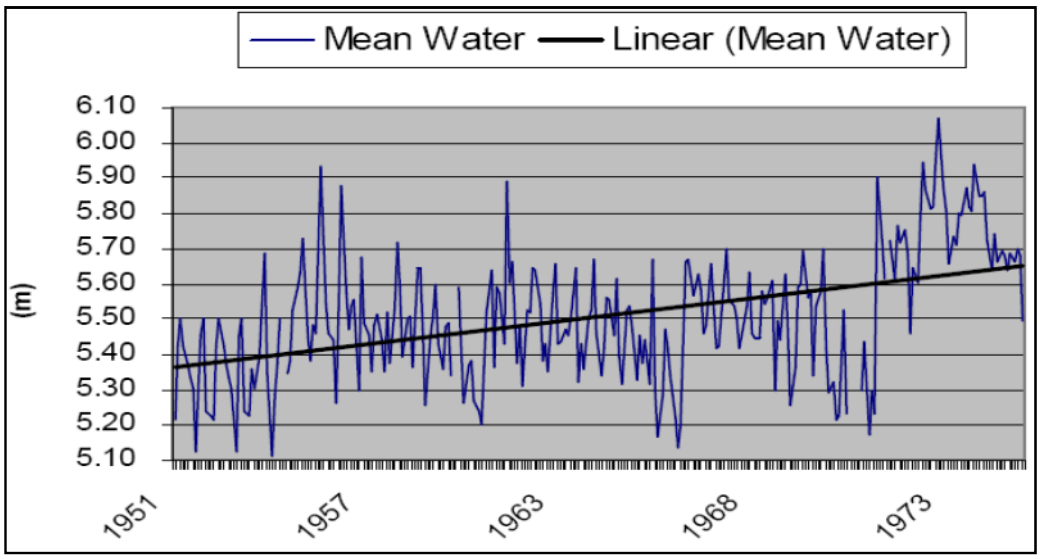


Figure adapted from the UNEP 2005 report titled "Geotechnical & Hydraulic Assessment of the East Demerara Water Conservancy Dam", pg. 6.

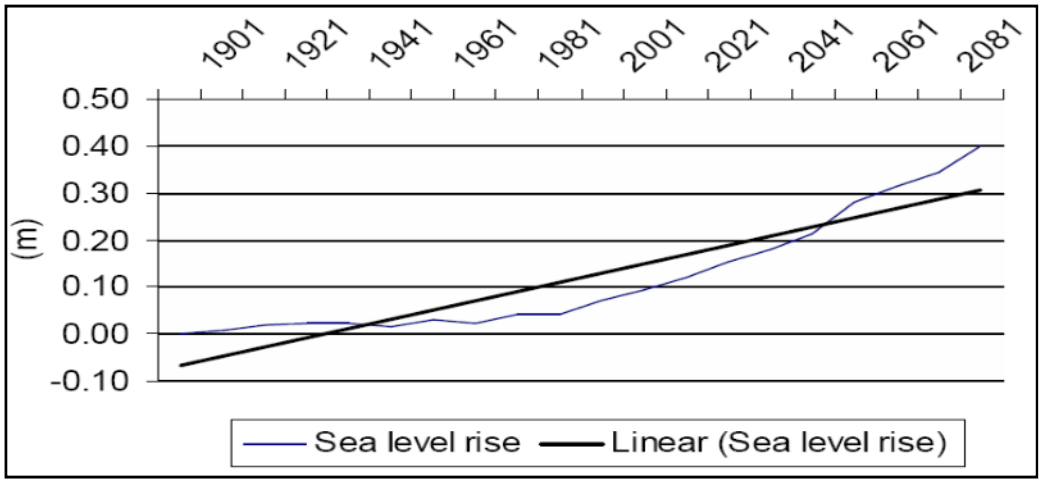
Data for the period 1951 to 1979 collected at the Georgetown port confirm a mean sea level rise of 10.2mm/yr, more than five times the global average (See Figure 5). Local vulnerability assessments also predict that by 2081, the country's coastal population will have to adapt to a rise in sea level of between 0.3m and 0.4m (EPA, 2002) - a particularly great feat considering that the coast is already experiencing the negative effects of climate change and sea level rise (ECLAC, 2005) (See Figure 6).

Figure 5: Observed Sea Level Changes at port Georgetown, Guyana - 1951 -1979.



Source: Guyana's National Vulnerability Assessment to Sea Level Rise, 2002, EPA.

Figure 6: CGCM 11 Future Sea Level Rise Projections for Georgetown, Guyana.



Source: Guyana's National Vulnerability Assessment to Sea Level Rise, 2002, EPA.

To date, Georgetown has encountered:

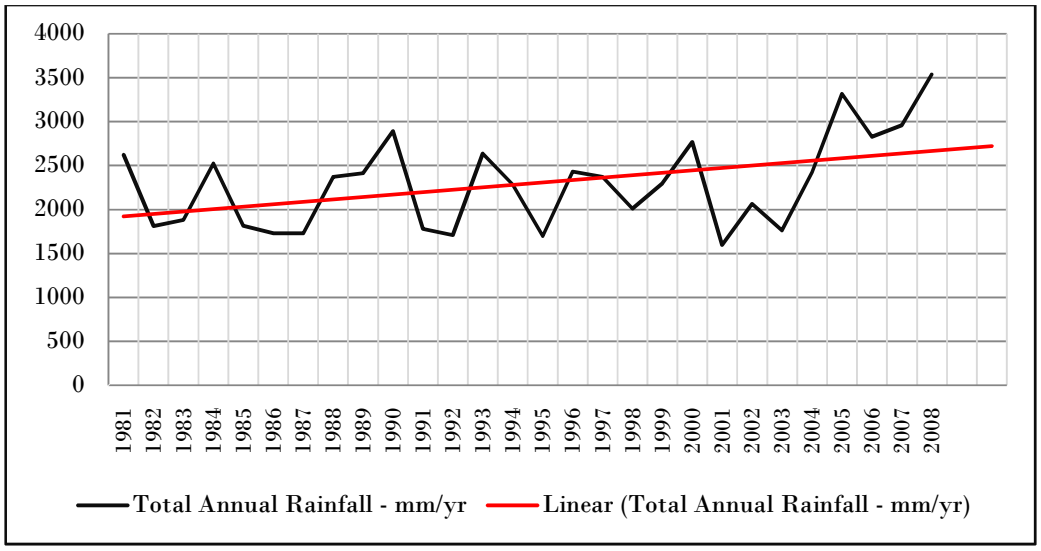
1. **Storm surges** which have resulted in overtopping of the sea wall, damage to infrastructure (i.e. sea walls and groynes), coastal erosion, and most importantly, flooding. This was exemplified during October 16-19 2005, when a wave event along the Atlantic coast damaged 1520m of sea defenses and flooded several low-lying coastal neighbourhoods (Ledden, et al. 2009); and
2. **Changes in precipitation patterns** which have brought about both droughts and floods. May - June and December - January are usually the two rainy seasons, while the rest of the year there is low to moderate rainfall. However, in recent years, there has not only been an increase in the total annual rainfall (see Figure 7), but also a change in the distribution of rainfall throughout the year. In 2005, 2006, and 2008,

there was more rain in the rainy seasons, and less rain in the dry seasons (see Figure 8). While droughts present challenges for agriculture, it is the persistent rains that pose a greater challenge because:

a. There is a small time frame i.e. low tide, for an increased amount of water to exit the drainage system via sluices. This leads to water accumulating inland, eventually resulting in floods.
b. Increased rainfall intensity also heightens the pressure placed on the East Demerara Water Conservancy (EDWC) which has a limited capactiy. If water levels are to exceed 59 feet (18m), the dams would be breached, and widespread flooding would occur accross most of Region 4, where Georgetown is located. In January 2005, Georgetown experienced the worst case of flooding in over a century, when January's rainfall totalled 1108.2mm, almost 6 times the 30 year average of 185.2mm (Economic Commission for Latin America and the Caribbean 2005). The dam of the EDWC was not breached although water levels rose to 58.7ft (17.9m). Flood waters remained for 3 weeks and 72% of the Region 4 population[1] was severely affected. Thirty-four (34) deaths were recorded, seven directly attributed to drowning by flood waters, and 27 due to illnesses arising out of the flooded conditions (Economic Commission for Latin America and the Caribbean 2005).

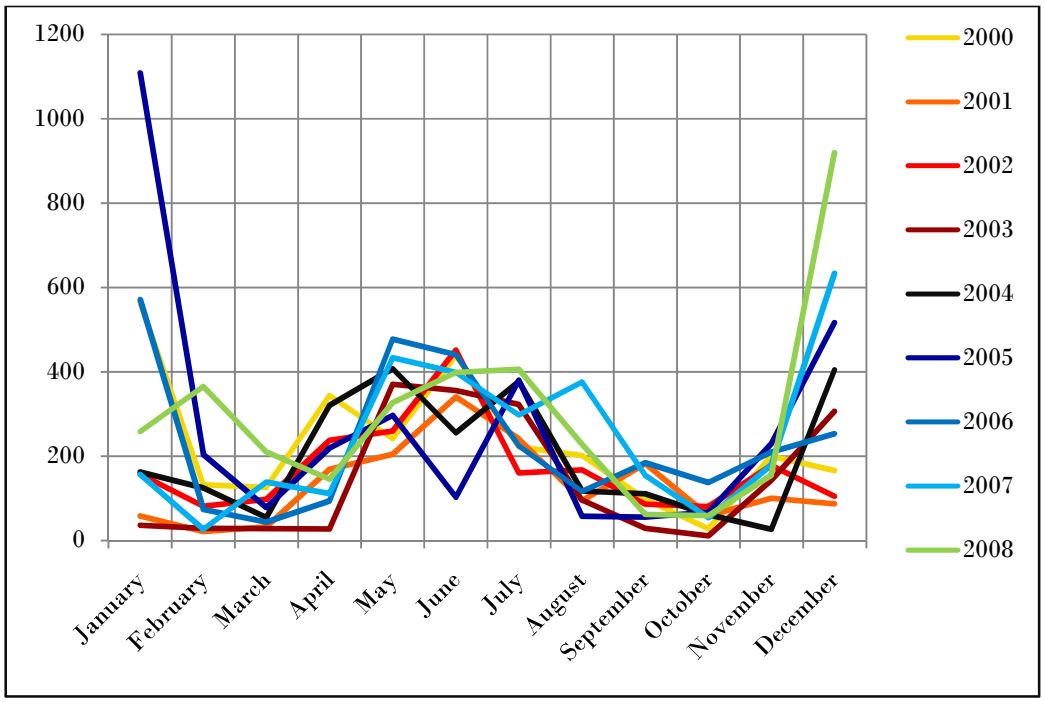
[1] Georgetown's population of approximately 242,000 accounts for 78.3% of Region 4.

Figure 7: Total Annual Rainfall for Georgetown from 1981 to 2008.



Data source: Guyana Bureau of Statistics, 2010.

Figure 8: Total Monthly Rainfall for Georgetown, 2000 - 2008.



Data source: Guyana Bureau of Statistics, 2010.

Recognition of the potential negative impacts of climate change on Guyana prompted the Government to address the issue more aggressively. In 2001, A National Climate Change Action Plan was deveoped by the Environmental Protection Agency (EPA) with assistance from the UNDP. Unfortunately, the plan was ineffective because it was not preceeded by reliable vulnerability studies and lacked an impementation strategy. In fact, it was not until 2002 that a coastal vulnerability assessment was carried out.

In June 2009, the Office of Climate Change (OCC) was established and tasked with the development of Guyana's Low Carbon Development Strategy (LCDS), intended to promote investment in low carbon economic sectors, infrastructure and human capital. The Government of Guyana also signed a Memorandum of Understanding (MoU) with the Kingdom of Norway. Under this MoU, Norway will provide financial support proportional to Guyana's success in limiting greenhouse gas emissions from deforestation and forest degradation (Government of Guyana, MoU, 2009). Collectively, these ventures suggest that the Government of Guyana is committed to doing its part in the global fight against climate change. However, such mitigation measures may prove irrelevant as success depends on the cooperation of some of the largest and most industrialized countries. As such, they may fail to directly address the looming threat of sea level rise to Guyana.

Satterthwaite *et al.* (2009) attribite the imbalance between mitigation and adaptation to the inability of low-income governements to grasp the need to reduce urban residents' vulnerability to the many direct and indirect

impacts of climate change. As such, they endorse adaptations that are planned in anticipation of potential climate change impacts.

The IPCC defines *adaptation* as "adjustments in human or natural systems in response to actual or expected climate stimuli or their effects, which moderates harm, or exploits beneficial opportunities." Adaptation measures are generally characterized as either structural or non-structural.

2.2 Structural Adaptation Measures

Structural measures include any built alterations to the natural environment intended to make cities and their populations more resilient to the forces of nature. They include sea defence structures, building alterations, groynes and dams. They effectively provide a degree of protection, however, the drawback is that they often require large amounts of capital to construct and maintain. As such, they are often out of the reach of low-income countries with highly vulnerable coastal populations.

In 1997, the Netherlands completed construction of the 'Delta Project', arguably the most extensive and expensive flood-protection infrastructure in the world. It was built with the intention to end the threat of flooding once and for all, and was deemed necessary as one-third of the total land area is below sea level and another third is susceptible to flooding by rivers in periods of high discharge. The dense population (some 460 persons/km^2) (VanKoningsveld, et al. 2008) of the Netherlands coupled with its history of devastating floods (particularly the 1953 flood which claimed over 1800 lives) led to the project receiving public approval as financial means increased during the 1950s &

1960s. Table 1 compares the potential impacts of sea level rise without any structural adaptation measures in Guyana and the Netherlands, and then highlights what adaptation would cost each country individually, and as a percentage of their respective GNPs. It shows that when losses are considered as a percentage of GNP, Guyana has much more at stake and is therefore more vulnerable. Also, while adaptation costs for the Netherlands are several times more than that of Guyana, they actually account for a much smaller percentage of the Netherlands' large GNP. By extension, installation of suitable adaptation measures would be a greater feat for Guyana, despite the fact that both its population and vulnerable land mass are smaller, because it is a low-income developing country, unlike the Netherlands.

Table 1: Potential impacts of sea level rise vs. adaptation costs: comparison between Guyana and the Netherlands[2].

	People affected		Capital Value at Loss		Land At loss		Adaptation/ protection costs	
Country	**# of people *1000**	**% of Total**	**Million US$**	**% of GNP**	**Km²**	**% of total**	**Million US$**	**% GNP**
Guyana	600	80	4,000	1115	2,400	1.1	**200**	**0.26**
Nether-lands	10,000	67	186,000	69	2,165	5.9	**123,000**	**0.05**

Adapted from Nicholls, 2003.

[2] This assumes existing development and a 1 meter rise in sea level. All impacts assumed no adaptation, while adaptation assumes protection, except in areas of low population density. Results were derived using the widely accepted Global Vulnerability Assessment Method (GVA).

The global vulnerability assessment method (GVA) is widely accepted and believed to yield reliable results. However, the results in Table 1 for Guyana's adaptation costs appear conservative when compared to the Government of Guyana's 2009 and 2010 budget statements. Expenditures for sea and river defense amounted to US$38 million and US$56 million respectively[3] and accounted for 2.56% and 3.77% of of the GNP for 2009 and 2010 – significantly higher than Table 1 although it does not include the costs associated with instituting and enforcing non-structural adaptation measures.

2.3 Non-Structural Adaptation Measures

Non-structural measures on the other hand refer to building codes, site development standards, infrastructural maintenance programs, land use planning policies, environmental restoration plans, community involvement, and relocation strategies (Hallegatte 2009). While Hardoy and Pandiella (2009) recognize the implementation of such adaptation measures as crucial, they acknowledge that 'adaptation' cannot eliminate all risks from hazardous events such as flooding. As such, they promote 'impact avoidance' initiatives involving disaster preparedness planning, hazard warning systems, and public awareness programs, as well as the strengthening of the resources, institutions and networks needed for effective post-disaster response.

[3] The majority of expenditure for sea and river defences for 2009 and 2010 were put toward maintenance of existing infrastructure, as opposed to new construction.

2.4 Application of adaptation measures in Georgetown

Structural 'adaptation' measures have been utilized from the inception of Georgetown, as the land was initially mangrove swamps and flooded savannahs (Lakhan 1994). Naturally, it was prone to flooding and uninhabitable in the absence of sea defence and drainage infrastructure (Wu, Mensah and Edwards 2005). The Dutch-engineered sea walls and drainage system therefore served as the city's main opposition to the threat of flooding, and continue to do so today although much of the infrastructure is beyond its 50 year design life. To give an indication of the poor condition of water management infrastructure in Georgetown, Ledden, *et al.* (2009) note that the most recently constructed (1945-1959) part of the sea wall (between Eve Leary and Kitty) is more than fifty years old, and in gross disrepair. The functions of various canals and pump stations have also been compromised over the years as silting and improper garbage disposal have reduced drainage capacity.

The constant threat of flooding has also resulted in a unique architecture, which entails the building of houses on stilts. This traditional building method elevates the premises out of the way of flood waters by raising the housing unit three to four meters above the ground.

Image 1: Typical home built on 'stilts' with an open-air 'bottom house'.

The space below is then used for recreation, storage, work areas or small private businesses. Individuals also frequently raise or concrete their yards when financial means allow, minimizing the direct impacts of flooding (Wu, Mensah and Edwards 2005). Unfortunately, this increases the run-off that the already stressed drainage system must handle, and sabotages government efforts to maintain drainage infrastructure. Pelling (1997) estimates that between 1963 and 1993, impervious areas in Georgetown increased by 50%. He argues that the inability of the government and the Georgetown City Council to successfully maintain the drainage system, and institute and enforce non-structural adaptation measures (e.g. suitable building codes and land use planning policies), are the main reasons for private residents choosing to address flooding events through raised yards and houses built on stilts.

Over time, the combination of concreted yards and raised housing units, coupled with the housing shortage and low wages has facilitated the conversion of flood-susceptible spaces into rental units also known as "bottom houses". These units are generally utilized by lower income families/groups that lack the financial means to avoid direct impacts and easily recover from flooding events. They have no higher place to put their belongings (furniture, appliances etc.) in the event of a flood, and are therefore more susceptible to not only financial loss and discomfort, but also water borne illnesses.

The frequency of flooding events can in some instances be linked to the incompetence of the city's administrative bodies. However, it is important to connect the success of adaptation plans to the 'adaptive capacity' of the city.

The IPCC defines *adaptive capacity* as "the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences." Bicknell, Dodman and Satterthwaithe (2009, 9) add that *adaptive capacity* is "the inherent capacity of a system, population or individual/household to undertake actions that can help to avoid loss and can speed recovery from any impact of climate change." Elements of adaptive capacity include knowledge, institutional capacity, financial, human and technological resources. Torre, Fajnzylber and Nash (2009) note that low-income populations tend to have lower adaptive capacities than high-income populations because of their reduced capacity to afford good quality housing on safe sites and avoid dangerous livelihoods. There may also be a wide range among city and national governments in their adaptive capacities, relative to the resources available to them, the information base to guide action, the infrastructure in place, and the quality of institutions and governance systems.

Georgetown is a typical example of a low-income city limited by its 'adaptative capacity'. For instance, although its drainage system has been lauded for its design, it is unable to function effectively due to ad hoc cleaning, upgrading, inspection and maintenance programs, which require more financial, administrative and skilled human resources than are currently available. In the wake of the 2005 floods, the Government of Guyana acknowledged its low adaptive capacity. Since then, efforts are being made to:

I. Develop a disaster preparedness/response plan;

II. Collect more relevant data to assist in decision making;

III. Seek international funding for coastal environmental and infrastructural maintenance;

IV. Ammend the building codes so that they are more responsive to the threat of flooding;

V. Increase public awareness about climate change, sea level rise and littering, which sabotages drainage infrastructure (GOG 2009); and

VI. Devlop and implement the Low Carbon Development Strategy to assist mitigation efforts on the global scale while increasing income that may potentially be used to increase local adaptive capactiy.

Table 2 gives a summary of the adaptation measures currently being employed in Guyana.

Table 2: Structural & Non Structural Adaptation Measures used in Georgetown.

Structural Measures	Details of Measures
Sea Defence: - **Sea Wall** - **Groynes**	The Atlantic Coast of Georgetown is protected by 2 groynes and a series of masonry seawalls built between 1882 and 1959. The majority of sea defences are now in very poor condition as they are beyond their 50 year design life. Maintenance has generally been reactive to failure due to financial shortages (Lakhan 1994).
Water Management: - **Canals** - **Kokers/Sluices** - **Pump Stations** - **East Demerara Water Conservancy (EDWC)**	The Dutch system of canals, kokers, pump stations and the East Demerara Water Conservancy (EDWC) is now largely in disrepair. The drainage capacity of the canals has been reduced due to silting and improper garbage disposal (Wu, Mensah and Edwards 2005). Many kokers and pump stations were also damaged subsequent to the 2005 floods. As such, an Infrastructure Recovery Task Force was appointed to oversee the recovery of the drainage and irrigation sector. To date, the task force has obtained funding from international bodies in the amount of US $50 million and funding is being sought in the amount of US$200-300 million for future maintenance and improvements (GOG 2006).
Raised Yard Levels	Although contrary to the site development standards for Georgetown (which stipulate site coverage allowances by ward), many individuals have raised the level of their yards by filling and concreting them. From 1963 to 1993, impervious areas within Georgetown increased by 50%. In most cases, this is done to reduce the impacts of flooding for private individuals. However, it simultaneously raises the volume of run-off channelled through the city's already stressed drainage system, and exacerbates the

	issue of flooding in other areas (Pelling 1997).
Building Homes on Stilts	Traditionally, buildings were erected on stilts to combat the threat of flooding. However, shortages in the housing stock and economic pressures have increasingly resulted in a significant number of 'bottom houses' being enclosed and rented out or used as an extension of the home (Wu, Mensah and Edwards 2005).
Municipal Drainage Cleaning	Subsequent to the 2005 floods, the National Drainage and Irrigation Board received funding to de-silt and clean a number of the main canals. However, the problem of silted drains continues at the city scale due to insufficient capacity and funding of the Georgetown City Council, whose mandate includes regular cleaning of neighbourhood drains (UNEP 2005).
Non- Structural Measures	
Homeowner's Flood Insurance	Insurance coverage for damages due to natural disasters such as flooding was not available before 2002 (GOG: Environmental Protection Agency 2002). Since then, it has been gaining popularity slowly with 9 – 12% of the city's population estimated to have some form of flood insurance as of 2005. After the 2005 floods, insurance claims amounted to ~G$750 million (US$3.75 million) from about 600 claims. Of the claims, 80% were from households while the remainder was from industry & commerce (Economic Commission for Latin America and the Caribbean 2005).
Building Codes	Present building codes were not drafted with the anticipated challenges of sea level rise in mind. Rather, guidelines address structural issues, building heights and floor-space ratios. Raised buildings and other flood proofing measures are

	not required by law. However, subsequent to the 2005 floods, NGO Habitat for Humanity has agreed to raise all new homes at least 1m above ground. In 2009, a National Building Code Committee (funded by the CDB) was appointed to develop a new building code which is more responsive to the threats of both floods and fires (Stabroek News 2008).
Site Development Standards	The National Building Code includes site development standards dealing with setbacks, site coverage, surface hardening and drainage. However, they are poorly enforced and frequently disregarded by individuals wishing to either facilitate a greater density or lessen the impacts of flooding (Pelling 1999).
Public Awareness Campaigns/ Education - **E.g. Littering**	Since 2001, the Integrated Coastal Zone Management Committee (within the EPA) has been committed to increasing public awareness about climate change and sea level rise through education campaigns aimed at elementary school children. They also spearheaded public awareness campaigns highlighting the negative impacts of improper garbage disposal (e.g. dumping refuse in drains or canals) on local drainage systems (UNEP 2005).
Flood warning systems	Although there is still no official flood warning system in place, the hydrometeorological authority's capability to monitor and predict weather developments was greatly improved in 2009 with the installation of the country's first Doppler Radar (GOG: Ministry of Finance 2010). The EPA is also establishing a National Disaster Management Council which will coordinate with various relevant agencies to better prepare for and respond to flooding events (Economic Commission for Latin

	America and the Caribbean 2005).
Disaster Preparedness Plans	A National Disaster Preparedness Plan was developed in 1985. However, it has not been amended since and has become somewhat irrelevant as settlement patterns and social conditions have evolved.
Maintenance and Inspection Programmes	Inspection and maintenance of Georgetown's drainage infrastructure has generally taken place in an ad hoc/reactive manner due to the paucity of both financial and skilled human resources (UNEP 2005).
Community Involvement/ NGO's, CBO's	Most of the existing CBO's and NGO's in Guyana have been involved in assisting affected persons/families post disaster, as opposed to pre-disaster.
Land Use Planning Policies	Although flooding has plagued Georgetown since its inception, planning policies have not traditionally responded to the challenge. This is evidenced by the fact that every housing scheme prior to the 2002 National Vulnerability Assessment to Sea-level Rise, is located in areas projected to be severely impacted within the next 50 years (GOG: Environmental Protection Agency 2002).
Relocation Strategies	Social and financial ties to the capital have caused relocation to be given little consideration in the past. Recent studies detailing the impacts of flooding have recommended gradual retreat from especially vulnerable areas (Economic Commission for Latin America and the Caribbean 2005). However, the problem is that the whole of Georgetown is deemed to be very vulnerable, and an effective relocation strategy would require the population to move at least 30km inland (GOG: Environmental Protection

	Agency 2002).
Wetland restoration and creation	The Drainage and Irrigation Board has acknowledged the role of mangroves in reducing the stress put on local sea defence structures and the occurrence of overtopping. As such, they co-ordinated with NARI (National Agricultural Research Institute) to begin mangrove replanting along the most vulnerable parts of the sea wall (UNEP 2005).

Summary

While both structural and non-structural measures are being used to differing degrees, Georgetown remains very vulnerable to the potential negative impacts of SLR and CC because of its peculiar location, topography, low adaptive capacity and sheer concentration of assets. To better understand the effectiveness of various city-wide adaptation measures, and the general public's responses to the threat of flooding, local communities/ wards were studied.

Chapter 3.0 Methodology

3.1 Goal

To date, vulnerability studies for sea level rise and flooding have been carried out for various parts of the Guyana coast including Georgetown. However, the majority have outlined general impacts on a town-scale, as opposed to a neighbourhood or community (also referred to as a 'ward') scale. Although this scale may not be justifiable for smaller towns, it is essential for Georgetown due to the sheer concentration of assets (i.e. people, businesses, housing and infrastructure). It is also necessary for the development of suitable adaptation plans because resources are currently limited, and issues will need to be prioritized. As such, this thesis investigates at the ward[4] scale the negative impacts being experienced due to flooding. Using four sample wards, differing by income level, land tenure, sewerage system, and garbage disposal method, the thesis examined how various wards were responding to the threat of sea level rise and flooding with the resources available to them i.e. how the people were adapting and minimizing the consequences of future flooding events. Each sample ward was then used as an indication of how wards with similar characteristics are adapting.

[4] Georgetown is divided into 49 wards for administrative purposes. They vary in size and population, and may consist of one or more communities. Nevertheless, they tend to exhibit a degree of uniformity within, as many of the boundaries are based on communities that were developed since the late 1800's.

3.1.0 Scope

The overarching goal of this thesis is to identify relevant and implementable adaptation opportunities for Georgetown as a whole, as well as for specific wards/ communities within. Four sample wards differing by 1. Income level; 2. Land tenure; 3. Sewerage system; and 4. Garbage disposal method will be investigated. The situation found to exist in each ward will then be taken to be somewhat indicative of the situation in wards with similar characteristics. The limited time frame and resources available for this thesis do not allow for ward-by-ward investigation. As such, the method assumes that wards with like characteristics will respond similarly to the threat of flooding, and will benefit in the same way from the adaptation options recommended for the sample. Naturally, this method has room for error in that wards with similar characteristics may actually respond differently due to characteristics beyond the four defining ones outlined above. At the same time, the four defining characteristics are basic enough that they justify the assumption of similar responses by comparable wards, and allow for a simplified and uniformed understanding of flooding impacts, and adaptation responses across Georgetown. In terms of adaptation options/ strategies, both structural and non-structural will be considered. However, there will be a greater focus on physical land use planning solutions.

3.1.1 Limitations

- Specific data on income is unavailable in Guyana as the Bureau of Statistics had minimal success in getting persons to truthfully answer

income related questions in the 2002 census. As such, certain economic/ social impacts will not be quantified, but rather only identified.

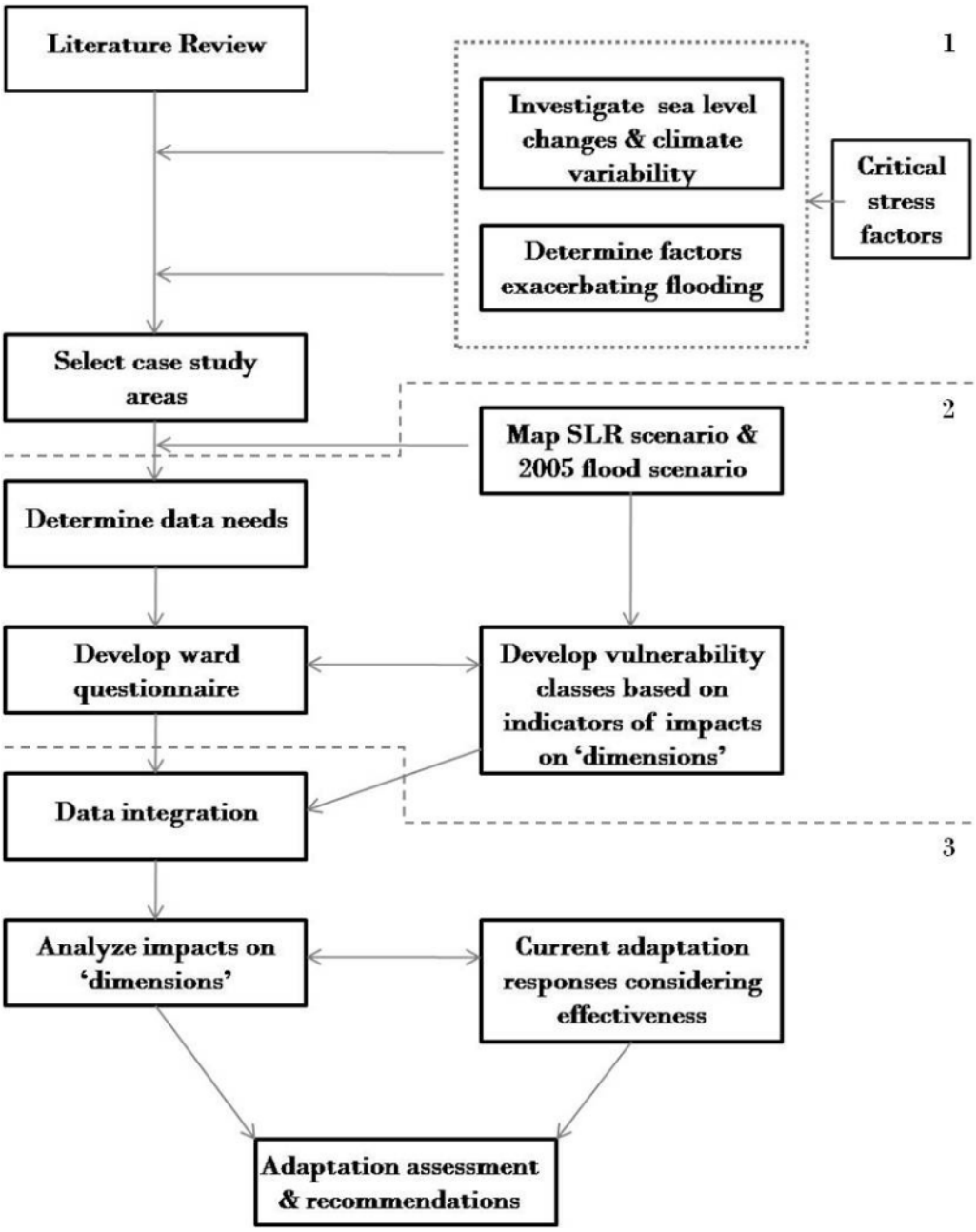
- This project is concerned with the impacts of future events, the frequency and severity of which cannot be known at this point due to the lack of historical flooding data. As such, negative impacts cannot be accurately ascertained beyond stating what could happen based on a given scenario. The sea level rise scenario which this thesis will consider will be one meter (1m). A reoccurrence of the January 2005 flooding event will also be the scenario which precipitation-related flooding adaptation strategies will be considered against.
- Some mapping will be done manually due to certain ArcGIS shape-files for Georgetown being unavailable.

3.1.2 Method

To investigate the research problem, the following were completed:

1. Literature review and case study area selection;
2. Data collection based on dimensions, indicators and options; and
3. Data integration and analysis (see Figure 9).

Figure 9: Flow diagram illustrating research approach.



1: The literature established that climate change is indeed taking place, and will be accompanied by sea level rise and climate variability, both of which will result in flooding for low-lying coastal cities such as Georgetown. It also confirmed that the following factors are likely to exacerbate the impacts of flooding and SLR in Georgetown:

i. Low coastal elevation & soil permeability;
ii. Increased amount & severity of rainfall;
iii. Low income/ insufficient resources;
iv. Insufficient disaster preparedness;
v. Improper building styles;
vi. Drainage systems with outdated capacities;
vii. Increases in impermeable surfaces;
viii. Illegal occupation of state lands (i.e. squatting);
ix. Primitive sewage systems (e.g. pit latrines);
x. Improper garbage disposal; and
xi. High population densities.

The above factors were all considered when selecting case study wards. However, income was the main factor as it influences most of the above factors.

2: This section is based on the belief that we can avoid or minimize the impacts of climate change related flooding, and adapt, only to the extent that we are able to understand how it is affecting us currently, and how it will impact us in

the future. As such, it looks at four case study wards with the understanding that each one has five *dimensions* as follows:

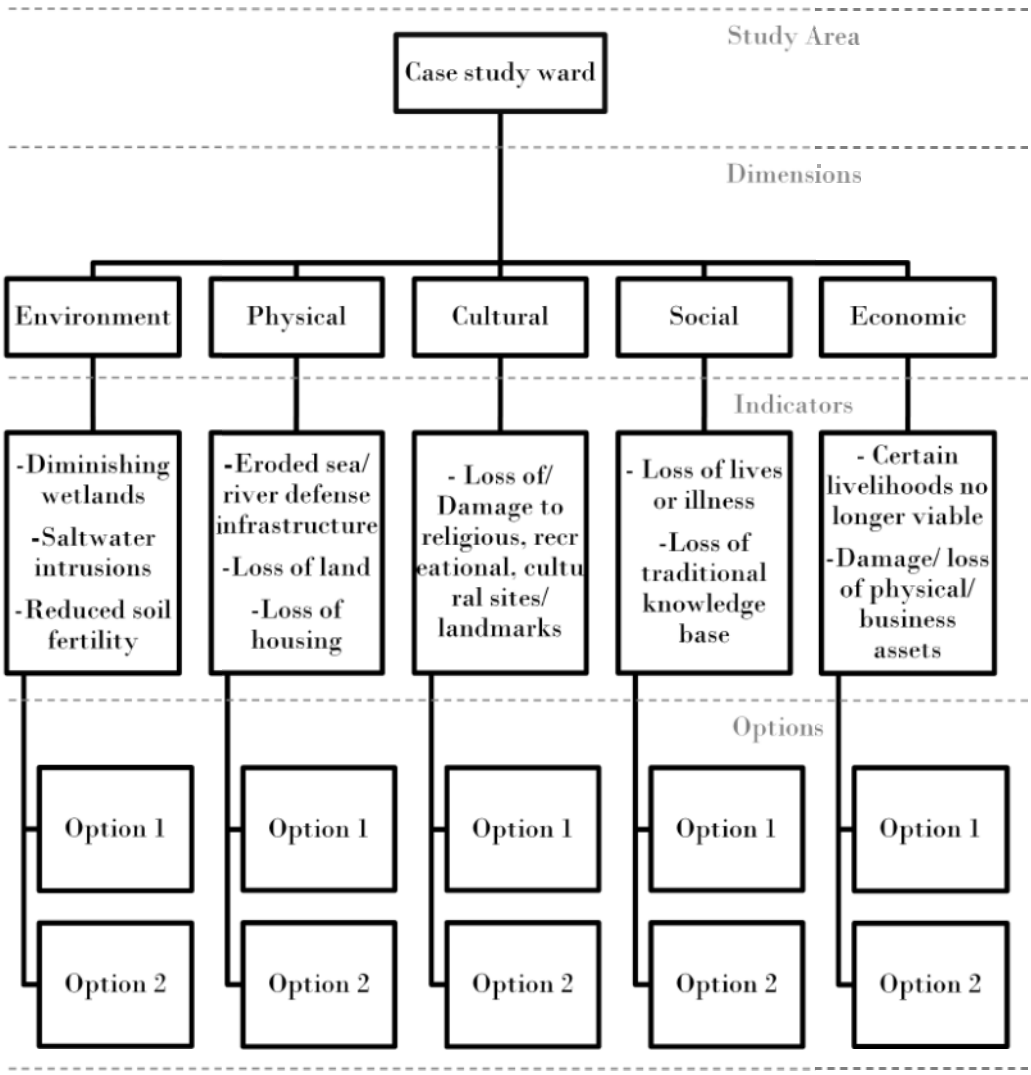
- Environmental;
- Physical;
- Cultural;
- Social; and
- Economic.

Table 3: Data sets collected by dimension, along with their sources.

Dimension	Data Collected	Source
Environmental	Soil types and vegetation	GL&SC topographic maps
	Topography & drainage patterns	Ikonos satellite images
	Rainfall amounts and patterns	HydroMet
Physical	Location of squatting	GBoS
	Land use patterns within Georgetown	Central Housing & Planning Authority (CHPA)
	Building characteristics within wards	Questionnaire and field observations
	Location/ age of sea defense and drainage infrastructure	Topographic maps by Guyana Lands & Survey Commission (GL&SC) & Drainage and Irrigation Authority
	Structural adaptation responses	Questionnaire
Cultural	Recreational, religious and cultural built points of interest.	GL&SC topographic maps
Social	Population, garbage disposal method, sewage system, household size, occupations and density within case study wards.	Guyana Bureau of Statistics (GBoS), 2002 National Census.
	Home owners vs. renters in wards.	Questionnaire and GBoS
Economic	Government expenditure on sea defense and drainage as a percentage of GDP.	Guyana Information Agency (GINA)
	Financial impacts of past major floods	Economic Commission for Latin America and the Caribbean (ECLAC) Report, 2006.

Since Georgetown is indeed experiencing the impacts of climate change related flooding, by logical extension, there should be evidence of stress on each of the above dimensions. These critical stress signs are referred to as *indicators*. Indicator determination was based on findings from the literature and data.

Figure 10: Flow diagram illustrating the relationship between dimensions, indicators and options[5].



[5] Options may also be referred to as "potential adaptation strategies". Also, 'options' may be more numerous than this diagram suggests. However the research focuses on physical planning strategies.

3: A survey was administered to bridge data gaps in the socio-economic ward profiles and infrastructural asset profiles. Using questionnaires[6], the survey examined past experiences and perceptions of flood hazards, household vulnerability, responses (i.e. household flood hazard management mechanisms), and flood impacts on property and household members to establish the ***general*** and ***relative*** vulnerability of each ward and its adaptation capacity (see Appendix 2).

To establish the ***general*** vulnerability of a case study ward, the research considered it in the context of the impact categories used by the IPCC in the Third Assessment Report (see Table 5). This was insufficient however, as the impact categories were strongly linked to flood history and topography, thereby resulting in most of Georgetown's wards being rated as either highly vulnerable or critical. As such, wards were separately considered in light of the 'critical/ potential stress factors' previously identified, to give a better understanding of their vulnerability ***relative*** to each other. The method is essentially an adaptation of the 'planning balance sheet analysis method' devised by Nathaniel Lichfield in 1960. It proved more pertinent as most studies have already shown the whole of Georgetown to be susceptible to the impacts of SLR. From a planning perspective, it therefore makes sense to identify the most critical areas, in order to prioritize resources as it relates to adaptation.

[6] Within each case study ward, a sample area of 200 households was randomly chosen from an ordinance survey map for field surveys. Fifty questionnaires were then completed (one per household) in each ward by persons from the sample area. In Sophia, 50 households represented only 5.5% of the total households, while in South Cummingsburg, it accounted for 7% of the total household. In Roxanne Burnham Gardens and Bel Air Park, it represented 26% and 17.5% of the total households respectively.

Table 4: General vulnerability classes used in '3'.

Adapted from IPCC Third Assessment Report, 2001[7].

Impact Categories	Vulnerability Classes			
	Low	Medium	High	Critical
People affected (no. of people/ total population) x 100%	≤1%	1-10%	10-50%	≥50%
People at risk ∑ (no. of people/ flood probability[8]) / 1000	≤10	10-100	100-500	≥500
Land loss (area loss/ total area) x 100%	≤3%	3-10%	10-30%	≥30%

Table 5: Example of how critical/ potential stress factors will be valued to determine relative vulnerability.

Critical/ Potential Stress Factor	Status	Increases flood impact	Decreases flood impact	Points
Elevation	Low	Yes	No	+1
Soil permeability	Low	Yes	No	+1
Income	High	No	Yes	-1
Disaster preparedness	Low	Yes	No	+1
Building style	Unsuitable	Yes	No	+1
Impermeable surfaces	Frequent	Yes	No	+1
Land tenure	Mainly freehold	No	Yes	-1
Sewage systems	Dependent on city sewer	No	Yes	-1
Garbage disposal method	Municipal collection	No	Yes	-1
Density	Medium	No	No	0
TOTAL				**+1**

[7] The IPCC Third Assessment also included capital value loss and wetland loss in the impact categories being considered. However, it is not possible to do the same for this specific research as it would be beyond the scope of the project to quantify the capital being lost at the ward scale. Also, none of the case study wards include areas that function as wetlands, but are all susceptible to inundation depending on the SLR scenario. As such, land loss was taken as the percentage area of a ward that could be potentially lost via inundation in a 1m SLR scenario.

[8] Flood probability is the chance of a flood event taking place each year. For instance, 0.5% flood probability would translate to one flood every 200 years. It may also be expressed as 1÷ RP/100 (where RP is the recurrence period).

With regards to Table 6, where the status of the potential stress factor is such that it will exacerbate the impacts of flooding, a value of +1 is given. When the status of the potential stress factor is such that it will reduce the impacts of flooding, a value of -1 is given. If the status neither affects the impacts of flooding negatively or positively, a value of 0 is given. Naturally, when the points were added together, the areas with higher points were taken to be more vulnerable to the impacts of flooding, than those with lower scores. The indicators of stress of the various dimensions were then considered in light of the ward's adaptive ability.

This method is fairly simple and has the potential to be used by decision making bodies that can replicate the method to assess and compare all wards, thereby identifying those that ought to be a priority when devising adaptation strategies and allocating limited resources. On the other hand, this method assumes equal importance for each of the critical stress factors. As such, the end results may present a less than accurate picture. This shortcoming can be minimized however, through the use of a more complex measuring system using multiple points to reflect the status each critical stress factor.

3.2 Case Study Selection

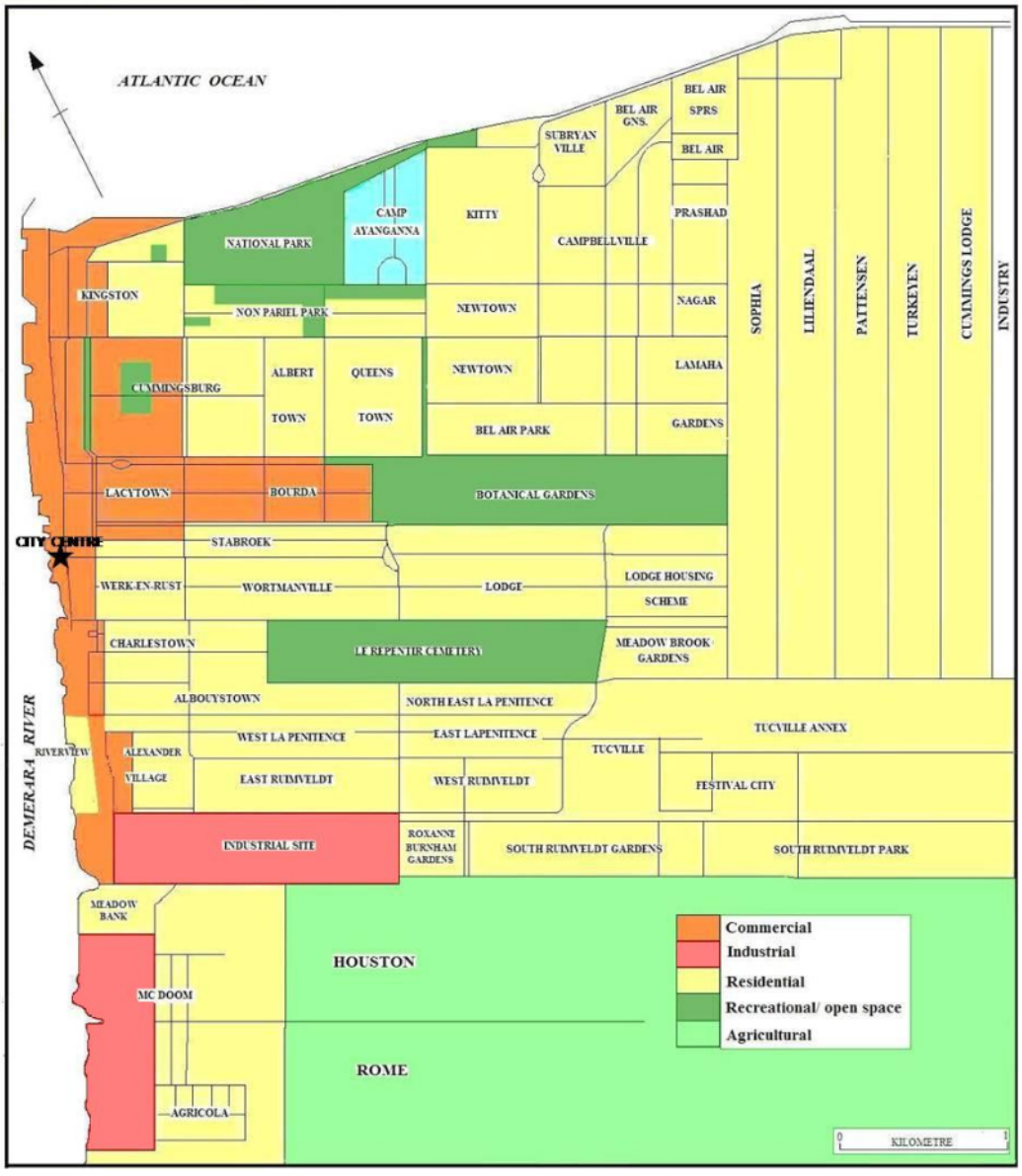
Although traditionally favored for its abundant supply of fertile agricultural land, the flat geography, clayey soils and low elevation of the Atlantic coastal plain make it difficult to drain after the rainstorms that are characteristic of the region. Consequently, it is highly vulnerable to precipitation related flash floods and inundation via SLR. Whereas this project is concerned at a general level with the impacts of sea level rise and climate variability on the coastal plain of Guyana, this area is too large and varied in population, infrastructure, and land use to fit the scope of this thesis. As such, the focus area was limited to Georgetown, which has maintained its primate city status, like many other capital cities in the developing world.

With an area of just 35 km^2, Georgetown houses 39% of the national population and accounts for 43% of the country's GDP (Economics of Climate Adaptation Working Group 2009). As a result, it has the greatest concentration of physical, economic, social and cultural assets at risk in the event of severe flooding and/or SLR. The spatial structure exhibits a riverside dominance, with most of the warehouses, businesses and industries located along the banks of the Demerara River (see Map 2). The residential pattern on the other hand segregates neighborhoods along socio-economic and ethno-racial lines (Wu, Mensah and Edwards 2005). The northern wards of Kingston, North Cummingsburg, Subryanville, Bel Air Park and Queenstown continue to be the upper and middle income areas of the city. However, in recent decades, housing densities in these areas have increased significantly due to the shortage of

affordable housing coupled with rural to urban migration patterns. The once common large 'garden plots' have come under immense pressure for housing developments via plot subdivision, to the point that only a handful of the high-end districts (e.g. Bel-Air Park, Prashad Nagar & Bel Air Gardens) still have sizeable single detached dwellings and 'garden plots'. In contrast, the southern wards of Georgetown have always been home to lower-income people. However, even here the modest detached houses that once dominated working-class neighborhoods such as Lacytown, Bourda, Charlestown, Werk-En-Rust and Albouystown, have undergone decline as properties are subdivided and existing houses are divided into smaller units for renting (see Figure 12).

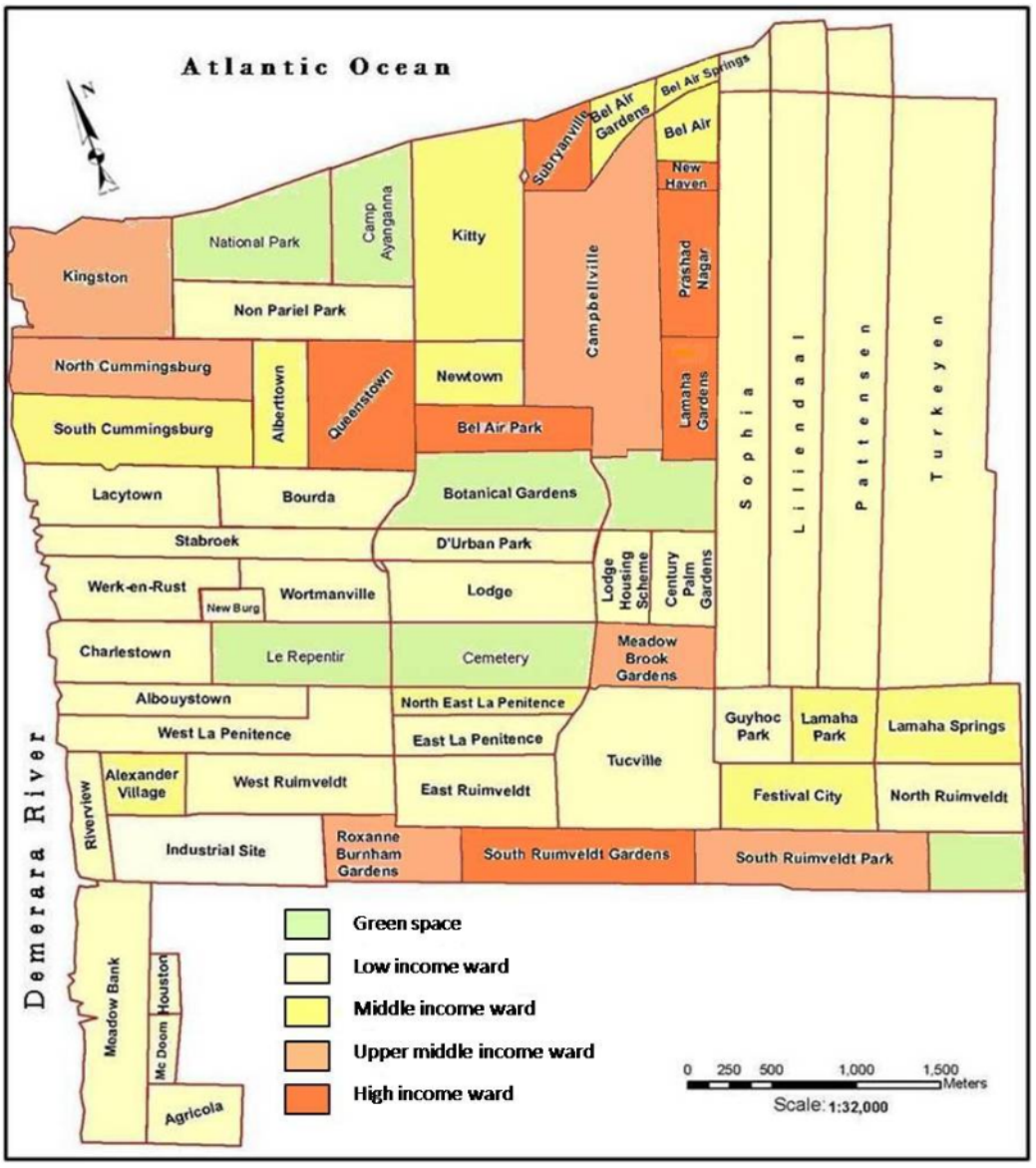
Although all of Georgetown is susceptible to flooding, the intensity and severity (i.e. flood-water heights and staying times) vary from ward to ward depending on location, but more importantly, on the financial means available to the population of the ward in question. Generally, adaptation responses differ according to the socio-economic profiles and history of wards. These tend to be uniformed both physically and economically as their boundaries are synonymous with those of neighborhoods, which by their very nature, have common development histories. This does not necessarily mean that a high-income ward is less susceptible to the impacts of flood events, but rather, that there is a degree of homogeneity in the adaptation responses and impacts within that ward. As such, this research utilizes sample wards as indicators of how well various socio-economic groups are able to adapt to the threat of SLR and flooding, by extension.

Figure 11: Georgetown showing wards and land uses.



Base map provided by Central Housing & Planning Authority, Government of Guyana, 2010. Map produced by Kira Lise Leung.

Figure 12: Georgetown showing wards according to income level.



Base map provided by CH&PA, 2010. Map produced by Kira Lise Leung using income classifications determined in Figure 13[9].

[9] In the absence of specific income data by the Bureau of Statistics, income classifications in Figure 13 are based on the frequency of three groups of occupations differing by wage range. The research assumes that where there are greater percentages of higher earners, it is likely a high-income area, and vice versa. Naturally, high, upper-middle, middle, and low are relative to the average wages paid in Guyana. High-income wards are taken as having more than 50% legislators, senior officials etc. (blue on Figure 13), while low income wards are taken as having more than 50% service workers, shop and market sales workers etc. (green on Figure 13). Upper middle income wards are taken to have 40-50% legislators, senior officials etc. (blue on Figure 13), while all other wards are assumed to be middle income, having a medium mix of all occupations.

3.2.0 Criteria for case study area selection

Factors shown by the literature to determine the impacts of flooding and SLR in Georgetown are as follows:

I. ***Elevation & soil permeability***: Unfortunately, these cannot be taken as decisive factors in this specific scenario, since all of Georgetown has the same clay based soils (with low moisture absorption characteristics) and is at least 2m below sea level. Each ward is therefore equally prone to the exacerbation of impacts caused by these.

II. ***Sewage system***: This has a lot of bearing on whether or not certain water borne diseases are likely to spread in the event of flooding.

III. ***Garbage disposal method***: The frequency of blocked (or reduced capacity) drains in Georgetown due to improper garbage disposal makes this an important factor to consider, as it has the potential to slow down run-off/drainage in the event of a flood.

IV. ***Density***: Higher population densities have been shown to correlate with lower incomes in LACs (as persons cannot afford large plots of land), resulting in higher concentrations of assets at risk (Torre, Fajnzylber and Nash 2009). Density will therefore be examined in the local context to show whether a relationship exists between higher vulnerability & lower adaptive capacity.

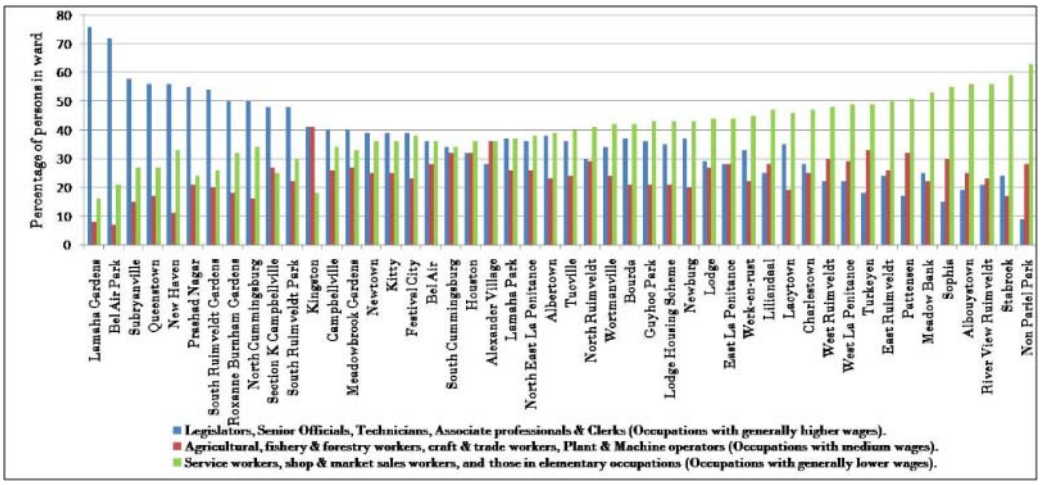
V. ***Prevalence of impermeable surfaces***: Run-off intended for the built drainage system (which has a set capacity) increases as green and brown spaces are converted to grey space (i.e. asphalt and concrete). This

research therefore investigates whether a co-variant relationship exists between the frequency of grey plots within wards and flood water levels.

VI. ***Dwelling style***: certain architectural styles enable persons to adapt to the threat of flooding while others exacerbate impacts. Building styles in the selected wards will thus be investigated to determine whether they are related to income level and land tenure.

VII. ***Income level***: the literature shows that income levels have the greatest impact on the adaptive capacity of a community as it directly impacts all the above decisive factors, with the exception of land elevation and soil permeability. To date, the Guyana Bureau of Statistics has been unsuccessful in collecting reliable income-related data in all of its past censuses. Ideally, case study area selection should be based mainly on income, with some consideration given to the status of other decisive factors. However, in the absence of dependable income related data, this research will consider the distribution of various occupations in the wards of Georgetown, since they are an excellent indicator of the population's income. Occupations are grouped according to those with generally higher wages (i.e. legislators, senior officials, technicians, associate professionals and clerks), medium wages (i.e. agricultural, fishery, and forestry workers, craft and trade workers, and plant and machine workers), and lower wages (i.e. service workers, shop and market sales workers, and those in elementary occupations). Figure 13 shows the distribution of occupations within the wards of Georgetown.

Figure 13: Chart showing the distribution of occupations within the wards of Georgetown.



For a clearer version of this chart, see attachment namely 'Figure 13'.

3.2.1 Case Study Wards

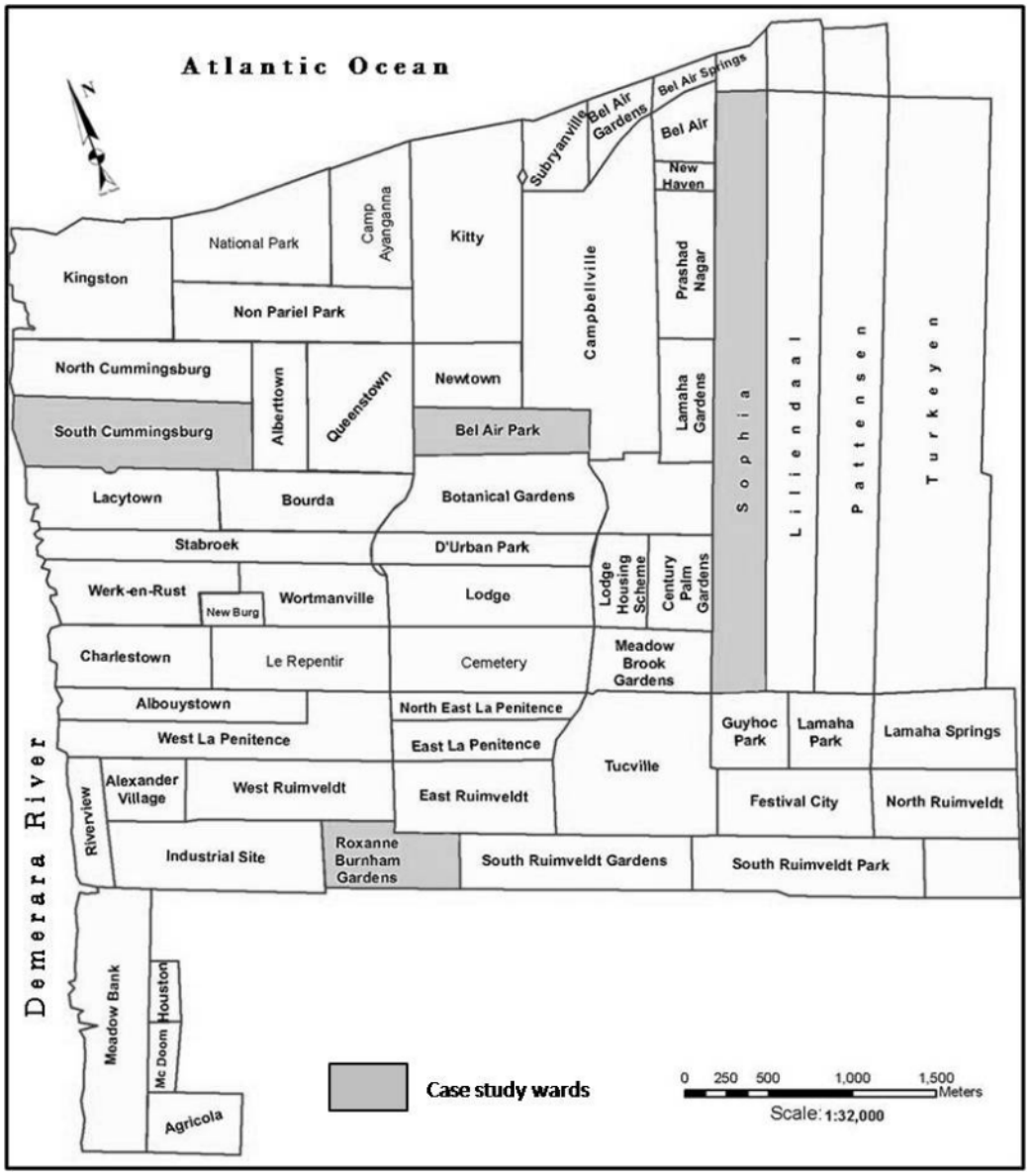
To allow qualitative comparison, four case study sites were selected from 49 wards within Georgetown (see Table 3 and Figure 13). These were Bel Air Park, Roxanne Burnham Gardens, South Cummingsburg and Sophia. They are differentiated by occupation profile (used as an indicator of income), sewerage infrastructure, and location. Within each ward, an area of around 200 households was randomly chosen from an ordinance survey map for field surveys.

Table 6: Characteristics of case study areas.

Ward	Ward Character	Population	Population Density	Total Households	Household density
Bel Air Park	Septic tank/ professional - high income/ central Georgetown	676	2,704 persons/ km²	286	2.4 persons/ household
Roxanne Burnham Gdns	Septic tank/ professional- upper middle income/ south Georgetown - suburban	556	1,588 persons/ km²	190	3.0 persons/ household
South Cummings-burg	Sewer/ working class – middle income/ west Georgetown – riverside central	1942	3,467 persons/ km²	789	2.5 persons/ household
Sophia	Pit latrine/ low-income - non professional/ east G/town – self help settlement	2290	1,635 persons/ km²	897	2.5 persons/ household

Source: Guyana Bureau of Statistics, 2002 Census.

Figure 14: Georgetown showing the location of the four case study wards.



Data source: Central Housing & Planning Authority, 2010. Map produced by Kira Lise Leung, 2010.

3.2.3 Location of Case Study Wards

Figure 14 shows the locations of the four case study wards in relation to the rest of Georgetown. They are not all situated along the Atlantic Coast and

the Demerara River. However, they have all experienced flooding in the past. This is due to the flatness of Georgetown and its gravity drainage system which allow widespread flooding during times of excess precipitation, and also when certain critical dams, or the EDWC are breached. In cases where the Sea Wall was breached, the areas behind it were inundated continually during high tides. During low tides, attempts were made to sand-bag the coast line and reduce flood levels by pumping water out to sea. This occurs because the whole of Georgetown is below sea level and punctuated by large (i.e. usually 30 ft wide) drainage canals which actually facilitate flooding under certain conditions. As such, areas directly adjacent to the Atlantic Coast or the Demerara River are not necessarily more vulnerable to flooding than others further inland as Figure 15 below illustrates.

Figure 15: Illustration comparing a typical coastline to the Georgetown coastline which is protected from the ocean by a seawall.

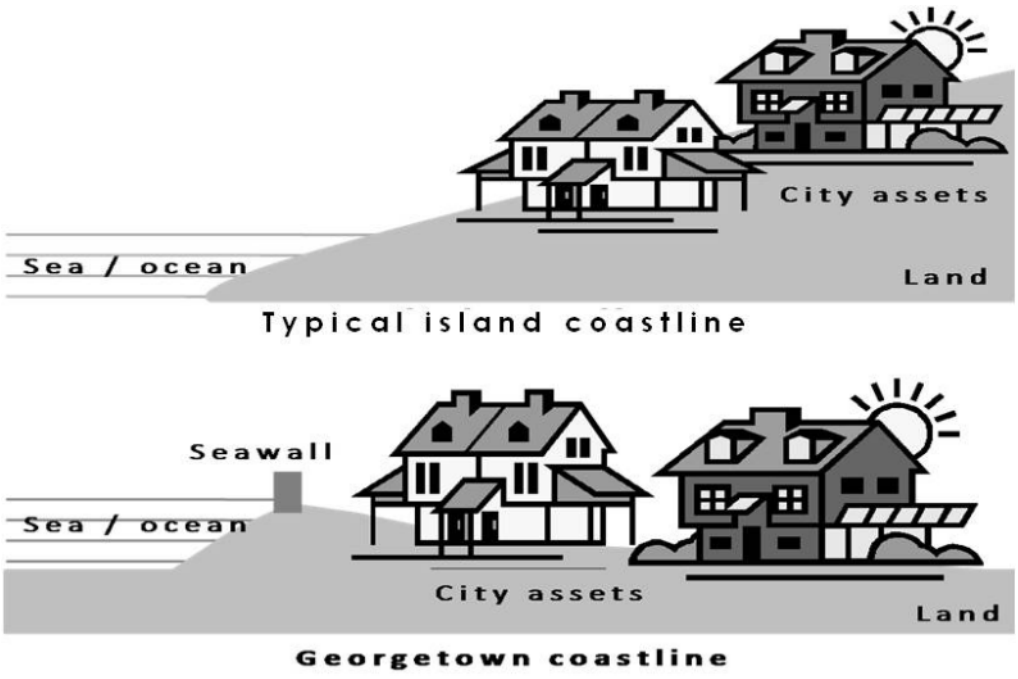
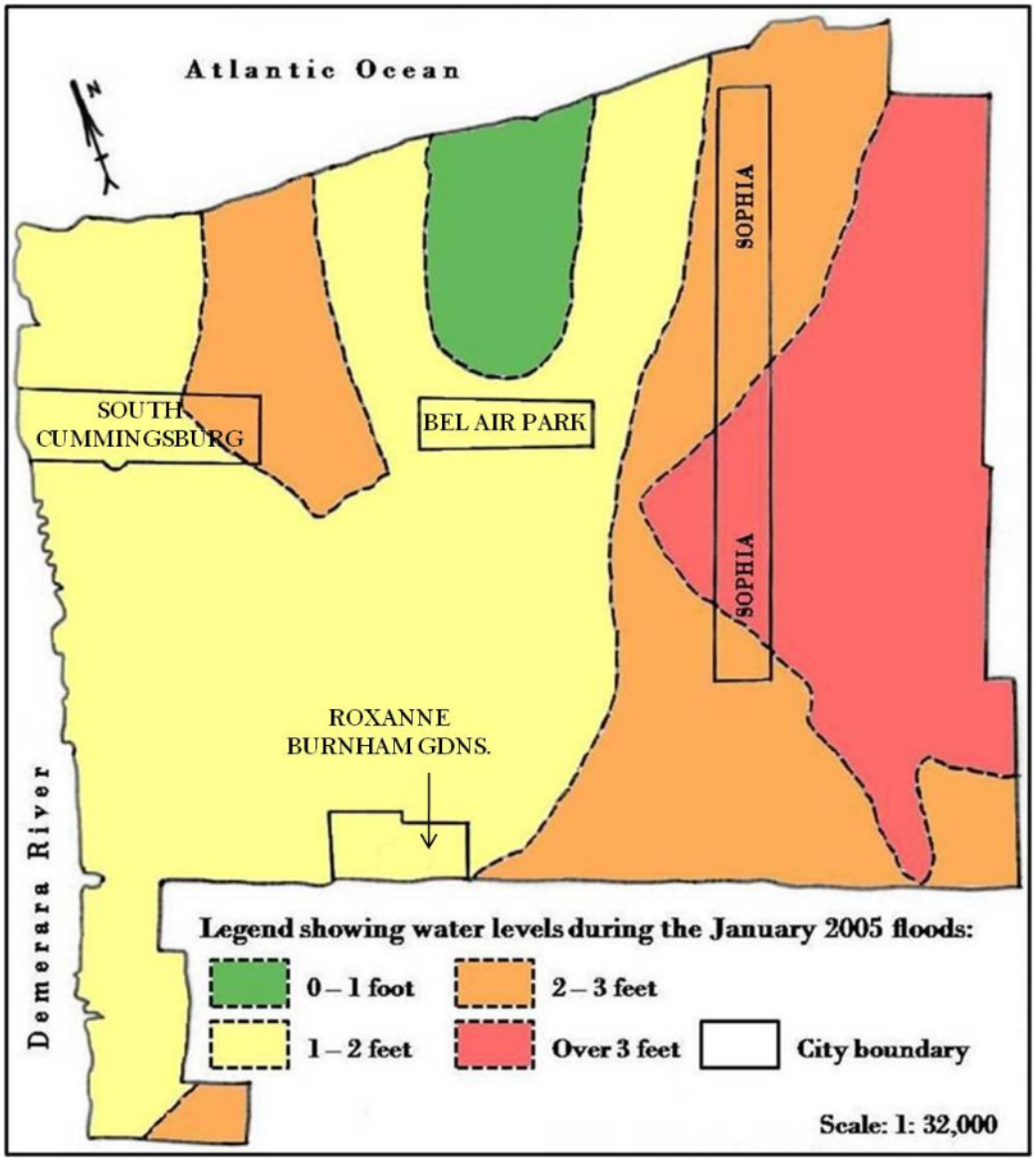


Figure 16: Georgetown showing the water levels experienced by the case study wards during the January 2005 'great' flood.



Map produced by Kira Lise Leung. Base information provided by the Guyana Central Housing and Planning Authority and the Office of Climate Change.

Figure 16 illustrates the point that the severity of flooding in different parts of Georgetown is not necessarily proportional to a ward's closeness to the Atlantic Ocean or the Demerara River. Instead, it is dependent on the

elevation of the land and the ability of the drainage infrastructure in the area to facilitate the water and discharge it to the river / ocean – either via gravity drainage, or mechanical pumping. However, in the coastal belt outside Georgetown where agriculture is the mainstay, areas immediately adjacent to the Atlantic tend to be prone to more severe flooding as there is no sea-wall (see Figure 17).

Figure 17: Flood levels along the Region 4 Coast during the January 2005 flood.

Source: GOG, Office of Climate Change.

N.B: The agricultural lands which Guyana depends on are experiencing the most severe flooding. Soil quality is also changing due to saltwater intrusions.

Chapter 4.0 Survey Results

4.1 General Vulnerability

The table below illustrates that the IPCC Third Assessment classification system is not suitable for determining the vulnerability of each ward in relation to each other. Nevertheless, it is not useless because it is intended to be able to evaluate a variety of locations around the globe, and clearly it shows that even by these standards, many of Georgetown's wards are in a critical state, requiring the implementation of suitable adaptation and mitigation strategies.

Table 7: General Vulnerability of Case Study Wards based on the IPCC Third Assessment classification system.

Impact Categories	Sophia	South Cummings-burg	Roxanne Burnham Gardens	Bel Air Park
	Vulnerability Classes			
People affected (no. of people/ total population) x 100%	100% i.e. critical	88% i.e. critical	86% i.e. critical	84% i.e. critical
People at risk ∑ (no. of people/ flood probability) / 1000[10]	(2290x27) /1000 = 61.83 i.e. medium	(1942x33) /1000 = 64.08 i.e. medium	(556x13) /1000 = 7.28 i.e. low	(676x33) /1000 = 22.3 i.e. medium
Potential land loss (area loss/ total area) x 100%	100% i.e. critical	100% i.e. critical	100% i.e. critical	100% i.e. critical

[10] The results for the 'People at Risk' category is comparable to the total population, which is small in every case due to the fact that this study deals with ward populations as opposed to city populations. For this reason, the wards are deemed to have either medium or low vulnerability, in stark contrast to the other categories where they are all deemed to be critically vulnerable.

4.2 Case Study Ward Results

4.2.1 Sophia

Sophia was initially a 'squatter' settlement developed in the 1980's and 1990's by lower income persons lacking the ability to afford housing in central Georgetown. Prior to this, it was by and large low vacant land highly susceptible to flooding, and thereby undesirable. However, in recent years, it has begun to be regularised and the governement has made strides to improve general living conditions as it relates to roads, sanitation, water supply and electricity. Still, sanitation remains poor with 82% of households using pit latrines (that pose severe health hazards during periods of flooding), and 89% of persons either burying or burning garbage as of 2002.

The workforce is dominated by service workers, shop & market sales workers, and others in elementary occupations. As of 2002, 42% of households had freehold title to their land, while 32% comprised of illegal occupants (i.e. squatters). It was chosen as the low-income case study because of its unique development history, sizeable population and location. Other wards showed greater frequencies of low-income persons, however, challenges related to safety[11], location, low populations and land use, made Sophia the preferred choice.

[11] The other low-income wards that were considered had significantly higher crime rates than Sophia. Selecting any of these wards may have unnecessarily endangered the females who distributed questionnaires. As such, safety concerns played a role in the selection of Sophia as a case study ward.

Socio-economic profile based on survey results (see Appendix 3)

Of those surveyed in Sophia, 98% were aware that both sea levels and air temperatures were rising. Of these persons, 96% believe it will cause flooding to be either 'more severe' (26%), 'more frequent' (28%), or both (42%). Persons surveyed had lived there for 11 years on average. However, no person claimed to have 'never experienced flooding'. Instead, 54% acknowledged that they had experienced flooding four or more times, 32% claimed to have experienced flooding once, while 6% and 8% claimed to have experienced it twice and thrice respectively. On average, each household passed through at least three floods. As such, the average flood probability for those surveyed over the past 11 years would be 1 every 3.75 years i.e. 27% FP.

Calculations

Average length of time persons spent living in Sophia = total years lived there by all residents / number of residents surveyed = 567/ 50 = **11.3 years**

Average number of floods each household experienced in Sophia= total number of floods reported/ number of households surveyed = 142/ 50 = **2.8 or 3 (round)**

Flood probability in Sophia = 3 floods every 11.3 years, or **1 flood every 3.75 years** i.e. **27% FP**[12].

[12] Flood probability calculations for all case study areas are conservative because where persons claimed to have experienced 'four or more floods' on the questionnaires, calculations used 'four'.

Land Tenure

As of June 2010, 70% of persons reported having freehold titles to their land, 6% were renting, 16% were living rent-free[13], while 8% were squatting (i.e. occupying the land illegally). This represents a vast improvement from 2002 when regularization was in the early stages and only 42% of persons held freehold titles to their land, while 32% were squatting. As expected, 46% of persons listed the availability of free land (most likely to squat) as one of the primary factors affecting their decision to live there.

Families accounted for 98% of the households surveyed. Of these, 82% included children who are shown to be more vulnerable to the impacts of flooding. On average, there were 2 employed persons per household, in keeping with Sophia's 'working class' nature. Twenty-six percent (26%) of persons felt it was an affordable area, while 30% felt it was a good neighborhood. Only 10% of persons had inherited their property. This is indicative of the relative 'newness' of the community.

Building construction, design and infrastructure

Property construction details were surveyed to gain a better understanding of income as persons are often uncomfortable releasing such private information. Results showed that 66% of persons had houses with wooden exterior walls, while 30% and 4% had concrete and brick respectively. In Georgetown, wood is generally more expensive to build with despite the fact

[13] This often occurs when the owner, possibly an extended family member, has migrated and does not want to leave their homes empty. As such, they may locate a friend or family member to reside in the house for security reasons.

that it is one of Guyana's primary exports. Furthermore, persons tend to avoid it due to the maintenance costs associated with timber. As such, it initially seems contrary that there would be such a dominance of wood in a low-income area like Sophia. However, observations within the study area revealed that many of the wooden homes were likely constructed using waste wood (commonly unpainted or painted in several different colors) which is often found at dump sites for free. This hypothesis is also supported by the fact that 76% of dwellings were small single storey homes either raised, or flat on the ground. Eight percent (8%) of dwellings also had plywood floors which are relatively cheap and often used as a last resort to flooring as they are highly susceptible to damage via moisture (and flooding by extension). Generally, Sophia's building style profile contrasts greatly with the other case study wards where two and three storey dwellings are common and plywood floors are not reported.

Image 2: Typical small wooden raised one-storey house found in Sophia.

On a positive note, Sophia had the greatest proportion (44%) of dwellings with open-air 'bottom-houses' (i.e. ground floors) which are less vulnerable to the negative impacts of flooding. Of the 56% of dwellings with enclosed bottom-houses, 18% were used as living space for a tenant, while 34% were used as living space for the owner. In most cases (16 out of 17) where the

Image 3: Example of a former single-storey dwelling where the 'bottom-house' was enclosed to accommodate tenants.

owner occupied the ground storey, the dwelling consisted of just one storey flat on the ground, most likely due to limited resources. When tenants occupied a ground floor, it was more often part of a two storey dwelling where rental income likely subsidizes the owners above i.e. on the upper storey. Regardless, in both scenarios, persons were more vulnerable to the negative impacts of flooding, in part due to their financial resources.

Past flood experience

Although Sophia had the greatest proportion of dwellings with open-air 'bottom houses', it was also the place where the greatest number of people (46%) reported flooding inside their homes, as opposed to only their yards or roads. This is likely because many homes were raised enough (2 feet or 0.6m) to endure small regular floods, but not sufficient to withstand the negative impacts of floods such as those in January 2005, and January 2006 where flood levels in parts of Sophia were 4-5 feet (i.e. 1.3 – 1.5m) (see Image 2 for an example). Flood related losses were also exacerbated because yards are generally much lower in elvation than the roads and parapets. For instance, all respondants (i.e. 100%) claimed to have had their yards flooded in the past. However, 64% of persons reported their roads and parapets being flooded in the past. This is of particular concern as many persons carry out small-scale

agriculture (e.g. rearing chickens, growing cash crops) where they sell their products within the community, or use them to supplement their food supply. As such, 52% of persons reported that their 'businesses' (many unofficial) bore financial costs as a direct result of flooding while (60%) claimed that either their house or its contents suffered flood damage. Moreover, 50% of persons reported lost earnings due to time away from work. Also, 33 of the 41 (i.e. 80%) households with children reported them having to be absent from school. This is likely due to the poor quality of the roads which deters regular transportation systems from entering Sophia during times of flooding.

Image 4: Typical unpaved road in Sophia.

The results of the survey showed that Sophia's basic infrastructure and services have improved greatly since 2002 when the last national census was done. For instance, 52% of respondents reported dependence on a septic tank instead of a pit latrine, compared to 82% in 2002. Also, residents reported that there was a private garbage collection initiative within the community, which 34% of respondents utilized. Nevertheless, 66% of persons were still burning

(58%), burying (6%), or dumping (2%) garbage, while 48% continued to use pit latrines.

It is a well established fact that poor sanitation aids the spread of disease during times of flooding. The Sophia case study is no exception as 46% of respondents reported experiencing health problems during and after periods of flooding. However, the quality of sanitation infrastructure (and all other physical development) is dependent on the availability of financial resources, which have defined Sophia from its inception as a 'squatter settlement'. In the absence of city by-laws, building codes, site development standards, city services and formal planning, the community developed itself based on a short term plan to immediately address the basic needs of food and shelter. Little or no consideration was given to disaster preparedness or resilience, due to a lack of foresight, and human and financial resources.

Local responses to flooding

Respondents in Sophia generally expressed willingness to do their part to combat the threat of flooding. Forty-six percent (46%) of persons felt individual households held 'a lot' of responsibility in protecting themselves from floods, while the remaining persons felt the bulk of the responsibility should be on the national government and the Georgetown City Council. However, 66% of persons rated the 'poor maintenance of the large

Image 5: A large canal in Sophia that can hardly be discerned due to grass overgrowth.

drainage canals' as the main cause of flooding, followed by the low land elevation, and improper garbage disposal. Increased impermeable surfaces were deemed the least important contributor to flooding. This is not surprising considering that only 6% of respondents had concreted their yards, most likely because of the associated costs. Nevertheless, 74% of respondents felt that their household was either 'very prepared' (VP) or 'somewhat prepared' (SP) to deal with flooding events. Fifty-two percent (52%) and 80% also felt that the community and social welfare organizations respectively were similarly prepared. In contrast, 72% felt that the local government/ city council and the emergency services were either 'not very prepared' (NVP) or 'not at all prepared' (NAAP) – see Appendix 3, Question 25.

Image 6: Example of a dwelling where the respondents felt they were 'very prepared' to deal with flooding events. Note the height of the open-air 'bottom house'.

Of all the case study wards, Sophia reported the greatest number of adaptation efforts. Sixty-two percent (62%) of persons raised the floor level of their homes and 72% raised their yard levels. Ninety-four percent (94%) claimed to keep the smaller drains around their properties clean, while 56% moved valuables to higher ground. However, only 4% had taken out flood insurance policies, likely because of the costs involved. When questioned about the factors preventing individual households from preparing for floods, 'cost' and 'the need for cooperation with others' were identified as the greatest

deterrents. Otherwise, persons felt they had the skills and time necessary to undertake adaptation efforts.

Perhaps because Sophia is well known as a low-income neighbourhood where both frequent and severe flooding occurs, there was a high degree of helpful intervention in the wake of flooding events. Seventy-eight percent (78%) of respondents reported being helped by friends/ family not living with them, while 38% and 10% were assisted by Community based organizations and the Georgetown City Council respectively. Sixty-two percent benefitted from government relief funds at some point, while 56% and 28% were assisted by NGO's (non-governmental organizations) and the Guyana Police Service respectively. Nevertheless, it appears residents were not satisfied with the state of affairs in their community as 76% of persons claimed they would consider relocating further inland if they could access the same financial opportunities available in Georgetown.

4.2.2 South Cummingsburg

South Cummingsburg is one of the oldest parts of Georgetown. Centrally located along the Demerara River, it houses several businesses and residential dwellings, and has a comparatively high density of 3,467 persons per km^2. Many of its defining characteristics today are as a result of its long history. For instance, it is one of the few wards connected to the municipal sewerage system and fully serviced by the city's garbage collection service. Despite its central location, it has an even distribution of occupation groups (see figure 13), and a high frequency (50%) of households that 'don't know' their land tenure status. This makes for an interesting case study because although the population is much more able to access important services (e.g. health care facilities etc.), the age of the ward has facilitated insecure housing situations, more susceptible to dwelling and land subdivision, and subsequent 'bottom house' rentals.

Socio-economic profile based on survey results (see Appendix 3)

Like Sophia, there was a high level of awareness (96%) about rising sea levels and air temperatures with 78% of respondents believing that it will cause flooding to be either more frequent (8%), more severe (26%) or both (44%). Of the households surveyed, 68% were families with children, 20% were families without children, and 12% were either single persons or unrelated groups of people living together. Every household included at least one working person while 34% and 32% included two and 'three or more' employed persons respectively. This is hardly surprising considering SCB's location relative to the

city center and the fact that 38% of the responding households were renting. Perhaps because SCB is so close to central Georgetown and in demand by renters, the average person surveyed had lived there for 9 years (comparatively shorter than residence times in other case study wards). Sixty percent (60%) of persons claimed to experience flooding events four or more times, 10% experienced it only once, while 8% and 10% passed through flooding twice and thrice respectively. On average, each household endured at least three floods. As such, the average flood probability for those surveyed over the past 9 years would have been 1 every three years i.e. 33% flood probability (FP).

Calculations

Average length of time persons spent living in SCB = total years lived there by all residents/ number of residents surveyed = 455/ 50 = **9.1 years**

Average number of floods each household experienced in SCB = total number of floods reported/ number of households surveyed = 148/50 = **2.96 or 3 (round)**

Flood probability in SCB = 3 floods every 9.1 years, or **1 flood every 3 years** i.e. **33% FP**.

Land tenure

Being an established neighbourhood, 48% of respondents held freehold titles to their property and no squatting was reported. However, 38% of households were renting, while 14% of persons claimed to be living there rent-free. Ninety percent (90%) of persons claimed they had not considered flood risk when moving to SCB although it is known to experience frequent flooding.

This could possibly be because 40% of residents had inherited their properties. Furthermore, 36% and 46% listed the affordable rental costs and the closeness to family and friends respectively as factors that affected their decision to live there. In addition, 50% of persons felt it was a good neighbourhood, and 20% felt it had low crime. As such, persons possibly felt other advantages outweighed the disadvantages associated with flooding.

Building construction, design and infrastructure

SCB is part of the original 'Georgetown', formerly named Stabroek by the Dutch colonial rulers. Traditionally, it was an upper middle class neighbourhood known for its abundance of large wooden colonial-style dwellings (Barros 2003). However, over time, it has become more of a working class neighbourhood with a high percentage of renters. As such, many older buildings have gone into disrepair as the original owners have passed away in many cases, and units are now being rented to persons with less ability to or interest in maintaining their dwelling. As such, the survey showed that 42% of dwellings consisted of wooden exteriors and floors, while 52% were now built of concrete. Only 6% of dwellings were single storeys, while 78% and 16% were double and triple storeys respectively. This was expected based on SCB's higher population density and location.

Image 7: Typical large wooden home in South Cummingsburg where the 'bottom-house' has been enclosed

Of the 50 respondents surveyed, only 1 (i.e. 2%) lived in a dwelling with an open-air 'bottom house'. The other 98% of dwellings all had enclosed bottom-houses, 4% and 18% of which were used as storage and 'other[14]' respectively. Otherwise, 38% were used as living spaces for owners, and 38% were used as living spaces for tenants. When compared to the other case study wards, SCB had the highest occurrence of renters, possibly because of the high demand for SCB's urban location and the heavy use of ground floors. Fifty-eight percent (58%) of yards were also predominantly concreted, while 42% had grass, sand, dirt or mud. Such a high frequency of concreted yards is likely to increase run-off, thereby stressing the drainage canals which already have reduced capacities due to silting.

Image 9: Example of a dwelling with an enclosed 'bottom-house' used for 'classes'.

Image 8: Example of a road in SCB. Note that the parapets are the same level as the road - unlike Sophia where the roads drain off into yards.

Results from the survey showed improvements in SCB's basic infrastructure and services since the 2002 census – albeit based on a very small

[14] 'Other' uses included a place to 'hang out clothes', recreate, or run a small business or office. For instance, a teacher may enclose and use her bottom-house as a place for students to come and have after school lessons/ tutoring.

sample. All respondents were dependent on either the city sewer (98%), or a septic tank (2%). There were no occurrences of pit latrines which are known to exacerbate the negative health impacts of flooding. These improvements were reflected in the fact that only one person of fifty (i.e. 2% of all respondents) recounted experiencing health problems as a result of flooding. Respondents also all (100%) reported dependence on the municipal garbage collection system. Furthermore, in 2002, 10% of SCB's population was squatting on land along the former train-line track which is situated between two of the major canals draining the area. One of these is the largest in the city, namely the Lamaha Canal. This resulted in both canals being constantly blocked as squatters regularly dumped their refuse into the canal itself. However, since then, the squatters have been relocated to a more suitable housing scheme, and the two canals in question have been cleaned of both silt and refuse. Attempts to maintain the drains along the major avenues running through SCB have also been more frequent in recent years (Rawle Edinborough, Director of the CH&PA, 2010).

Image 10: Georgetown City Council worker cutting the grass along the newly built concrete drains along New Market St., SCB.

Past flood experience

Although SCB had the highest frequency of enclosed 'bottom-houses', less persons (36%) reported the inside of their dwelling being flooded – compared to 46% in Sophia. This is likely due to the fact that 46% of respondents raised their yard levels to either that of the road, or slightly above the road level. As such, greater numbers of persons reported their yards (90%), roads (96%) and bridges/parapets (90%) being flooded instead of their dwelling units. Of the 36% of persons that experienced flooding inside their homes, 30% reported that either the dwelling itself or its contents suffered flood damage. Twenty-six percent (26%) also claimed that their business (legally registered or not) bore financial costs as a direct result of flooding. Furthermore, despite SCB's proximity to the city centre where most job opportunities exist, and the availability of organised transport systems, 36% of persons reported lost earnings due to time away from work during flood events. Also, of the 37 households with children, 14 (38%) reported cases where children were unable to attend school due to flooding. This is likely linked to the frequency of flooding on roads in particular.

Local responses to flooding

Unlike Sophia, the majority of SCB respondents felt that private households/ individuals should have little responsibility in the prevention of flooding events. Instead, 88% and 76% believed that the Georgetown City Council and the National Government respectively should bear the bulk of the responsibility. Forty-four percent (44%) of respondents felt that the 'poor

maintenance of drainage' by the relevant authorities was the most important cause of flooding, followed by the 'low land elevation', and 'improper garbage disposal' – despite the improvements in refuse management in recent years. At the same time, 72% of persons felt the 'increase in impermeable surfaces' was the least important contributor to the problem of flooding – even though 58% of persons had concreted their yards. Perhaps the prevalence of concreted yards contributed to the fact that 70% of persons believed their household was either 'very prepared' or 'somewhat prepared' for future flooding events. Of these, 62% believed their community similarly prepared. In contrast, 70% felt that the local government/ City Council were either 'not very prepared' (NVP) or 'not at all prepared' (NAAP) to deal with future flooding events. People also had little confidence in the emergency services as 72% of persons rated them as NVP or NAAP – see Appendix 3, Question 25.

SCB reported significantly less adaptation efforts than Sophia. No surveyed household had taken out a flood insurance policy and only 28% reported raising the floor level of their home. Nevertheless, 52% of persons had moved valuables to higher ground, while 46% had raised their yard level. Sixty-two percent (62%) of respondents also kept the drains around their property clean to combat the threat of flooding. When questioned about the factors preventing individual households from preparing for floods, 'the need for cooperation with others' was listed as the greatest deterrent followed by the costs involved. Otherwise, persons felt they had the skills and time necessary to undertake adaptation efforts. Unfortunately, there was very little helpful intervention in the wake of flooding events despite the central location of SCB.

Although 56% of persons reported receiving help from friends or family not living with them, only 8% reported assistance from a community based organization or non-governmental organization. No one recounted being helped by the Guyana Police Service, the Georgetown City Council, or national Government relief funds. Still, there was a greater degree of attachment to place in SCB as 48% (compared to 24% in Sophia) of persons said they would not consider relocating further inland even if they could have the same financial opportunities available to them in Georgetown.

4.2.3 Roxanne Burnham Gardens

Roxanne Burnham Gardens was established in the 1970s under the People's National Congress as an "aided self help scheme". Initially, it consisted of medium sized lots with either bungalows or single story houses raised on stilts. Today, its appearance is very different as many persons have expanded their homes, or transformed 'bottom houses' into rental units, to generate additional income, or simply accommodate growing families. In many ways the social-economic profile of the ward has improved greatly, with professionals accounting for 50% of the workforce. Ninety-two percent (92%) of properties are owned by one or more inhabitants. This facilitates 'bottom house' renting by lower-income groups and makes for an interesting case study where persons are financially able to adapt their homes (e.g. through raised yards) to the threat of flooding, yet depend on income generated by vulnerable lower-income persons with few housing options.

Socio-economic survey based on survey results (see Appendix 3)

Of the four case study wards, RBG was where the lowest level of awareness existed. Sixteen percent (16%) of persons were unaware that both sea levels and air temperatures were rising. Of the 84% that were aware, 34% believed it would have no effect on the frequency or severity of flooding in Georgetown. Coincidentally, although the average person had lived there 15.5 years, 14% of respondents claimed to have never experienced flooding and 44% reported only experiencing it once – in many cases this one-time occurrence referred to the January 2005 'great' flood. Otherwise, only 34% of persons had

experienced flooding four or more times, compared to 60% in SCB and 54% in Sophia. On average, each household experienced at least two floods. As such, the average flood probability for those surveyed over the past 15.5 years is 1 every 7.75 years i.e. 13% FP, the lowest of all the case study wards – see below for relevant calculations.

Calculations

Average length of time persons spent living in RBG = total years lived there by all residents/ number of residents surveyed = 775/ 50 = **15.5 years**

Average number of floods each household experienced in RBG = total number of floods reported/ number of households surveyed = 100/ 50 = **2**

Flood probability in RBG = 2 floods every 15.5 years, or **1 flood every 7.75 years** i.e. **13% FP.**

Results confirmed that RBG was an established neighbourhood suitable for families, which accounted for 98% of all respondents. Of the households surveyed, 68% included children and 40% believed it was a good neighbourhood (i.e. low crime, and well serviced with sound infrastructure). This may be partially due to the fact that 54% of persons had inherited their properties, and were therefore quite comfortable with the area. The high frequency of freehold land tenure (78%) may have also contributed to households' financial ability to physically prepare their homes for future flooding events. On average, there were two employed persons per household, and if the majority had no rent to pay, this would likely enable persons the

financial means necessary to prepare e.g. by raising their yard or floor levels. Only 14% of persons were renters, while 8% reported that they resided in their dwelling rent free.

Building construction, design and infrastructure

Property construction details were assessed as part of the survey under the assumption that higher income groups would be able to afford better quality homes and vice versa. As such, it was used to substantiate the income profiles determined in Figure 13 using occupation profiles. In the case of RBG, which was identified as an 'upper middle income' ward, buildings definitely appeared to be of a better quality. Eighty-eight percent (88%) of dwellings had exterior walls constructed using either brick or concrete, and 64% had pre-cast concrete floors. Fifty-eight percent (58%) of properties also had concreted yards, which are generally more common in higher income areas. Nevertheless, 26% of homes consisted of a single storey built flat on the ground, and 90% of respondents reported that the ground floor of their home was enclosed. This could be linked to the origin of the ward as an 'assisted self help scheme'. Among the homes with enclosed ground floors, 44% were used as 'living space for the owners', and 9% were used as

Image 11: Example of a concrete dwelling in RBG where the ground floor was enclosed and used as living space for a tenant.

living space for tenants. Another 44% were used for 'other[15]' purposes, while 3% were used for storage.

Past flood experience

Of the 20% of persons that experienced flooding inside their homes, 18% reported that either the dwelling itself or its contents suffered flood damage. However, 24% of respondents reported that their 'businesses' (registered or not) bore financial costs due to flooding. This can be accounted for by the fact that several people had small businesses or offices on their ground floors. Thirty-six percent (36%) of persons also reported that they had lost earnings due to time away from work, while children in 23 of the 34 households with children (i.e. 68%) were caused to be absent from school. This can likely be explained by the frequency of road and yard flooding.

Image 12: Example of a water-proof concrete barrier in place at the door of a home in RBG.

Many persons dealt with the problem of flooding creatively by placing water-proof concrete barriers at the entrances to their ground floors. While it is somewhat inconvenient and less than pleasing aesthetically, it has been shown to be cheap and effective in keeping out water during flooding events. Generally,

[15] E.g. places to hang clothes, recreate, run a small shop or business, or have an office.

the barriers were between one and two feet in height (see Image 12), often depending on the height of the yard. This was not one of the 'adaptive' or 'preventative' actions surveyed using the questionnaire. However, based on anecdotal observations, it is quite likely one of the reasons that only 20% of persons reported flood waters ever entering their homes (compared to 46% in Sophia) despite the frequency of enclosed ground floors used as living spaces, and the fact that 74%, 88%, and 84% of persons had experienced flooding of their parapets, yards and roads respectively.

Results from the survey revealed that RGB had the necessary infrastructure in place to minimize the impacts of flooding. Water was piped into all dwellings and every household was connected to the city's electrical grid as of the 2002 census. The survey also showed that 98% of persons depended on septic tanks (88%) or the city's sewerage system (10%), while 98% utilized the municipal garbage collection system. As such, it is not surprising that only 6% of persons reported health problems related to flooding, compared to 46% in Sophia.

Local responses to flooding

Like SCB, respondents in RBG felt that private households should have little responsibility for flood prevention. Instead, 64% and 80% believed that the National Government and the Georgetown City Council respectively should bear the bulk of the responsibility. This is to be expected as 64% of persons rated 'the poor maintenance of drainage', which is the joint duty of the national and local government, as the most important cause of flooding. This

was followed by the 'low land elevation' and 'improper garbage disposal[16]'. Once again, respondents believed that the increase in impermeable surfaces contributed minimally to the frequency and severity of flooding.

Although only 6% of respondents had taken out flood insurance policies, 84% of persons felt their household was either 'very prepared' (VP) or 'somewhat prepared' (SP) to deal with future flooding events. Of these, 62% also believed that their community was similarly prepared. In contrast, 82% felt that the government/ City Council was either 'not very prepared' (NVP) or 'not at all prepared' (NAAP). Respondents also had little confidence in the abilities of the emergency services (i.e. the police, ambulance and fire service) as 90% rated them as either NVP or NAAP. On the other hand, there was a lot of confidence in social welfare organizations as 80% of persons rated them as either VP or SP – see Appendix 3, Question 25.

Like SCB, RGB reported significantly less adaptation efforts than Sophia[17]. Only 12% of persons had raised the floor level of their homes. However, 38% had raised their yard level and 54% had moved valuables to higher ground. Seventy-eight percent (78%) had also habitually cleaned the drains around their property. 'Cost' was reported by 50% of persons to be the most important factor preventing persons from preparing for floods. It was

[16] Although the smaller drains around private properties in all of the case study wards were generally clean, garbage can be seen in many of the larger drainage canals which the city depends on. The capacity of several others has also been decreased by silting and overgrown grasses/ plants. This is likely the reason why persons continue to believe that it is an important contributor to the problem of flooding.

[17] It should be noted that the concrete barriers used at the entrances to ground floors was not anticipated or surveyed as an adaptation effort, and this could be one of the reasons that RBG's efforts appear to be less.

followed by 'the need for cooperation with others'. Once again, respondents felt they had the time and skills necessary to properly prepare for future flooding events.

Residents of RBG reported little to no helpful intervention from outside the community (i.e. from the police, local NGO's, government relief funds, and CBO's) in the wake of flooding events. Nevertheless, 44% of respondents admitted to receiving help from friends and family not living with them, or neighbors. Furthermore, although the survey showed RBG to fare better than other wards during flooding events and have very high levels of freehold land tenure, 64% of persons reported willingness to consider relocating further inland if they could access the same financial opportunities available to them in Georgetown.

4.2.4 Bel Air Park

In the 1950s, ***Bel Air Park*** was a small high-income suburb of old Georgetown. Today it is much more connected due to urban expansion. Residents depend on the city's garbage collection, transportation and health systems. Seventy-one percent (71%) of properties are owned by one or more of the inhabitants, while 26% of households are unaware of their land tenure status. According to Figure 13, Lamaha Gardens has the highest frequency of upper-income professionals. However, Bel Air Park was chosen to be the high-income case study as it exhibits the same characteristics of Lamaha Gardens, and is not located in such proximity to Sophia (the low-income case study).

Socio- economic profile based on survey results (see Appendix 3)

Of those surveyed in BAP, 88% were aware that both sea levels and air temperatures were rising. Furthermore, 78% believe it will cause flooding to be 'more severe' (10%), 'more frequent (8%), or both (60%). BAP is generally dominated by single-family homes and the average respondent resided there for 9 years (compared to 15 in RBG). Still, 16% of persons claimed to have 'never experienced flooding'. At the same time, 48% reported having experienced flooding four or more times, while 28% and 8% had experienced it once and twice respectively. On average, each household passed through at least three floods. As such, the average flood probability for those surveyed over the past 9 years would have been one flood every three years.

Calculations

Average length of time persons spent living in BAP = total years lived there by all residents/ number of residents surveyed = 432/ 50 = **8.6 years or 9 (round)**

Average number of floods each household experienced in BAP = total number of floods reported/ number of households surveyed = 142/ 50 = **2.84 or 3**

Flood probability in BAP = 3 floods every 9 years, or **1 flood every 3 years** i.e. **33% FP.**

Perhaps because BAP is an upper-income area with predominantly professionals in the labor force, there was a lower occurrence of families with children (only 64% compared to 82% in Sophia). Instead, 20% of respondents were from households with no children, while 12% were single persons living on their own. Also, because salaries are likely higher per person among professionals, there were less employed persons per household (1.6 to be exact, compared to 2+ in the other case study wards). Freehold land tenure stood at 68% and was not as high as RBG, where is it 78%. Renters on the other hand accounted for 28% of respondents. This is likely

Image 13: Example of a typical large single family dwelling in BAP. Note the significantly raised & concreted yard.

because BAP is a popular area for foreign professionals[18] residing in Guyana to rent large single-family type dwellings. As such, it is not surprising that 50% of persons listed the low crime rate in the area as one of factors that affected their decision to live there. Another 72% moved there because they believed it was a good neighborhood.

Building construction, design and infrastructure

The survey showed that double and triple storey dwellings accounted for 92% of BAP dwellings although households were smaller – see Table 3. They were all constructed of concrete and 76% of them also had concrete floors – in keeping with BAP's high income nature. Single storey homes accounted for only 8% of those surveyed, and none of these were raised. As such, 100% of BAP dwellings had enclosed ground floors, most likely because persons who initially had raised-single-storey homes acquired the financial means to enclose the 'bottom-house'. Of the enclosed ground floors, 64% and 20% were used as living spaces for owners and tenants respectively. The remaining ones were used for storage and other miscellaneous purposes. It appears that the most common response to the threat of flooding was to raise one's yard using concrete, as 76% of yards were concreted – compared to only 6% in Sophia and 58% in SCB and RBG respectively. It therefore seems that there is a parallel relationship between the frequency of concreted yards and higher incomes. Unfortunately, concreting one's yard sabotages the community and its overall

[18] Foreign professionals are often hired by CARICOM or Consulates and may have the earning power to rent large dwellings. On other occasions, the companies hiring such persons may rent a large dwelling and facilitate several professionals within it.

drainage system, despite the fact that it may make a household less susceptible to the negative impacts of flooding. For instance, both of the recreational play fields in BAP have now become swamps for the greater part of the year. This is likely because the land remains low while private citizens raise their surrounding yards. The result is that water pools in the fields, thereby rendering them useless to the community. Instead, they become attractive breeding grounds for mosquitoes.

Image 14: Alamander playfield in BAP during the rainy season. Note that the beige home in the background is the same one shown in Image 13 with the completely concreted yard.

Past flood experience

When compared to the other case study wards, BAP appeared to fare relatively well during flooding events. Only 18% of persons had experienced flooding inside their homes, although 94% reported their streets being covered by flood waters. Furthermore, only 26% reported losing earnings due to time away from work, less than any other case study ward. There was also a lower occurrence of both school absences for children and health problems during times of flooding. Perhaps this is due to the fact that all surveyed households utilized septic tank systems and the municipal garbage collection system. Anecdotal observations of the area also revealed that residents generally appeared to put great emphasis on keeping their surroundings clean and orderly.

Local responses to flooding

Although the majority of respondents in other case study wards felt the most important cause of flooding was 'the poor maintenance of drainage, 62% of respondents in BAP (62%) felt 'the low land elevation' was the biggest contributor, followed by 'poor drainage maintenance' and 'improper garbage disposal'. Interestingly, they also felt that 'the increase in impermeable surfaces' was the least important cause of flooding, despite its impact on the drainage system and its frequent occurrence within the ward. Of course, this could be because it largely refers to private adaptation acts which respondents are responsible for. As such, they may be inclined to think they are improving the situation.

Generally, BAP residents expressed willingness to do their part to combat the threat of flooding. In fact, 42% of persons felt individual households held 'a lot' of responsibility in protecting themselves from the impacts of flooding. Furthermore, results show that 72% of persons admitted to regularly cleaning the drains around their property, while 46% had moved their valuables to higher ground. However, the frequency of adaptation actions was lowest in BAP as no one had taken out insurance policies. Nevertheless, 86% of persons felt that both their household and their

Image 15: Typical example of a property drain in BAP. Note that is is not overgrown or blocked, and instead well maintained.

community were either 'very prepared' or 'somewhat prepared' for future flooding events. Ninety-two percent (92%) of respondents also felt that social welfare organizations were similarly prepared. The local government/ City Council and emergency services were viewed less favourably however, as 52% and 60% of persons accordingly rated them as either 'not very prepared', or 'not at all prepared'. When questioned about the factors that might prevent local residents from preparing for floods, the overwhelming response was that persons had 'other things to think about'. This is very much at odds with the other case study wards where 'cost' was the most prohibitive factor. Instead, persons in BAP reported that 'the need for cooperation with others' and the 'cost' would 'not at all' prevent them from preparing. Like SCB and RBG, respondents in BAP also reported little helpful intervention in the wake of flooding from local parties outside of personal friends and family not living with them. Nevertheless, 60% of persons reported that they would not consider relocating further inland, even if they could access the same financial opportunities available in Georgetown.

4.3 Relative Vulnerability

The results from the survey of the case study wards were plugged into the balance sheet method to determine whether their vulnerability in relation to each other was indeed dependent mainly on income, as the literature suggested. The result was opposite in that the wards with the highest and lowest incomes namely Sophia and Bel Air Park, were shown to be equally vulnerable to the negative effects of flooding (and climate change by extension), while the most densely populated urban area, that is South Cummingsburg, was the most vulnerable (see Table 8). Roxanne Burnham Gardens, which is classified as an upper-middle income area, fared the best due to good basic infrastructure and their relatively low density.

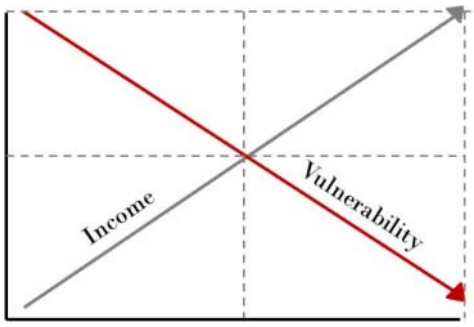


Figure 18: Illustration of the inversely proportional relationship between income and vulnerability, as established by the literature review.

Table 8: Relative Vulnerability of the four Case Study Wards

Potential Stress Factor	Sophia Status	Sophia points	SCB Status	SCB Points	RBG Status	RBG Points	BAP Status	BAP Points
Elevation	Low	+1	Low	+1	Low	+1	Low	+1
Soil Permeability	Low	+1	Low	+1	Low	+1	Low	+1
Income	Low	+1	Medium	0	Medium	0	High	-1
Disaster preparedness	High	-1	Medium	0	Medium	0	Low	+1
Building style	Medium suitable	0	Unsuitable	+1	Unsuitable	+1	Unsuitable	+1
Impermeable surfaces	Seldom	-1	Regular	0	Regular	0	Very Frequent	+1
Land tenure	Mainly freehold	- 1	Mainly renters	+1	Mainly freehold	-1	Mainly freehold	-1
Sewage systems	Largely latrines	+1	City sewer	-1	Septic tanks	-1	Septic tanks	-1
Garbage disposal method	Mainly burning	+1	Municipal collection	-1	Municipal collection	-1	Municipal collection	-1
Density	Low	-1	High	+1	Low	-1	Medium	0
TOTAL Points		**+1**		**+3**		**-1**		**+1**

For a clearer version of this table, see attachment namely 'Table 8'.

Table 8 and Figure 19 illustrate that the relationship between income and vulnerability is not simply inversely proportional in the Georgetown case study, as the literature review suggests. Instead, higher incomes are shown to increase vulnerability as individuals can afford to modify their private surroundings in ways that sabotage the overall resilience of their communities.

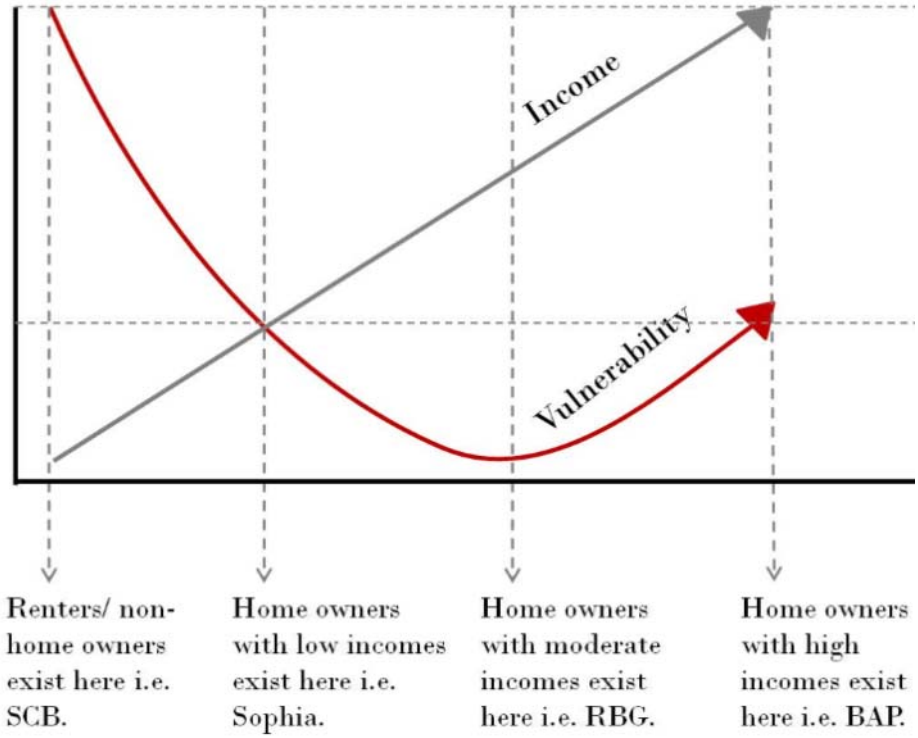


Figure 19: Relationship between income and vulnerability in the Georgetown case study.

The two main modifications that impacted vulnerability adversely were flat enclosed ground floors and concreted yards. The present building code does not address the problem of flooding sufficiently in that it does not require ground floors to be elevated. However, it does regulate site coverages and setbacks according to wards and zones.

Current site coverage and setback regulations do not apply to Sophia because it was not an official ward when the building codes were developed. Nevertheless, Sophia had the lowest occurrence of impermeable concreted yards because persons either could not afford this modification, or relied on their plots for subsistence agriculture. In comparison, the other case study wards (which are bound by site coverage and setback regulations) had greater occurrences of impermeable yards, proving the building codes to be ineffective in assisting proper drainage at the city level. The CH&PA accredits this failure to a lack of enforcement, which is in turn linked to a lack of both human and financial resources, and the presence of corruption, via bribery of enforcement officers (Edinborough 2010). Other elements shown to increase communities' vulnerability to the negative impacts of flooding in Georgetown included use of land for subsistence agriculture and primitive sewage systems. Urban locations such as SCB were also shown to be particularly vulnerable to the impacts of CC and SLR related flooding because their location facilitated higher densities and greater household incomes. These in turn enabled buildings to be unsuitably altered, and thereby less resilient to the threat of flooding.

4.4 Results Summary

Figure 20: Evidence of SLR related stress on case study wards with possible adaptation options.

This is an oversize figure. As such, see attachment namely “Page 92”.

Chapter 5.0 Analysis and Discussion

The results confirmed that all residents of Georgetown are suffering differing degrees of stress due to flooding associated with climate change and sea level rise. As the immediate environment evolves in response to CC and SLR, each dimension is affected, causing residents to not only suffer economically, but also physically, socially and culturally. According to the literature, sea levels and air temperatures are not rising at uniform rates. Instead, they are increasing at accelerated rates, and will continue to do so as this century continues, in the absence of immediate, drastic and unlikely changes in the amount of greenhouse gases being emitted. As such, it is believed that the earth is still in the early stages as it relates to the impacts of climate change, but is expected to soon reach 'the tipping point' – after which certain impacts will be irreparable (Pearce 2007).

According to the EPA (GoG), sea level is expected to rise by 0.4m during the present century along the Guyana coastline. While this has not been mapped by the EPA, a 1m rise has been mapped (see Figure 1), and under that scenario, the entire city of Georgetown would be inundated. While neither of these are the worst-case scenario of 7m projected by the IPCC, relevant bodies are yet to accurately ascertain what they will translate to in terms of the specific 'costs' of flooding. However, the Guyana Office of Climate Change estimates that annual losses due to flooding will amount to US$150 million by 2030.

This research showed conservative flood probability estimates in the various wards to range between 13% and 33%, i.e. at least one flood every 3 to 7 years. Naturally, as sea levels rise, drainage infrastructure, which is already beyond its design life and capacity, will be further stressed, and unable to handle the current trend of increased precipitation. It will also be prone to more frequent overtopping and structural damage. Combined, these will translate to significantly increased flood probability rates and greater losses. While infrastructure including both buildings and drainage systems can be adapted to better handle the threat of flooding, costs to do so are projected to exceed US$1 billion i.e. more than half of Guyana's 2009 GDP of US$1.48 billion (GOG: Guyana Office of Climate Change 2010). Furthermore, there is no guarantee that this 'solution' will be sustainable in the long term as Georgetown will also have to address a range of problems associated with saltwater intrusion, which is already accompanying SLR and affecting water and soil quality along the coast.

Guyana, and Georgetown by extension, depends heavily on its agricultural endeavours for employment, income and food. The main crops are rice, sugar cane and coconuts, and the majority of agriculture takes place along the Atlantic coast between the mouths of the Berbice, Demerara and Essequibo Rivers. As such, agricultural-based areas are particularly vulnerable to the flood events expected to accompany SLR (see Figure 17). In 2005 and 2006, the rice and sugar industries were devastated by flooding, and forced to withstand great losses. As such, the possibility exists that many of these

industries may no longer be viable and capable of supporting Georgetown, as flood probability rates increase and saltwater intrusions expand. Future adaptation plans should therefore consider vulnerability reduction strategies to ensure Georgetown's continued existence in the potential absence of its agricultural backbone, if relocation is not the preferred solution.

5.1 Vulnerability Reduction and Income

According to the literature review, higher vulnerabilities are more frequent among low income groups lacking freehold land tenure. However, the survey results showed that the relationship between vulnerability and income is not so straightforward in the Georgetown context. This is illustrated by the fact that upper income areas and households[19] were more capable of modifying their vulnerability for the private better by raising their yards, while simultaneously reducing the resilience of the larger community (see Table 9).

Table 9: Dwelling ownership and yard modification.

Case Study Ward	% of households occupied by owner households and with raised yards	% of households occupied by non-owner households and with raised yards
Sophia	54[20]	18
South Cummingsburg	26	22
Roxanne Burnham Gdns.	36	2

[19] Higher available incomes are assumed among owner households, and those where two or more persons are employed – with the exception of Sophia where lands were regularized and employed persons frequently fill lower paying positions in services and agriculture.
[20] Only 5% were raised using concrete. All others were raised using a combination of sand/ dirt.

Bel Air Park	32	2
Total[21]	**37**	**11**

Increased incomes also afforded many of the same households the ability to own larger multi-storey homes, enclose their ground floors and maximize their living space, thereby increasing their vulnerability to the negative impacts of CC and SLR related flooding (see Table 10). Initial anecdotal observations suggested that the majority of these ground floor dwellings were being utilized by renters. However, Table 11 shows that they are predominantly used by their owners, with the exception of South Cummingsburg where the urban location seems to increase demand for rental spaces. Essentially, income is forcing persons who lack the ability to modify their physical surroundings to inhabit dangerous sites, and therefore be more vulnerable to the impacts of CC and SLR related flooding. It should be noted that when owners of multi-storey dwellings utilize their ground floors as living spaces, they are still less vulnerable than renters utilizing similar spaces because during flooding events, owners have the option to move their belongings and activities to the upper floors, while renters often have no other place since they may only be renting the ground floor. Furthermore, because Georgetown tends to flood at a relatively slow rate (i.e. over several hours and even days), owners can easily move their belongings before flood waters enter

[21] 48% of all households surveyed had raised yards.

the dwelling itself. Renters on the other hand stand to have appliances, furniture, cupboards etc. either damaged or rendered completely useless.

Table 10: The relationship between ground floor dwellings and employment.

Case Study Ward	% of all multi storey dwellings with enclosed ground floors and 2 or more employed persons	% of all multi storey dwellings with enclosed ground floors and less than 2 employed persons
Sophia	24	0
South Cummingsburg	50	26
Roxanne Burnham Gdns.	26	8
Bel Air Park	48	34
Total[22]	**37**	**17**

Table 10 above suggests that higher employment rates within households increase the occurrence of enclosed ground floors, which may then be used by renters who are by nature less financially secure.

Table 11: Ground floor dwellings being used by owners vs. renters.

Case Study Ward	% of enclosed ground floor used as living space by owners	% of enclosed ground floors used as living space by non-owners
Sophia	36	18
South Cummingsburg	**38**	**42**[23]
Roxanne Burnham Gdns.	42	14

[22] 54% of all households lived in multi-storey buildings with enclosed ground floors.
[23] South Cummingsburg's central location makes it attractive for renters who prefer to spend a bit more on rent as opposed to transportation from a more distant location.

Bel Air Park	68	20
Total[24]	**46**	**18.5**

Table 11 shows that although a great deal of enclosed ground floors are inhabited by renters/non-owners, the majority are utilized by owners, with the exception of South Cummingsburg where the central location causes ground floor units to be in greater demand by renters.

Moreover, while higher incomes afforded persons the ability to adapt their physical surroundings more readily, higher frequencies of house floods were noted among households with raised yards and more than two employed persons (see Tables 12 and 13). As such, it appears that higher incomes may actually facilitate higher vulnerabilities when resources intended for adaptation are used ignorantly i.e. 1. To make yards impermeable, thereby sabotaging the neighbourhood's drainage system; and 2. To enclose ground floors to be used as extended living spaces.

Table 12: The relationship between house floods and yard modification.

Case Study Ward	% of ground floor dwellings experiencing a house flood and with raised yards	% of ground floor dwellings experiencing a house flood and without raised yards
Sophia	26[25]	6
South Cummingsburg	20[26]	10

[24] 64.5% of all households used enclosed ground floors as a living space.

[25] The high occurrence of ground floor house floods in Sophia in dwellings with raised yards is likely related to the fact that the land is lower than the other case study wards and therefore more vulnerable to flooding, whether yards are raised or not.

Roxanne Burnham Gdns.	4[27]	16
Bel Air Park	12	6
Total[28]	**15.5**	**9.5**

Table 13: The relationship between house floods and employment.

Case Study Ward	**% of households with 2 or more employed persons experiencing house floods**	**% of households with less than 2 employed persons experiencing house floods**
Sophia	26	6
South Cummingsburg	16	14
Roxanne Burnham Gdns.	16	4
Bel Air Park	12	6
Total	**17.5**	**7.5**

Survey results suggest that private motivation to adapt increases alongside the severity of the threat. In Sophia, where the land is lower and persons stand to lose a great deal, they more frequently undertake adaptation efforts. However, since the building codes and site development standards were

[26] The frequency of house floods among dwellings with raised yards is double that of those without raised yards in SCB and BAP, where impervious concreted yards can be found in more than 50% of all properties.
[27] House floods may be less frequent in RBG as raised yards and enclosed ground floors are also accompanied by door barriers shown in Image 12, but not surveyed. Furthermore, many enclosed ground floors in RGB were used for 'other' purposes, instead of living spaces.
[28] 25% of all ground floor dwellings experienced house floods.

not designed to address the threat of flooding, and are not properly enforced, private households at large become agents in the production of either vulnerability or security. As such, they are capable of determining (by the adaptation efforts they undertake) individual security and community vulnerability. Without doubt, the most secure households were those where all living spaces were raised at least 4 feet and the ground floor/ bottom house was used for temporary uses such as hanging out clothes. While this was a lot more common in past times, the current housing shortage has forced individuals to increase their living spaces to accommodate extended family members, or create additional income. This was especially the case in South Cumminsburg and Bel Air Park which are more centrally located. While Sophia had a much higher frequency of dwellings raised on stilts, their vulnerability was still increased because many households benefitted financially from using their yards for subsistence agriculture. Poor transportation systems were also shown to magnify flood impacts in Sophia as they forced school absenteeism among children and prevented others from getting to their place of employment.

5.2 Implications for Adaptation

The survey revealed that neither structural nor non-structural adaptation measures will be able to function effectively in isolation. Instead, any adaptation plan for Georgetown must include both, and in such a way that they complement each other. Since there is no prescribed way to address SLR related flooding, options must be outlined and evaluated taking financial, human and institutional resource limitations into consideration. In the Low Carbon Development Strategy (2010), the Government of Guyana identified the following as the "most beneficial adaptation measures":

1. Upgrades for both infrastructure & assets to protect against flooding;
2. Systematic and behavioural adjustments;
3. Development of financial risk management and insurance measures to aid resiliency; and
4. Shifts to flood resistant crops.

It is worth noting that this 'plan' does not consider relocation as an adaptation option, and depends mainly on structural measures. It also assumes significant increases in Guyana's GNP (for 'environmental services' rendered) will give Georgetown the ability to adapt in place (like the Netherlands - structurally) as opposed to re-locating further inland. Table 14 shows the expected increases in income for Guyana as a result of its Low Carbon Development Strategy, and the intended uses for its 'new' income. It should be noted that even if this projection materializes, in-place adaptation will still be less financially feasible than it was in the Netherlands as adaptation costs are

now estimated at US$1 billion (compared to US$200 million in Table 1 – Chapter 2), which translates to 50% of Guyana's GNP, compared to the Netherlands, where adaptation was estimated to cost 0.05% of their GNP.

Table 14: Projected increases in Guyana's GDP resulting from environmental services being rendered.

Phase	REDD[29] payments available to Guyana	Description/ Potential Uses
Phase 1: 2009		° Interim payments to launch the LCDS[30]
Phase 2: 2010 - 2015	° Starts at: ~US$60 million ° Ramps up to US$230 - US$350 million	° Transitional funding that will be used for: - Capacity building - Human capital development - Investment required to build a low carbon economy
Phase 3: 2013 - 2020	° Starts at ~US$250 to ~US$350 million ° Ramps up to US$580 million	° Continued payments to avoid deforestation ° Payments will be used for further: - Investments in low carbon economy - Capacity building - Climate change adaptation
Phase 4: 2020 onwards	At or above EVN[31] (≥US$580 million)	° 'At-scale' REDD mechanism should: - Provide incentives at or above EVN - Account for increasing value of the forests (e.g. reset EVN periodically).

Source: Guyana Office of Climate Change, 2010.

[29] REDD is the abbreviation of 'Reducing Emissions from Deforestation and Degradation'.
[30] LCDS is the abbreviated form of "Low Carbon Development Strategy".
[31] EVN is the abbreviated form of "Economic Value to the Nation".

5.2.0 Possible uses for income generated by the LCDS

While it is quite possible that Guyana's GDP could increase exponentially through the implementation of its 'Low Carbon Development Strategy', it is important to note that this will take time, while the costs of flooding escalate. Nevertheless, if resources are allocated correctly and transparently, increased financial resources should result in greater adaptive capacity. This would involve investing in public awareness programs, institutional capacity building, early warning infrastructure and the necessary human resources. The survey results also suggest that there is not enough impact avoidance as hazard warning systems and disaster preparedness planning are either non-existent or ineffective. The widespread absence of help in the wake of flooding[32] also makes the case for resources, institutions and networks necessary for effective post disaster response to be strengthened.

In the short term while resources for adaptation are still very limited, it may be in the people's best interest for the State to expand the implementation of less expensive, effective adaptation measures such as building on stilts and raising yards (using permeable or semi-permeable fill). For this to be achieved, the present building and site development standards will have to be amended and enforced, and the urban housing shortage addressed. Suitable financial incentives may also have to be developed, since individual adaptation efforts

[32] The middle and upper income wards of BAP, RBG and SCB were shown to receive less post disaster assistance than the low income ward of Sophia.

were shown by the survey to be limited by available household income and housing availability (see Appendix 3 – Question 23 & 8).

5.2.1 Potential for in-situ adaptation

While household and community adaptation efforts have been shown to have bearing on the production of both vulnerability and security, it is crucial that they are accompanied by effective adaptation efforts at the city scale as each has the potential to bolster or sabotage the other. In the case of Georgetown, city scale adaptation must include suitable improvements to the city's drainage system (i.e. including the sea wall, canals, kokers and pump stations), if in-place adaptation is the favoured solution. This sentiment was also common among surveyed residents as 53% felt that the 'poor maintenance of drainage' was the most pressing contributor to the problem of flooding. Furthermore, when the initial drainage system was designed and developed by the Dutch in the 1800's, sea level rise and climate change were not of concern. Flooding was the major threat, and if managed properly, the drainage system was designed to have the ability to address it, so long as the threat remained constant. If it is the intention of the State to adapt the drainage system in light of new CC and SLR concerns, it seems justifiable and important that more research be done to determine whether the current drainage system is sustainable in the long run, even if upgraded and better maintained. Higher sea levels will mean lower low-tide water levels and a less capable 'gravity' system. A pump system may therefore be necessary, along with sea-wall extensions to protect not only the city, but supporting agricultural lands. The issue of

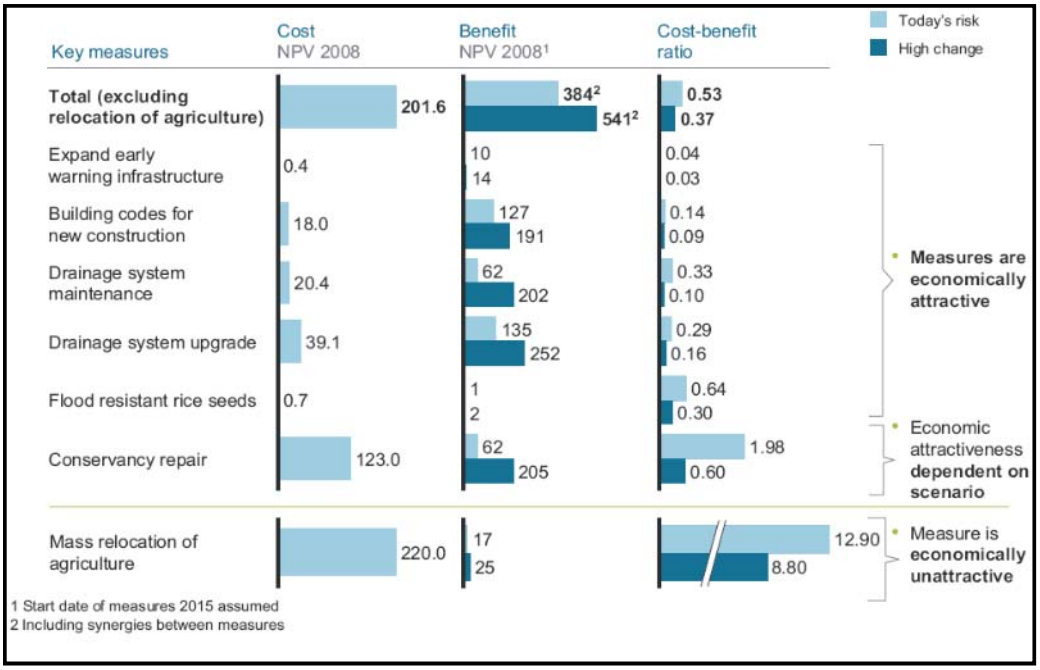
saltwater intrusions will also have to be addressed, lest poor soil quality sabotage agricultural production and urban livelihoods by extension.

5.2.2 Evaluation of adaptation options

According to the Economics of Climate Adaptation Working Group (2009), the most economically attractive adaptation measures include:

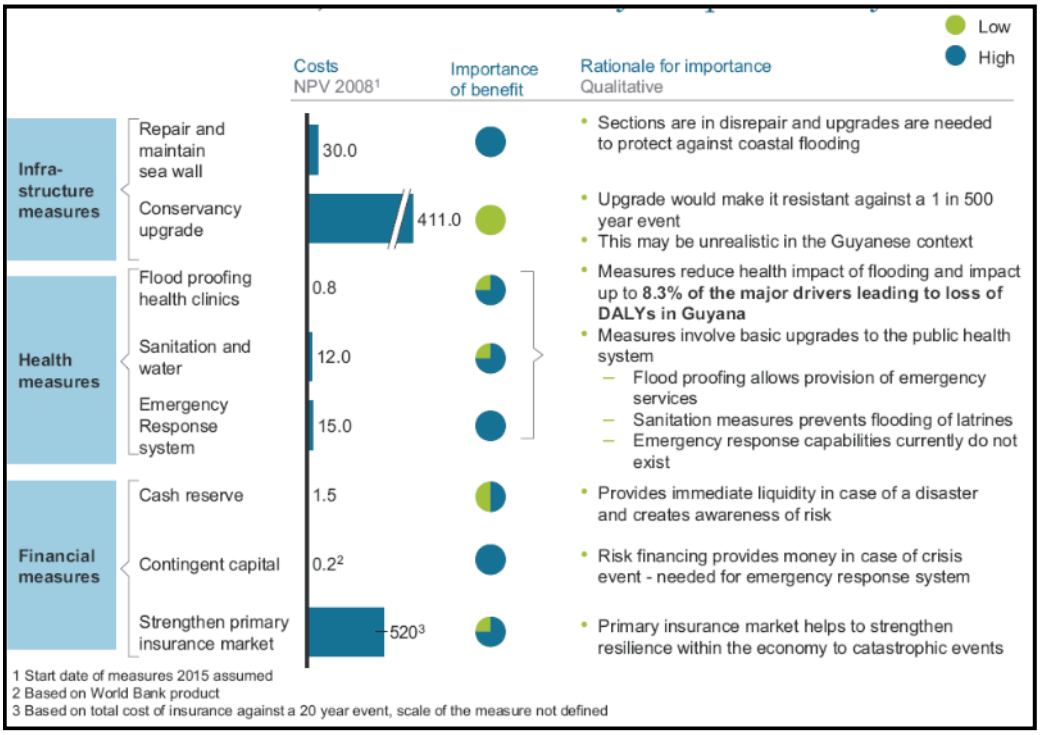
- expanding early warning infrastructure;
- maintaining and upgrading the drainage system;
- investing in flood resistant rice seeds;
- ammending current building codes for new construction;
- improving the emergency response system; and
- strengthening the primary insurance market.

Figure 21: Cost/ benefit comparative analysis identifying economically attractive adaptation options.



Source: Economics of Climate Adaptation Working Group, 2009.

Figure 22: Evaluation of adaptation measures whose benefits could not be quantified.



Source: Economics of Climate Adaptation Working Group, 2009.

The results of Figures 21 and 22 can only be taken as a basic guide to future adaptation due to the shortage of data and the margin for error. However, it should be noted that several of the recommendations are beginning to be implemented. For instance, both the disaster response plan and the building codes are currently being amended to address the threat of flooding. The State is also making strides toward an accessible data collection system that is capable of assisting in decision making in the various involved ministries (GOG 2009). Unfortunately, few changes have been made in the housing sector which is currently increasing vulnerability, despite its potential to create social security.

5.2.3 The Housing Shortage

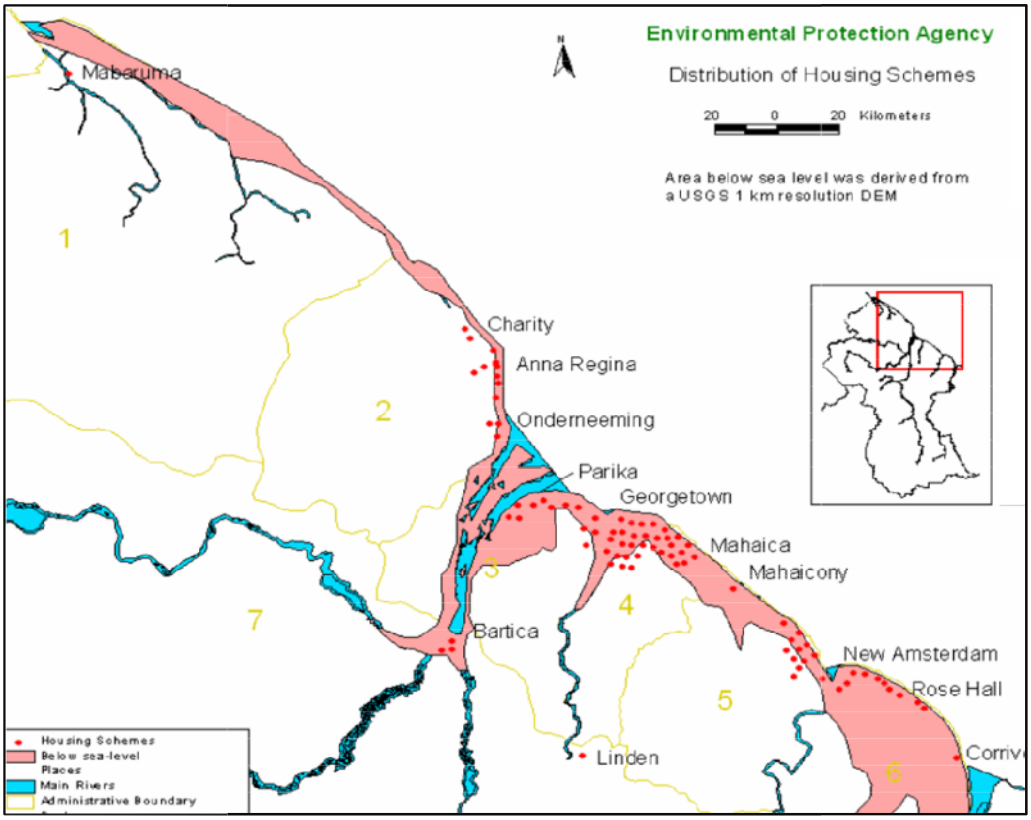
In recent years the Government of Guyana has made great efforts to reduce the housing shortage by subsidizing the sale of house lots and developing low-income housing schemes. However, many of these schemes have proven to be unsuccessful developments as there is more political interest in the quantity of house-lots/ houses being allocated, as opposed to the quality of the settlements being developed[33]. Since 1990, almost every housing scheme developed by the CH&PA is located in an area shown to be vulnerable to inundation in the event of a 1 metre rise in sea level (GOG: Environmental Protection Agency 2002) – see Figure 23.

The data revealed that many persons are reluctant to leave Georgetown and settle far from it, not necessarily because of their attachment to, or comfort level within Georgetown (as the results of the questionnaire showed), but rather because housing schemes are being developed without the commercial opportunities and amenities necessary to support them. As such, if persons choose to live in a scheme outside of Georgetown, the likelihood is that they will have to commute to Georgetown (and put more of their limited financial resources toward transportation) to access work and other basic amenities, since this is where the majority of industries are located. The result is that many persons are opting to stay within Georgetown, thereby increasing the demand for housing in areas such as South Cummingsburg (which is close

[33] Interview with Rawle Edinborough, Director of the Central Housing and Planning Authority of Guyana, June 24th, 2010.

to the city centre and most job opportunities) which have been shown to be highly vulnerable to the impacts of SLR and flooding.

Figure 23: Locations of housing schemes developed by the CH&PA of Guyana.



Source: Environmental Protection Agency, 2002.

5.3 Possible Adaptation Strategies

The case studies suggest that two possible adaptation strategies exist for Georgetown if it is to combat the threat of CC and SLR related flooding. They are:

1. **Decentralization or relocation** – this involves relocating the most vulnerable persons to less vulnerable locations in stages.
2. **In-situ adaptation** – this would require a combination of urban regeneration, adapted buildings, and upgraded drainage infrastructure.

Option 1: Decentralization/ Staged Relocation

Since Guyana does not have a shortage of land suitable for building, housing schemes need to be located in areas naturally less vulnerable to the impacts of sea level rise and flooding – particularly as it relates to elevation. To make this viable, certain industries dependent on the areas upland of the main river systems (i.e. the Essequibo and Demerara in particular) need to be relocated further inland, and at least above the 7m contour line – based on the worst case scenario sea level rise predictions for the coming century. Naturally, housing schemes would have to accompany industrial development/ relocation. While it is a daunting task requiring much strategic planning, it can be facilitated through suitable incentives and improved transportation networks. Additionally, by decentralizing development away from the Atlantic coast, and moving further inland along the main rivers, industries will have easier access to the rivers which they currently use to transport their relevant raw materials e.g. citrus fruits, sand and lumber. Costs associated with the negative impacts

of flooding will also be greatly lessened for both private citizens as well as businesses.

Experience has shown that neither housing schemes nor industries are able to flourish in the absence of each other. Schemes supply the human resources necessary for industries, which in turn provide income opportunities. If this balance is facilitated over time, housing schemes will have a much greater likelihood of appealing to persons as they may be able to access a better quality of life a short distance outside of Georgetown.

Justification: Since resources are constantly being funneled into unsustainable vulnerable housing schemes outside of Georgetown, the potential exists for similar resources to be better channeled into schemes that have the ability to be chosen by persons over vulnerable locations within Georgetown. While history has shown that 'moving a capital' is rarely successful (e.g. Brasilia, Ankara, Belmopan) due mainly to persons' sentimental attachments to a place, 53% of questionnaire respondents admitted a willingness to move further inland if presented with the same financial opportunities available in Georgetown. This is not surprising however, considering that Guyana has battled migration and 'brain-drain' continually since the 1970's.

Option 2: In-situ Adaptation – i.e. Urban Regeneration/ Densification coupled with Adapted Buildings and Upgraded / Maintained Drainage Infrastructure

Georgetown's primate city nature coupled with the low success rate of relocation in other parts of the world makes relocation a less desirable option. As such, the government appears to favor in-situ adaptation, which will undoubtedly require the implementation of extensive structural adaptation measures related to the upgrade and maintenance of the current drainage system. It will also require the buildings in vulnerable urban areas to be adapted to the threat of flooding via stilts or other 'floating' mechanisms. Increased access to less vulnerable, secure housing near the urban centre can also be achieved through urban regeneration/densification programs which acquire and exploit under-utilized spaces. This option may be more expensive in the short term. However, it is likely the better option for CH&PA to pursue in the long term, unless effective transportation systems are put in place to accommodate and facilitate the 'bedroom' housing schemes outside of Georgetown. Either way, CH&PA will have to develop and implement vulnerability reduction strategies for both existing and future housing schemes.

Under the British rule (that is prior to 1966), Georgetown was known as the 'Garden City' throughout the Caribbean. It was just as low in elevation and susceptible to flooding. However, far less flooding events occurred. Lakhan (1994) accredits this to better maintenance of the drainage system, a lower frequency of impermeable surfaces, and more widespread vegetation. These factors indeed have the potential to reduce flooding as they facilitate run-off

and allow greater absorption by the soil. As such, it would be in the state's interest to investigate the potential role of replanting vegetation as a means of reducing flooding.

The public also needs to be better informed about the factors that exacerbate flooding, and how they can assist at the individual and communal levels to reduce flooding events as well as their impacts. Increased public awareness may also make persons more willing to comply with building codes that are responsive to the threat of flooding.

Chapter 6.0 Conclusion

Flooding has traditionally been facilitated by Georgetown's low elevation, improper management of the koker systems and infrastructure failures during the rainy seasons. However, this research shows that the frequency and severity of flood events is now being exacerbated by climate change and sea level rise because they are translating to changes in precipitation patterns locally and putting increased stress on expired infrastructure (particularly the sea wall). Institutional weaknesses also contribute to the problem as the public agencies in charge of drainage management are severely under-resourced and therefore incapable of proper infrastructure maintenance.

As flooding is imposed upon a largely pre-existent urban structure, all social classes and urban environments are potentially vulnerable to the impacts of flood events. Nevertheless, household experiences of flooding and its impacts were shown to be influenced by household asset profiles, which were in turn, linked to location (i.e. urban or semi-urban) and dwelling construction style. Location affected vulnerability because urban wards tended to have better access to transportation and good basic infrastructure. They (e.g. South Cummingsburg) also exhibited the highest frequency of rentals, which in turn increased densities (as their locations were in demand) and the occurrence of less flood-resilient dwellings. Semi-urban low-income wards (e.g. Sophia) on the other hand suffered increased flood impacts (i.e. illness, loss of capital/ earnings, and school absenteeism) because of poor transportation systems and

primitive sewerage infrastructure. Coincidentally, Sophia (which was the semi-urban low-income case study) had the highest frequency of flood-resilient dwellings. Still, excessively low yards coupled with the dependence on subsistence agriculture increased losses despite the fact that 44% of dwellings were built on stilts while only 6% of yards were concreted (i.e. impermeable). Children in this area were also particularly vulnerable to flood impacts through forced school absenteeism and health vulnerability.

While relative vulnerability appeared to be highest in the most centrally located/urban ward, the highest levels of household vulnerability were characterized by low household incomes, unsuitable dwelling construction, and little community organization and were encountered in both urban and semi-urban wards. Bel Air Park was the exception as increased household incomes facilitated more expensive but less flood-resilient building styles, and concreted yards that sabotage the overall drainage system. Logically, raised yards should reduce the occurrence of house floods. However, the research proved otherwise as there was a greater frequency of house floods among those with raised yards, with the exception of Roxanne Burnham Gardens where they were often successfully supplemented by raised water-proof blockages at doors. Perhaps this can be linked to their overall negative impact on the drainage system (if impermeable), and their capacity to raise water levels throughout a ward by reducing soil permeability. With the exception of Sophia (where persons lost agricultural capital and income due to poor transportation systems), raising dwellings on stilts and moving valuables

to higher ground appeared to be the most effective means of avoiding flood impacts. Unfortunately, this building style existed predominantly among persons either lacking the financial means to modify their dwelling, or having the financial comfort of by-passing the potential income opportunity of renting. As such, the most vulnerable physical locations do not automatically imply that those residents are the most vulnerable to the negative impacts of flooding in the overall picture.

Increased flood impacts appeared to be rooted in the lack of access to secure housing encountered among households with little economic and social assets. As such, there is a recognized need for both the private and public housing sectors to develop safe (i.e. designed to reduce vulnerability), urban middle and low-income housing opportunities. Once this takes place, a reduction in the number of households living in overcrowded or unsuitable accommodation, or in vulnerable rental accommodation could occur. Needless to say, such developments must be accompanied by amended building codes that better respond to the threat of flooding. If this is not done and enforced, the problem stands to be magnified as persons may choose to utilize their new 'bottom houses' as rental income opportunities. Drainage infrastructure throughout the city also needs to be urgently addressed. In the short term, this may mean better maintenance programs and the installation of a pump system. However, adaptation plans for the long term need to be researched and developed (if staged relocation is not pursued) as sea levels are expected to rise and potentially devastate Georgetown and its surrounding areas.

While vulnerability reduction strategies are crucial, they do not negate the potential of a disaster occurring. As such, impact transfer options need to be surveyed. The primary insurance market needs to be strengthened and cash reserves/ contingent capital may have to be developed. Post-disaster responses should also be addressed as results confirmed that residents received little help in the wake of flood events. In the past, community based organizations (CBOs) have not received the political and financial support necessary to facilitate their objectives, despite their potential to provide practical support for communities in times of need. By involving such groups in both pre and post disaster planning, the relevant authorities may be able to provide residents with the services necessary to reduce impacts and recover. CBOs may also be able to assist in filling data gaps currently hindering the development and implementation of effective adaptation strategies.

6.1 Recommendations

The results of the case studies suggest that the following recommendations should be included in future adaptation plans as they are likely to be effective in reducing Georgetown's vulnerability to the threat of CC and SLR related flooding, and increasing its adaptive capacity.

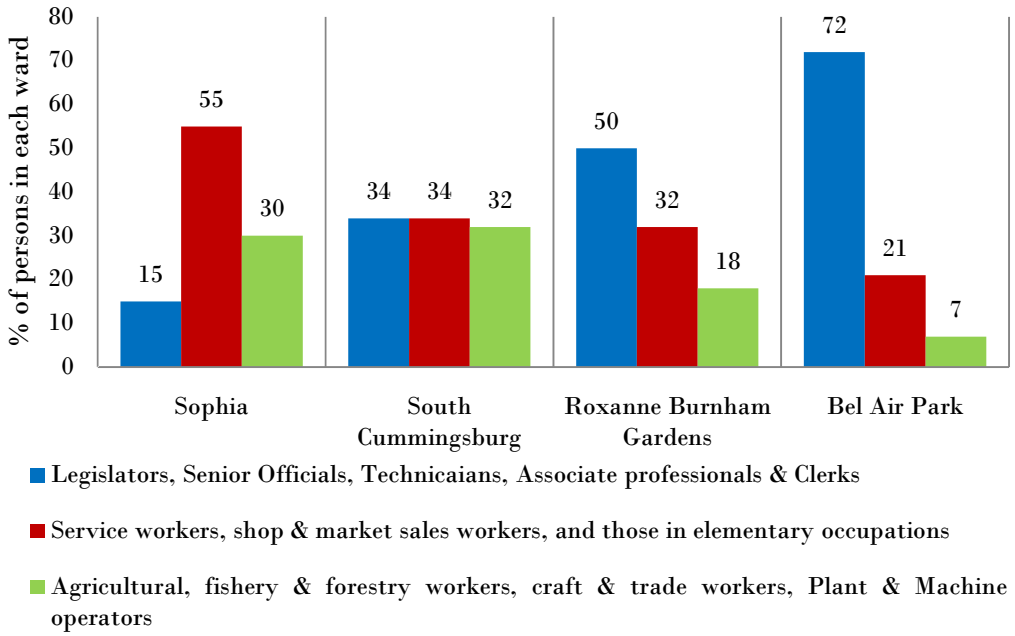
1. Increase public awareness about climate change, sea level rise, and flooding. Particular emphasis should be placed on preparation measures (intended to reduce the negative impacts of flooding events) and post-disaster responses;

2. Fill the data gaps that are currently hindering decision making and the development of effective adaptation strategies;
3. Develop a disaster preparedness plan that is responsive to the threat of CC and SLR related flooding;
4. Amend the building codes (e.g. require new buildings to be raised) so that they are more responsive to the threat of flooding, and improve enforcement;
5. Transparently manage income resulting from the Low Carbon Development Strategy so that the funds necessary to improve Georgetown's adaptive capacity will be available;
6. Facilitate NGOs and CBOs;
7. Develop (and maintain) drainage infrastructure with the potential to address the threat of CC and SLR related flooding;
8. Improve garbage collection and sewerage systems;
9. Develop transportation systems that support self-sufficient housing outside of vulnerable areas;
10. Facilitate development of both the public and private housing sectors, especially outside of naturally vulnerable locations;
11. Replant vegetation and enforce site coverage regulations; and
12. Strengthen impact transfer options such as the primary insurance market. It may also be in the population's best interest for the state to develop cash reserves and contingent capital.

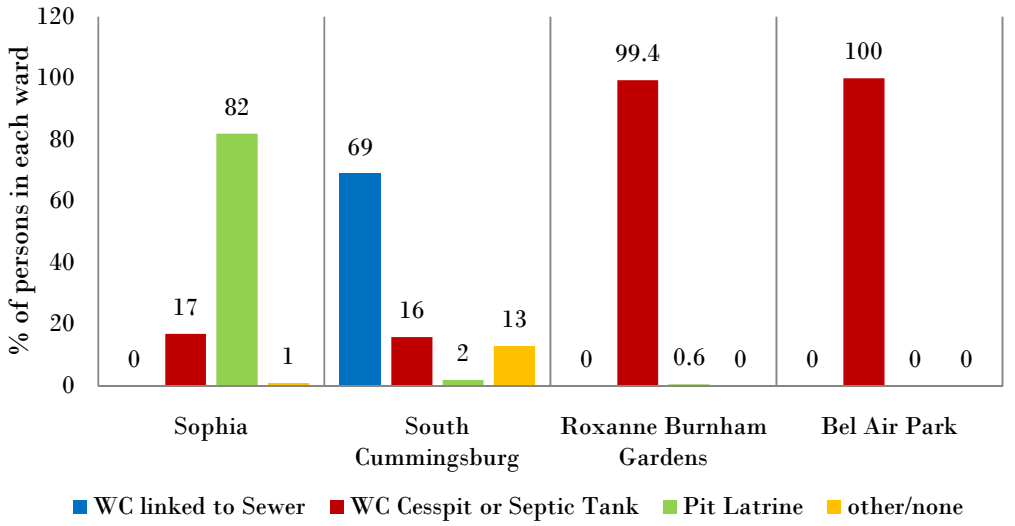
Appendices

Appendix 1: Profiles of case study wards according to occupation, sewage system, land tenure and garbage disposal method.

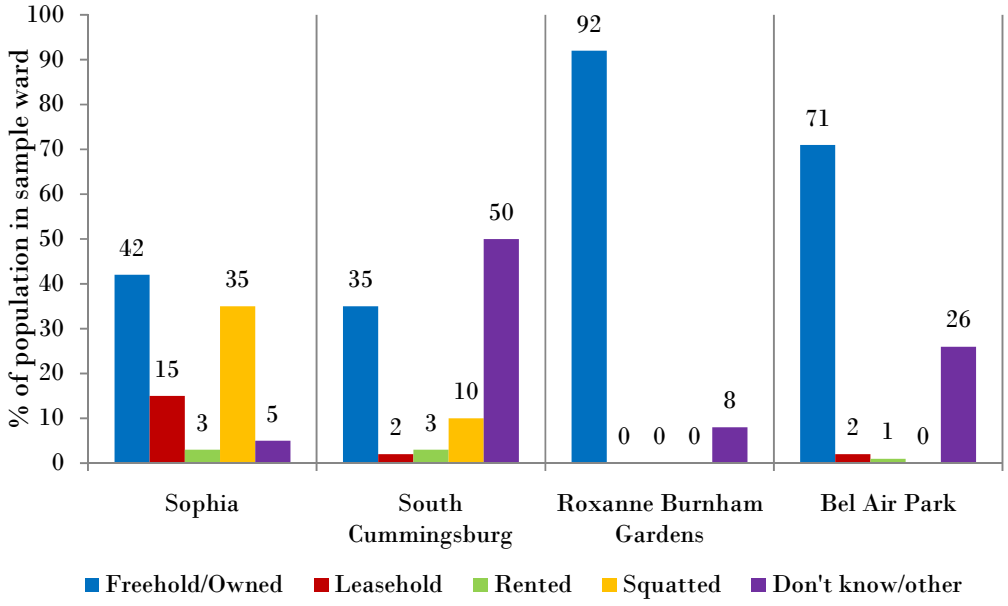
Occupation by Population in sample wards, 2002.



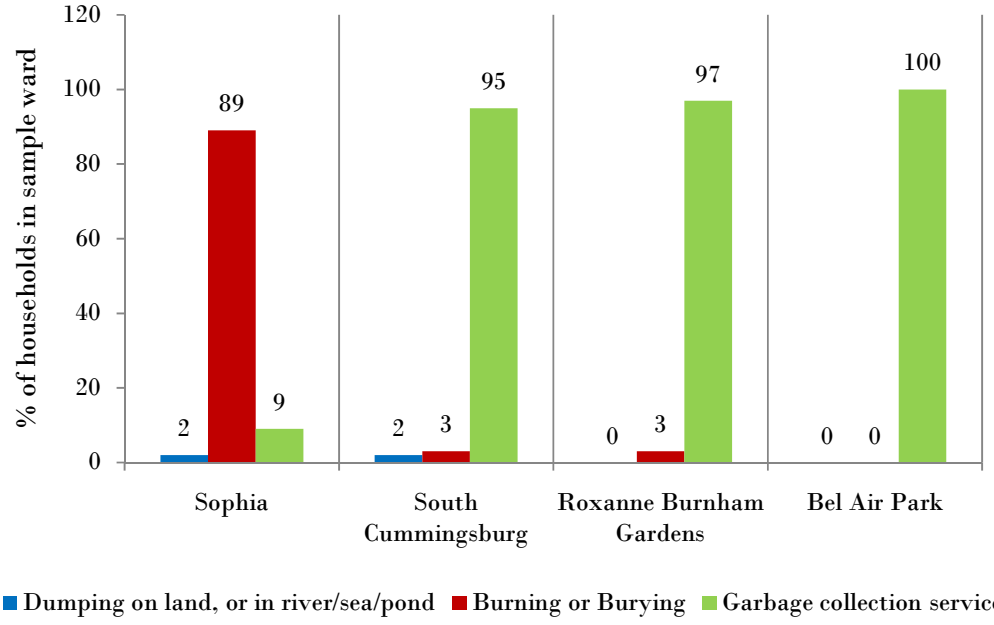
Sewage system by household in sample wards, 2002.



Land tenure by population of sample wards, 2002.



Garbage disposal method by household in sample wards, 2002.



Appendix 2: Sample Questionnaire

1. **Are you aware that both sea levels and air temperatures are rising?**

☐ Yes ☐ No

2. **In your opinion, this will cause flood events to be:**

☐ More frequent ☐ More severe

☐ Both of the above ☐ The same

3. **How long have you lived at your current address? _____ years _____ months**

4. **While living at this address, how many times have you experienced flooding?**

☐ Never ☐ One ☐ Two ☐ Three ☐ Four or more

5. **Which of the following best describes your household?**

☐ Family with children ☐ Single person

☐ Family without children ☐ With other people

6. **How many persons in your household are employed?**

☐ None ☐ One ☐ Two ☐ Three or more

7. **Which of the following best describes the situation you are living in now?**

☐ This dwelling is owned by someone in my household

☐ I/we rent this dwelling

☐ I/we live in this building rent-free

☐ I/we are squatting

8. **Which of the following factors influenced your decision to move/live here?** Tick all that apply.

☐ Good neighbourhood ☐ Affordable rent/ rent free ☐ Low crime rate

☐ Close to family/friends ☐ Inherited property ☐ Low home price

☐ Free available land

9. **Did you consider flood risk when moving here?** ☐ Yes ☐ No

10. **Property construction details, if you know them:** Tick all that apply.

Exterior Walls.. ☐ Brick ☐ Concrete ☐ Wood

Floors…… ☐ Plywood ☐ Concrete ☐ Wood

Storeys…….. ☐ One- flat ☐ One raised ☐ Two ☐ Three

Ground floor…. ☐ Open-air ☐ Enclosed

Yard……. ☐ Grass ☐ Concrete ☐ Sand/dirt/mud

11. **If the ground floor is enclosed, what is it used for?**

☐ Storage ☐ Living space for the owner

☐ Living space for a tenant ☐ Other_____

12. **Which of the following sanitation systems are used at your home?**

☐ City sewer ☐ Septic tank ☐ Latrine ☐ Other _____

13. **Which garbage disposal method do you utilize?**

☐ Burying ☐ Burning ☐ Dumping ☐ City collection service

14. **Which of the following have been flooded in the past**?

☐ The inside of your home ☐ Your yard

☐ Your bridge/ parapet ☐ Your road

15. **Has your house, the contents or any of your household's other possessions suffered from flood damage in the past?** ☐ Yes ☐ No

16. **Did you or your business bear any financial costs as a direct result of flooding, that was not covered by insurance (excluding loss of earnings, if any).**

☐ Yes ☐ No

17. **Have previous floods caused you to experience any loss in earnings due to time away from work?** ☐ Yes ☐ No

18. **Have previous floods caused the children in your household to miss school?**

☐ Yes ☐ No ☐ No children in this household

19. **Did you, or any of your household members experience any health problems as a result of flooding?** ☐ Yes ☐ No

20. **On the scale below, rate the following causes of flooding?**

1 = Least important, 5 = most important

	1	2	3	4	5
° Poor maintenance of drainage					
° Low land elevation					
° Increased impermeable surfaces					
° Improper disposal of garbage					
° Other _____					

21. **When flood events occur, do you receive a formal flood warning?** ☐ Yes ☐ No

22. **Has your household undertaken (or do you intend to undertake) any of these prevention measures to combat the threat of flooding?**

			I intend to
° Taken out household insurance against flooding	☐ Yes	☐ No	☐
° Raised the floor level of your home	☐ Yes	☐ No	☐
° Raised your yard level	☐ Yes	☐ No	☐
° Kept ditches and drains around the property clean	☐ Yes	☐ No	☐
° Moved valuables to higher ground	☐ Yes	☐ No	☐

23. **To what extent might each of the following prevent you from preparing for future floods?** Not at all 1 2 3 4 5 A lot

- Cost
- Skills required to prepare
- Other things to think about
- Need for cooperation with others

24. **Please indicate on the scale whose responsibility you believe it is to protect us from floods?** Not at all 1 2 3 4 5 A lot

- National government
- Georgetown city council
- Individual households

25. **How prepared do you believe the following groups are for future flood events?**

	Very prepared	**Somewhat prepared**	**Not very prepared**	**Not at all prepared**
° Your household				
° Your community				
° Local govt. /city council				
° Emergency services (police)				
° Social welfare organizations e.g. Red Cross				

26. **During/after past floods,**

which of the following groups helped or supported your household?

- Friends/ Family–not living with you/ Neighbours ☐ Yes ☐ No
- Community based organizations ☐ Yes ☐ No
- Georgetown city council ☐ Yes ☐ No
- Police ☐ Yes ☐ No
- Government relief fund ☐ Yes ☐ No
- Non-governmental organizations/ charities ☐ Yes ☐ No

27. **Would you consider re-locating further inland if you could have the same financial opportunities available in Georgetown?** ☐ Yes ☐ No

Appendix 3: Questionnaire Results

Questions and Options	Case Study Wards and Answers			
	Sophia	South Cummings-burg	Roxanne Burnham Gardens	Bel Air Park
Question 1: Are you aware that both sea levels and air temperatures are rising?				
Yes	49	48	42	44
No	1	2	8	6
Question 2: You believe this will cause flooding to be...				
More Frequent	14	4	3	4
More Severe	13	13	8	5
Both of the above	21	22	22	30
The same	2	11	17	11
Question 3: How long have you lived at your current address?				
1 year or less	1	10	1	5
2 to 5 years	5	16	8	17
6 to 10 years	16	7	14	14
11 to 15 years	19	4	8	5
Over 15 years	9	13	19	9
Question 4: How many times have you experienced flooding at your current residence?				

Never	---	6	7	8
One	16	5	22	14
Two	3	4	2	4
Three	4	5	2	---
Four or more	27	30	17	24
Question 5: Which of the following best describes your household?				
Family with children	41	34	34	32
Family without children	8	10	15	10
Single person	---	4	1	6
With other people	1	2	---	2
Question 6: How many persons in your household are employed?				
None	2	---	3	3
One	11	17	10	21
Two	26	17	20	18
Three or more	11	16	17	8
Question 7: Which of the following best describes your living situation?				
I/ we own this dwelling	35	24	39	34
I/we rent this dwelling	3	19	7	14
I/ we live here	8	7	4	2

rent free				
I/ we are squatting	4	---	---	---
Question 8: Which of the following factors affected your decision to live here?				
Good neighborhood	15	25	20	36
Affordable rent/ rent free	13	18	4	10
Low crime rate	9	10	3	25
Close to family/ friends	14	23	9	13
Inherited property	5	20	27	13
Low home price	9	4	13	2
Free available land	23	---	---	---
Question 9: Property construction details…				
Exterior walls…				
Brick	2	3	6	1
Concrete	15	26	38	45
Wood	33	21	6	4
Floors…				
Plywood	4	---	---	---
Concrete	8	20	32	38

Wood	38	30	18	12
Storeys…				
One – flat	16	2	13	4
One – raised	22	1	17	---
Two	11	39	20	44
Three	1	8	---	2
Ground Floor…				
Open Air	22	1	5	0
Enclosed	28	49	45	50
Yard…				
Grass	28	11	14	10
Concrete	3	29	29	38
Sand/ Dirt/ Mud	19	10	7	2
Question 10: Did you consider flood risk when moving here?				
Yes	12	5	13	4
No	38	45	37	46
Question 11: If enclosed, what is your ground floor used for?				
Storage	2	2	1	3
Living space for tenant	9	19	4	10
Living space for owner	17	19	20	32

Other	---	9	20	5
Question 12: Which of the following sewage systems is used at your home?				
City sewer	---	49	5	---
Septic tank	26	1	44	50
Latrine	24	---	---	---
Other	---	---	1	---
Question 13: Which garbage disposal method is used at your home?				
Burying	3	---	---	---
Burning	29	---	1	---
Dumping	1	---	---	---
City Collection service	17 (private)	50	49	50
Question 14: Which of the following have been flooded in the past?				
The inside of your home	23	18	10	9
Your bridge/ parapet	33	45	37	37
Your yard	50	45	44	32
Your road	32	48	42	47
Question 15: Has your house or its contents suffered from flood damage in the past?				
Yes	30	15	9	15
No	20	35	41	35

Question 16: Did your business bear any financial costs as a direct result of flooding?				
Yes	26	13	12	13
No	24	37	38	37
Question 17: Have past floods caused you to loose earnings due to time away from work				
Yes	25	18	18	13
No	25	32	32	37
Question 18: Have past floods caused the children in your household to miss school?				
Yes	33	14	23	14
No	8	23	11	18
No children in household	9	13	16	18
Question 19: Have you experienced health problems as a result of flooding?				
Yes	23	1	3	4
No	27	49	47	46

Question 20: Rate these causes of flooding. 1 = least important, 5 = most important.

	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Poor maintenance of drainage	2	---	4	11	33	5	3	11	9	22	1	---	4	13	32	9	3	10	10	18
Low land elevation	---	7	6	22	15	3	11	8	20	8	8	3	8	18	13	1	6	12	10	21

Increase impermeable surfaces	24	12	12	2	---	21	7	12	8	2	16	18	8	8	---	16	20	9	3	2
Improper garbage disposal	3	11	21	15	---	3	15	18	8	6	13	16	13	5	3	10	10	15	8	7

Question 21: Which of the following prevention measures has your household undertaken to combat the threat of flooding?

	Yes	No	Yes	No	Yes	No	Yes	No
Taken out flood insurance	2	48	---	50	3	47	---	50
Raised the floor level of your home	31	19	14	36	6	44	9	41
Raised your yard level	36	14	23	27	19	31	17	33
Cleaned drains around property	47	3	31	19	39	11	36	14
Moved valuables to higher ground	28	22	26	24	27	23	23	27

Question 22: Do you receive formal flood warnings prior to flooding events?

Yes	6	---	1	---
No	44	50	49	50

Question 23: To what extent might the following prevent you from preparing for floods?

1= Not at all 5= A lot	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

Cost	4	2	11	7	26	14	5	9	4	18	11	---	8	6	25	28	2	6	3	11
Skills required to prepare	17	17	5	6	5	10	8	7	4	21	19	2	3	6	20	15	11	9	2	13
Other things to think about	18	10	11	3	8	6	3	7	9	25	31	---	4	1	14	10	2	9	9	20
Need for cooperation with others	5	4	5	13	23	17	8	3	5	17	18	3	3	3	23	24	2	10	1	13
Question 24: Whose responsibility do you believe it is to protect us from floods?																				
1= Not at all 5= A lot	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
National government	1	4	5	17	23	1	1	4	6	38	4	1	5	8	32	7	0	5	8	30
Georgetown city council	1	---	5	14	30	---	---	2	4	44	4	---	4	2	40	2	1	1	5	41
Individual households	7	3	8	9	23	11	6	9	12	12	13	5	9	7	16	15	4	7	3	21
Question 25: How prepared do you believe the following groups are for future events? VP-very prepared; SP- somewhat prepared; NVP-not very prepared; NAAP- not at all prepared																				
	VP	SP	NVP	NAAP	VP	SP	NVP	NAAP	VP	SP	NVP	NAAP	VP	SP	NVP	NAAP				
Your household	13	24	12	1	19	16	13	2	26	16	6	2	26	17	7	---				

Your community	2	24	14	10	7	24	15	4	9	22	16	3	21	22	4	3
Local government/ city council	5	9	22	14	4	11	17	18	2	7	12	29	15	9	10	16
Emergency services	1	13	18	18	2	11	16	21	2	3	11	34	10	10	10	20
Social welfare organizations	13	27	7	3	25	16	6	3	16	24	6	4	40	6	2	2

Question 26: During past floods, which of the following groups helped your household?

	Yes	No	Yes	No	Yes	No	Yes	No
Family/ friends/ neighbours	39	11	28	22	22	21	17	25
Community based organizations	19	31	1	48	1	42	4	38
Georgetown city council	5	45	---	49	1	42	1	41
Police	14	36	---	49	1	42	---	42
Government relief funds	31	19	---	49	1	42	2	40
NGO's/ charities	28	22	3	46	2	41	2	40

Question 27: Would you consider relocating further inland if you could have the same financial opportunities available in Georgetown?

Yes	38	26	32	20
No	12	24	18	30

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