The Implications of Sea-level Rise for Tourism in St. Lucia

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Sea-level rise is one of the most certain impacts of climate change that will have major long-term implications for tourism in the Caribbean. Sea-level rise will impact coastal tourism through inundation and erosion, damage to tourism infrastructure, (e.g., hotels/resorts, transportation) and also essential coastal resources (e.g., beaches and coral reefs).

The study examines the implications of projected scenarios of sea-level rise for tourism in St. Lucia. Using geospatial analysis that integrates elevation data from satellites and digitized locations of tourism properties, transportation infrastructure (airports and cruise ports) and areas that have been zoned for future tourism development, this study identifies tourism assets that would be at risk to permanent inundation from a 1 m sea-level rise, flooding from storm surge associated with a 1/25 year storm event under 1 m sea-level rise, and exacerbated erosion associated with 1 m sea-level rise. The results indicate that while 1 m of sea-level rise would cause permanent inundation at only 4% of the 73 tourism properties assessed (impacting 7% of 4947 of rooms on the island), the additional exposure to storm surge and waves under a 1/25 year storm event would cause flooding damages at 30% of 73 tourism properties impacting 54% of rooms on the island. This study also found that erosion associated with 1 m of sea-level rise would impact 100% of the coastal resorts with inventoried beach assets. The study uses Google Earth and field observations to examine the potential of inland retreat as an adaptation strategy for coastal tourism resorts. Results indicate that 24 of 37 coastal tourism properties assessed would be unable to retreat due to current development or physical barriers, (e.g., water surfaces, protected areas, cliffs). The study reviewed 16 national policies and planning documents to examine to what extent sea-level rise was considered in tourism planning and development, and found that only two policy documents referred to sea-level rise within the context of tourism. The thesis concludes with a discussion of additional research needs and recommendations for long-term planning and decision-making that are aimed at improving tourism adaptation to climate change and sea-level rise in St. Lucia.

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List of Acronyms

AOGCM	Atmosphere-Ocean General Circulation Model
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
CARICOM	Caribbean Community and Common Market
CCCCC	Caribbean Community Climate Change Centre
CDERA	Caribbean Disaster Emergency Response Agency
CIAT	International Centre for Tropical Agriculture
CPACC	Caribbean Planning for Adaptation to Climate Change
DEM	Digital Elevation Model
ECLAC	Economic Commission for Latin America and the Caribbean
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographic Information System
ICZM	Integrated Coastal Zone Management
IDEA	International Design and Entertainment Associates
IPCC	Intergovernmental Panel on Climate Change
LDC	Least Developed Country
MACC	Mainstreaming Adaptation to Climate Change (Caribbean)
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmosphere Administration
NWHO	Nordic World Heritage Office
OAS	Organization of American States
OECS	Organization of Eastern Caribbean States
SEDU	Sustainable Economic Development Unit
SIDS	Small Island Developing States
SLTB	Saint Lucia Tourist Board
SLHTA	Saint Lucia Hotel & Tourism Association
SPCR	Strategic Program for Climate Resilience
SRES	Special Report on Emissions Scenarios (from the IPCC)
SRTM	Shuttle Radar Topography Mission
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNWTO	United Nations World Tourism Organization
USAID	US Agency for International Development
USGS	U.S. Geological Survey
WMO	World Meteorological Organization
WTTC	World Travel and Tourism Council
XCD	Eastern Caribbean Dollars

1. Introduction

1.1. Study Context and Rationale

Climate change is recognized as one of the most challenging issues of the 21st century (IPCC, 2007). According to the Intergovernmental Panel on Climate Change (IPCC) (2007) sea-level rise is considered one of the most certain impacts of climate change, "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures widespread melting snow and ice, and rising global average sea levels" (p. 5). The IPCC (2007) Fourth Assessment Report (AR4) projected that sea-levels could rise between 0.18m and 0.59m by 2100; however, these predictions have been criticized by a long list of researchers as being conservative, as they do not include contributions from changes in the Greenland and Antarctic ice sheets (Hansen, 2007; Oppenheimer, Neill, Webster & Agrawala, 2007; Pittock, 2009; Pfeffer, Harper, & O'Neel, 2008). Since the IPCC (2007) AR4, recent studies have projected that sea levels could rise as much as 1 m to 2 m above the observed levels of the late 20th century (Grinstead, Moore, & Jevrejeva, 2009; Horton et al., 2008; Jevrejeva, Moore, & Grinstead , 2012; Vermeer & Rahmstorf , 2009).

Despite the uncertain projections for sea-level rise, several researchers have concluded that the increasing rates of sea levels will not have homogeneous impacts across regions (IPCC, 2007; Pittock, 2009). Sea-level rise is expected to be most problematic for Small Island Developing States (SIDS) and low-lying coastal areas (IPCC, 2007). Coastal environments are important areas because they are usually more densely populated than inner areas and possess high ecological and economic value (Small & Nicholls, 2003).

The Caribbean region consists of several SIDS and is considered one of the most vulnerable areas to sea-level rise (Mimura et al., 2007). Projections indicate that sea-level rise in the Caribbean will exceed the global average by 1.2 mm yr^{-1} to 1.4 mm yr^{-1} (Tamisiae & Mitrovica, 2011). Higher sea levels will exacerbate the impacts of storm surges from extreme weather events, and will have more severe flood impacts on populations, coastal infrastructure, beach erosion and shoreline retreat (Nicholls, 2011; Nicholls et al., 2007). Moreover, inundation of coastal zones will have important consequences for the Caribbean's economy as these areas generate high revenues for key sectors such as fisheries and more significantly tourism (Burke, Greenhalgh, Prager & Cooper, 2008).

According to the World Tourism and Travel Council (WTTC) (2004), the Caribbean region is one of the most tourism-dependent regions in the world. In 2011, tourism contributed US$ 47.1 billion to the Caribbean's GDP and by 2022 total tourism contributions are expected to reach US$65.5 billion (WTTC, 2012b). In 2011 tourism GDP contributions for most Caribbean nations ranged from 25% to 50%, and were as high as 70% in the islands of Anguilla and Antigua & Barbuda (WTTC, 2012b).

The Caribbean islands have long been marketed under the image of sun, sand and sea to attract visitors from various regions around the world (Jayawardena, 2007). Most of the outdoor activities provided by resorts, such as swimming, water skiing and diving, take place in coastal regions and depend heavily on warm climate. Because of these factors and its geographical location the Caribbean is commonly considered one of the most climate change-sensitive regions of the world where tourism will be affected (Scott et al., 2008).

According to the Economic Commission for Latin America and the Caribbean (ECLAC) (2010c), projections indicate that as climate change and sea-level rise impacts become more pronounced, Caribbean countries will experience greater environmental challenges in sustaining their natural resources (e.g. beach assets, forests, coral reefs etc.). These environmental changes will affect the aesthetic attractiveness of destinations, which are important factors for the marketing image of beach-tourism destinations (Becken & Hay, 2007; Scott et al., 2008; Scott et al., 2012a).

In addition, the majority of tourism developments in the Caribbean are located along low-lying coastal areas and fragile ecosystems, which are prone to windstorm-related events, such as hurricanes and tropical storms (ECLAC, 2010a). Between 1990 and 2008 the Caribbean experienced 165 natural disasters including hurricanes, tropical storms, and floods, which caused damages and losses of about US$165 billion (ECLAC, 2010a). By 2025, climate change is expected to cost Aruba, Barbados, Dominican Republic, Guyana, Jamaica, Montserrat, St. Lucia and Trinidad and Tobago a totalled US$ 5.77 billion (ECLAC, 2010b). According to Bueno, Herzfeld, Stanton &Ackerman (2008) the Caribbean could experience total losses of US$22 billion in 2050 to as much as US$46 billion by 2100 due to hurricane damages and losses to tourism revenue. While there are varying estimates on the economic impacts that climate change will have on the Caribbean region, several studies have concluded that it will be very significant. The IPCC (2012) stated that based on observed trends, "a changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events" (p.5). Additionally, extreme weather events or climate events decrease the adaptive capacity and resilience of countries, causing them to be more vulnerable to future extreme weather events (IPCC, 2012).

In an effort to meet these challenges of extreme weather events and climate change in the Caribbean, governments in the region have developed various policies and plans. In 2009, the Caribbean Community (CARICOM) member states endorsed the *Liliendaal Declaration,* which outlined the national and international position of member states in relation to climate change mitigation and adaptation (Caribbean Community Climate Change Centre (CCCCC), 2009). These commitments include five strategic elements: (1) mainstreaming climate change adaptation into the sustainable agendas of CARICOM member states; (2) promoting the implementation of specific adaptation measures to address the vulnerabilities in the region; (3) promoting actions to reduce greenhouse gas emissions through fuel reduction, energy conservation, and renewable energy sources; (4) encouraging action to reduce the vulnerability of natural and human systems; and (5) promoting action to derive social and environmental benefits from the management of standing forests in CARICOM member states. Since then, these strategic elements have been implemented as part of the 'Caribbean Regional Framework for Achieving Development Resilient to Climate Change for 2009-2015' (CCCCC, 2009). In the CCCCC (2009) framework, the second of the aforementioned five strategic elements outlined five goals to help address climate change adaptation for the tourism sector:

(1) Promote the adoption of measures and disseminate information that would make water supply systems resilient to climate-induced damage (this would include coastal aquifers and water systems that are particularly vulnerable to the impacts of salinization caused by rising sea-levels and subject to extreme weather events),
(2) Promote the implementation of measures to reduce climate impacts on coastal and marines infrastructure,
(3) Promote the adoption of measures and the dissemination of information that adapt tourism activities to climate impacts,

(4) Promote sound conservation practices in coastal and marine ecosystems to shelter these resources from climate-induced damage, and;

(5) Promote the adoption of sound practices and measures to prevent and/ or reduce climate-induced health in the community (such as exposure to vector-borne diseases resulting from increased temperatures and extreme rainfall and flooding events). (Pp.17-18).

More recently, to help build on these five strategic elements and goals, the CCCCC (2012) report ‘Delivering Transformational Change 2011-2021’, discussed implementation plans for the ‘Regional Framework for Achieving Development Resilient to Climate Change’ by focussing on the capacity assessment challenges facing individual CARICOM member states. Both the regional framework and its implementation plan have underlined the need for better research and knowledge management that is aimed at reducing climate change vulnerability and resilience issues, which are affecting the tourism sector. However, the report pointed out that the successes of these approaches will depend heavily on the ability of CARICOM member states identifying and addressing regional and national institutional legislative challenges (CCCCC, 2012).

One of the main challenges affecting a collective climate change adaptation effort for the Caribbean tourism sector is the limited priority it is given in relation to other economic sectors such as agriculture and forestry (Medeiros, Hove, Keller, Echeverría, & Parry, 2011). Furthermore, although the Caribbean has a vast economic dependence on tourism, the sector’s importance varies in scale for individual countries. Generally, these circumstances affect the level of commitment and resources that governments are willing to allocate to climate change adaptation for the tourism sector (Medeiros et al., 2011).

In addition, Caribbean climate change adaptation efforts have mainly been funded and stipulated by international organizations such as the Organization of American States (OAS), Global Environment Fund (GEF), Canadian International Development Agency (CIDA) and the World Bank. Over the last 15 years climate change projects including the Caribbean Planning for Adaptation to Climate Change (CPACC) 1997-2001, Adaptation to Climate Change in the Caribbean (ACCC) 2001-2004, Mainstreaming Adaptation to Climate Change (MACC) 2004-2007 and the Special Program on Adaptation to Climate Change (SPACC), 2007-2011 received about US$13.6 million from international organizations (CARICOM Secretariat, 2011). While these internationally funded programmes have improved knowledge about climate change and improved research and capacity-building needs in the Caribbean, they are limited to the adaptation needs of the Caribbean countries selected for pilot projects. Moreover, these pilot projects have given little consideration to climate adaptation for the tourism sector. Scott et al. (2012a) argued that there is a need for better knowledge of how climate change will impact tourism resources and economies in individual Caribbean nations.

For example, in the recently completed SPACC project, which focussed on the implementation of adaptation measures in coastal zones, and included pilot projects in St. Lucia, St. Vincent and the Grenadines and Dominica, the tourism sector was only addressed in one location and project. Of the three Caribbean islands, St. Lucia was the single location where pilot projects included a tourism resort, the Coconut Bay Beach Resort and Spa, which is located along the island's southern coastline (CCCCC, 2011). While this pilot project was successful in developing a rain-harvest system, which is aimed at reducing the potential impact of fresh water scarcity in St. Lucia's tourism sector, it only addressed a single aspect of climate change for that sector.

In addition to drought, climate-related events such as hurricanes, tropical storms, storm surge flooding and coastal erosion have proven disastrous for St. Lucia's social, environmental, and economic sectors, especially tourism (Tulsie, d'Auvergne & Barrow, 2001). In 1980, Hurricane Allen caused a 50% loss in tourism-stay-over days (Government of St. Lucia-SPCR, 2011). Assessments show that as a result of extreme storm events (i.e.12 tropical cyclones) during the period 1963 -2007, St. Lucia incurred an average of US$94.6 million in economic damages per storm event (ECLAC, 2011a). Recently, in 2010, Hurricane Tomas caused more than US$336.2 million, 10% of GDP losses to the island's economy (ECLAC, 2011b).

Furthermore, although St. Lucia's tourism sector is considered one of the most vulnerable sectors to climate change and sea-level rise, little attention have been given to policies that would address climate change adaptation within that sector (Singh, 2010). Noteworthy, in 2003, the United Nations Educational, Scientific and Cultural Organization (UNESCO) outlined recommendations for coastal setbacks for St. Lucia of 15m to 49m for coastal development along the north-west based on evidence obtained from beach monitoring since 1995 (UNESCO, 2003). These recommendations were aimed at reducing the impacts of erosion damage on infrastructure within these north-west coastal zones. However, to date these recommendations by UNESCO

(2003) have not been further developed into planning policy and guidelines for coastal development.

In 2001, St. Lucia's First National Communication Report to the United Nations Framework Convention on Climate Change (UNFCCC) outlined five main adaptation strategies for the tourism sector:

(1) The relocation of structures

(2) Strengthened development controls

(3) Economic diversification

(4) Hard and soft coastal engineering protection measure

(5) Flood control (Tulsie et al., 2001).

Despite the concerns outlined by the First National Communication Report for the tourism sector, many of the report's recommendations have not been implemented (Singh, 2010). To date only two national policies have made specific recommendations for sea-level rise adaptation for the tourism sector: the National Climate Change Policy and Plan, 2002; and the Natural Hazard Mitigation Policy and Plan, 2006. These two plans emphasize the need for more research on areas that are susceptible to flood impacts as a result of sea-level rise and storm surge from extreme weather events. Notably, while these two national policies have attempted to address the issues of climate change for the tourism sector, St. Lucia still does not have an enacted tourism policy. Despite having had a National Tourism Policy draft since 2003, the process to implement this policy has been stagnant. Moreover, the National Tourism Policy neglected the opportunity to address the issues of climate change and sea-level rise challenges for the tourism sector which, had been outlined by St. Lucia's First National Communication Report to the UNFCCC in 2001.

Whereas international and regional climate change policies, and adaptation strategies and plans call for greater understanding of climate change for the tourism sector, on a national scale, climate change and sea-level rise adaptation for St. Lucia's tourism sector remains significantly unaddressed. Hall (2011) noted that one of the challenges in developing effective policy is the lack of up-to-date and reliable information to guide policy decision-making. Tulsie et al. (2001) stated that there is a need to improve scientific knowledge about the vulnerabilities of various areas in St. Lucia, which will help improve decision-making for climate change adaptation on a national scale.

Scott et al. (2012) discussed that although literature on the impacts of sea-level rise on coastal tourism emerged about two decades ago with the work of Gable (1990), several researchers have observed that there is a research gap on the impacts of sea-level rise on tourism. To date, only a small number of research studies, including Brecht, Dasgupta, Laplante, Murray & Wheeler (2012), Dasgupta, Laplante, Meisner, Wheeler, & Yan (2008), and Simpson et al., 2010, have attempted to understand the consequences of elevated sea levels on Caribbean islands. Moreover, only a limited number of researchers, (Cambers, 2009; Pulwarty, Nurse & Trotz, 2010; Pulwarty & Hutchinson, 2009; Schleupner, 2008b; Simpson et al., 2010; Scott et al., 2012; Sookram, 2010; Wielgus, Cooper, Torres & Burke, 2010) have considered the implications of sea-level rise within a Caribbean tourism context. In many instances, the region is often considered holistically by using regional-scale analysis, despite the many distinctive characteristics (e.g. landscape, economy, coastal development's governance etc.) of each individual island, which may determine its varying degree of vulnerabilities to sea-level rise.

Consequently, there is a gap in the literature regarding the implications of sea-level rise for tourism in a case-specific Caribbean nation, where pertinent policies and adaptation strategies are also considered. Lewsey, Cid & Kruse (2004) noted that:

> Once countries assess the vulnerability of their coastal infrastructure and land uses to climate change and identify the adaptive means for countering the projected impacts, it will then be possible to develop strategic plans for reducing their vulnerability. They can then evaluate their existing capacity for implementing such plans, and identify capacity and information gaps in the process (p.408)

This study contributes to recent studies that have examined the relationship between climate change, sea-level rise and tourism. In addition, it provides new information that assesses the vulnerability of coastal tourism infrastructure that will help to improve the adaptive capacity of St. Lucia's tourism sector.

To address the information gap on tourism sustainability and climate change in St. Lucia, this study examines the impacts of a 1 m sea-level rise for the tourism sector as well as further implications of 1/25 year storm surge and wave height superimposed on 1 m sea-level rise. This study uses a 1 m sea-level rise projection by 2100 because it represents a central estimate of the projections for sea-level rise found in recent studies. The study applies a mixed methods approach, which is guided by an overall research goal, and five specific objectives.

1.2. Research Goal and Objectives

The overall goal of this study is to assess the implications of sea-level rise for coastal tourism sustainability in St. Lucia. In order to achieve this goal, five research objectives were established:

(1) To analyze the potential inundation impacts on tourism infrastructure and future tourism development projects associated with 1 m of sea-level rise by using a Geographical Information System (GIS).

(2) To analyze potential erosion impacts on tourism infrastructure based on potential landward retreat associated with 1 m of sea-level rise by applying the Brunn Rule.

(3) To analyze changes in tourism infrastructure exposure to storm surge damage (1-25 year event) associated with 1 m of sea-level rise.

(4) To evaluate coastal protection strategies for tourism using Google images to identify the 'hard-engineered' coastal protection structures that are in place to reduce flood impacts on tourism infrastructure and assess where coastal retreat is a potential adaptation strategy.

(5) To review national policy and planning instruments to understand how they address the issue of sea-level rise within the tourism sector, and make recommendations where policy gaps are identified, so as to improve tourism adaptation planning for sea-level rise.

1.3. Thesis Structure

This thesis has been divided into six chapters. Chapter 1 introduces the research topic, and outlines the research goal and objectives. Chapter 2 contains a literature review that provides an overview of six main topics: (a) climate change, (b) sea-level rise, (c) tourism, (d) climate change and tourism, (e) tourism in the Caribbean, and (f) St. Lucia and tourism. Chapter 2 will also identify the knowledge gaps that motivated this study. Chapter 3 outlines and discusses the research methods and approaches used to achieve the main goal and five objectives of this study. Chapter 4 reports the findings of the research methods on the case study area. Chapter 5 provides a discussion on the results of this study in comparison to the findings of previous research studies, while Chapter 6 reviews the main findings, offers recommendations and identifies the opportunities for future research that are aimed at improving tourism adaptation for climate change and sea-level rise in St. Lucia.

These research components provide relevant information that allows this study to produce recommendations and understandings that are important to impending tourism adaptation planning in St. Lucia. These recommendations emphasize the need to develop national policy and planning tools, and strategies that are inclusive of the tourism sector. Moreover, this research study identifies opportunities for future research on sea-level rise and tourism in St. Lucia.

2. Literature Review

2.1. Introduction

The literature review is divided into six main sections. The first section provides an overview of anthropogenic climate change and the current understandings of 21st century and projections across various regions. The second section describes the causes of sea-level rise and current projections for sea-level rise. Sea-level rise is one of the most certain impacts of climate change, which will have negative impacts on coastal resources and populations worldwide (IPCC, 2007). The third section examines the economic importance of global tourism, and focusses on the areas of sustainable and coastal tourism. The fourth section explores the relationship between climate change and tourism by reviewing the impacts of climate change on tourism and tourism's contribution to climate change. The fifth section provides an overview of tourism in the Caribbean and the current and future challenges that climate change presents. The final section in this review describes the study area of St. Lucia and examines its development of climate change and tourism policy, and its coastal management planning for the tourism sector.

2.2. Climate Change

Climate is defined as "the typical range of weather, including its variability, experienced at a particular place" (Pittock, 2009, p.1). It usually considers averages of temperature, rainfall, humidity, wind etc. over several years to decades. The annual or decadal change in average weather at a particular location is referred to as climate variability. This observed change in the characteristics of climate over lengthy time scales, such as one or more centuries, is normally referred to as 'climate change'.

The IPCC (2012) defines climate change as "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer" (p.5). Climate change is attributed "to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC, 2012, p.5). According to the World Meteorological Organisation (WMO), the growing use of energy and expansion of the global economy during the 20th century has resulted in an increased concentration of greenhouse gases in the atmosphere (UNFCCC, 2011). These greenhouse gases include carbon dioxide, methane, and nitrogen oxides, which absorb long-wave heat radiation (Pittock, 2009).This heat radiation is then released both upwards into space and downwards to the earth. Greenhouse gases act like a blanket over the earth's atmosphere and lead to greater levels of absorption, scattering and emission of radiation at the earth's surface (air, land, and ocean) leading to warmer temperatures (Pittock, 2009).

Historical data show that climate change has influenced warmer temperatures since 1900 and contributed to long-term changes at continental, regional and oceanic basin scales (IPCC, 2007; Pittock, 2009). From 1906-2005, the earth's surface temperature increased by 0.74°C, with most of this warming occurring within the last 50 years of that period (IPCC, 2007).

2.2.1. Climate Change Projections

In an effort to understand the impacts of anthropogenic activities on climate change and provide relevant policy advice to governments and other stakeholders, the IPCC commissioned modelling scenarios that were based on greenhouse gases and aerosol sulphate emissions leading up to the year 2100 (Pittock, 2009). In 2000, the IPCC reported these scenarios through its 'Special Report on Emissions Scenarios' (SRES), with the intention of encouraging discussions on the potential impacts, vulnerabilities and adaptations for various sectors, countries, and regions to climate change (Appendix 1). SRES projection scenarios for emissions are based on an interactive system that takes into account projections and probabilities using indicators such as population change, sociological development, and technological change (Pittock, 2009).

According to IPCC (2007), temperature change and sea-level increases will occur in all scenarios (i.e. B1, A1T, B2, A1B, A2 and A1F1) (Table 1). SRES A1F1 scenarios show that temperature change could occur in the likely range of 2.4°C to 6.4°C, while sea levels could rise between 0.26m to 0.59m (Table 1).

Table 1: Projected Global Average Surface Warming and Sea-level Rise at the End of the 21st Century

Greenhouse Emissions Scenario	Temperature Change (°C at 2090-2099 relative to 1980-1999)[a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999) Model-based range excluding future rapid dynamical changes in ice flow
	Best Estimate	Likely Range	
Constant Year 2000 concentrations[b]	0.6	0.3 – 0.9	NA
B1	1.8	1.1 – 2.9	0.18 – 0.38
A1T	2.4	1.4 – 3.8	0.20 – 0.45
B2	2.4	1.4 – 3.8	0.20 – 0.43
A1B	2.8	1.7 – 4.4	0.21 – 0.48
A2	3.4	2.0 – 5.4	0.23 – 0.51
A1FI	4.0	2.4 – 6.4	0.26 – 0.59

Source: IPCC, 2007. Notes: [a] these estimates are assessed from a hierarchy of models that encompass a simple climate model, several Earth System Models of Intermediate Complexity and a large number of Atmosphere-Ocean General Circulation Models (AOGCMs).[b] Year 2000 constant composition is derived from AOGCMs only.

Projections indicate that over the next 20 years that the earth will experience warmer temperatures due to increased concentrations of atmospheric carbon dioxide (Pittock, 2009). Warmer temperatures due to current levels, or increased greenhouse emissions, are also expected to cause widespread changes in levels of precipitation, arctic temperatures, sea levels, ocean salinity, severe storm patterns, droughts and flooding events (IPCC, 2007; Kusky, 2009; Nicholls et al., 2007; Pittock, 2009) (Table 2).

Climate variability is expected to affect climatic seasons and the magnitude of extreme events such as storms and floods (Pittock, 2009). Noteworthy, the IPCC (2012) has stated that although there is limited evidence to conclude that climate change caused extreme weather patterns, such as tropical cyclones and weather- related natural disasters (e.g. flooding), the lack of statistical data on a global scale does not confirm or refute that climate change is associated with extreme weather patterns. According to the IPCC (2012):

> The impacts of climate extremes and the potential for disasters result from the climate extremes themselves and from the exposure and vulnerability of human and natural systems. Observed changes in climate extremes reflect the influence of anthropogenic climate change in addition to natural climate variability, with changes in exposure and vulnerability influenced by both climatic and non-climatic factors …, a changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of

extreme weather and climate events, and can result in unprecedented extreme weather and climate events. (p.7)

Climate events and extreme weather events will continue to have life-threatening impacts on small islands and coastal low-lying regions due to their high populations and coastal proximity to oceans (Nicholls et al., 2007). Extremes such as heat waves and droughts are expected to become more frequent, while changes in precipitation patterns are expected to increase in high latitudes, and decrease in nearly all subtropical land regions (Pittock, 2009).

Observed changes show that ice caps in areas such as Mt Kilimanjaro in Kenya, and glaciers in North America and Canada are experiencing rapid recession (Pittock, 2009). Climate change is also attributed to shrinking sea ice in the Arctic and Antarctic regions, which predictions indicate may completely disappear by the latter part of the 21st century (Pittock, 2009). Moreover, thermal expansion of oceans, melt water from the glaciers, and ice flow from Greenland and Antarctica are expected to increase sea levels.

Since the IPCC AR4 report was presented in 2007, a number of researchers have contended that sea-level rise will exceed 1 m by 2100 due to the faster melting rate of the ice shelves (Horton et al., 2008; Jevrejeva, Moore, Grinstead & Woodworth, 2008; Jevrejeva et al., 2012; Nicholls & Cazenave, 2010; Pittock, 2009; Rahmstorf et al., 2007; Vermeer & Rahmstorf , 2009). Rahmstorf et al. (2007) argue that since the 1990s greenhouse gas emissions have been at or exceeded the highest levels of the SRES A1F1 scenarios; these higher levels of emissions are expected to increase global temperatures and sea-levels above the projected IPCC (2007) levels for 2100. These warmer temperatures and rising sea-levels as well as other impacts (e.g. precipitation changes) of climate change will have consequences for the global environment (IPCC, 2007; Pittock, 2009).

2.2.2. Impacts of Climate Change

Climate change has been identified as one of the most problematic issues for the 21st century largely due to its overwhelming impact on weather patterns and socio-economic systems (IPCC, 2007). Climate change impact assessments have become an important aspect of projecting and understanding how climate change may impact various regions and countries.

Climate change impacts are not expected to be homogenous across regions countries; however they will have far-ranging implications for global environments in the decades ahead (Table 2).

Table 2: Projected Regional Impacts of Climate Change

Africa	• By 2020, between 75 and 250 million of people are projected to be exposed to increased water stress due to climate change. • By 2020, in some countries, yields from rain-fed agriculture could be reduced by up to 50%. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition. • Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10% of Gross Domestic Product (GDP).scenarios (TS). • By 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate.
Asia	• By the 2050s, freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease. • Coastal areas, especially heavily populated mega-delta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some mega-deltas, flooding from the rivers. • Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanisation, industrialisation and economic development. • Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle.
Australia & New Zealand	• By 2020, significant loss of biodiversity is projected to occur in some ecologically rich sites, including the • Great Barrier Reef and Queensland Wet Tropics. • By 2030, water security problems are projected to intensify in southern and eastern Australia and, in New Zealand, in Northland and some eastern regions. • By 2030, production from agriculture and forestry is projected to decline over much of southern and eastern Australia, and over parts of eastern New Zealand, due to increased drought and fire. However, in New Zealand, initial benefits are projected in some other regions. • By 2050, on-going coastal development and population growth in some areas of Australia and New Zealand are projected to exacerbate risks from sea level rise and increases in the severity and frequency of storms and coastal flooding.

Europe	• Climate change is expected to magnify regional differences in Europe's natural resources and assets. Negative impacts will include increased risk of inland flash floods and more frequent coastal flooding and increased erosion (due to storminess and sea level rise). • Mountainous areas will face glacier retreat, reduced snow cover and winter tourism, and extensive species losses (in some areas up to 60% under high emissions scenarios by 2080). • In southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity. • Climate change is also projected to increase the health risks due to heat waves and the frequency of wildfires.
North America	• Warming in western mountains is projected to cause decreased snowpack, more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources. • In the early decades of the century, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5 to 20%, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilised water resources. • Cities that currently experience heat waves are expected to be further challenged by an increased number, intensity and duration of heat waves during the course of the century, with potential for adverse health impacts. • Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.
Polar Regions	• The main projected biophysical effects are reductions in thickness and extent of glaciers, ice sheets and sea ice, and changes in natural ecosystems with detrimental effects on many organisms including migratory birds, mammals and higher predators. • For human communities in the Arctic, impacts, particularly those resulting from changing snow and ice conditions, are projected to be mixed. • Detrimental impacts would include those on infrastructure and traditional indigenous ways of life. • In both Polar Regions, specific ecosystems and habitats are projected to be vulnerable, as climatic barriers to species invasions are lowered.
Small Islands	• Sea level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. • Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources. • By mid-century, climate change is expected to reduce water resources in many small islands, e.g. in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low-rainfall periods. • With higher temperatures, increased invasion by non-native species is expected to occur, particularly on mid- and high-latitude islands.

Source: IPCC, 2007

Turvey (2007) stated three categories of causal factors (economic, geographical and socio-political) that ultimately determine the vulnerability of places in particular to climate change. Many assessments show that developing countries are likely to experience the most extreme climate change- related challenges, as they lack the required financial resources and technologies to implement the most effective adaptation strategies (IPCC, 2007; Nicholls et al. 2007; Nicholls, 2011; Pittock, 2009; Sem & Moore, 2009; Vergara, 2005). By 2030, the estimated annual costs for rebuilding infrastructure damaged by climate change-related processes in developing countries may range from US$2 to US$41 billion (Haites, 2008). However, other reports which vary in scope and approaches, have estimated that climate change adaptation in developing countries will cost as much as US$86 billion annually by 2020 (Oxfam, 2007; United Nation Development Programme (UNDP), 2007; World Bank, 2006).

2.3. *Sea-level Rise*

Although there is great uncertainty about the range, rates and specific time periods in which global sea levels will increase (Horton et al., 2008; IPCC, 2007; Pittock, 2009; Solomon et al., 2007); sea- level rise is one of the most certain impacts of climate change, which will progress well beyond the 21st century (IPCC, 2007; Nicholls & Tol, 2006; Schaeffer, Hare, Rahmstorf & Vermeer, 2012; Vermeer & Rahmstorf, 2009; Woodard, Perkins & Brown, 2010).

Global sea-level rise occurs as a result of two key factors: (1) thermal expansion due to ocean warming and (2) the melting of ice from either or both land and ‘land water reservoirs’ (Nicholls, Brown, Hanson &Hinkel, 2010). According to Walsh et al. (2004), there are four factors that also influence regional variations in sea-level rise:

(1) geological effects caused by the ongoing slow rebound of land that was covered by ice during the last Ice Age (“isostatic rebound”)
(2) the flooding of continental shelves since the end of the last Ice Age, which pushes down on the shelves and causes the continent to push upwards in response (“hydro-isostatic effect”)
(3) tectonic effects caused by changes in land height in volcanically active regions
(4) changes in atmospheric wind patterns and ocean currents that could be caused by climate change. (p. 587)

Also, according to Cahoon et al. (2009) oil and gas extraction are also contributing factors to sea-level rise variations in the US. In their study, Cahoon et al. (2009) argued that gas and oil extraction contributes to land subsidence downward, and is partly responsible for 9.85 mm of sea-level rise per year at Grand Isle, Louisiana.

Between 1961 and 2003, thermal expansion contributed to 25% of global sea-level rise with higher observed contributions of 50% occurring during the better part of that period, 1993-2003, (FitzGerald, Fenster, Argow & Buynevich, 2008; Nicholls et al., 2010) (Figure 1). Many studies have identified a retreat of glaciers and small ice caps as key contributing factors to recent sea-level rise (Hansen, 2007; Horton et al., 2008; Vermeer & Rahmstorf, 2009; IPCC, 2007). According to Pittock (2009) "Simulations and paleo-climatic data indicate that Greenland and Antarctica contributed several meters to sea-level rise some 130 000 to 127,000 years ago, at a time when global temperatures were about the same as presently projected for 2100 " (p. 89). Kusky (2009) noted that increasing temperatures in ocean depths of 1.9 miles (3km) have been occurring since 1961, and approximately 80% of heat energy linked to global warming is being absorbed by ocean water. Glacial retreat is observed to have been most significant during the 1990s and contributed to approximately 30% of sea-level rise from 2003-2009 (Nicholls et al., 2010). Thomas, Franco & Hill (2006) reported that between 1993/4-1998/9 and 1998/9-2004, accelerated- discharge-net-mass loss from Greenland more than doubled. In recent decades, the retreat rate of the Pantagonian ice fields in South America has increased, with 63 of its largest outlet glaciers showing higher volume loss during the period 1995 to 2000 (0.105± 0.011 mm per year) than observed during 1969 to 2000 of (0.042 ± 0.002 mm per year) (Pittock, 2009). In addition, Kusky (2009) argued that sea levels have risen about 0.7 inches per year (0.18cm/yr.) since 1961, and increased to a rate of 0.12 inches per year (0.31 cm/yr.) since 1996.

Figure 1: Contributions to Sea-level Rise (1961-2003)

Source of seal level rise	Rate of SLR (mm year^{-1}) 1961–2003	1993–2003
Thermal expansion	0.42 ± 0.12	1.6 ± 0.5
Glaciers and ice caps	0.50 ± 0.18	0.77 ± 0.22
Greenland ice sheet	0.50 ± 0.12	0.21 ± 0.07
Antarctic ice sheet	0.14 ± 0.41	0.21 ± 0.35
Sum of individual climate contributions to SLR	1.1 ± 0.5	2.8 ± 0.7
Observed total SLR	1.8 ± 0.5[a]	3.1 ± 0.7[a]
Difference (observed minus sum of estimated climate contributions)	0.7 ± 0.7	0.3 ± 1.0

[a] Data prior to 1993 are from tide gauges and after 1993 are from satellite altimetry. Source: FitzGerald et al., 2008

Glacier contributions are important factors in sea-level rise (Figure 1); however, much like the other components of climate change, there is great uncertainty about how their rates may vary over time affecting sea levels (Rignot, Velicogna, van den Broeke, Monaghan & Lenaerts, 2011). Rignot et al. (2011) found that for 1992 -2009, the acceleration rate in ice discharge in both Greenland and Antarctica were an equivalent 9.0 ± 1 Gt/yr^2. Earlier work by Rignot (2008) found the thinning rates of the Pine Island Glacier in Antarctica accelerating during the period 1980 to 2008 with an increase from 0.8 % in the 1980s to 2.4 % in the 1990s, to 6% in 2006, reaching 16% by 2007-2008. Wingham, Wallis & Shepherd (2009) also examined thinning rates at the Pine Island Glacier, and although their study occurred over a shorter time period, 1995 – 2006, findings also showed that volume loss had occurred at accelerated rates. According to Wingham et al. (2009), volume loss had quadrupled from 2.6 ± 0.3 km3 yr^{-1} to 10.1 ± 0.3 km3 yr^{-1} during 1995-2006. Importantly, Rignot et al. (2011) estimated that if ice sheet loss continued at the rate of 36.3 ± 2 Gt/yr^2, it could contribute 15 ± 2 cm to global sea levels by 2050, compared to 2009 or 2010.

According to the IPCC (2007), regional variation in sea-level change over the coming century is about ± 30 to 40% of the global average. Solomon et al. (2007) found that under an A1B scenario, by 2080 sea-level rise will be above global averages in Arctic regions. Moreover, under this same scenario, regional and global levels will deviate by as much as 0.8 m (Solomon et al., 2007). Despite the projected variations in sea-level rise across regional scales, estimates indicate an increase of global sea levels over the next several decades (Pittock, 2009).

2.3.1. Sea-level Rise Projections

Although there is uncertainty among researchers about when the highest increases in sea-level rise will occur, it is agreed that sea-level rise is one of the most certain impact of climate change (Nicholls & Cazenave, 2010; Pittock, 2009). While the IPCC (2007) projects a global sea-level rise of 18 to 59cm between 1993-2100, more recent studies have projected that due to the accelerating melting rates of glaciers, sea- level rise will exceed the IPCC (2007) threshold to more than 1 m by 2100 (Grinstead et al. (2009); Hansen, 2007; Horton et al., 2008; Jevrejeva et al. (2008); Nicholls & Cazenave, 2010; Rahmstorf et al., 2007) (Table 3).

According to Solomon et al. (2007) if averages for A1B, A2 and B1 scenarios are assumed, total contributions from melting glaciers and ice caps (8 ± 4 cm), and thermal expansion of the oceans (9 ± 3 cm) could add 32 ± 5 cm to sea levels by 2100. In addition, Rignot et al. (2011) discussed that although there is uncertainty about the accelerating rates of ice sheet mass loss, there is the possibility that ice sheet loss (excluding all other contributing factors to sea-level rise) could account for almost all of the IPCC (2007) projected sea level increase by 2100. Rignot et al. (2011) estimated that "at the current rate of acceleration in ice sheet loss, starting at 500 Gt/yr in 2008 and increasing at 36.5 Gt/yr², the contribution of ice sheets alone scales up to 56 cm by 2100" (p.4).

Table 3: Scenarios of Global Sea-level Rise in the 21st Century

	2050*	2100		
		Low range	Central estimate	High range
Continuation of current trend (3.4 mm/year)	13.6 cm	_	30.6cm	_
IPCC (Solomon et al., 2007)	8.9-23.8 cm	18 cm	_	59 cm
Rahmstorf (2007)	17-32 cm	50 cm	90 cm	140 cm
Horton et al. (2008)	~ 30cm	_	100 cm	_
Vermeer and Rahmstorf (2009)	~ 40 cm	75 cm	124 cm	180 cm
Grinstead et al. (2009)	_	40 cm	125 cm	215 cm
Jevrejeva et al.(2008)	_	60 cm	120 cm	175 cm

Source: adapted from Scott, Simpson & Sim (2012) * where not specified interpreted from original sources.

Despite the varying assumed contributions of glaciers and ice caps or impacts of thermal expansion, the consequences of higher sea levels will pose greater environmental and socio-economic challenges for low-lying coastal regions and SIDS, which are among the most vulnerable areas (Mimura et al., 2007; Nicholls & Cavenave, 2010; Nicholls et al., 2007; Nicholls, 2011; Tompkins et al., 2005; Turvey, 2007).

One of the most important uses of coastal regions, especially in SIDS, is tourism. The consequences of sea-level rise such as inundation and erosion will have important implications, especially for those destinations that depend exclusively on coastal tourism (Becken &Hay, 2007; Scott et al., 2012b).

2.4. Tourism

Tourism is defined as "the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes not related to the exercise of an activity remunerated from within the place visited" ((Scott et al., 2008, p.33). Tourism is one of the fastest growing global industries (United Nations Environmental Programme (UNEP), 2009; WTTC, 2012a), and ranks 4th as a global export category (i.e. after fuels, chemical and automotive products) (UNWTO, 2012). In 2012, international tourism accounted for 30% of the world's exports of services, and 6% of overall exports in goods and services (UNWTO, 2012).

International tourism arrivals rose from 798 million in 2005 to 940 million in 2010 (UNWTO, 2011), and surpassed 1 billion in 2012 (WTTC, 2013a). The WTTC (2013a) reported that tourism contributed 9.3% of global GDP, more than US$ 6 trillion in revenue and provided 261 billion jobs in 2012. By 2023 tourism is expected to account for 10% of all GDP, generate about US$10 trillion, and provide 337.8 million jobs worldwide (WTTC, 2013a). In 2011, international tourism receipts for the first time exceeded US$1 trillion (US$1.2 trillion), an increase from US$928 billion in 2010 (UNWTO, 2012). Tourism is expected to post US$9.6 trillion by 2014 (WTTC, 2004) and reach its highest level of international arrivals (1.8 billion) by 2030 (UNWTO, 2012).

Tourism is the main source of foreign exchange earnings in 46 of the 49 Less Developed Countries (LDCs), and has been identified as a potential instrument for alleviating poverty in many developing and LDCs (UNEP, 2009). In most SIDS, tourism accounts for at least 25% of their overall GDP (WTTC, 2004; Sem & Moore, 2009, UNEP, 2009).

One of the key characteristics of tourism is that it is heavily dependent on natural and finite resources, such as coastal and natural habitats (e.g. coral reefs, beaches, forest, wild life), which form part of the vacation experience year round (Gössling & Hall, 2006; UNEP, 2009). For this reason, tourism is often considered one of the causes of environmental degradation, although many of the impacts associated with environmental degradation can also be linked to other activities such as fishing, dredging, and coastal development (Gössling & Hall, 2006). Nonetheless, discourses on tourism have identified ecological damage as one of the challenges that are worsened by tourism which will have consequences for that sector (Gössling & Hall, 2006; Wall & Mathieson, 2006). As a response to these realities within the last two decades, sustainable tourism has emerged and developed as a path to balancing the two-way relationship between tourism and the environment.

2.4.1. Sustainable Tourism

Sustainable tourism emerged because of increasing concerns about the environmental impacts (e.g. overcrowding and beach erosion) of mass tourism, which had become more noticeable since the 1960s and 1970s (Gössling & Hall, 2006). The term sustainable tourism which started gaining popularity in the 1990s, developed from the concept of sustainable development, which was first defined in the 1986 World Commission on Environment and Development Brundtland's Report, as "development which meets the needs of present without compromising the ability of future generations to meet their own needs" (Lindberg, 1999, p.8). Since its introduction the Brundtland's Report, has been criticized by people, governments and organizations worldwide for offering a vague interpretation of 'sustainability'. The most problematic issues for applying 'sustainability' are who should define it, and what exactly should be sustained (Lindberg, 1999).

Despite these contentions, the term is widely applied across sectors such as tourism and its many planning processes. According to Mycoo (2010) two of the most comprehensive definitions for sustainable tourism are:

(1) Sustainable tourism is a positive approach intended to reduce the tensions and friction created by the complex interactions between the tourism industry, visitors, the environment and the communities which are host to holidaymakers. It is an approach, which involves working for the long-term viability and quality of both natural and human resources. It is not anti-growth but it acknowledges that there are limits to growth (p.490 as cited in Bramwell & Lane, 1993).

(2) Sustainable tourism is a concept designed not to stop tourism but to manage it in the interests of all three parties involved – the host habitats and communities, the tourists, and the industry itself. It seeks a balance between development and conservation. It seeks to find the best form of tourism for an area taking into account its ecology and its culture. It may mean limits to growth, or in some cases no growth at all. It seeks not just to plan for tourism, but also to integrate tourism into a balanced relationship with broader economic development and with conservation goals. A well thought out long term vision is essential. That vision should be thought out with the people, not just for the people (p.490 as cited in Lane, 2001).

Despite these variations in understanding sustainable tourism, it has become an increasingly highlighted theme in tourism to help project a more positive outlook of the impact of tourism on the environment. Moreover, in recent years, sustainable tourism been treated with more urgency as a result of debates on global warming and climate change (Scott, 2011).

According to Hall (2011) there are three underlying dimensions or pillars of sustainable tourism that describes the goals and objectives for achieving sustainable tourism. These are:

(1) Economic sustainability, which means generating prosperity at different levels of society and addressing the cost effectiveness of all economic activity. Crucially, it is about the viability of enterprises and activities and their ability to be maintained in the long term.

(2) Social sustainability, which means respecting human rights and equal opportunities for all in society. It requires an equitable distribution of benefits, with a focus on alleviating poverty. There is an emphasis on local communities, maintaining and strengthening their life support systems, recognizing and respecting different cultures and avoiding any form of exploitation.

(3) Environmental sustainability, which means conserving and managing resources, especially those that are not renewable or are precious in terms of life support. It requires action to minimize pollution of air, land and water, and to conserve biological diversity and natural heritage (Hall, 2011, p.659.)

The three pillars for sustainable tourism development are an important aspect of the tourism planning framework; however, to be effective, it requires the involvement of stakeholders at local, regional and global levels (UNEP, 2009).

Gössling, Hall & Weaver (2009) argued that one of the most noticeable barriers to achieving sustainable tourism is that economic development takes precedence over social and environmental concerns. Moscardo (2011) echoed that tourism is often promoted as a solution to economic and social challenges for developing countries, and is guided by planning decisions that aim to achieve these goals. However, these economic promises are usually unmet, and result in conflict and concern among host nations and communities (Moscardo, 2011). In order to curb this imbalance tourism stakeholders must be committed to developing and strengthening human, resource and institutional capacity building among various tourism-related sectors and departments (e.g. agriculture, and fisheries) (UNEP, 2009). Moreover, there is a the need for more proactive coastal management planning strategies that are essential to managing coastal development, the use of marine resources (e.g. coral reef) and beaches which are important to coastal tourism.

2.4.2. Coastal Tourism

Coastal tourism is one of the 'most common' types of tourism, and is based on the unique combination of land and sea resource amenities such as beaches, infrastructure, and marine biodiversity (UNEP, 2009). In 2000, 12 of the top 15 tourism destinations were countries with extensive coastlines. Coastal zones provide two key categories of recreational uses for coastal tourism: (1) consumptive (fishing, shell collection etc.) and (2) non-consumptive (snorkeling, surfing, swimming, bird watching etc.) (UNEP, 2009).

In 2008, the Mediterranean coastline attracted 250 million visitors, while in the US coastal tourism generates US$640 million per year (UNEP, 2009). In France, coastal tourism accounts for 43% of jobs in coastal regions (UNEP, 2009). Marine habitats such as coral reefs are essential to coastal tourism, especially in SIDS because they generate high revenues. Burke et al. (2008) reported that at least 40% of visitors to Tobago and 25% of visitors St. Lucia, were attracted to these destinations because of coral-reef-related recreation (e.g. snorkeling). In that same study, the total direct and indirect tourism impact of coral reefs were estimated at US$101 to US$130 million for Tobago, and US$160 to US$194 million for St. Lucia (Burke et al., 2008).

Coastal tourism also faces severe environmental challenges mostly because of its geographical proximity to shorelines (Gössling & Hall, 2006) (Table 4). Events such as tsunamis, floods, erosion, and algae bloom are considered key threats to coastal environments which can impact tourism resources such as beaches and infrastructure (Moreno, 2010). In addition, anthropogenic activities such as sand mining and improper waste management are factors that hinder the sustainability of coastal tourism (UNEP, 2009).

Table 4: Main Climate Drivers for Coastal Systems, their Trends Due to Climate Change, and their Main Physical and Ecosystem Effects (trend: ↑ increase; ? uncertain; R regional variability).

Climate driver (trend)	Main physical and ecosystem effects on coastal systems
CO_2 concentration (↑)	Increased CO_2 fertilisation; decreased seawater pH (or 'ocean acidification') negatively impacting coral reefs and other pH sensitive organisms.
Sea surface temperature (↑, R)	Increased stratification/changed circulation; reduced incidence of sea ice at higher latitudes; increased coral bleaching and mortality ; poleward species migration; increased algal blooms
Sea level (↑, R)	Inundation, flood and storm damage; erosion; saltwater intrusion; rising water tables/impeded drainage; wetland loss (and change).
Storm intensity (↑, R)	Increased extreme water levels and wave heights; increased episodic erosion, storm damage, risk of flooding and defence failure
Storm frequency (?, R)	Altered surges and storm waves and hence risk of storm damage and flooding
Wave climate (?, R)	Altered wave conditions, including swell; altered patterns of erosion and accretion; re-orientation of beach plan form.
Run-off (R)	Altered flood risk in coastal lowlands; altered water quality/salinity; altered fluvial sediment supply; altered circulation and nutrient supply.

Source: Nicholls et al., 2007

Importantly, in an effort to improve the challenges that face coastal tourism development in vulnerable regions, Integrated Coastal Zone Management (ICZM) is becoming a more popular planning system (UNEP, 2009). ICZM provides a holistic approach to ensuring a balanced use and protection of coastal environments (UNEP, 2009). As defined by the UNEP (2009), ICZM is "a continuous, proactive and adaptive process of resource management for sustainable development in coastal areas" (p.51). ICZM planning requires the "comprehensive understanding of the relationships between coastal resources, their users, uses, and the mutual impacts of development on the economy, society and the environment" (UNEP, 2009, p. 50). By integrating various components, ICZM encourages several positive outcomes for social, economic and environmental sectors (UNEP, 2009) (Figure 2). Between 1993 -2000 ICZM efforts in 9 regions (i.e. North America, Central America, South America, Europe, Asia, Near East, Caribbean, Oceania and Africa) increased from 59 to 98 respectively.

Figure 2: The Social, Economic and Environmental Benefits of ICZM

SOCIAL BENEFITS	ECONOMIC BENEFITS	ENVIRONMENTAL BENEFITS
Provides diverse opportunities for recreation, leisure and cultural activities and thus improves the quality of life	Supports sustainable economic activities and thereby ensures income in the long run	Ensures integrity of the coastal environment and biodiversity as a natural system
Helps resolve conflicts	Allows better zoning and use allocation	Ensures the sustainable use of natural resources
Strengthens institutional frameworks and enforces cooperation among stakeholders on the basis of shared objectives	Improves management (legal framework, risks, help to the decision-making process) and thus permits gains in efficiency and time	Preserves and improves natural areas (habitats, species and biodiversity)
Provides security from natural hazards and risks	Develops new economic instruments to finance environmental protection	Improves pollution control
Raises public awareness and favours information exchange on sustainable development and environmental issues	Promotes environmentally-friendly technologies and cleaner production for the markets of tomorrow	Improves beachfronts and soil alteration management
Encourages broader public participation	Adds value to products through eco-labelling schemes	Integrates river basin management

Source: UNEP, 2009.

2.5. Climate Change and Tourism

The tourism industry is extremely sensitive to climate change (Becken & Hay, 2007; Gössling & Hall, 2006; Scott et al., 2012a). Although the literature on climate change and tourism emerged as early as the 1980s, prior to the 21st century very few studies had focused on climate change and tourism research (Scott et al., 2012a). Since the beginning of the 21st century, more attention has been given to climate change and tourism through publications, collaborations and initiatives (Scott et al., 2012a). In 2005, a new Expert Team on Climate and Tourism (formed by UNWTO and the WMO) led to the commissioning of a White paper on *Weather and Climate Information for Tourism* in 2009 (Scott et al., 2012a; Scott & Lemieux, 2010). To date, one of the most comprehensive reports on climate change and tourism is *Climate Change and*

Tourism: Responding to Global Challenges by Scott et al. (2008) which was commissioned by UNWTO, UNEP and WMO (Scott et al., 2012).

Despite these improvements in climate change research on tourism, Scott et al. (2012a) emphasized that more detailed and accurate research on climate change and tourism is necessary to assist tourism stakeholders (e.g. governments of tourism destinations) understand and plan for "associated risks and to capitalize upon new opportunities posed by climate change in an economically, socially and environmentally sustainable manner" (p.52).

Moreover, Scott & Becken (2010) argue that although research on tourism and climate change has increased over time, it has been largely limited to a Western context (Europe and North America). Scott & Becken (2010) argue that there is limited research on how climate change will impact the economies, natural and cultural resources in areas such as the Caribbean, Africa, Pacific Islands, South America and East Asia. Thus, priority should be given to improving knowledge about the consequences of climate change in these regions.

2.5.1. Climate and Tourism

Climate and weather are important decision-making factors for tourism stakeholders and tourists (Scott & Lemieux, 2010). Tourism is heavily dependent on the predictability of climate and the availability of natural resources (Gössling & Hall, 2006). Environmental features are an essential component of tourism marketing. Natural resources such as beaches, forests, coastlines, and oceans are important factors that affect destination attractiveness and determine the quality of the tourism product (Gössling & Hall, 2006). Climate can affect the quality of environmental features, and as a consequence can affect the tourism product. Climate is both a push and pull factor for tourism and can lead to changes in seasonality at different destinations which can affect the travel behaviours of tourists (Gössling & Hall, 2006). Climate can affect the overall travel experience and satisfaction of tourist and impact tourist expenditures and activity choices (Scott et al., 2012). Although there are research gaps in understanding how tourists choose and plan their destination choices and activities (Scott et al., 2012a), the consensus is that climate is important to tourism because it affects the attractiveness and suitability of destination choices for tourists (Becken & Hay, 2007). Climate is also one of the key factors that will affect and influence the operational costs for tourism, such as the heating and cooling, snow-making, and insurance expenses (Scott et al., 2008; Scott et al., 2012a).

Noteworthy changes in tourism flows may not always be directly related to favourable climatic factors such as temperature, but instead relate to the impact that these factors would have on the physical attributes of destinations. Warmer temperatures are identified as one of the main causes of degrading marine ecosystem causing impacts, such as decreased fish populations and coral bleaching. These changes in environmental attributes are expected to have implications for tourism. Uyarra et al. (2005) found that environmental features namely coral reefs, and beach quality and size, were important parts of the tourism experience for tourists vacationing in Bonaire and Barbados. Similarly, in Fiji, marine environments are essential to the tourism sector, where more than 60% of tourists engage in activities such as swimming and snorkeling (Becken, 2004).

One of the most commonly used approaches to assess the impact of climate on tourism is measuring the suitability of destinations by using climatic parameters (Hein, Metzger & Moreno, 2009). While studies like Hamilton, David, Maddison & Tol. (2005) use a single parameter (i.e. temperature change) as an indicator to assess the impact of climate change on the attractiveness of tourism destination choices, most studies including Scott, McBoyle, & Schwartzentruber (2004) in North America, Amelung & Viner (2006) in the Mediterranean, Whittlesea & Amelung (2010) in the UK, Hein et al. (2009) in Spain, and Amelung, Nicholls &Viner (2007) provide global analyses on the Tourism Climate Index (TCI) developed by Mieckzkowsi (1985). TCI consists of a more composite set of weather parameters such as temperature, precipitation and wind to measure the suitability of climatic factors to tourists and understand how they would impact tourism flows and activities (Hein et al., 2009). Although TCI is a popular measure for assessing tourism flows it can present different results across models.   Hein et al. (2009) applied a TCI analysis using Hadley Centre Coupled Model, version 3 (HadCM3) A1, and the Industrial Research Organization- Climate Model Version 2 (CSIRO2) A1 climate scenario, under the assumption that calculations of weather characteristics from 1961- 1990 was representative for 2004. Under HadCM3-A1, results showed that if the preferences of tourists from 2004 did not change that by 2060 Spain would see a 14% decrease in its tourism flow, while under CSIRO2-A1 only a 5% decrease was observed. Although Hein et al. (2009) explained that more positive changes in CSIRO2-A1 was attributed to the occurrence of more favourable weather in north-western Europe, this study does not take into account other important factors such as travel costs and environmental issues, which are also expected to affect tourism flows.

2.5.2. Impact of Climate Change on Tourism

Assessing the impacts of climate change on tourism is extremely challenging mainly because of the numerous inter-connections of the tourism industry. For instance, indicators such as employment and investments occur indirectly across other industries and sectors and as a result "the full impacts of climate change will continue to be underestimated, especially at the regional level and for the most visitor-intensive regions" (Scott & Becken, 2010, p.293). However, a range of impact assessments on climate change have revealed that "tourism is likely to be strongly affected by climate change" (Hein et al., 2009) (Table 5).

Table 5: Main Impacts of Climate Change and their Implications for Tourism

Impacts	Implications for Tourism
Warmer temperatures	Altered seasonality, heat stress for tourist, cooling costs, changes in plant-wildlife-insect populations and distribution range, health impacts such as infectious and vector-borne disease ranges
Increasing frequency and intensity of extreme storms	Risks for tourism facilities, increased insurance costs/loss of insurability, business interruption costs
Reduced precipitation and increased evaporation in some regions	Water shortages, competition over water between tourism and other sectors, desertification, increased wildfires threatening infrastructure and affecting demand
Increased frequency of heavy precipitation in some regions	Flooding damage to historic architectural and cultural assets, damage to tourism infrastructure, altered seasonality (beaches, biodiversity, river flow)
Sea-level rise	Coastal erosion, loss of beach area, higher costs to protect and maintain waterfronts and sea-defences
Sea-surface temperature rise	Increased coral bleaching and marine resource and aesthetic degradation in dive and snorkel destinations
Changes in terrestrial and marine biology	Loss of natural attractions and species from destinations, higher risks in tropical-subtropical countries
More-frequent and larger forest fires	Loss of natural attractions, increase of flooding risk, damage to tourism infrastructure
Soil changes (moisture levels, erosion, acidity)	Loss of archaeological assets and other natural resources, with impacts of destination attractions and agriculture.

Source: Simpson et al. (2011) p.1

Scott et al. (2012a) argued that "the impacts of climate change on tourism are anticipated to be widespread with no destination unaffected" (p.190). As discussed earlier, various studies have examined the implications that climate change will have on destination attractiveness, using various indicators (e.g. climatic parameters, environmental attributes etc.) in regions including North America, Europe, Africa, and Caribbean. Building on these contributions, Scott et al.

(2012a) provides a comprehensive understanding of the impacts of climate change for tourism by identifying four main pathway categories of potential climate change impacts that will affect the competiveness and sustainability of tourism destinations:

(1) ***Direct impacts from changing climate regimes includes***: changes in climatic conditions and (e.g. temperature, humidity, winds and precipitation) frequency and severity of extreme events (e.g. storm events or droughts). These factors will affect the suitability of locations for a wide range of activities, define seasonality (length and quality of tourism seasons); increase tourism operational costs (e.g. insurance, food and water supply) and impact the profitability of the tourism sector.

(2) ***Indirect environmental change and cultural heritage impacts***: changes in the natural environment that impact the attractiveness of destinations. Climate-induced environmental changes would impact water availability, terrestrial and marine biodiversity (e.g. coral reef), alter wildlife productivity and distribution (e.g. sport fish and bird migrations), altered landscape aesthetic (e.g. loss of glaciers), altered agricultural production (e.g. wine tourism), coastal erosion and inundation, and the increasing incidence of vector-borne diseases (e.g. malaria). In addition, climate change impacts on environmental resources will also affect cultural heritage assets that associated with tourism in some destinations.

(3) ***Indirect impacts associated with societal change*:** national and international security risks that will intensify steadily, particularly under greater warming scenarios. Historical response indicates that tourists are highly averse to terrorism, armed conflict and political instability and societal unrest. A security-related decline in tourism would exacerbate deteriorating economic conditions in destinations afflicted by climate change-induced unrest, with the potential to further undermine development objectives in some of the least developed countries.

(4) ***Impacts induced by climate change mitigation and adaptation in other sectors***: policy response to climate change will also have consequences for tourism. Mitigation policies will impact changes in cost structures that can cause tourist to reconsider transportation modes and the distances they travel for tourism experiences. (Pp.190-192)

Noteworthy, while environmental and cultural changes have been important topics for some time in the area of sustainable tourism, there have been recent attempts to better understand how mitigation policies might affect travel costs for tourists and thus the tourism sector. Gössling, Peeters & Scott (2008) found that aviation- sector mitigation policies would have negative impact on travel costs and thus demand for tourists to 10 tourism dependent SIDS. Gössling et al. (2008) concluded that aviation policies could lead to relative price increases, which would affect tourism arrivals for islands, particularly those that are more dependent on tourism. In another study, Gössling & Schumacher (2010) surveyed 298 respondents in the Seychelles Islands on plans for the islands to become carbon-neutral tourism destination. The authors found that more respondents (29%) were unwilling to incur higher travel costs to accommodate carbon offsetting versus willing respondents (21%) who agreed to an increase of £100.

Penelow & Scott (2011) also examined the impact that mitigation policies would have on international aviation by 2020 for 21 Caribbean countries under 4 policy scenarios (Business-as-usual, A, B and C) which consider the cost of carbon emissions, oil prices and price elasticity. Under these variables all 21 Caribbean countries experienced impacts on tourist arrivals at varying scales. In Barbados and the Bahamas, mitigation policies were found to affect tourism arrivals by 1.8%-6.3% and 2%-6.9% under an A and B scenario, when compared to a business-as-usual scenario. Similar trends, but smaller impacts were noted for tourist arrivals in Dominica, St. Vincent and the Grenadines and Cuba, which showed a decrease of 0.5%, 0.8%, and 0.9% respectively.

While there is concern that mitigation policies will increase air travel costs and affect trends by the majority of tourists, for the most part, it is still unclear whether tourists would rather incur higher travel costs rather than altering their desired vacation experiences (Gössling & Schumacher, 2010). While for some destinations climate change policies may present greater challenges in maintaining tourism demand they may not affect the positive growth trend in international tourists (Gössling et al., 2008). Gössling et al. (2008) concluded that although Anguilla, Bonaire, Comoros, Cuba, Jamaica, Madagascar, St. Lucia, Samoa and Sri Lanka would maintain an average positive growth for international arrivals from 2005 to 2020 under 'serious' climate change policy in 2012, there will also be an overall decrease in demand from their main tourism markets by 2020.

2.5.3. Tourism Contribution to Climate Change

Tourism is both an impactee of and a contributor to climate change (Becken & Hay, 2007).

Although transportation has long been recognized as one of the main sources of greenhouse gas emissions, and tourism is one of the most transportation-dependent industries, the earliest discussion of tourism's contributions to global climate change did not emerge in literature until 1996 (Scott & Becken, 2010). Moreover, it took an additional six years before tourism-based emissions were first quantified for a destination.

On a global scale, tourism's contribution to climate change is substantial (5%) and is expected to become more pronounced (Gössling, Hall, Peeters & Scott, 2010) as emerging and newly industrialized regions such as Africa and the Middle East are projected to increase international tourist arrivals by 2020 (Scott et al., 2012a) . Evidence shows that developed countries emit the highest levels of tourism-related emissions in comparison to developing nations (Gössling et al., 2010) due to the wealth component, which allows for longer travel distances (Scott et al., 2012a). SIDS contribute only 1% to global greenhouse gas emissions; however, projections show that they are among some of the most climate-change-impacted regions (Mimura et al., 2007). In addition, factors such as growth in mobility, growth in aviation and "increasing mobile lifestyle reflected by changes in income levels…changing cultural, social and political relations" are expected to influence transportation greenhouse emissions (Scott et al., 2012a, p. 98).

Tourism contributes to climate change through three main subsectors (i.e. transportation, accommodation and activities); and these include domestic, international and business travel. In 2005, it was estimated that tourism contributed a 5% share to all human-made greenhouse gases (Scott et al., 2008; Scott et al., 2012a) (Table 6). This is mostly due to tourism's heavy reliance on aviation, which accounts for 40% of industry's CO^2 emissions (Gössling et al., 2010; Scott et al., 2012a) (Table 6) Other tourism-related emissions include cars (32%), accommodation (21%) and cruise ships (1.5%), (Table 6).

Table 6: Distribution of Emissions from Tourism by Subsector (2005)

Subsectors	**Carbon dioxide (Mt)**	**Percentage**
Air transport	515	40
Car transport	420	32
Other transport	45	3
Accommodation	275	21
Activities	48	4
Total	1,304	100
Total World (IPCC, 2007)	26,400	
Tourism contribution		**5%**

Source: Scott et al. (2008), updated in Scott et al. (2012)

Within the next 15-20 years the tourism transportation sector is expected to produce carbon dioxide emissions at a rate of 2.7 % per annum, with other tourism sectors contributing at a slower rate of 2.5% per annum until 2035 (World Economic Forum, 2009). According to the Scott et al. (2008), tourism-related carbon dioxide emissions under a technology-adjusted business-as-usual scenario may increase by 135% between 2005 and 2035, largely due to the aviation sector.

Tourism also contributes to environmental change in the form of energy consumption, changes in land cover and emissions (Hall, 2011). In 2007, tourism contributed to 0.6- 0.66% change in land cover, higher than the estimates for 2001, which were 0.5% (Table 7).

Table 7: Tourism's Contributions to Environmental Change

Dimension	2001 estimates	2007 estimates
# of international tourist arrivals	682 million	898 million
# of domestic tourist arrivals	3,580.5 million	4,714.5 million
Total # of tourist arrivals	4,262.5 million	5,612.5 million
Change of land cover-alteration of biologically productive lands	0.5% contribution	0.6-0.66% contribution
Energy consumption	14,080 PJ	18,585.6 PJ
Emissions	1400 Mt of CO2-e	1848 Mt of CO2-e(1461.6 Mt of CO2)

Adapted from Hall (2011).

2.5.4. The Implications of Sea-level Rise for Coastal Tourism

As already discussed, climate change and sea-level rise will have more negative consequences in particular for coastal areas and their resources by the 21st century. These implications for coastal areas will mean that coastal tourism will encounter more challenges in adapting to sea-level rise (Scott et al., 2012a). Evidence shows that within the last century most of the world's sandy beaches retreated largely due to sea-level rise (IPCC, 2007), and coastal systems are expected to sustain more disturbances by inundation and erosion as a result of climate change (Nicholls et al., 2007; Scott et al., 2012a).

Brunel & Sabatier (2009) calculated relative sea-level rise along the French Mediterranean coast in two different areas and types of beaches from 1895-1977(open beaches in Camargue and pocket beaches in Provence), and found that sea-level rise contributed to 60% of shoreline retreat in those regions. In another study, Wielgus et al. (2010) estimated that if beach erosion in the Dominican Republic continued at its current rate, within the next decade resorts could incur losses of US$52- US$100 million in revenue. In North Carolina, 14 of 17 recreational swimming beaches are expected to completely erode by 2080 (Bin, Dumas, Poulter & Whitehead, 2007). In addition, North Carolina's losses in recreation value by climate-induced-sea-level rise is expected to be US$93 million a year by 2030, and US$223 million a year by 2080 (Bin et al., 2007). Bin et al. (2007) reported that 50% of North Carolina's coast is at high or very high risk because of sea-level rise. Becken (2004) found that most tourism infrastructure located in Fiji is below a 5m elevation, and is likely to be impacted by sea-level rise and storm surges.

Sea-level rise will also impact the value of coastal properties for tourism. In the last 5 decades the average US coastal property has increased from 8% to 45% compared to comparable inland properties (Bin et al., 2007). In North Carolina, a sea-level rise of 43cm (8 inches) by 2080 would cause a total loss of US$ 2.8 billion in residential and non-residential property values across the following four coastal counties : Bertie, Dare, Carteret and New Hanover (Bin et al., 2007).

Increased flooding due to sea-level rise will also impact the cost of insurance coverage for coastal properties. In a 1991 Federal Emergency Management Agency (FEMA) report, it was estimated that a sea-level rise of 0.91 m across the US could increase property insurance values by 100-200% (Cooper, Beevers, & Oppenheimer, 2008). Recently, the US government signed the new Flood Insurance Reform Act 2012, which allows for an annual increase rate of 20% per year on flood insurance over a five year period, to help improve coverage for properties damaged by flooding. These changes will have implications for the tourism sector. Scott et al. (2012a) identified increased insurance rates as an important factor, which that will cause higher operational costs for tourism properties.

2.5.5. Coastal Adaptation to Climate change and Sea-level Rise

Although climate change and sea-level rise will have varying magnitudes of impacts across coastal regions, small islands and mega- deltas in both developing and developed countries, the consensus is that developing countries will incur the most devastating environmental and socio-economic consequences, mostly as a result of their limited adaptive capacity (IPCC, 2012; Nicholls, 2011).UNFCCC (2008) advises that

> Because of the speed at which change is happening due to global temperature rise, it is urgent that the vulnerability of developing countries to climate change is reduced and their capacity to adapt is increased and national adaptation plans are implemented. Future vulnerability depends not only on climate change but also on the type of development path that is pursued. Thus adaptation should be implemented in the context of national and global sustainable development efforts. (p. 10).

It is important that the proper frameworks are applied to improve climate-change-adaptive practices, so that they do not result in maladaptation (adaptation measures that do not succeed in reducing vulnerability but increase it instead) (UNFCCC, 2008).

Scott et al. (2012a) warned that tourism destinations will have to implement climate change adaptation strategies in "order to minimize associated risks and capitalize on new opportunities in an economically, socially and environmentally sustainable manner" (p. 374). In addition, the World Bank (2009) advised that "climate change management efforts must be comprehensive in nature, leveraging synergies between adaptation and mitigation, and understanding inherent trade-offs" (p.66). Climate change management efforts will require the involvement of various stakeholders who understand that climate change responses are closely connected with development choices and actions across numerous sectors. Adaptation planning for coastal flooding and sea-level rise is particularly important to protecting tourism infrastructure and resources, such as beach assets, biodiversity, coastal landscapes and marine habitats.

Nicholls (2011) echoes that planned adaptation offers three main strategies for decreasing the impacts of sea-level rise on coastal settlements, resources and tourism infrastructure: (1) (Planned) Retreat: which refers to moving coastal infrastructure back, and enforcing coastal-land-planning guidelines for new development (2); accommodation: which refers to minimize human impacts "by adjusting human use of the coastal zone via flood-resilience measures, such as warning systems and insurance" (p.151); and (3) protection which applies soft or hard engineering methods. This includes beach nourishment, the building of seawalls and breakwater structures.

Importantly, while adaptation strategies are important to decreasing vulnerability to climate change, it requires a vast amount of expertise, planning, and financial resources to ensure it is implemented properly. Recent estimates show that the costs for coastal adaptation in the developing world will range from "US$26-US$ 89 billion a year by the 2040s depending on the magnitude of sea-level rise" (Nicholls, 2011, p.154). The accessibility of required resources are particularly challenging for developing countries and SIDS which heavily depend on coastal zones for tourism revenue (Nicholls, 2011).

2.6. *Tourism in the Caribbean*

The Caribbean is considered one of the most tourism dependent regions of the world (ECLAC, 2012b; WTTC, 2004). In 2011, tourism contributed US $47.1 billion (13.9%) of GDP to the Caribbean region. In that same year tourism accounted for as much as 74.9 % and 70.2 % of national GDP in Antigua and Barbuda and Anguilla respectively (Table 8)(WTTC, 2012b). In 2011, tourism capital investments totalled US$ 1.1 billion in both Cuba and Puerto Rico, and accounted for more than 500,000 jobs in these economies (WTTC, 2012b). By 2022 the Caribbean region is expected to grow its tourism market share and generate about US$ 65.5 billion in revenue and account for 747, 000 jobs (WTTC, 2012b).

Table 8: Contributions of Tourism to Caribbean Economy by Country for 2011

Countries	GDP (US$ billion)	% of GDP	Employment '000 jobs	Capital Investment US$ billion
Anguilla	0.2	70.2	5.0	0.0
Antigua & Barbuda	0.9	74.9	19.6	0.2
Aruba	1.8	66.6	33.1	0.2
Bahamas	3.5	46.2	90.3	0.4
Barbados	1.8	43.5	59.7	0.2
Bermuda	0.7	12.2	6.8	0.0
British Virgin Islands	0.8	52.3	8.5	0.0
Cayman Islands	0.7	23.6	8.0	0.1
Cuba	7.9	11.4	519.4	1.1
Dominica	0.1	31.8	10.3	0.0
Dominican Republic	8.6	15.1	554.3	0.5
Grenada	0.1	22.2	9.4	0.0
Guadeloupe	1.9	16.0	20.9	0.2
Jamaica	3.9	25.6	278.6	0.3
Martinique	1.2	10.4	14.1	0.1
Puerto Rico	6.4	6.3	59.7	1.1
St. Kitts & Nevis	0.2	28.0	6.3	0.0
St. Lucia	0.4	42.5	30.4	0.1
St. Vincent & the Grenadines	0.2	25.3	9.8	0.0
Trinidad & Tobago	1.9	7.0	55.9	0.1
US Virgin Islands	1.7	35.0	19.2	0.4

Compiled by author. Source WTTC, 2012b

2.6.1. The Implications of Sea-level Rise for Tourism in the Caribbean

The Caribbean is one of the most vulnerable regions to sea-level rise (Mimura et al., 2007). Reports show that the Caribbean sea levels rose by 20cm within the last century and projections indicate an additional increase of between 10 to 50 cm by 2025 and 65 cm by 2100 (Schleupner , 2008b). While there is a growing body of literature that has examined the impacts of sea-level rise in the Caribbean, only a few studies have examined the impacts of sea-level on tourism in the region (Scott et al., 2012a). Moreover, although some studies have provided insight into the regional scale impacts of sea-level rise on tourism in Caribbean destinations, they provide insufficient details on individual countries for analysis (Scott et al., 2012a).

As part of one of the first global analysis on sea-level rise Dasgupta et al. (2008) provided regional analyses on 25 Latin and Caribbean countries. In these regional analyses, estimates showed that 1 m to 5 m of sea-level rise would affect more than five million people and cause more than US$3 billion in losses to annual GDP (Dasgupta et al., 2008). While this study provided some insight on the impacts that sea-level rise would have on the Caribbean's economy and coastal land resources, such as urban lands and agricultural lands which are essential to tourism, it omitted several Caribbean SIDS, and did not quantify the impacts that sea-level rise would have on tourism in an individual country or on a regional scale.

Since this study, other researchers have examined the impacts of sea-level rise on tourism. In a Caribbean regional-scale study, Sookram (2010) presented aggregated costing on the impacts of sea-level rise on tourism and ecosystems in Aruba, Barbados, the Dominican Republic, Guyana, Jamaica, Montserrat, the Netherlands Antilles, St Lucia, and Trinidad and Tobago under A2, B2 and BAU scenarios (Table 9) . In this study, by 2100, under a BAU, scenario sea-level rise is expected to have economic impact of US$ 26,731 million. While this study provided some information for the economic impact of sea-level rise and ecosystems, there was limited focus on the impacts to tourism infrastructure and beach resources.

Table 9: Aggregated Costing for A2, B2 and BAU scenarios: Sea-level rise and destruction of ecosystems (Aruba, Barbados, the Dominican Republic, Guyana, Jamaica, Montserrat, the Netherlands Antilles, St Lucia, and Trinidad and Tobago). (Costs in $US million - 2007 dollars)

Year	A2	B2	BAU
2025	13,745.2	13,968.6	14,094.8
2050	21,532.7	21,654.6	22,185.8
2075	25,547.5	25,608.2	26,628.4
2100	25,648.5	25,709.5	26,731.0

Source: Sookram (2010)

In another regional scale study, Scott et al. (2012b) examined the potential impacts for 1 m of sea-level rise for 906 major coastal resort properties across 19 Caribbean Community (CARICOM) countries. Under a 1 m scenario for sea-level rise, Scott et al. (2012b) estimated that 266 (29%) of resort properties would be impacted by partial or full inundation, while between 440 (49%) and 546 (60%) of resort properties would experience erosion damage from 1 m of sea-level rise. In addition, sea-level rise would result in a more than 50% loss of coastal properties in five countries, three of which are significantly reliant on tourism. Mimura et al. (2007) estimated that ± 0.5m of sea- level rise contributed to 38% beach loss in Bonaire and the Netherlands Antilles. Vergara et al. (2009) estimated that by 2080 sea-level rise will cause an annual land loss cost of US$20.2 million in 20 Caribbean countries (i.e. Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St Kitts and Nevis, St Lucia, St Vincent and The Grenadines, Surinam, Trinidad and Tobago, Turks and Caicos Islands, Virgin Islands (UK)). By 2080, annual hotel room replacement costs (caused by flood damages to tourism infrastructure) will be US$46 million in these 20 countries. In addition, land loss across these 20 countries will cause a further loss of US$88.1 million (30%) in sea-related expenditures (Vergara et al., 2009).

There are few country-scale studies that have attempted to calculate the detailed impact of sea-level rise on coastal tourism assets in Caribbean destinations. As part of a study that quantifies the potential impacts of climate change on tourism in Barbados, Moore, Harewood, & Grosvenor (2010) analyzed five scenarios for coastal squeeze, based on rises in sea levels using empirical calculations for 181 establishments (i.e. hotels, guesthouses and apartments). Scott et al. (2012a) defines coastal squeeze, as "an environmental situation where the coastal margin is squeezed between some fixed natural or human made landward boundary (e.g. rocky cliff, sea wall or building) and the rising sea level, thereby reducing its former area" (p.224). In the five scenarios developed by Moore et al. (2010), the first three reflected projections from Barbados' Ministry of Physical Development Environment: (1) 0.2 m rise in sea levels by 2020 with a maximum land loss of 3.3 m; (2) 0.5 m rise in sea levels by 2050 with a maximum land loss of 8 m; (3) 1 m rise in sea levels by 2100 with a maximum land loss of 32 m; (4) a 50 m land loss; and (5), a 100 m land loss. According to Moore et al. (2010), there was a 0% impact under the first two scenarios; however, in the worst- case scenarios, coastal squeezes of 50 m and 100 m impacted between 23 (13%) and 70 (40%) respectively. While Moore et al. (2010), highlighted the impact that coastal squeeze could have on beach assets due to rising sea levels, their study failed to consider the added impacts of storm surge and wave heights that would accelerate the rate of beach loss over these time periods, an understanding expressed among several researchers including (Nicholls, 2011; Pittock, 2009; Scott et al., 2012a; Tobey et al., 2012). Schleupner (2008b) used a GIS model to conduct a spatial vulnerability analysis on coastal assets and natural resources between a 1 m to 10 m elevation on the island of Martinique, and found that 70% of beaches, 80% of hotels and 92% of main coastal destinations which do not provide overnight stays (e.g. distilleries), were at risk of coastal squeeze due to sea-level rise.

There is a gap in country-scale studies that examines the impact of sea-level rise on tourism in Caribbean countries. While regional-scale studies such as Scott et al. (2012a), Sookram (2010) and Vergara et al. (2009), and some country-level studies, like Scheulpner (2008b), have provided relevant insight into the impacts of sea-level rise for tourism in the Caribbean, these authors have emphasized the need for further contextualized assessment impacts of sea-level rise on individual island tourism economies within the Caribbean.

2.6.2. The Impact of Extreme Weather Events on Tourism in the Caribbean

According to the IPCC (2012), "Extreme and non-extreme weather or climate events affect vulnerability to future extreme events by modifying resilience, coping capacity, and adaptive capacity" (p.6). The Caribbean region is extremely susceptible to natural hazards such as hurricanes and tropical storms which have proven to have devastating impacts, especially for coastal regions in many islands (Binger, 2004; Bueno et al., 2008; Méheux, Dale-Dominey-Howes & Lloyd, 2007; Nicholls et al., 2007; Vergara, 2005). According to the Simpson Scale, a category 1 hurricane can cause storm surges of 1.0 m to 1.7 m, while a category 5 hurricane can affect storm surges more than 5.6 m and cause catastrophic infrastructural damage (Table 10).

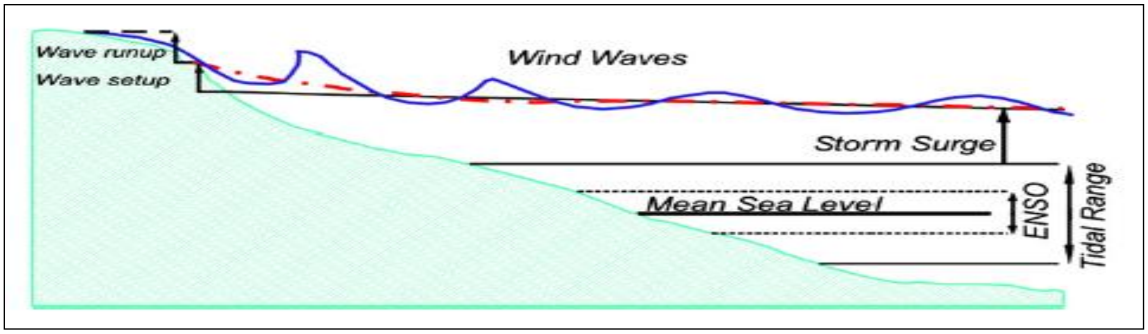
Table 10: Hurricane Strength and Potential Infrastructural Damage

Saffir/Simpson (SS) Scale	Maximum Sustained Wind Speed (m/s)	Storm Surge (m)	Potential Infrastructural Damage
Category 1	33-42	1.0-1.7	No major damage to buildings (5%)
Category 2	43-49	1.8-2.6	Moderate damages to buildings (10%)
Category 3	50-58	2.7-3.8	Extensive damage to building (35%)
Category 4	59-69	3.9-5.6	Extreme damage (50%)
Category 5	>69	>5.6	Catastrophic damage (75%)

Source: Gray et al., 1997; Moore et al., (2010)

The intensity and frequency of strong winds, high waves and storm surges determine the additional impacts that sea-level rise will have, especially in low-lying coastal areas (Cambers, 2009; Nicholls, 2011; Nicholls et al., 2007; Simpson et al., 2010; Walsh, McInnes & McBride, 2012) (Figure 3).

Figure 3: The Contributions to Sea Level due to Tides, Storm Surge and Waves



Source: Walsh et al. (2012). *El Niño Southern Oscillation (ENSO)

The Caribbean region is expected to experience increasingly warmer temperatures between the 2010 and 2069 period. Higher temperature will vary from 0.48°C to 1.06°C from 2010-2039, then from 0.79°C to 2.45ºC and range from 0.94° to 4.18°C from 2040-2069 (Mimura et al., 2007; Pulwarty et al., 2010). The IPCC (2012) reported that "it is likely that anthropogenic influences have led to warming of extreme daily minimum and maximum temperatures at the global scale" (p.7). Moreover, the IPCC (2012) stated that "average tropical cyclone maximum wind speed is likely to increase, although increases may not occur in all ocean basins. It is likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged" (p.11).

Tropical cyclones and natural disasters have had costly impacts for Caribbean tourism destinations causing losses and damage to tourism infrastructures, which are mostly located along coastal lines (Bueno et al., 2008; Scott et al., 2012a). In most Caribbean countries, 95%, of all tourism infrastructures are located within 10 km of the sea, making them extremely vulnerable to sea-level rise and storm surges (Medeiros et al., 2011). In addition, the majority of the region's capital cities and transportation infrastructure are located within coastline areas, and interruption to their functions would have widespread economic effects on tourism and other sectors (Medeiros et al., 2011; UNEP, 2008). In 2004, Hurricane Ivan caused a total (i.e. direct and indirect) US$828,952 billion, US$305,786 billion and US$91,339 billion in economic damages to the tourism sector of the Cayman Islands, Grenada and Jamaica respectively (Table11).

Table 11: Economic Damage and Loss Caused by Natural Disasters in Tourism Sectors Across Caribbean Countries, (1990-2008)

Country	Disaster Event	Damage to Tourism as a % of Total Effect to Economic Sector	Losses to Tourism as a % of Total Effect to Economic Sector	Total Direct Economic Damage of Natural Disasters on Tourism (US$ '000s)	Indirect Economic Damage of Natural Disasters on Tourism (US$ '000s)
Anguilla	Hurricane Luis (1995)	75.69%	13.30%	37,423	6,573
Bahamas	Hurricane Frances and Jeanne (2004)	18.91%	52.04%	43,772	120,441
Belize	Hurricane Dean (2007)	1.06%	6.43%	775	4,721
Belize	Hurricane Keith (2000)	37.54%	10.98%	72,764	21,284
Cayman Islands	Hurricane Ivan (2004)	30.67%	19.38%	505,367	323,585
Cayman Islands	Hurricane Paloma (2008)	39.77%	26.13%	14,562	9,568
Dominica	Hurricane Dean (2007)	2.11%	2.63%	913	1,141
Dominican Republic	Hurricane Frances & Jeanne (2004)	25.54%	19.20%	224,658	168,896
Grenada	Hurricane Ivan (2004)	56.54%	18.73%	229,678	76,108
Guyana	Floods (2005)	0.17%	3.93%	8,778	201,663
Haiti	Tropical Storm Fay, Gustav, Ike, Hanna , (2008)	1.32%	4.58%	216,618*	754,521*
Jamaica	Hurricane Ivan (2004)	3.49%	8.41%	26,775	64,564
Netherlands Antilles	Hurricane Luis, Marilyn (1995)	35.96%	28.42%	409,486	323,585
St. Lucia	Hurricane Dean (2007)	17%	0.54%	2,953	94
Suriname	Floods (2006)	4.74%	4.16%	1,074,638	943,385

Source: ECLAC (2010c) * economic figures for Tropical Storm Fay

Hurricane events can have devastating impacts for tourism, in particular for coastal tourism where waves and storm surges can exacerbate coastal retreat. The UNEP (2003) reported that as a result of Hurricane Luis in 1995, selected Caribbean islands experienced between 3 and 18 m of coastline retreat (Table 12).

Table 12 : Coastline Retreat as a Result of Hurricane Luis in 1995

Caribbean Island	Distance to the Centre of Hurricane Luis, (km)	Coastline Retreat (m)
Barbuda	5	18
Anguilla	28	9
Antigua	40	5
St. Kitts	70	4
Nevis	90	5
Montserrat	90	4
Dominica	180	3

Source: UNEP, 2003.

2.6.3. Current and Future Challenges

Climate change is one of the main challenges for the Caribbean, and will have broad consequences for socio-economic sectors (e.g. agriculture, water resources and health), policy development, and long-term planning in the region (Colley, Haworth & Firth, 2011). This will all have implications for tourism. One of the important features of small islands is the strong two-way interaction between climate change and tourism (Becken & Hay, 2007). Climate change is linked to many factors that impact tourism, such as climatic factors (e.g. temperature, precipitation etc.), environmental factors (e.g. energy and transportation, coastal management which includes land- use planning, erosion, pollution, congestion etc.) and economic factors (e.g. employment, GDP etc.). Bueno et al. (2008) estimated that climate change could cost the Caribbean tourism sector an accrued US$6.4 billion or more by 2100, if no action is taken to reduce its impact. Storm activity is expected to cause additional losses of US$7.9 billion, and losses to infrastructure is projected to be US$31.9 billion for that same period (Bueno et al., 2008). By 2100, climate change is expected to cause an average loss of 22% in GDP for Caribbean countries (Bueno et al., 2008). However, in some countries like Haiti, Grenada, Dominica, and St. Kitts and Nevis losses are expected to be more significant with a more than 75% loss to GDP (Bueno et al., 2008).

Many researchers including Attzs (2009), Belle & Bramwell, (2005), Binger (2005), Clayton (2009), Emmanuel & Spence (2009), Gössling & Hall, (2006), Medeiros et al. (2011), Simpson et al. (2011), UNEP (2008), Vergara (2005) have identified the absence of policy development as one of the central issues threatening sustainable tourism in the Caribbean. Factors such as a heavy reliance on natural resources, vulnerability to natural disasters, high indebtedness, high transportation, energy and communication costs, poverty, and inadequate data collection, hinder both the sustainable development and sustainable tourism agenda for the region. For the most part, the region's resilience to the aforementioned challenges is weakened by existing policy inconsistencies at both the regional and national level; but particularly, there is a lack of long-term planning for the tourism sector at the national scale (Colley et al., 2011). Moreover, there is a poor level of integration amongst tourism-related sectors and sustainability initiatives, and plans for national development among the region's countries appear fragmented (WTTC, 2004). Thus far, only a few countries have implemented a national tourism policy and created master plans to guide future growth within the tourism industry (WTTC, 2004).

Noticeably, while policy is considered a beneficial tool for achieving sustainable tourism, it can also have undesirable consequences. Although already discussed in a global context, it is important to reiterate that one of the main concerns of implementing mitigation policy (that would also benefit the sustainable tourism agenda) is the impact of higher travel costs, which they are likely to generate. For the Caribbean, mitigation policy is expected to have a slightly negative impact on tourism arrivals. In the study by Penelow & Scott (2011) policy was shown to have varying impacts on tourist arrivals in over 21 Caribbean countries.

Gössling et al. (2008) also found that while Anguilla, Cuba, Jamaica, and St. Lucia will continue an average positive projection in growth for international arrivals from 2005 to 2020, under 'serious' climate change policy in 2012, there will also be an overall decrease in demand from their main tourism markets by 2020.

In addition to the expected issues with policy, the Caribbean also faces challenges such as a lack of awareness on the impact of tourism both on a national and regional scale. There has been a slow adoption of improvements in information management technologies, and the development of human resources that would benefit methods of collecting, storing and disseminating relevant information for policy development and planning for the region (WTTC, 2004).

Moreover, issues such as congestion, pollution, and erosion are some of the main tourism-related environmental threats to tourism in the Caribbean (EU-ACP, 2007). The tourism sector generates large amounts of untreated liquid waste from restaurants and hotels (e.g. raw sewage, pesticides, fertilizers from resort landscaping and golf course maintenance etc.). According to EU-ACP (2007) the about 75% of Caribbean treatment plants are incapable of managing waste material. Although tourists produce waste material of about 30,000 tons per year, which is less than domestic sources that produce 47,000 tons per year, the overall impact is an increased level of waste material for disposal.

Furthermore, factors such as a heavy reliance on internationally owned and operated carriers for air access makes the region extremely vulnerable to external disruptions such as labour disputes, and market shifts etc. (WTTC, 2004). There is a need to create a viable regional air transport system to guarantee sustainable air transport services. The WTTC (2004) argued that, for the most part the "economic contributions of cruise tourism to Caribbean economies are arguably negligible" (WTTC, 2004, p.11). Although there have been improvements in developing a better connection to land-based tourism, which has helped increase the economic benefits of cruise tourism to Caribbean destinations, there is need for more effective planning in that area. One of the necessary long-term plans is the development of a regional cruise line strategy to address issues such as port charges, carrying capacity, and infrastructural development (WTTC, 2004).

With a growing population, which almost doubled between 1950 and 1995 (Lewsey et al., 2004), rising poverty levels, and an increasingly high dependency on tourism for employment, the Caribbean is expected to face greater challenges within its tourism sector in the future. The rising demand for coastal tourism and uncoordinated land-use planning is expected to further increase land prices, making land resources less affordable to both local and foreign investors thereby impacting tourism development. Lewsey et al. (2004) noted that, the issue of poor-land-use planning as a huge problem which will have significant implications for coastal resources and affect the impact of climate change variability on Caribbean coastal zones.

One of the greatest challenges for Caribbean tourism is perhaps the imbalance of common interests and priorities by various national governments. Tourism is of varying importance to Caribbean countries, especially those which exclusively rely on its economic contributions (WTTC, 2004). While all literature related to Caribbean tourism seems to emphasize the enormous importance of tourism activity to the region's economic viability, far less attention is given to the implications that these varying economic dependency levels can have on overall Caribbean tourism development. Medeiros et al. (2011) found that only six of 12 Caribbean countries considered tourism a priority sector for adaptation. The tourism sector was the least common priority area among five other sectors (i.e. agriculture, water resources, biodiversity and forest, coastal zones and health). According to Gössling et al. (2009),

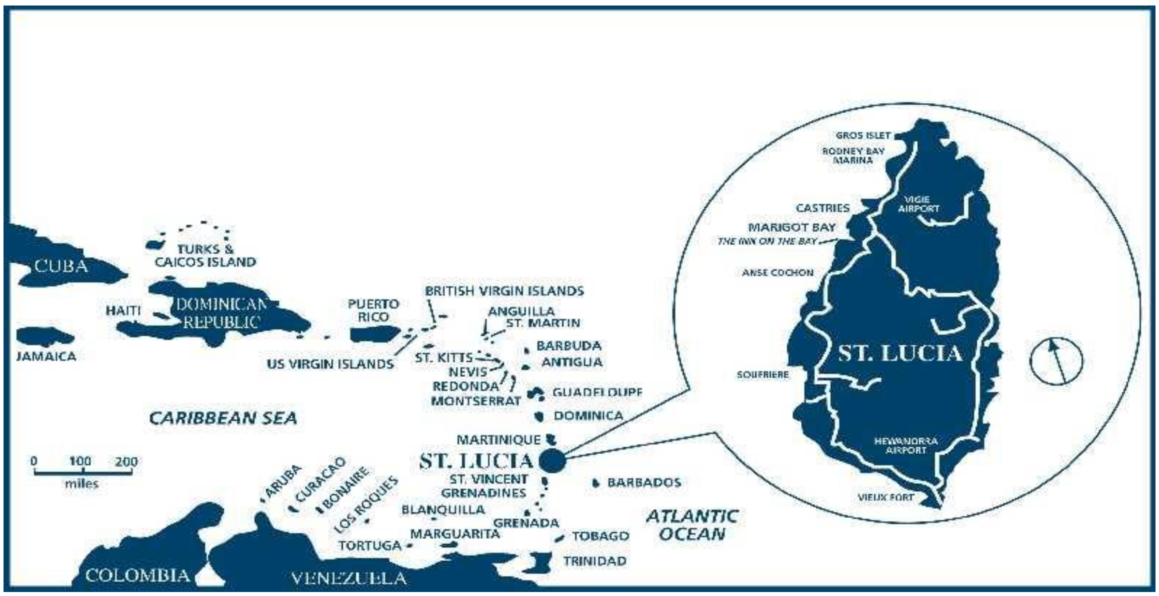
> The most obvious barrier identified is economic priority over social concerns. This is inextricably linked with political governance's short focus and multiple other barriers arise out of this. A focus on short term objectives creates negative feedback loop with economic priority-the shorter the political term, the more attention is focused on job creation and development for growth and other immediate results, which leads to economics being given priority over environmental and social concerns. A four to five year political term is simply not enough to achieve sustainable policy objectives, which by definition are long term…Most destinations focus on numbers of tourists rather than yield, and measures of effectiveness and success of tourism policies invariably relate to the numbers of tourists that arrive at destinations rather than the net benefits that accrue to a destination. (p.48)

The ways in which Caribbean governments prioritize and focus on tourism policy development will have both short and long- term implications for overall planning within that sector, especially for climate change adaptation (Gössling et al., 2009).

2.7. St. Lucia and Tourism

St. Lucia is situated 13°59´ N, 61° W between the islands of Martinique and St. Vincent and forms part of the Lesser Antillean Arc in the Caribbean Archipelago (Tulsie et al., 2001) (Figure 4).

Figure 4: Map of St. Lucia and the Caribbean



Source: Saint- Lucia.com

St. Lucia has an area of 238 sq. mi (616 sq. km), which spreads 43km from north to south, and 23 km from east to west (Isaac & Bourque, 2001). The island contains a narrow coastal ridge, with a winding coastline of approximately 158km, and numerous beaches that provide a vital resource for St. Lucia’s tourism development and economy (Tulsie et al., 2001). In the latest census report of May, 2010, St. Lucia recorded a population of 166,526 (Government of St. Lucia, 2011).

2.7.1. Climate and Biodiversity

St. Lucia has an annual sea surface temperature of 26.7° C and an average air temperature of 28°C. St. Lucia receives varying rainfall of 1152 mm in coastal areas, and more than 3000 mm in elevated regions (Isaac & Bourque, 2001). The island has a mean annual maximum temperature of 30.1°C, and a mean minimum temperature of 24.5°C (Government of St. Lucia, 2006a). The island's rainfall pattern is described by two seasons (wet and dry). St. Lucia is exposed to seismic-hazard tsunamis or seismic-induced sea waves due to the island's proximity to volcanoes in nearby islands, Mt. Pelée in Martinique (North), Soufriere in St. Vincent (South) and the Submarine volcano Kick 'em Jenny in Grenada (South) (Government of St. Lucia, 2006a).

St. Lucia has a vast number of ecosystems with a range of flora and fauna species. The island possesses 27 endangered plant species, which are mainly located in coastal habitats, more than 1000 plant species and 150 bird species, which includes 5 endemic species: "the rare St. Lucia Parrot or Jacquot (Amazona versicolor); the St. Lucia Blackfinch or "Moisson Pied–Blanc" (Melanospiza richardsoni); "Semper's Warbler" or "Pied Blanc" (Leucopeza semper); the St. Lucia Oriole or Carouge (Icterus laudabilis); and the St. Lucia Pewee or gobe-mouche (Contopus oberi)" (Tulsie et al., 2001, p.7).

2.7.2. Tourism Development in St. Lucia: History, Trends and Markets

Tourism is a crucial part of St. Lucia's economy. In 2012 St. Lucia's travel and tourism generated US$500 million (XCD$1,338.6 million), an equivalent of 39% of the islands' total GDP (WTTC, 2013). In that same year, tourism provided approximately 31,000 jobs, which accounts for 42.3% of total employment, and accounted for over US$30 million of government revenue. By 2023 the industry is expected to increase its contributions to national GDP in the amount of US$844 million (XCD$2, 280 million), and expand the employment sector to 47,000 jobs (53.5% of total employment) (WTTC, 2013b). St. Lucia's tourism industry is heavily dependent on natural resources (e.g. marine habitats, beaches etc.), and tourist properties are concentrated mainly in coastal areas. Estimates showed that St. Lucia's coral reefs had a total (direct and indirect) economic impact between US$160 to US$194 million with other values such as local use and consumer surplus accounting for a total US$54.2 to US$111.4 million (Burke et al., 2008). Cruise tourism accounts for the largest number of St. Lucia's tourist arrivals, increasing from 359,573 (52.2 % of a total 668,229 tourist arrivals) in 2006 to 630,304 (65.1 % of a total 968,082 tourist arrivals) in 2011 (St. Lucia Tourist Board, 2012).

St. Lucia's tourism expansion has largely been attributed to the significant decline in banana agricultural exports that began throughout the 1990s, due to intense economic competition in the banana industry (Tulsie et al., 2001).

Figure 5: Passenger Arrivals to St. Lucia 1990, 1995 &2000-2009

SAINT LUCIA'S NUMBER OF PASSENGER ARRIVALS : 1990, 1995, 2000 - 2009

(No.of Persons)

	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TOTAL ARRIVALS	250,662	410,849	728,377	746,859	647,394	683,005	791,151	719,844	669,154	905,640	915,441	977,797
RESIDENTS	...	...	...	...	...	...	...	...	...	...	...	...
TOTAL VISITORS	250,662	410,849	728,377	746,859	647,394	683,005	791,151	719,844	669,154	905,640	915,441	977,797
TOURIST	146,578	231,259	269,850	250,132	253,463	276,948	298,431	317,939	302,510	287,518	295,761	278,491
EXCURSIONISTS	2,136	10,019	12,853	6,815	6,751	12,817	11,441	7,541	7,051	7,777	...	...
CRUISE PASSENGER	101,948	169,571	445,674	489,912	387,180	393,240	481,279	394,364	359,593	610,345	619,680	699,306
TOTAL ARRIVALS	...	...	713,401	740,044	640,643	670,188	779,710	712,303	662,103	897,863	915,441	977,797
Arrivals By Air	...	...	269,850	250,132	253,463	276,948	298,431	317,939	302,510	287,518	295,761	278,491
Arrivals By Sea	...	...	443,551	489,912	387,180	393,240	481,279	394,364	359,593	610,345	619,680	699,306

Source: CARICOM (2011)

In 1990, St. Lucia recorded a total of 146, 578 stop-over arrivals, and 101,948 in cruise ship arrivals (CARICOM, 2011). By 2004 these figures had more than doubled, with 298, 431 stop over arrivals and 481,279 arriving by cruise ships within that year (CARICOM, 2011). Cruise passengers increased from 40% of total tourist arrivals in 1990, to 61 % in 2000, and then to 71% in 2007 (Figure 5). For the period extending from 2000 to 2009, the St. Lucia had increases in passenger arrivals, except in 2002, 2005 and 2006, when total arrivals were 647,394, 791,844 and 699,154 respectively (Figure 5). Coastal tourism is the main type of tourism in St. Lucia; however in the last 10 years Village Tourism has emerged as a potential brand. Village Tourism refers to community-based development, which is centered on the cultural attributes and uniqueness of village communities and their people (International Design and Entertainment Associates (IDEA), 2008). Although Village Tourism offers a new branding opportunity for

St. Lucia, there is need for better planning among national tourism stakeholders who must also be willing to invest in various

> improvements to services and infrastructure, including building and street enhancement projects, as well as overall beautification of all villages… leisure spaces for the enrichment of the residents' quality of life. This enhancement will also provide the opportunity for hospitality and commercial growth, and will be enjoyed by both the local community and tourists. (IDEA, 2008, p.20)

European nations and the US form the largest part of St. Lucia's tourism market (CARICOM, 2011; St. Lucia Government Statistics Department (SLGSD), 2009). In 2007, St. Lucia accommodated a total of 79,180 from the UK and 113, 433 from the United States (SLGSD, 2009) (Table13). In 2008, although tourist arrivals from the US decreased by almost 5000, it remained the main tourism market for St. Lucia (CARICOM, 2011). In both 2007 and 2008 St. Lucia's 3rd and 4th largest tourism market was the Caribbean and Canada, in that order.

Table 13: Total Number of Tourist Arrivals to St. Lucia by Markets

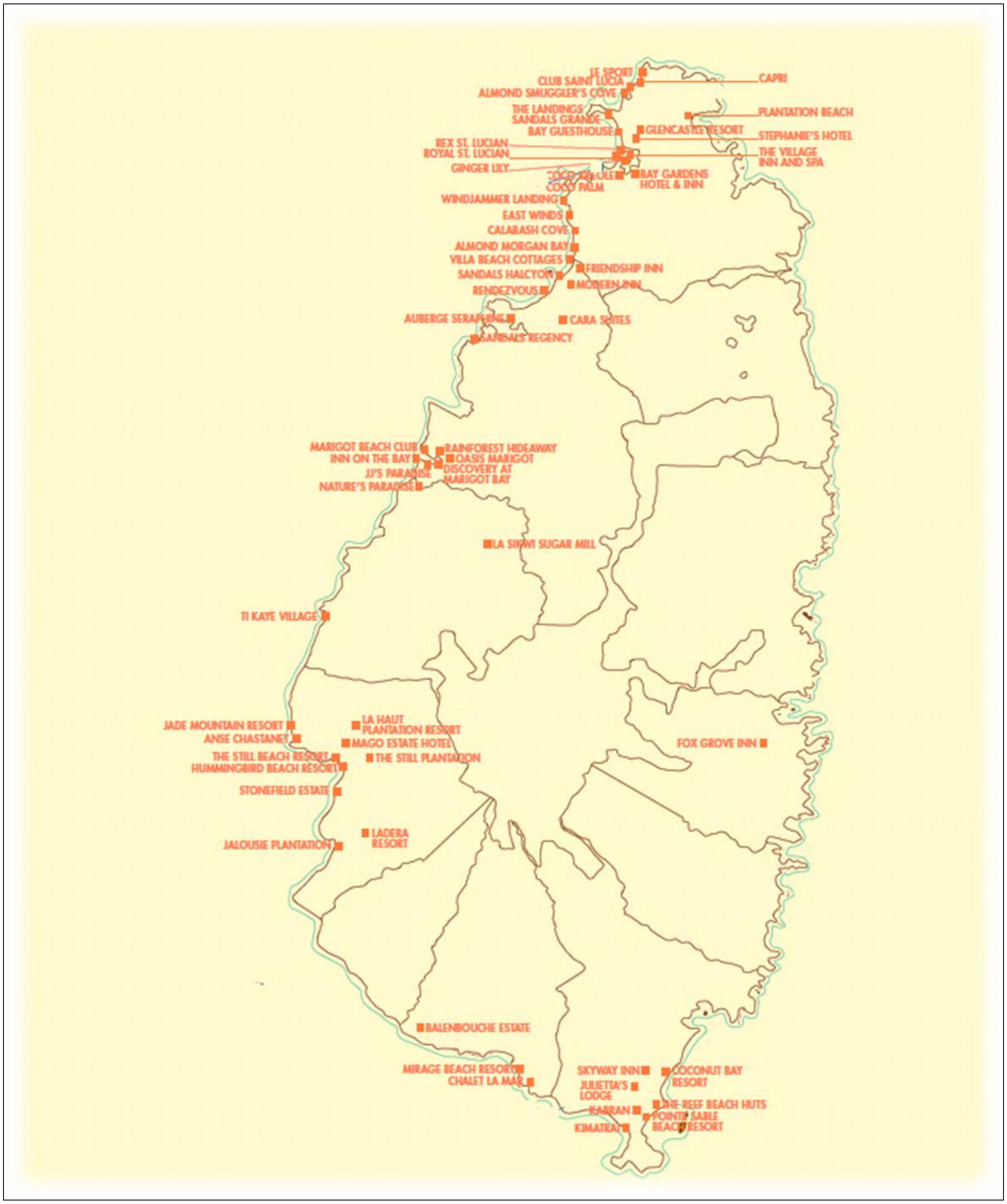
Tourism Markets	2008	2007
USA	108,596	113,433
Canada	26,279	18,640
UK	83,693	79,180
Germany	1,823	1,592
France	4,271	3,642
Rest of Europe	7,084	4,414
Caribbean	59,757	59,049
Rest of World	4,258	7,459
Total	295,761	287,407

Sources: CARICOM (2011); SLGSD (2009).

2.7.3. Geographic Concentrations of Tourism

Most of St. Lucia's tourism development has occurred within the northern, western and south western coastal zones (IDEA, 2008) (Figure 6). The Rodney Bay area which is located in the north of the island is a prime tourist area and contains a number of accommodations such as hotels, resorts, and guest houses as well as many shopping amenities and commercial services.

Figure 6: Map Showing Concentrations of Tourism Properties in St. Lucia



Adapted from IDEA, 2008

St. Lucia's capital city, Castries, is the largest urban area on the island, and contains the island's cruise ports, and a variety of historical buildings, shopping areas etc. which are part of the daily excursions available to visitors from tour operators.

The south-western part of the island, the town of Soufriere, is also very important to St. Lucia's tourism, and is portrayed as one of the most significant areas to the island's growing eco-tourism trend which includes nature trail tours, and bird watching. The Soufriere area also provides many accommodations for tourist and in addition is home to some of the island's unique landscapes and attractions such as the 'majestic' twin pitons, and the sulphur springs drive- in volcano that draw many visitors to the area on a daily basis (Visions Magazine, 2011).

2.7.4. Tourism Attractions

One of the main reasons why people travel is the desire to experience something unfamiliar landscapes, cultures etc. (Hall, 2008).Tourism attractions are a crucial aspect for tourism destination development, as they assist in the marketing and promotion of the tourism product (Hu & Wall, 2005; Global Environmental Facility (GEF), 2007). As previously mentioned, St. Lucia also possesses unique landscapes such as the Twin Pitons and Sulphur Springs which have become distinctive parts of the island's tourism marketing image. Other popular attractions include the Diamond waterfalls, Pigeon Island National Park, Maria Islands and the Mamiku Botanical Gardens. Recreational and outdoor activities include turtle and whale watching, zip lining, and scuba diving (IDEA, 2008; Vision's Magazine, 2011). St. Lucia also attracts several thousand visitors annually to its main cultural celebrations, the most popular being the International Jazz Festival held in the month of May, and Carnival, in the month of July.

2.7.5. The Impacts of Climate and Natural Disasters on Tourism

St. Lucia is expected to be impacted by warmer temperatures, changes in extreme weather patterns, and sea-level rise as a result of climate change (Tulsie et al., 2001). These factors are expected to have implications for the timing and duration of St. Lucia's tourism season, biodiversity and water resources (Tulsie et al., 2001) (Table 14). Moreover, St. Lucia's natural environment is closely linked to local and touristic socio-cultural dynamics, and so the degradation of natural resources will pose challenges in providing tourism- related services, particularly, eco-tourism.

As a coastal tourism destination, St. Lucia's coastal resources play an important role in attracting visitors. However, the overall health of St. Lucia's natural environment is considered a key motivation for tourists. While it is believed that many visitors to Caribbean destinations are motivated by the pull factors sun, sand, and sea, in a National Tourist Board survey in 1998-1999 visitors to St. Lucia ranked these factors 4th after the natural environment (Tulsie et al., 2001).

Table 14: Anticipated Impacts of Climate Change on St.Lucia's Tourism Related Infrastructure and the Environment to which the Population has Attached Socio-cultural Value

Climate Change Impacts	Implications
Sea-level rise Beach erosion, beach loss and loss of coastal vegetation	-Loss of recreational beaches for visitor and local use. -Reduced aesthetic appeal of beaches. -Reduction in the quality of a major tourism product. -Shoreline exposed and unprotected and increasingly vulnerability to subsequent storm events -Reduction or removal of the buffer zone protecting coastal land and infrastructure from wave action -Loss of income and livelihoods resulting from damage to or loss of tourism related property/ amenities; and the destruction and/or damage to coastal infrastructure e.g. airports and seaports, hotels, restaurants, roads and infrastructure related to the services indicated above. -Economic cost of relocating, replacing and/or repairing infrastructure, which has been destroyed, dislocated or damaged. -Economic disruptions relating to interruptions in the provision of telecommunications, electrical power, water and sanitation services. -Anticipated increase in the cost of insurance for tourism related properties. -Precipitate the intrusion of salt water into fresh water lenses, particularly in low-lying coastal areas reducing quantity and quality of potential potable water.

Climate Change Impacts	Implications
-Temperature and precipitation changes (flooding or drought).	-Potential loss of rainforest and its biodiversity, particularly endemic species, will represent loss of income and employment for individuals and communities, which depend on tourism and consequently losses of revenue to the eco-tourism sector, the tourism industry and the economy in general. -Increased mortality due to temperature increase that will result from coral bleaching and/or impaired reproductive functioning of the coral. Threatens the survival of eco-tourism sector and near shore fisheries. -Increase in the incidence of water borne and food borne infectious diseases.
Socio-economic and demographic dislocation resulting from land loss, destruction and/or damage to property, infrastructure and other components of the built environment, resulting from the impacts stated above.	-Negative impact on investment climate in the tourism sector
Vulnerable locations/groups:	
Coastal communities particularly those established on the west coast.	-Social disruption resulting from the loss of geographical locations and physical structures (e.g. beaches, archaeological and historical sites, parks, landmarks, museums etc.), which constitute the core of cultural and historical existence of the population.

Adapted from Tulsie et al. (2001)

In St. Lucia, losses from climate-related events are usually reported aggregately (i.e. inclusive of multiple national sectors). As a result, the precise total impact losses from climate-related events on the tourism sector are commonly unknown (ECLAC, 2011b). In addition, the costs of climate-related events on the tourism sector may also be underestimated, due to lack of reporting on losses and damages from tourism accommodations (ECLAC, 2011b). Moreover, in most cases, climate-related impacts on tourism are calculated in relation to losses in tourism arrivals and stay-overs, which are used to determine revenue losses for that particular sector.

Since 1980, St. Lucia has been impacted by a number of tropical cyclones, which have impacted various sectors such as forestry, tourism, agriculture etc. These have caused huge economic setbacks for the island (Government of St. Lucia-SPCR, 2011). As a result of one disaster, Hurricane Tomas in 2010, St. Lucia incurred damages of US$332 million (Table 15). Economic damages from Hurricane Tomas represented 43.4% of St Lucia's GDP (Government of St. Lucia-SPCR, 2011).

Table 15: Economic Impact of Natural Disasters in St. Lucia 1994-2010

Year	Type of Disaster	Damage in US$(million)
1994	Tropical storm	85.16
1996	Tropical wave	4.44
1998	Landslide	49
1998	Tropical wave	0.23
1999	Land slip	0.37
1999	Hurricane	6.26
2002	Tropical Storm	7.25
2003	Tropical Wave	1.14
2004	Hurricane	2.59
2010	Hurricane	332
Total		488.44

Complied by author. Sources: CARICOM (2004); (ECLAC, 2011a).

In St. Lucia, damages from 10 disasters between 1994 and 2010 totaled US$488.44 (Table15). Land slippages have resulted in extensive damage to biodiversity and infrastructure, with losses accruing to more than XCD$ 2 million (US$ 0.74 million) (Government of St. Lucia-SPCR, 2011). In 1980, Hurricane Allen caused a 50% loss in tourist stay-over days for the island (Haites 2002). According to Haites (2002), if this event had occurred at St. Lucia's current tourism level, total losses of US$500 million would have been incurred. In 2010, Hurricane Tomas halted all activities at the Hewannora International airport resulting in losses of EC$999,419 in aircraft landing fees (ECLAC, 2011b). In addition, cruise arrivals were severely impacted during that same period, due to cancellations by various cruise lines.

Within the next decades, climate change is projected to pose increasingly higher economic costs for St. Lucia's economy. Under a business- as- usual scenario, the island is expected to incur accrued economic impacts of US$ 108,323.50 million at the end of 2099 (ECLAC, 2010b) (Table 16).

Table 16: Projected Cost of Climate Change at the End of 2025, 2050, 2075 and 2099 for St. Lucia Under Scenarios A2, B2, A2B2 and BAU (1990 US$ million) Cost Per GDP Ratio: 45%, Discount Rate: 0.5%

Year	A2	B2	A2B2	BAU
2025	7,641.19	7,575.98	7,609.24	6,802.89
2050	28,926.54	27,757.31	28,341.84	23,159.91
2075	61,562.54	57,315.35	59,377.45	53,840.15
2099	85,863.72	87,159.37	86,223.03	108,323.50

Adapted from ECLAC, 2010b.

2.7.6. Tourism Policy and Management

St. Lucia remains one of the Caribbean nations that is yet to adopt a public participation strategy in their overall policy planning process (Intergovernmental Technology Conference (ITC), 2004). There are three main agencies in St. Lucia that oversee the tourism planning and development process: The Ministry of Tourism; the Saint Lucia Tourist Board (SLTB); and the Saint Lucia Hotel & Tourism Association (SLHTA). Although St. Lucia's final draft of its Tourism Policy was introduced in 2003, to date an official policy has not been enacted into cabinet. The drafted tourism policy includes eight overall objectives:

(1) To establish tourism as a strategic economic development priority;
(2) To expand local participation directly or indirectly in the tourism sector;
(3) To continuously improve the quality of the tourism experience and product;
(4) To stimulate and facilitate additional investment in the upgrading, expansion and diversification of the tourism infrastructure and production base;
(5) To strengthen the backward and forward linkages between tourism and Agriculture and other sectors of the economy;
(6) To project a positive and unique identity of Saint Lucia in tourism generating markets
(7) To improve the public's perception of and attitude towards tourism;
(8) To participate actively in and take full advantage of regional and international initiatives (Government of St. Lucia, 2003)

One of the key components under the third objective of the Tourism Policy draft (as outlined above), is to continuously improve the quality of the tourism experience and product, through protecting the integrity of the environment by formulating and implementing standards and policies based on research of models of sustainable preservation, conservation and use of the environment in areas used for tourism (Government of St. Lucia, 2003).

Even though there have been a number of strategies for tourism development in St. Lucia, the island is considered to be "still immature in export strategy formulation as a national planning exercise" (ITC, 2004, p.1). Many tourism-related areas and departments, such as forestry, and fisheries, remain detached from a sustainable tourism process, as the various decisions and management of national resources such as coral reefs and land-use planning are mandated outside the Ministry of Tourism by other government departments (Government of Saint Lucia-SPCR, 2011).

2.7.7. Overview of Policy and Frameworks

Policy development is hardly a new approach for pursuing sustainable tourism. Several authors (Byrd, 2007; Clayton, 2009; Gössling et al., 2008; Hall, 2008 & 2011; IPCC, 2007) within the last decade have noted the importance of policy implementation to help sustain the finite natural resources amid a globally and rapidly expanding tourism sector.

In St. Lucia, the Sustainable Development and Environment Unit (SD&EU) of the Ministry of Planning are chiefly responsible for coordinating the planning processes for sustainable development and the environment in St. Lucia. The unit was established in April, 2000, and focusses on the following four main areas: (1) Environment- Climate Change; Ozone Protection; Waste Management/Pollution; Prevention; Coastal Zone Management; Mineral Resources; (2) Energy- Renewable Energy Resources; Energy Policy; (3) Sustainable Development-Land Policy; SIDS-Plan of Action; and (4) Science and Technology-Public Awareness; Science and Technology Council (Government of St. Lucia, 2001).

Over the last 12 years, St. Lucia has made noticeable strides in its overall policy development; however to date it still lacks national legislation that is specifically geared towards tourism sustainability. Although the Constitution of St. Lucia is the principal policy instrument for environmental conservation and sustainable development, it appears "silent on environmental management and integrity" (GEF, 2007), is ambiguous and contains certain features that hinder the goals of environmental sustainability i.e.:

(1) do not recognize environmental integrity as a right to be enjoyed by the population"; (2) "have made private property rights sacrosanct, which are the very rights which needs

> controlling if a balance is to be attained between environmental and developmental concerns"; and (3) "leave all forms of environmental issues to statutory law and the powers of amendment by the political directorate. (GEF, 2007, p.15)

Writing about St. Lucia more than 15 years ago, Lorah, Conway & Jackiewicz et al. (1995) argued that:

> The existence of environmental laws seems to indicate that some coastal resources are being protected. Unfortunately, this is not the case, as the mere existence of regulations (even ones as weak as St. Lucia's) can lead to an unjustified belief that adequate environmental protection is taking place. Many of these regulations have not been fully implemented, many are out-dated, and many lack mechanisms to ensure effective implementation and are therefore not systematically enforced. (p.15)

After more than a decade, these same concerns are still echoed throughout studies pertaining to policies in St. Lucia. Lewsey et al. (2004) noted that:

> For many years, urban growth in St. Lucia occurred in the absence of a proper planning regime. Moreover, even with specific efforts to address this situation beginning in the early 1970s, the pre-existing conditions, the inadequacy of planning legislation itself, and the difficulties of enforcing this legislation have all led to intensive and relatively uncontrolled development in coastal areas. (p.9)

Presently, St. Lucia possesses a range of climate-change-related policies such as the National Energy Policy and the Sustainable Energy Plan, but the island did not develop its first National Climate Change Policy until 2002. Despite the presence of legislation, national- action levels and enforcement have been described as inadequate towards climate change adaptation (Government of St. Lucia-SPCR, 2011). To date, much of the island's climate change-related policies have focused on hazard mitigation and disaster management in relation to storm events. Although recent policies, such as the National Land Policy, National Water Policy and the National Environmental Policy, outline considerations to climate change in areas such as the environment and natural resource management, many of St. Lucia's policies, procedures and plans have not been revised to address the challenges of climate change (Government of St. Lucia-SPCR, 2011).

The *Coastal Zone Management (CZM) in Saint Lucia: Policy, Guidelines and Selected Projects* programme led to the adoption of a national CZM policy in 2004. Since the national

CZM policy, which offers the most current and integrated approach towards climate change adaptation, more national sectors have begun to emphasize climate change adaptation; however, this improvement has only taken place on a small scale (Government of St. Lucia-SPCR, 2011). Recent reviews of various policies and frameworks for St. Lucia have identified policy gaps, and financial and human resources as the most limiting factors in St. Lucia's capacity building and sustaining climate change resilience (GEF, 2007; Government of St. Lucia-NCSA, 2007; Prip, Gross, Johnston & Vierros, 2010; Singh, 2010).

2.7.8. Coastal Zone Characteristics

St. Lucia's coastal zones contains a diversity of ecosystems including mangroves, coral reefs, sea grass beds, and beaches, which play a significant role in tourism, and provide natural coastal defenses for the island (Government of St. Lucia, 2001; Convention of Biological Diversity (CBD), 2009). Many of these resources are threatened by a range of anthropogenic activities (e.g. sand mining, pollution etc.) which will have resounding implications for both local livelihoods and coastal tourism (Table 17).

Table 17: Main Threats to St. Lucia's Coastal and Marine Ecosystems

Threats	**Drivers/Causes**
➢ Destruction of coral reefs patchy and narrow fringing reefs affected by sedimentation and land-based pollutants ➢ Reduction in beach length ➢ Loss of mangroves ➢ Diminishing stocks of most commercially important benthic species	➢ Poor solid and liquid waste management ➢ Unregulated land development esp. in coastal areas ➢ Sand mining ➢ Erosion from poor soil/land management practices in agriculture, mining, quarrying, etc. ➢ Conversion and reclamation of mangroves ➢ Marine invasive species ➢ Over-harvesting of commercially important species ➢ Illegal trade in coral and other protected species ➢ Illegal and unsustainable (destructive) fishing methods

Source: CBD (2009).

Thus far, the coastal zone region map is one of most updated planning tools that St. Lucia has developed to help improve its hazard mitigation and coastal zone management strategies (Walker, 2006) (see Figure 18). The map identifies the most vulnerable storm-wind areas, critical coastal resources such as watersheds, coral reefs and the island's various coastal communities.

In addition, to the island's coastal regions map, St. Lucia has also developed a national comprehensive land-use map as part of its National Vision Plan (see Appendix 1). The National Comprehensive Map is aimed at reducing land-use conflicts among various sectors in planning. This map identifies existing land, uses and designates specific areas for future development (IDEA, 2008).

2.7.9. Tourism Planning

St. Lucia's tourism planning strategies have long been criticized (e.g. Lewsey et al., 2004; Lindberg, 1999; Lorah et al., 1995; Sustainable Economic Development Unit (SEDU), 2002 ; Singh, 2010) for its lack of integrated approaches to developing and implementing policies, and executing plans especially where environmental sustainability is concerned. The absence of a tourism policy has limited the potential for a proper tourism planning and development process.

At the 2004 Intergovernmental Technology Conference themed *Small States in Transition- from Vulnerability to Competitiveness* it was emphasized that:

> Where there is no tourism policy and plan the industry has not been adequately conceptualized. There must be an approach by the relevant public and private sector interests and stakeholders which utilizes their skills and insights to develop a conceptual view of the hotel plant and industry that will bring optimum social and economic benefits to St Lucia. In the absence of such a plan each investor has no choice but to seek solely his interests, which often militate against the interest of the nation...Also the location of critical economic and social infrastructure in relation to tourism amenities must be adequately considered so that spatial development is in keeping with the long term expectations for national development. Associated with this concern is the need for balancing environmental concerns and protection with tourism development expansion. (p.2)

Moreover, Lorah et al. (1995) echoed that in order for St. Lucia to encourage sustainable tourism, more efforts would have to be directed towards conservation and protection of natural resources. Continuous urban development in coastal areas for tourism expansion and commercial activity, along with rising population density, has increased pressure on the island's coastal resources.

Moreover, Barker & Roberts (2004) examined the impact of tourism on the Soufriere Marine Management Area (SMMA), and found that coral reefs in the SMMA attracted an overwhelming number (28,000) of divers each year, a number which exceeded the area's threshold. Barker & Roberts (2004) used the estimated threshold of between 4000-6000 dives a year for this study, which is based on earlier studies (e.g. Riegl & Velimirov, 1991; Hawkins & Roberts, 1997). This determined a diving threshold that would influence rapid increases of coral cover loss, and coral colony damage levels (Barker & Roberts, 2004). Barker & Roberts (2004) found that approximately 73.9% of scuba divers to the SMMA caused disruptions to coral reef habitats by coming into contact with them (Barker & Roberts, 2004).

In a more recent study, Singh (2010) found that a concerted effort for tourism expansion by the St. Lucian government is leading to further large-scale tourism development in areas that contain immense biodiversity, thereby compromising ecosystems and habitats. In earlier literature, Lewsey et al. (2004) had made similar observations and pinpointed the Rodney Bay area as an excellent example of how urban development, through the construction of marinas, and port facilities, had encroached onto coastal ecosystems, most especially mangrove wetlands. SEDU (2002) recognized that in St. Lucia that,

> Physical planning laws regulate development and construction of tourism facilities. However, hotel construction on the beachfront and the clearing of land for tourist facilities have resulted in slope instability, erosion and sedimentation of the near-shore marine environment and in some instances the destruction of mangroves …In some instances the location of hotel sites has resulted in wildlife disturbance and habitat loss. The construction of the Jalousie hotel is an example of development in an ecologically sensitive area. This site was nominated as a United Nations World Heritage Site. (p. 68)

In St. Lucia, the majority of the national policies that facilitate sustainability plans originate from non-tourism sectors, which focus on environmental protection, conservation and coastal zone management. These policies include: the National Land Policy; National Forest Policy; Coastal

Zone Management plans; the Mauritius Strategy; and The St. George's Declaration (Government of St. Lucia- SPCR, 2011). Although St. Lucia's tourism sector benefits from a wide variety of sustainability initiatives, which are undertaken by other national sectors and regional organizations such as CARICOM and the OECS, the lack of tourism- specific planning instruments are likely to affect the island's ability to perform sustainably in the long-run (Government of St. Lucia- SPCR, 2011).

3. Methods

3.1. Introduction

This chapter entails the research approach and rationale, data sources and research methods, and research observations, limitations and challenges. There are three main research components in this study: (1) a GIS analysis which used digital elevation models (DEMs) to model impact scenarios (i.e. inundation and erosion) associated with a 1 m of sea-level rise and storm surge for a 1/25 year storm event for an inventory of 77 tourism infrastructures (i.e. 73 properties, two airports and two cruise ports) and six areas zoned for future tourism development, (2) an adaptation analysis which examined the potential for coastal retreat as an adaptation strategy and also identified existing 'hard-engineered' coastal protection structures at tourism properties, and; (3) a document review of policy and planning documents to understand the policy considerations and provisions for sea-level rise in the tourism sector.

3.2. Research Approach and Rationale

According to the IPCC (2012) SIDS are some of most vulnerable areas where sea-level rise impacts such as inundation, erosion, shoreline changes, salt water intrusion into coastal aquifers, and disruption to ecosystems. These issues will have important implications for the tourism industry (Scott et al., 2008). The Caribbean region consists of 23 of the 52 SIDS that exist worldwide, thereby making it one of the most susceptible regions to sea-level rise. Tourism has become increasingly important to the Caribbean region with international tourism receipts increasing from US$16 billion in 2002 (WTTC, 2004) to US$23 billion in 2011 (UNWTO, 2012). Moreover, forecasts indicate that Caribbean tourism will contribute US$65 billion to total GDP by 2022. These factors highlight the concern for the future Caribbean tourism.

As part of its five strategic elements to achieving development resilient to climate change, the CCCCC (2009) and CCCCC (2012) reports explained that it was important to promote the adoption of measures that adapt tourism activities to climate impacts. Sea-level rise is one of the most certain impacts of climate change that will impact the tourism sector, causing damages to coastal infrastructure and losses to tourism revenue that is important to improving the economic sustainability of several SIDS in the Caribbean (UNEP, 2008b).

The sustainability of coastal tourism will require on-going, integrated planning and management approaches to ensure that the most effective climate change adaptation strategies are being applied. Scott et al. (2012a) identified six key elements that have been tested among international organizations and used in the practice of climate change adaptation, that are applicable to the tourism sector: (1) getting the right people involved in the participatory process, (2) screening for vulnerability: identifying current and potential risks, (3) identifying adaptation options, (4) evaluate adaptation options and select course of action, (5) implementation, and (6) monitoring and evaluation adaptations.

This study contributes to steps 2 and 3 for the St. Lucian tourism sector. This study focuses mainly on St. Lucia's coastal tourism; since the majority of tourism resorts and accommodations are located within 1 km of the coast and 3S (sand, sun and sea) tourism is the main market segment. Moreover, sea-level rise is noted as being most problematic for coastal regions (Nicholls, 2007 and 2011; Simpson et al., 2010; Vergara, 2005). Therefore, by focusing on coastal tourism, this study addresses the most vulnerable and important areas for tourism on the island. This study uses both quantitative and qualitative methods to examine the diverse data needed to achieve its stated goal and objectives.

This research study and area was motivated by four main factors:

(1) St. Lucia has an expanding tourism sector which plays a crucial economic role in the island's development. St. Lucia's total visitor arrivals increased from 726,254 in 2000 to 791,151 in 2005 to 905,640 in 2007, then to 982,764 and 983,593 in 2009 and 2010 respectively. As a SIDS which depends largely on tourism, St. Lucia is susceptible to the impacts of climate change and sea-level rise.

(2) Access to a national GIS database and policy documents that would facilitate in-depth analysis.

(3) Climate change is mainly understood from a global or regional context. In most climate change studies, the Caribbean region is considered holistically and much of the distinct characteristics that define each island's potential and limitations remain largely unrecognized. By examining the impacts of climate change and sea-level rise on a national scale, the risks of climate change and potential adaptation strategies that are suitable to economic and governance realities can be better understood.

(4) As a former resident of the island who frequently visits and has strong ties, I possess a unique knowledge and understanding of the various national features and tourism development that has occurred over time. My interest in climate change and environmental issues combined with my decision to pursue tourism research offers me the opportunity to examine these interlinked challenges as they relate to sustainable tourism development and the Caribbean. By conducting my thesis research in St. Lucia, I contribute to the body of literature on climate change and tourism, and help give a better understanding of the implications of sea-level rise for tourism in SIDS broadly and St. Lucia specifically. The research will allow for more proactive development of adaptation strategies that can be implemented on a national or community scale, even as our understanding of sea-level rise continues to improve. It will contribute to building adaptive capacity in St. Lucia and the Caribbean, which are priority areas according to CCCCC (2012) and the UNEP (2009).

3.3. Data Sources and Research Methods

To understand the implications of sea-level rise for tourism in St. Lucia this study incorporates three main research components:

(1) GIS to analyze inundation impacts associated with 1 m of sea-level rise on (a)tourism properties, (b) transportation infrastructure (i.e. airports and sea-ports), (c) areas zoned for future tourism development and; flooding and erosion,

(2) a potential adaptation analysis on coastal retreat and coastal protection; and

(3) a review of national policy and planning documents.

3.3.1. GIS Analysis

DEMs provide the most common approach for extracting geographical data and modelling surface processes (Bolch, Kamp & Olsenholler, 2005). In this study ASTER and SRTM DEMs elevation data were used to construct a DEM in order to examine the impacts of inundation scenarios associated with 1 m sea-level rise for tourism in St. Lucia.

3.3.1.1. Calculating Sea-level Rise, Storm Surge and Wave Heights

Although studies like Cooper et al. (2008) and Heberger, Cooley, Herrera, Gleick & Moore (2009) in the US and global analyses by Li et al. (2009) and Dasgupta et al. (2007) have used greater than 1 m sea-level rise scenarios as have studies in California and the Netherlands to assess the potential flood impacts on coastal areas , this study used a 1 m level of global sea-level rise, as it represents a more central estimate of most studies involving sea-level rise projections (Tamisiae & Mitrovica, 2011) (Table 18). Moreover, a projected 1 m of global sea-level rise is more comparable to "regional and global SLR impact assessment studies that use arbitrary 1 m incremental scenarios" (Scott et al., 2012b, p.890).

A 1/25 year storm event period was selected for this study as there exist a high probability that a 1/25 year event will occur in the latter half of this century, when sea-level rise scenarios are expected to be well advanced. According to CDMP, projections under a 1/25 year storm event period, three of St. Lucia's major towns and villages, i.e. Castries, Dennery and Vieux-Fort, could experience approximately 0.3 m of storm surge and 4.5 m of wave heights (Figure 7). These three locations are significant to tourism in St. Lucia as they provide attractions, places of leisure and several tourism accommodations (e.g. resorts). In particular, Castries and Vieux-Fort are vital tourism areas as they contain major cruise ports and the only two airports in St. Lucia.

The Caribbean Disaster Mitigation Project (CDMP) was conducted from 1993-1999 as a joint initiative between the US Agency for International Development (USAID) and Organization of American States (OAS) to help improve planning and policy strategies that would help mitigate the impacts of storm hazards within the Caribbean (OAS, 2002). One of the important successes of CDMP was the development of the *Atlas of Probable Storm Effects in the Caribbean Sea* which provided estimates for the intensity of storm surge, wind and waves for a 1/10, 1/25, 1/50 and 1/100 year storm return period for 15 islands within the region, including St. Lucia (OAS, 2002). This mapping system also identified the main sites where storm surge, wind and wave heights were most intense for each island under the various storm events.

As previously mentioned, temporary inundation caused by storm surges and waves from extreme weather events will exacerbate the impacts of sea-level rise in coastal zones (IPCC, 2007; Nicholls, 2011). In order to better understand the various magnitudes of flood scenarios that can result from temporary inundation and permanent inundation (caused by sea-level rise) multiple scenarios were considered. This range of flood scenarios presented the best and worse-case scenarios of projections of storm surge and wave heights for St. Lucia and projections for sea-level rise based on most recent studies. Noteworthy, temporary flooding was calculated for various storm event scenarios (1/10, 1/25, 1/50 and 1/100) and a 1 m (central estimate from recent studies) and 2m scenario of sea-level rise by 2100 was considered based on the projections of recent studies (Table 18). The DEMs available in this study only allowed for 1 m increments, therefore storm surge and wave height figures under storm event scenarios 1/10, 1/25, 1/50 and 1/100 were rounded to 4, 5, 6 and 7 m respectively (Table 18).

The maximum inundation scenario in this study was calculated based on a 1 m projection in global sea-level rise and included a 5m estimate for storm surge and wave height under a 1/25 year storm event (Table 18).

By using a 1 m global sea-level rise scenario and a 1/25 year storm event period this study provides a more conservative inundation scenario than some studies like Li et al. (2009) and Snoussi, Ouchani & Niazi (2008).

Importantly, Walsh et al. (2004) concluded that:

> To incorporate sea level rise into estimates of storm surge return periods, it is usually adequate simply to add the sea level rise linearly to the storm surge …The effects of climate change may also include regional changes in storm frequency and intensity, which may affect the storm surge return periods in particular locations. The vulnerability to storm surge needs to be estimated at specific locations, as it depends on the details of geography and ocean depth at a particular location. (p. 592)

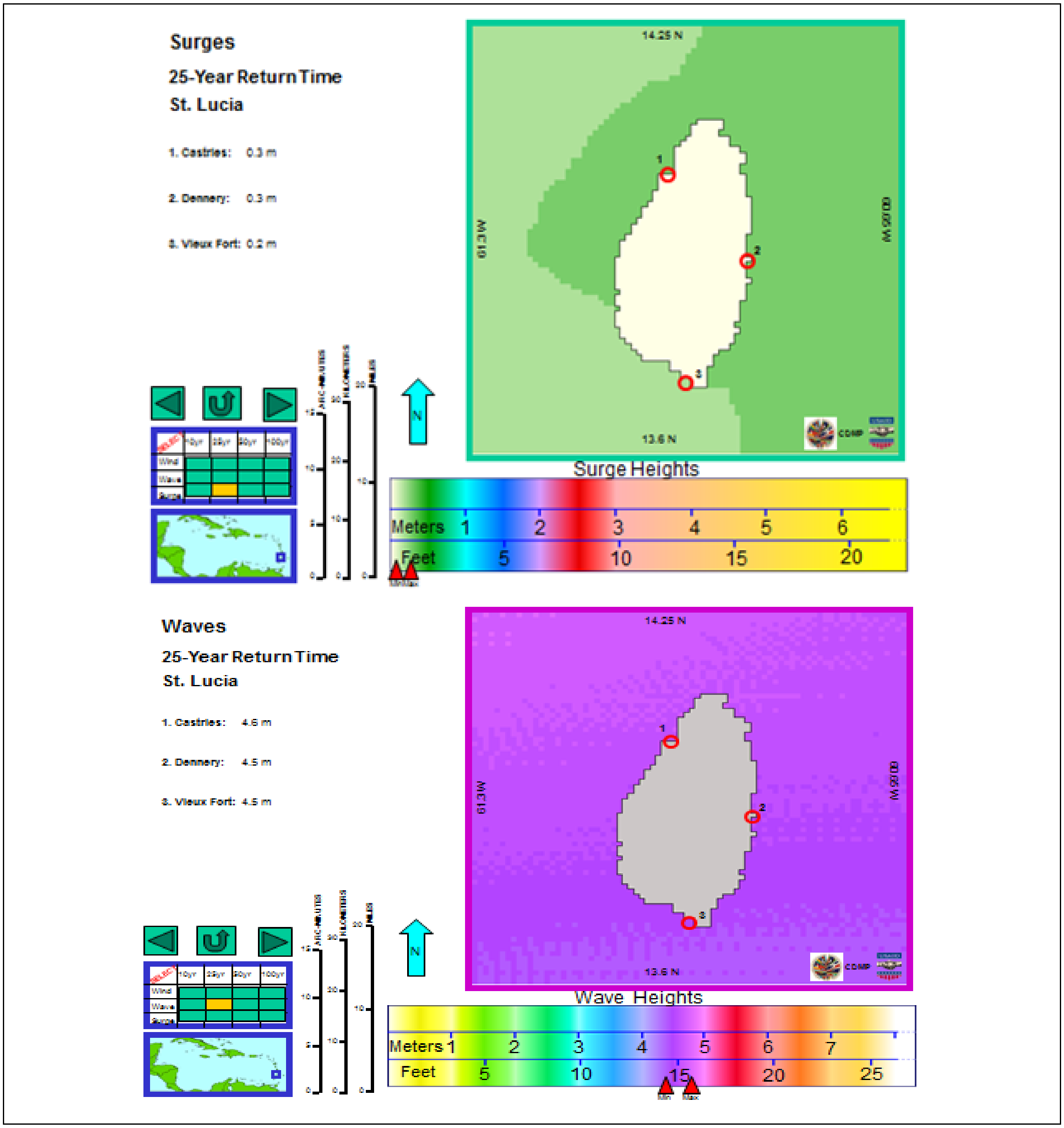
To calculate temporary flood scenarios (i.e. the baseline of today's storm impacts), data for storm surge and wave heights under various storm events for St. Lucia were added. Under the best (1/10 storm event) and worse-case scenario (1/100 storm event), temporary flooding was 3.6m and 6.6m respectively. Temporary flood levels were then added independently to a 1 m and 2m scenario of sea-level rise. This was done to estimate the additional exposed risks of inundation by a 1 m and 2 m of sea-level rise on temporary storm flooding (Table 18).

Table 18: Sea-level Rise Projections for St. Lucia with Contributions from Storm Surge and Waves

Storm Return Period	Storm Surge (a)	Waves (a)	Storm Surge + Waves (a)	Sea-level Rise + Storm Surge + Waves	
				1 m (b)	2 m (c)
1/10	0.1	3.5	3.6	4.6	5.6
1/25	0.3	4.5	4.8	5.8	6.8
1/50	0.4	5.3	5.7	6.7	7.7
1/100	0.6	6.0	6.6	7.6	8.6

Complied and calculated by author. Sources: (a) OAS (2002)- projection data for storm surge and waves; (b) Tamisiae & Mitrovica (2011)- central estimate projection of 1 m of sea-level rise by 2100; (c) Grinstead et al. (2009)- projection of 2 m by 2100 **(**high range).

Figure 7: 1/25 Year Storm Event Projections of Waves and Surges for St. Lucia



Source: Caribbean Disaster Management Project CDMP. OAS/USAID-Atlas of Probable Storm Effects in the Caribbean Sea (2002) http://www.oas.org/cdmp/document/reglstrm/index.htm

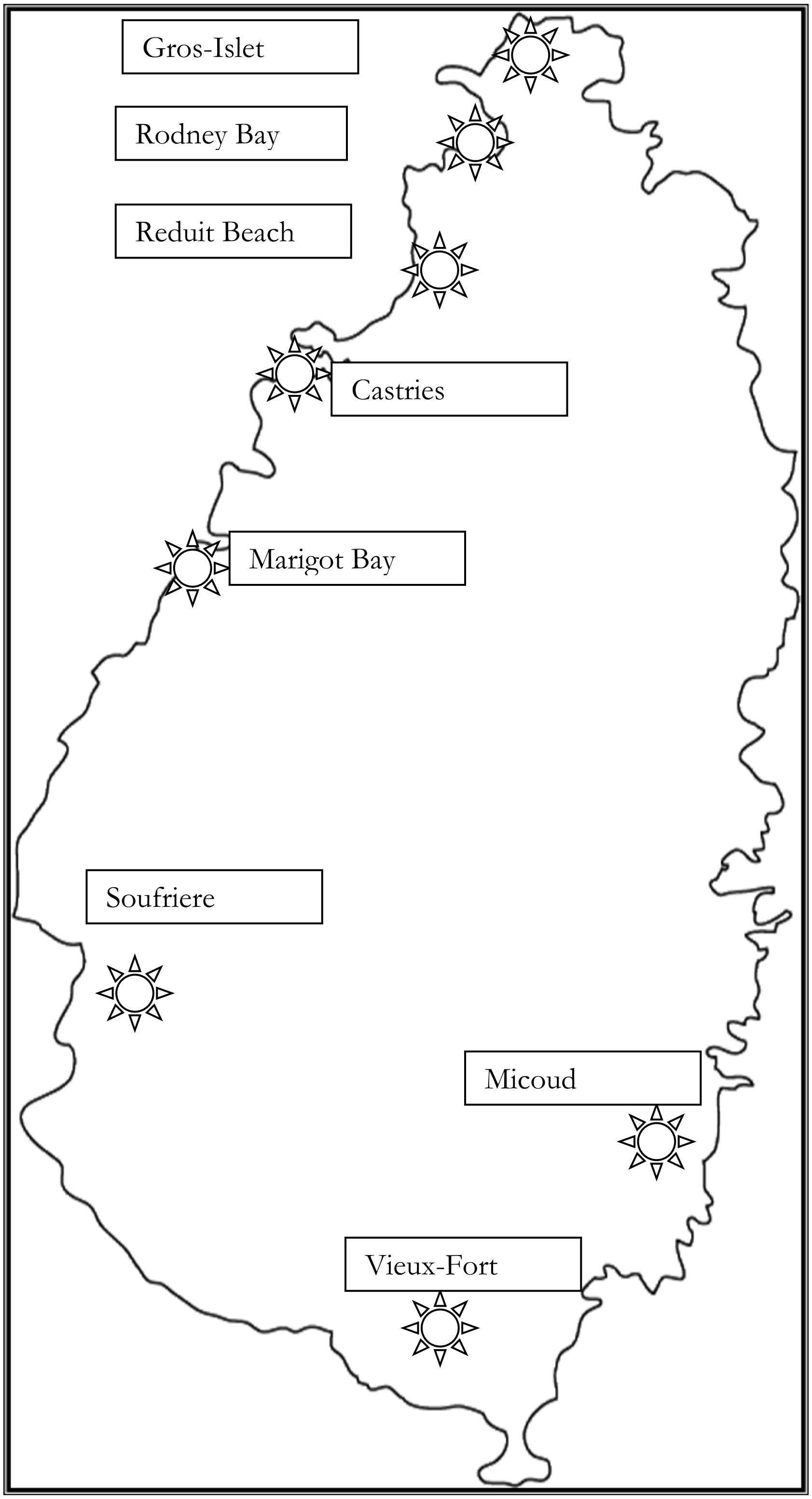
3.3.1.2. Preparation of Tourism Infrastructure and Asset Inventory

Using Google Earth, information from Tourism Departments in St. Lucia, Vision Magazine (2011), Tropical Traveller Magazine (2011), Paradise St. Lucia Magazine (2011) and the St. Lucia Tourist Board website, a listing of tourist assets were generated. A total of 83 features (73 tourism properties, 2 airports, 2 cruise ports, and 6 areas zoned for future tourism development as outlined by St. Lucia's 2008 National Vision Plan) were analyzed. Tourism properties were grouped based on their total room capacity. The classification scheme for total room capacity was set as follows: A= 1-50, B= 51-100, C=101-200, D=201-300 and E=301-350 (Appendix 3a to 3e).

There were 73 tourism properties which were all located within the northern, western and southern parts of the island within seven different areas: Gros-Islet, Rodney Bay, Castries (city/capital), Marigot Bay, Soufriere, Micoud and Vieux-Fort (Figure 8). The combined room capacity for all assessed tourism properties across St. Lucia was 4947 rooms. The name of all tourism properties, locations and room capacity groups can be found in Appendix 1.

In St. Lucia, the number of tourism properties and total room capacity varied by region and were as follows: Castries with 18 tourism properties (25%) and 1089 rooms (22 %), Gros-Islet with 15 tourism properties (21%) and 1805 rooms (36%), Marigot Bay with five tourism properties (7%) and 189 rooms (4%), Micoud with two tourism properties (3%) and 17 rooms (< 1%), Rodney Bay with 14 tourism properties (19%) and 841 rooms (17%), Soufriere, with 14 tourism properties (19%) and 366 rooms (7%) and Vieux-Fort with six tourism properties (8%) and 315 rooms (6 %).

Figure 8: Map Showing Locations of Clusters of Properties



Source: d-maps.com (modified by author)

3.3.1.3. Validation of ASTER and SRTM

In an effort to validate high resolution DEMs in the Caribbean, the United States Geological Survey (USGS) conducted a validation and spatial analysis study on the island of Grenada in 2004 (USGS, 2004). This study used both Shuttle Radar Topography Mission (SRTM) and Advanced Spaceborne Thermal Emission and Reflection Radiometre (ASTER) digital elevation models (DEMs), and validated both datasets for terrain and storm surge modelling.

To maintain the compatible and validated spatial resolution Digital Elevation Model (DEM) used by Sim (2011) and Scott et al. (2012b) to examine the impacts of sea-level on CARICOM countries, this study also used the research grade Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) data set that was released by North American Space Agency (NASA) and the Japanese Ministry of Economy, Trade and Industry. The GDEM covers about 99% of the earth's surface from 83° S to 83° N with elevation measurements taken at 30m intervals. The ASTER GDEM was downloaded from Japan's Earth Remote Sensing Data Analysis Centre using a rough outline of the study area to select the needed tiles.

Covering over 80% of the Earth‘s surface, the Shuttle Radar Topography Mission (SRTM) is an international research effort which combined digital elevation models on a large scale (56° S to 60° N). In February of 2000, the SRTM Digital Terrain Model (DTM) was created from terrain data collected during an 11-day STS-99 mission. Like many other satellite derived DEM‘s, the initial versions of SRTM DTM contained data anomalies (i.e. cloud areas and no-data areas), which occurred mostly in desert and mountainous regions. Noteworthy, the no-data areas accounted for a maximum of 0.2% of the total area surveyed on the first STS-99 mission. To date, the collaborated efforts in the scientific communities have improved the technology by using void filling algorithms and created a void-filled SRTM dataset. This study used the most recent version the CGIAR-CSI (Consortium for Spatial Information) version 4, released in 2009. This version of the SRTM DTM for 80% of the Earth‘s surface and provided data in 3 arc second (around 90 metre resolution).

3.3.1.4. Construction of GIS and Digital Elevation Model(DEM)

Geospatial data were obtained from a variety of sources including the Government of St. Lucia and public sources to ensure that the most accurate and complete data was compiled for road networks, airports, country and coastline boundary, coastal resources (e.g. coral reefs and mangroves etc.), tourism features and properties in St. Lucia. A detailed list of geospatial sources used in the sea-level rise impact assessment scenarios can be found in Table 19.

The location coordinates for the 83 tourism features were confirmed in Google Earth Pro©, then digitized in ArcGIS. This study examined the implications of 1 m of sea-level rise for tourism in St. Lucia by integrating 90 m Shuttle Radar Topography Mission (SRTM) and 30 m Advanced Spaceborne Thermal Emission and Reflection Radiom (ASTER) elevation data. The newly created digital elevation model (DEM) will be referred to as ASTER-SRTM throughout this study. In a recent study, Sim (2011) noted that SRTM and ASTER DEMs are both compatible for terrain and storm surge modelling within the Caribbean despite a higher root mean error (RSME) of +-5.38 displayed by SRTM. In addition, Sim (2011) also observed that cloud cover played a role in the inconsistencies of ASTER Global Digital Elevation Model (GDEM) and advises that it should not be used on its own for some areas near the equator.

ASTER-SRTM was created by first extracting tiles from version 4 of CIAT SRTM 90 m grid cell DEM to create a coastal digital terrain model. To create a study area polygon for St. Lucia, global datasets were extracted from the National Geospatial Intelligence Agency's World Vector Shoreline data. This helped reduce data repetition among other datasets. Notably, to improve the data quality all non-contiguous bodies of water such as lakes and disconnected tributaries e.g. ponds, lakes were masked out using Version 2 Global Self-consistent, Hierarchical, High-resolution Shoreline Database (GHHS) (NOAA, 2010). In this study all geospatial data was projected using the World Equal Area projection while horizontal datum was obtained from the World Geodetic System 1984.

Table 19: Sources of Various Geospatial Datasets used in Sea-level Rise Simulations for St. Lucia

Description	Dataset Name	Unit	Resolution	Source(s)
Geospatial Sources				
Aerial Imagery (Used for maps and tourism resort purposes)		n/a	Varying Scales	Google Earth Pro©
Coastline and country Boundary	WVS	km²	1:250,000	NOAA/NASA
Elevation Data	ASTER GDEM SRTM GDEM	m² m²	30 m 90 m	NASA/METI NASA
Global Airports	DIAFF (Digital Aeronautical Flight Information	Count	n/a	NIMA (National Imagery and Mapping Agency)
Lakes, and Water Bodies	GHHS	km²	1:250,000	Global Self-consistent, Hierarchical, High-resolution Shoreline Database (Version 2)
Major Tourism Resorts (coastal resorts , hotels, inns)*		Count	n/a	Scott et al. (2012b),Visions Magazine (2011),Paradise Magazine (2011),Tropical Traveller Magazine (2011), St. Lucia Tourist Board website (St. Lucianow.org)
Surface Geology of St. Lucia	Geo6bg	km²	1:250,000	USGS (United States Geological Survey) , Government of St. Lucia
Erodible Beaches*	UW Sea-level Rise Data	km²	1:250,000	Sim (2011) and Scott et al. (2012b)

*Data sources created in ArcGIS using geospatial data provided from Google Earth Pro© and online national/municipal sources.

3.3.1.5. Coastal Flooding Scenarios

To calculate the potential inundation impacts associated with 1 m of sea-level rise ASTER-SRTM flooded contiguous pixels were superimposed with the locations of tourism features and properties in ArcGIS. Due to the challenges with identifying property lines surrounding mapped tourism features, a 50 m buffer proved most suitable for conducting a proximity analysis. Therefore, a 50 m buffer was applied to the central point of each mapped tourism feature and property. Tourism features and properties were considered negatively impacted if their buffer was flooded by 5% or greater.

Flood scenarios were calculated using 1 m increments based on 1 m of global sea-level rise by 2100 with additional flood risks of 5 m due to storm surge and wave heights under a 1/25 year storm event.

3.3.1.6. Erosion Impact Scenarios

Beach resources are important to coastal tourism, but are threatened by accelerating rates of erosion which can be exacerbated by sea-level rise (Scott et al., 2012a). To provide a more in-depth analysis of the impact of 1 m of sea-level rise on tourism in St. Lucia, this research study also considers the potential impact of beach erosion associated with 1 m sea-level rise on beach assets by applying the Brunn Rule.

Despite criticisms, the Brunn rule is the most widely used model in studying beach changes in response to sea-level rise (Dickson, Walkden & Hall, 2007) and has been used in many studies over the past 15 years(e.g. Camber, 2009; Dickson et al., 2007; Scott et al., 2012b; UNESCO, 1997) that focus on erosion of sandy coastlines. The Brunn rule, as established by Brunn (1962), is based on a two-dimensional beach profile. The model assumes that as sea levels increase the upper beach profile will erode and deposit sediments into the lower and deeper beach profile which acts as a sink, thereby maintaining a constant water depth in the offshore (Dickson et al., 2007; Scott et al., 2012b). Scott et al. (2012b) further explains that this "… readjustment of the beach profile to an equilibrium state produces inland retreat of approximately 50- 100 times the vertical increase in sea level (i.e. for a 1 m sea-level rise of 50-100 m of erosion is predicted)" (p. 891).

Using a projected 1 m of sea-level rise by 2100, the low range of 50 m and high range of 100m, erosion scenarios were estimated for coastal tourism properties and beach assets in the study area.

In order to provide a more accurate analysis of the Brunn Rule coastal tourism properties were selected using the following three criteria:

(1) all tourism properties with erodible beach assets that were not situated near a cliff;

(2) all tourism properties without coastal protection; and

(3) all tourism properties with sea walls that did not have additional coastal protection structures (as beach loss can still occur even if structures are protected).

Based on these three criteria a total of 14 tourism beach properties were selected and analyzed in this phase of the research study. The 50 m and 100 m erosion scenario was estimated in Google Earth using the ruler measurement tool. Coastal protections were identified at each tourism beach property using aerial and ground based images from Google Earth.

In addition, as part of field observation, photographs were taken to show examples of how erosion has affected tourism beach assets in St. Lucia. The Rendezvous (Figure 9 & and 10), Rex St. Lucian, Royal St. Lucia and Sandals Grande are some examples of tourism properties where erosion was observed during this study.

Figure 9: Beach Erosion at the Rendezvous Beach Tourism Property

Photo by author, 2011.

Figure 10: Beach Erosion at Rendezvous Beach Tourism Property

Photo by author, 2011.

3.3.2. Adaptation Analysis

Nicholls (2011) notes that there are three main adaptation strategies for decreasing the impacts of sea-level rise on coastal settlements, resources and tourism infrastructure: (1) Retreat: which refers to the moving of coastal infrastructure back and enforcing coastal land planning guidelines for new development; (2) Accommodation: which refers to minimizing human impacts “by adjusting human use of the coastal zone via flood-resilience measures, such as warning systems and insurance” (P.151) ; and (3) Protection: which applies soft (e.g. beach nourishment) or hard engineering methods (e.g. seawalls and breakwaters) and aims to reduce flood impacts and damages to coastal properties and resources.

Since 1995 St. Lucia’s beaches have been measured for beach slope and width (UNESCO, 2003). In 2003, UNESCO presented recommendations for setbacks to coastal development along the north-west coast of the island ranging from 15 m-49 m (UNESCO, 2003). Based on the author’s observation and communication with the St. Lucia Ministry of Planning department, there has been no record of retreat by existing infrastructure since these recommendations were set. Moreover, while existing coastal management plans have acknowledged setbacks as a meaningful way to address and reduce the impacts of storm events in coastal areas; to date there is no existing policy that mandates the setback distances for which new development must be constructed along St. Lucia’s shorelines. This issue will be further explored in the policy review and discussion sections of this study.

By examining the physical options and challenges related to coastal setbacks and potential inland retreat of tourism properties, this section of the study builds on UNESCO (2003) findings and contributes to policy recommendations for improving adaptation strategies in the tourism sector. This study conducted a two part adaptation analysis focused on coastal retreat and coastal protection for tourism properties in St. Lucia.

3.3.2.1. *Potential for Coastal Retreat as Adaptation Strategy*

According to Cambers (1998) coastal retreat/setbacks help reduce the impacts of waves and storm events on coastal assets:

> The prudent use of coastal development setbacks or establishing a safe distance between buildings and the active beach zone can ensure that space is provided for a beach to move naturally, both during normal events and infrequent hurricanes, thereby ensuring the beach is conserved for all to enjoy and that coastal infrastructure remains intact. (p. 2)

Part one of the adaptation analysis identified the number of coastal tourism properties that could be able to implement a retreat strategy (see table 20 for description), based on surrounding land uses and physical barriers. Using Google Earth aerial images and field observation, 37 coastal tourism properties were identified. The surrounding land uses of these 37 coastal properties were then examined. The availability of land for retreat was confirmed where no existing buildings or urban development, water surface, rugged topography, road networks or protected areas existed immediately inland of the existing tourism property.

Table 20: Explaining Retreat as an Adaptation Strategy

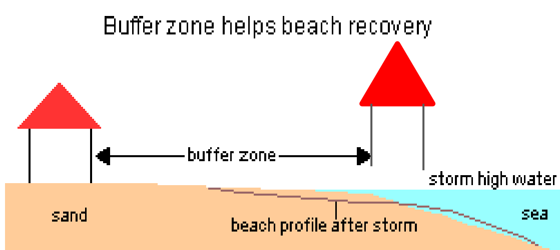
Retreat	
	A prescribed distance landward of a coastal feature (e.g., the line of permanent vegetation), within which all or certain types of development are prohibited. The intent of shoreline setbacks is to establish a coastal-hazard buffer zone to protect beachfront development from coastal beach erosion.

Diagram edited by author, source: Daniel & Abkowitz, 2005a.

3.3.2.2. Coastal Protection for Tourism Properties and Beach Assets

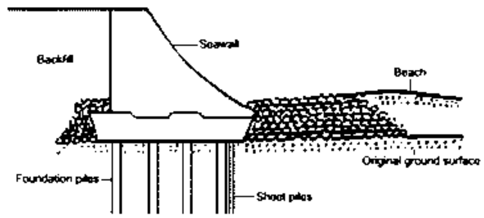
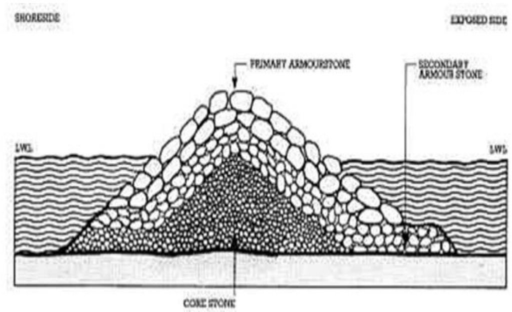
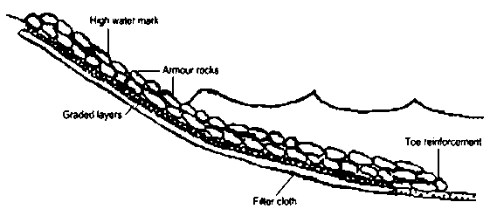
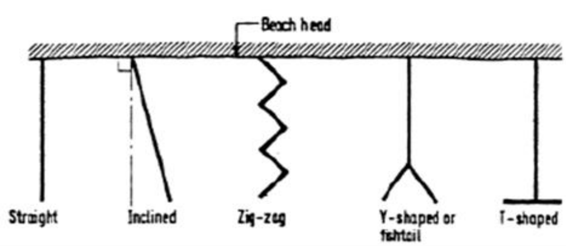
Although coastal setbacks are intended to safeguard coastal infrastructure it does not protect beach assets from the processes of erosion. Burke (2010) noted, that in the Dominican Republic each m of beach width adds US$1.57 to the average nightly room price per person. However, at the current rates of degradation and erosion, resorts are likely to lose US$52 -100 million over the next decade.

Various beach erosion studies within the Caribbean region including UNESCO (1997); Daniel & Abkowitz (2005a) ; UNEP (2003) have identified hard-engineering methods such as seawalls, break waters, jetties, groynes, and revetments as coastal protection structures which provide a degree of defence for both beach assets and coastal infrastructure.

Part two of the adaptation analysis in this study inventoried existing 'hard-engineering' coastal protection structures (i.e. seawalls, break waters, jetties, groynes, and revetments) at tourism properties and beach assets (see table 21 for descriptions). Google Earth aerial images and field observation were used to examine the five aforementioned hard-engineering solutions. There were a total of 37 coastal properties and 26 beach assets examined in this part of the study. The difference in number coastal properties and beach assets are due to two factors: (1) while all coastal tourism properties were within 1 km proximity to the sea, only 28 of the 37 total coastal tourism properties possessed beach assets; and (2) two coastal tourism properties had sea walls constructed adjacent to the properties thereby leaving beach assets unprotected. As a result, coastal properties with sea walls were considered to be without coastal protection for beach assets. Consequently, 37 coastal tourism properties were examined for coastal protection, while 26 of these 37 coastal tourism properties with erodible beach assets were included in analysis of coastal protection for beach assets.

This part of the study was useful in understanding, (1) the current adaptation strategies that are being used by tourism properties in St. Lucia; and (2) the likely responses for sea-level rise in the tourism sector.

Table 21: Diagrams and Definitions of Hard-Engineering Solutions

Hard Engineering Solutions	
	Sea wall: Vertical or sloping structures that are placed parallel to the shoreline in an attempt to stop, or at least retard, wave energy.
	Breakwater: Similar to seawalls except that they are placed beyond the coastline itself. Designed to break up wave energy and prevent it from reaching the coastline and inducing erosion.
	Revetment: This measure involves the placement of erosion resistant material on a slope or embankment to shield the area from waves and ocean currents.
	Groynes and Jetties: Short structures that are attached perpendicular to the coastline. The concept behind these structures is that they are designed to trap long-shore sediment movement and thus maintain the beach areas that would have eroded.

Source: US Army Corps of Engineers (1981).

3.3.3. Policy Review

A total of 16 national policy and planning documents were obtained from various sources for review (Table 22). During the period of this study, through its electoral process, St. Lucia experienced a change in national leadership which also affected the titles of previous government ministries and departments. Policy documents were retrieved from two government ministries, the Ministry of Tourism, Heritage and Creative Industries (formerly known as the Ministry of Tourism and Civil Aviation) and the Ministry for Physical Development, Housing and Urban Renewal (formerly known as the Ministry of Planning and the Environment). In addition, documents were also obtained from St. Lucia's Government websites and local libraries. Document review required on-going communication with various departments and officials in St. Lucia to ensure the most relevant and up-to date documents were being reviewed.

The review of policy and planning documents included a word search for the terms~~;~~ tourism, climate change, and sea-level rise to determine (1) which policies/plans acknowledged or considered sea-level rise in any way, and (2) to identify if any policies or recommended coastal adaptation strategies were specific to the tourism sector.

Table 22: Policy and Planning Documents Reviewed

1) Damage Assessment and Needs Analysis[DANA] Policy (Government of St. Lucia, 2005)
2) Disaster Management Policy Framework (Government of St. Lucia, 2009a)
3) Drought Plan (Government of St. Lucia, 2009b)
4) Hurricane Response Plan, (Government of St. Lucia 2007a)
5) National Flood Plan (Government of St. Lucia 2006b)
6) Natural Hazard Mitigation Policy & Plan (Government of St. Lucia, 2006c)
7) Coastal Zone Management Policy (Government of St. Lucia 2004b)
8) Forest Policy (Government of St. Lucia, 2008a)
9) Fisheries Act, (Government of St. Lucia, 1984)
10) National Biodiversity Strategy & Action Plan (Government of St. Lucia, 2000)
11) National Climate Change Policy and Adaptation Plan (Government of St. Lucia, 2002a)
12) National Energy Policy (Government of St. Lucia, 2003a)
13) National Environmental Policy & National Environmental Management Strategy (NEP/NEMS) (Government of St. Lucia, 2004a)
14) National Land Policy (Government of St. Lucia, 2007b)
15) Sustainable Energy Plan (Government of St. Lucia, 2002b)
16) Tourism Policy (Drafted) (Government of St. Lucia 2003b)

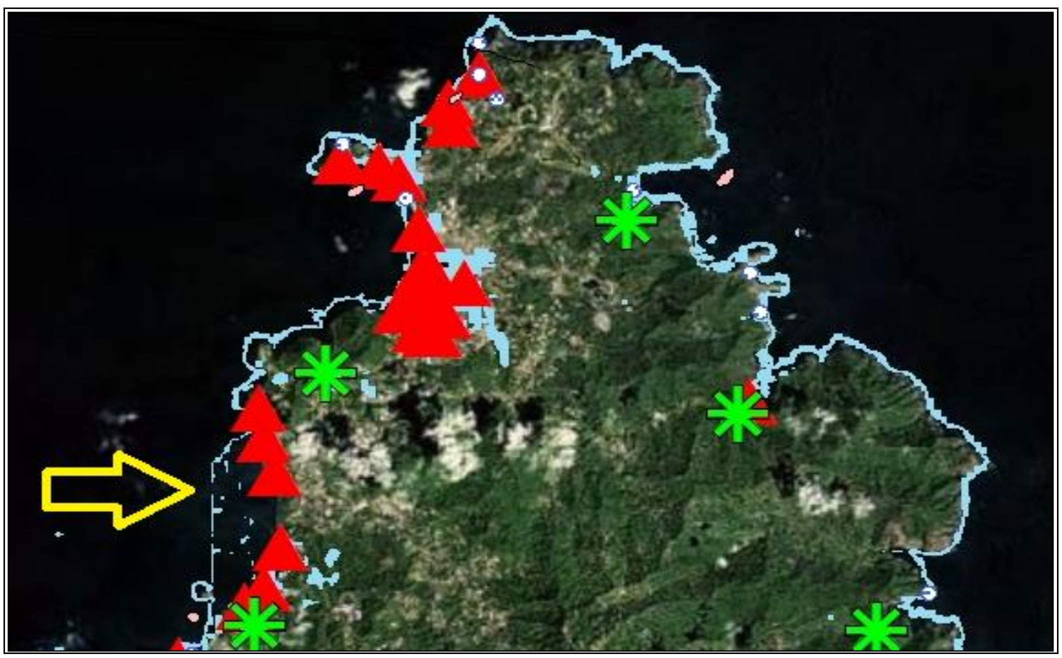
3.4. Research Observations, Limitations and Challenges

A combination of ASTER-SRTM data was proven useful to this study, however a few limitations were observed. Data for ASTER and SRTM were collected in different periods. While data for ASTER was collected more recently in 2009, SRTM contains data from 2000. Data for SRTM may not reflect recent changes in coastlines infilling, major erosion and terrain surfaces (e.g. landslides) for St. Lucia; however these are expected to be minimal.

Notably, there were gaps in ASTER data that were in-filled with SRTM data. Consistent with other studies in the Caribbean by Chirico (2004) and Sim (2011), cloud cover in coastal areas were observed to cause interruptions in continuity for ASTER. However, this observation was minimal and only occurred in two areas which did not contain tourism properties.

In addition, an irregular outward contiguous pattern was observed along the north-west coastline (Figure 11). Despite the irregular pattern by ASTER, SRTM data was extracted for this location.

Figure 11: ASTER Anomaly along North-west Coastline



Source: Google Images (yellow arrow showing anomaly).

Further investigation of the area in question with Google Earth images (which is marked by the yellow arrow in the Figure 11) revealed shallow waters where perhaps heavy amount of sand deposit or silt created a dark shadow-like pattern. According to Wang, Yang & Yao (2012) ASTER GDEM and SRTM GDEM are likely to show some different results when calculating water depths. While ASTER GDEM appears to overestimate the water depth, SRTM appears to underestimate water depth. This could explain the irregular pattern along the west coast of the island. Despite these imperfections, the integration of ASTER and SRTM GDEMs was useful for modelling flood scenarios in coastal areas where all tourism development is clustered.

Some international studies like Grohman, Kroenung & Strebeck (2006), Wang et al. (2012) and Bolch et al. (2005) and Caribbean studies like Chirico (2004) and Sim (2011) have noted the individual limitations and strengths of using ASTER and SRTM elevation data. In his study on Grenada Chirico (2004) argued that:

> Clouds, dense vegetation, and coastal features are important considerations for terrain modelling in the Caribbean. DEMs developed from optical sources such as ASTER and aerial photography may be negatively impacted by the frequency of cloud cover. In contrast, SRTM data penetrates clouds but does not fully penetrate dense vegetation. (p.10)

For this reason, both SRTM and ASTER may be suitable as they both produce results that are closer to digital surface model measurements and offer a lower cost solution to gathering DEM data over large areas (Chirico, 2004). Due to the rugged topography and low-lying coastal areas of the study area, the integration of ASTER and SRTM DEMs to form ASTER-SRTM proved beneficial for this study because it allowed for a more comprehensive analysis. This is particularly evident with the issue of cloud cover, where gaps in ASTER data were in-filled with SRTM data.

4. Results

4.1. Introduction

The results in this study provide an inventory of tourism infrastructure at risk to impacts resulting from 1 m of global sea-level rise for St. Lucia. Permanent inundation refers to flood impacts from 1 m of global sea-level rise, while temporary storm flooding refers to flooding from storm surge associated with a 1/25 year storm event under a 1 m sea-level rise. Also, the Brunn Rule is applied to estimate erosion associated impacts of 1 m sea-level rise. In addition, this study examines retreat as a potential adaptation strategy and identifies the number and types of 'hard-engineered' coastal protection structures used by tourism properties. Moreover, this study presents a review of St. Lucia's national policy and planning documents to help understand the existing gaps between sea-level rise and tourism.

4.2. Flooding Risk Analysis

St. Lucia is highly vulnerable to the consequences of climate change and sea-level rise because the island lacks established coastal defence systems (Simpson, 2010). Sea-level rise is problematic for tourism because it increases flooding risks and damages to important coastal tourism infrastructure and beach assets. In order to protect coastal properties from flooding risks, impact assessments for sea-level rise scenarios should be incorporated in coastal planning (Simpson, 2010). By using geospatial analysis to examine the implications of 1 m sea-level rise and storm surge associated with a 1/25 year storm event for tourism properties and assets, this study provides useful information for tourism adaptation in St. Lucia.

4.2.1. Tourism Infrastructure at Risk to Sea-level Rise: Permanent Inundation by 1 m Sea-Level Rise

This section provides the outcomes of ASTER-SRTM for tourism properties at risk to permanent inundation by 1 m of sea-level rise in two parts: (1) at risk tourism properties and (2) at risk rooms.

4.2.1.1. Tourism Properties

Overall, there were a total of 73 tourism properties with a room capacity of 4947 examined under a 1 m sea-level rise flood scenario (Table 23). The ASTER-SRTM analysis projected that a total of 3 (4%) tourism properties from room groups A (1-50), B (51-100) and D (201-300) would be permanently inundated by 1 m of sea-level rise. Only 2% of tourism properties were impacted in group A, while 11% and 50% of tourism properties in groups B and D were impacted respectively. ASTER-SRTM analysis projected that tourism properties and rooms for groups C and E would not impacted under a permanent inundation scenario of 1 m of sea-level rise.

4.2.1.2. Room Capacity

With regards to rooms on the island, the ASTER-SRTM analysis projected that a total of 358 rooms (7%) from groups A, B and D would be permanently inundated by 1 m of sea-level rise (Table 23). The most impacted room capacity group was D with 254 (49%) rooms, B with 100 (14%) rooms and A with 4 (1%) rooms. ASTER-SRTM analysis projected that tourism properties and room capacities for groups C and E would not impacted under a permanent inundation scenario of 1 m of sea-level rise.

Table 23: Permanent Inundation by 1 m Sea-level Rise by Room Capacity Groups.

Room Groups on the Island	# of Tourism Properties at Risk to Permanent Inundation by 1 m Sea-level Rise	# of Rooms at Risk to Permanent Inundation by 1 m Sea-level Rise
A	1 of 50 (2%)	4 of 768 (1%)
B	1 of 9 (11%)	100 of 693 (14%)
C	0 of 7 (0%)	0 of 970 (0%)
D	1 of 2 (50%)	254 of 514 (49%)
E	0 of 5 (0%)	0 of 1644 (0%)
Total	3 of 73 (4%)	358 of 4947 (7%)

4.2.2. Tourism Infrastructure at Risk to Sea-level Rise: Permanent Inundation by 1 m Sea-Level Rise by Destination Community

This section provides the outcomes of ASTER-SRTM for tourism properties at risk to permanent inundation by 1 m of sea-level rise by destination community in two parts: (1) at risk tourism properties by destination community, and (2) at risk rooms by destination community.

4.2.2.1. Tourism Property

Destination communities are important to tourism in St. Lucia. Different areas provide varying advantages such as commercial and leisure amenities to tourists. ASTER-SRTM analysis showed that two destination communities were impacted by 1 m of sea-level rise, Castries (North-West) with one at risk tourism property and Vieux-Fort (south) with a higher number of two at risk tourism properties (Table 24).

4.2.2.2. Room Capacity

The most at risk destination community was Vieux-Fort which showed 258 (82%) rooms at risk to permanent inundation by 1 m of sea-level rise (Table 24). Castries had 100 (9%) rooms at risk to permanent inundation by 1 m of sea-level rise. ASTER-SRTM analysis projected that five destination communities (Gros-Islet, Marigot Bay, Micoud, Rodney Bay and Soufriere) were not at risk to permanent inundation by 1 m of sea-level rise.

Table 24: Permanent Inundation by 1 m Sea-level Rise by Destination Community

Destination Communities	# of Tourism Properties at Risk to Permanent Inundation by 1 m Sea-level Rise	# of Rooms at Risk to Permanent Inundation by 1 m Sea-level Rise
Castries	1 of 18 (6%)	100 of 1089 (9%)
Gros-Islet	0 of 15 (0%)	0 of 1805 (0%)
Marigot Bay	0 of 5 (0%)	0 of 189 (0%)
Micoud	0 of 2 (0%)	0 of 17 (0%)
Rodney Bay	0 of 14 (0%)	0 of 841 (0%)
Soufriere	0 of 14 (0%)	0 of 366 (0%)
Vieux - Fort	2 of 6 (33%)	258 of 315 (82%)
Total	3 of 73 (4%)	358 of 4947 (7%)

4.2.3. Tourism Infrastructure at Risk to Sea-level Rise: Temporary Storm Flooding (6 m)

This section provides the outcomes of ASTER-SRTM for storm surge associated with a 1/25 year storm event under a 1 m of sea-level rise scenario. A 1 m of sea-level rise would exacerbate flooding to 6 m when storm surges and waves heights equalled 5 m. The results are presented in two parts: (1) at risk tourism and (2) at risk room capacity.

4.2.3.1. Tourism Property

ASTER-SRTM analysis showed that flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise would impact all room capacity groups. Under this scenario eight (16%) of 50 tourism properties in group A, six (67%) of nine tourism properties in group B, two (29%) of seven tourism properties in group C, two (100%) of two tourism properties in group E and four (80%) of five tourism properties in group E were impacted by flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise (Table 25). The highest numbers of impacted tourism were in groups A (8), B (6) and E (4). The least number of impacted tourism properties were in groups C (2) and D (2).

4.2.3.2. Room Capacity

Under ASTER-SRTM analysis of flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise, the highest numbers of impacted rooms were in group E with 1304 and group D with 514 (Table 25). However, the most impacted room capacity group was D with 100% and group E with 79%. The least impacted room capacity groups and rooms were found in group A with 129 (17%) of 768 rooms and group C with 249(25%) of 970 rooms. Notably, while group A had the highest number of impacted tourism properties, it also had the lowest number of impacted rooms under storm surge associated with a 1/25 year storm event under 1 m of sea-level rise.

Table 25: Tourism Infrastructure at Risk to Sea-level Rise: Temporary Storm Flooding by Room Capacity (6 m)

Room Capacity Groups	# of Tourism Properties at Risk to Flooding from Storm Surge Associated with a 1/25 Year Storm Event under 1 m Sea-level Rise (6 m)	# of Rooms at Risk to Flooding from Storm Surge Associated with a 1/25 Year Storm Event under 1 m Sea-level Rise (6 m)
A	8 of 50 (16%)	129 of 768 (17%)
B	6 of 9 (67%)	479 of 693 (69%)
C	2 of 7 (29%)	246 of 970 (25%)
D	2 of 2 (100%)	514 of 514 (100%)
E	4 of 5 (80%)	1304 of 1644 (79%)
Total	22 of 73 (30%)	2672 of 4947 (54%)

4.2.4. Tourism Infrastructure at Risk to Sea-level Rise: Temporary Storm Flooding by Destination Community (6 m)

This section provides the outcomes of ASTER-SRTM for tourism properties at risk to flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise by destination community. A 1 m of sea-level rise would exacerbate flooding to 6 m when storm surges and waves heights equalled 5 m. The results are presented in two parts: (1) at risk tourism properties and (2) at risk rooms.

4.2.4.1. Tourism Property

ASTER-SRTM analysis projected that six of seven destination communities were impacted by flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise (Table 26). Under this scenario, Micoud was the only destination community that was not impacted. The highest number of at risk tourism properties were in Rodney Bay, seven, Gros-Islet, five and Castries, four. However, the most at risk destination community was Rodney Bay (50%), Marigot Bay (40%), Gros-Islet (33%) and Vieux-Fort (33%) (Table 26). The least number of impacted tourism properties were in Vieux-Fort, Soufriere and Marigot Bay, each with two tourism properties impacted. The least at risk tourism destination community was Soufriere (14%) and Castries (22%).

4.2.4.2. Room Capacity

Under ASTER-SRTM analysis of flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise, the highest numbers of impacted rooms were in Castries with 803, Gros-Islet with 780 and Rodney Bay with 671 (Table 26). The lowest numbers of impacted rooms were in Soufriere with 16 and Marigot Bay with 144. Micoud was the only destination community that was not impacted by flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise. The most impacted destination community was Vieux-Fort (82%), Rodney Bay (80%) and Marigot Bay (76%). The least impacted destination community was Soufriere (4%), and Gros-Islet (43%). Noteworthy, four of seven destination communities showed a > 70% risk of inundation to their room capacities (Table 26).

Table 26: Tourism Infrastructure at Risk to Sea-level Rise: Temporary Storm Flooding by Destination Community (6 m)

Destination Communities	# of Tourism Properties at Risk to Flooding from Storm Surge Associated with a 1/25 Year Storm Event under 1 m Sea-level Rise (6 m)	# of Rooms at Risk to Flooding from Storm Surge Associated with a 1/25 Year Storm Event under 1 m Sea-level Rise (6 m)
Castries	4 of 18 (22%)	803 of 1089 (74%)
Gros-Islet	5 of 15 (33%)	780 of 1805 (43%)
Marigot Bay	2 of 5 (40%)	144 of 189 (76%)
Micoud	0 of 2 (0%)	0 of 17 (0%)
Rodney Bay	7 of 14 (50%)	671 of 841 (80%)
Soufriere	2 of 14 (14%)	16 of 366 (4 %)
Vieux - Fort	2 of 6 (33%)	258 of 315 (82%)
Total	22 of 73 (30%)	2672 of 4947 (54%)

4.2.5. Other Tourism Infrastructure at Risk to Sea-level Rise: Airports, Cruise ports, and Areas Zoned for Future Tourism Development

This section provides the outcomes of ASTER-SRTM for airports, cruise ports and areas zoned for future tourism development at risk to 1 m of sea-level rise. Transportation infrastructure is essential to the tourism sector as they provide access for several thousands of tourists every year. As already mentioned, St. Lucia receives its largest number of tourists through cruise ports, while all remaining visitors gain entry through the island's two airports, the George F.L Charles and Hewannora International airport. Notably, the six areas zoned for future tourism development are part of the St. Lucia's National Vision Plan. This study examined two airports, two cruise ports and six areas that were zoned for future tourism development.

4.2.5.1. Other Tourism Infrastructure at Risk to Permanent Inundation by 1 m of Sea-level Rise (airports, cruise ports, and areas zoned for future tourism development)

ASTER-SRTM analysis showed that one cruise port and one area zoned for future tourism development were at risk to permanent inundation by 1 m of sea-level rise (Table 27). The two airports were not impacted by permanent inundation under a 1 m of sea-level rise scenario. One of two cruise ports and five of six areas zoned for future tourism development were also not impacted under a 1 m of sea-level rise scenario.

Table 27: Other Tourism Infrastructure at Risk to Permanent Inundation by 1 m Sea-level-Rise (airports, cruise ports, and zoned areas for future tourism development)

Airports, Cruise Ports/Attractions and Zoned Areas for Future Tourism Development	Permanent Inundation by 1 m Sea-Level Rise
Airports	
GFL Charles Airport	No
Hewannora International Airport	No
Cruise Port	
La Place Carenage Visitor centre (Cruise Port)	No
Pointe Seraphine (Cruise Port)	Yes
Zoned areas for future tourism development	
Esperance Bay	No
Grand Anse	No
Pigeon Island	No
Pointe Sable	No
Riviere Doree	Yes
Troumasse (Micoud)	No

4.2.5.2. Other Tourism Infrastructure at Risk to Sea-level Rise: Temporary Storm Flooding (6m), (airports, cruise ports, and areas zoned for future tourism development)

ASTER-SRTM analysis of flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise showed that, all airports and cruise ports were inundated (Table 28). Under this same scenario five of six areas zoned for future tourism development were at risk to inundation. The only tourism feature that was not inundated by flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise was Esperance Bay, an area zoned for future tourism development.

Table 28: Other Tourism Infrastructure at Risk to Sea-level Rise: Temporary Storm Flooding (6m) (airports, cruise ports, and zoned areas for future tourism development

Airports, Cruise Ports/Attractions and Zoned Areas for Future Tourism Development	Flooding from Storm Surge Associated with a 1/25 Year Storm Event under 1 m Sea-level Rise (6 m)
Airports	
GFL Charles Airport	Yes
Hewannora International Airport	Yes
Cruise Port	
La Place Carenage Visitor centre (Cruise Port)	Yes
Pointe Seraphine (Cruise Port)	Yes
Zoned areas for future tourism development	
Esperance Bay	No
Grand Anse	Yes
Pigeon Island	Yes
Pointe Sable	Yes
Riviere Doree	Yes
Troumasse (Micoud)	Yes

4.3. Erosion Risk Analysis

Increased coastal erosion is one of the main impacts of sea-level rise (Daniel & Abkowitz, 2005b), while beach assets are one of the important resources for coastal tourism and (UNEP, 2009). St. Lucia has a growing tourism market that is largely based on coastal tourism and will require beach resources to continuously attract that niche. The Brunn Rule states that a 1 m of sea-level rise could cause erosion impacts of 50 m -100 m. To examine the exacerbated erosion associated with 1 m of sea-level rise the Brunn Rule was applied using the Google Earth measurement tool.

Notably, the second of these conditions applied because although sea walls provided protection against erosion for property and pool areas, they did not protect beach assets from erosion associated with 1 m of sea-level rise or storm surge and waves (Figure 12). The Villa Beach Cottages provide one example where an existing sea wall left beach assets entirely exposed to erosion and thus the potential for coastal squeeze.

Figure 12: Villa Beach Cottages- Beach is Lost Even if Seawall Protects Pool Area and Property

Source: Google Images (modified by author) * white arrows show direction to which Brunn rule applied (50m and 100m erosion)

There were a total of 14 coastal tourism properties selected based on the three criteria explain in section 3.3.1.5. Room groups were kept as A (1-50), B (51-100), C (101-200), D (201-300) and E (300-350). The 14 coastal tourism properties were examined using a 50 m and 100 m erosion scenario (Table 29). Group D was the only group where coastal tourism properties were not affected under a 50 m or 100 m erosion scenario.

4.3.1. Inventory of Coastal Tourism Infrastructure at Risk under a 50 m Erosion Scenario

There were 13 of 14 coastal tourism properties and 1343 of 1347 total coastal rooms affected under a 50 m erosion scenario (Table 29). The highest number of coastal tourism properties at risk to a 50 m erosion scenario was in group A with seven and group C with three. The lowest numbers of at risk coastal tourism properties were in groups B with one and group E with two. The most impacted coastal tourism properties groups were B, C and E, under a 50 m erosion scenario. In group A, 147 of 151 total coastal rooms were at risk under a 50 m erosion scenario.

4.3.2. Inventory of Coastal Tourism Infrastructure at Risk under a 100 m Erosion Scenario

Under a 100 m erosion scenario 14 of 14 coastal tourism properties and 1347 of 1347 total coastal rooms were impacted (Table 29). The most impacted group of coastal tourism properties under a 100 m erosion scenario was A, with eight and C with three. The least number of impacted coastal tourism properties were in group B with one and Group E with two. The most impacted coastal rooms were in group E with 681 and group C with 443.The lowest number of impacted coastal rooms were in group B with 72 and group A with 131.

Table 29: Erosion (50 m and 100 m scenarios) by 1 m Sea-level Rise by Coastal Room Capacity

Room Groups	# of Coastal Tourism Properties at Risk to Damage by Erosion (50 m scenario)	# of Coastal Rooms at Risk to Damage by Erosion (50 m scenario)	# of Coastal Tourism Properties at Risk to Damage by Erosion (100 m scenario)	# of Coastal Rooms at Risk to Damage by Erosion (100 m scenario)
A	7 of 8	147 of 151	8 of 8	151 of 151
B	1 of 1	72 of 72	1 of 1	72 of 72
C	3 of 3	443 of 443	3 of 3	443 of 443
D	0 of 0	0 of 0	0 of 0	0 of 0
E	2 of 2	681 of 681	2 of 2	681 of 681
Total	13 of 14	1343 of 1347	14 of 14	1347 of 1347

4.3.3. Inventory of Coastal Tourism Infrastructure at Risk under a 50 m Erosion Scenario by Destination Community

The results detailed in Table 30 show that Micoud had no coastal tourism properties with erodible beach assets. With the exception of Vieux-Fort, all destination communities were at risk under a 50 m erosion scenario. The highest number of at risk coastal tourism properties under a 50 m scenario was in Soufriere and Castries each with four coastal tourism properties and a total of 185 of 185 and 550 of 550 total coastal rooms respectively. There were three coastal tourism properties and 511 of 511 total coastal rooms at risk under a 50 m erosion scenario in Gros-Islet. The lowest number of impacted coastal tourism properties under a 50 m erosion scenario was in Rodney Bay and Marigot Bay, each with one impacted coastal tourism property. The hardest hit area under a 50 m erosion scenario was Castries and Gros-Islet with 550 of 550 and 511of 511 total coastal rooms impacted in that order. Rodney Bay and Marigot Bay has the lowest number of impacted coastal rooms, with a total of 72 and 25 coastal rooms respectively.

4.3.4. Inventory of Tourism Infrastructure at Risk under a 100 m Erosion Scenario by Destination Community

Under a 100 m erosion scenario results were similar to that which was found under a 50m erosion scenario with the only exception being Vieux-Fort which now had one impacted tourism property and four rooms impacted (Table 30). Under the maximum of 100 m erosion scenario all 14 of 14 tourism properties and a total of 1347 of 1347 total rooms were impacted.

Table 30: Erosion (50 m and 100 m scenarios) by 1 m Sea-level Rise by Destination Communities

Destination Communities	# of Coastal Tourism Properties at Risk to Damage by Erosion (50 m scenario)	# of Coastal Rooms at Risk to Damage by Erosion (50 m scenario)	# of Coastal Tourism Properties at Risk to Damage by Erosion (100 m scenario)	# of Coastal Rooms at Risk to Damage by Erosion (100 m scenario)
Castries	4 of 4	550 of 550	4 of 4	550 of 550
Gros-Islet	3 of 3	511 of 511	3 of 3	511of 511
Marigot Bay	1 of 1	25 of 25	1 of 1	25 of 25
Micoud	0 of 0	0 of 0	0 of 0	0 of 0
Rodney Bay	1of 1	72 of 72	1 of 1	72 of 72
Soufriere	4 of 4	185 of 185	4 of 4	185 of 185
Vieux - Fort	0 of 1	0 of 4	1 of 1	4 of 4
Total Coastal Rooms	13 of 14	1343 of 1347	14 of 14	1347 of 1347

4.4. *Potential for Coastal Retreat as Adaptation Strategy*

Although coastal retreat is recognized as an effective adaptation measure to sea-level rise (Nicholls, 2011); it is expected to be a challenging strategy for coastal tourism in St. Lucia and elsewhere because (1) it is resisted by developers because access to beach is what tourists seek and developers want to provide, and (2) in many islands and coastal tourism areas, inland properties are already developed, precluding landward retreat by coastal resorts.

This analysis examined whether inland retreat was even possible for coastal tourism properties, when existing land uses and physical barriers (e.g. rivers, lakes, cliffs) were considered. Using Google Earth images 37 coastal tourism properties were examined to determine the potential of coastal retreat as an adaptation strategy. There were differing circumstances that hindered the possibility of inland retreat for several coastal tourism properties which are described in the following three examples:

4.4.1. *A Retreat Potential Typology*

(1) Sandals Grande

This example shows two possible scenarios for inland retreat. In the case of Sandals Grande (left) inland retreat is not possible because of the peninsula (Figure 13 & Figure 15). Although there appears to be vacant land space (white star) that would allow inland retreat for Sandals Grande, there is also another coastal tourism property to consider, the Landing (right). The Landing would also need to retreat inland to avoid the impacts of inundation from sea-level rise, storm surge and waves. This study recognizes that there are various deciding factors that may have to be considered before any of these two tourism properties were to occupy the vacant space. For example, (1) who owns the land space and whether it is available for purchase and (2) which tourism property, if any is interested in this inland retreat option.

To remedy such complex scenarios for the purpose of this study the following rationale was used for examining the possibility of inland retreat for coastal tourism properties. In situations where two or more resorts were within proximity to unused land, priority for inland retreat was given to the tourism property with the lowest room capacity. This was done to present the worse-case scenario where inland retreat had to be considered for more than one tourism property and the unused land was inadequate to allow inland retreat by all existing tourism properties in that location.

Figure 13: Possible Retreat Options for Sandals Grande and the Landings

Source: Google Images (modified by author)* white arrows show direction for inland retreat is not possible because of peninsula and where possible is limited to one tourism property.

(2) Rodney Bay

Retreat is an unfeasible adaptation strategy for this area due to a high concentration of existing urban development (Figure 14 & Figure 15). Although there is one land area where inland retreat could occur (white star), it is a small marshland area that would require preparation for development and does not contain a beach. Rodney Bay is one of the most important tourism destination communities in St. Lucia. It is a key tourism shopping area and includes several restaurants, and bars. More importantly this area consists of 14 tourism properties with a total of 841 rooms which were inventoried in this study. In this study, the maximum flood scenario for Rodney Bay showed that seven of the total 14 (50%) tourism properties and 671(80%) of the total 841 rooms were at risk to partial of full inundation. Due to the importance of the Rodney Bay to tourism the potential risk of inundation and the limitation of applying coastal retreat as adaptation strategy, alternative adapation strategies may have to be examined. Similar to the case of Sandals Grande, coastal protection may provide a more feasible potential adaptation strategy to sea-levl rise flooding and erosion.

Figure 14: Rodney Bay (limited by existing development and marina)

Source: Google Images (modified by author)* white arrows show direction for inland retreat is not possible because of existing urban development.

Figure 15: Topographical Map of Sandals Grande and the Rodney Bay Destination Community

Source: Government of St. Lucia

(3) Coconut Bay Resort and Spa

The Coconut Bay Resort and Spa is unable to adopt an inland retreat adaptation strategy because although the adjacent land area is undeveloped it has been designated as an environmental protection area (Pointe Sables Protected area) (Figure 16 &17). While coastal retreat would be feasible if Pointe Sables Protected area was re-zoned for development, there would be significant environmental and economic implications as the area contains extensive biodiversity including 63 hectares of mangrove that also serves as natural coastal protection from inundation (Government of Saint Lucia-PSEPA, 2009). The Coconut Bay Resort and Spa is one of the largest resorts according to room capacity (group D) and contains 274 coastal rooms. It is also the largest resort located in the South end of St. Lucia and is very close to the island's only international airport which is the main port of entry for international and international tourist arrivals.

Figure 16: Coconut Bay Resort & Spa (limited by protected land status)

Source: Google Images (modified by author)* white arrows show that direction for inland retreat is not possible because of protected land status.

Figure 17: Topographical Map for Vieux- Fort Destination Community where Coconut Bay and Spa is Located

Source: Government of St. Lucia

4.4.2. Evaluating Coastal 'Retreat' as a Potential Adaptation Strategy for Coastal Tourism Properties by Room Capacity

Of the 37 coastal tourism properties identified for this study, 24 (65%) containing 2591 rooms (99%) were found to be restricted from inland retreat as an adaptation strategy due to current development, major infrastructure (e.g. road networks, building), water surfaces or protected areas (Table 31). Analysis revealed that 100% of coastal tourism properties in groups D (514 coastal rooms) were constrained from a 'retreat' adaptation option (Table 31). The retreat option was impractical for 50 % or more of the coastal tourism properties in group A (59%), B (88%), D (100%) and E (60%) (Table 31). Notably, the 22 tourism properties that were shown to be at risk to inundation impacts from 1 m of sea-level rise (see Table 31), were all constrained from using inland retreat as an adaptation strategy.

Table 31: Evaluating Coastal 'Retreat' as a Potential Adaptation Strategy for Coastal Properties

Room Groups	# of Coastal Tourism Properties from Total Tourism Properties	# of Tourism Properties Unable to Retreat	# of Coastal Rooms Unable to Retreat
A	17 of 50 (34%)	10 of 17 (59%)	273 of 389 (70%)
B	8 of 9 (89%)	7 of 8 (88%)	555 of 629 (88%)
C	5 of 7 (71%)	2 of 5 (40%)	289 of 689 (42%)
D	2 of 2 (100)	2 of 2 (100%)	514 of 514 (100%)
E	5 of 5 (100%)	3 of 5 (60%)	982 of 1644 (60%)
Overall	37 of 73 (51%)	24 of 37 (65%)	2591 of 2613(99%)

4.4.3. *Evaluating Coastal 'Retreat' as a Potential Adaptation Strategy for Coastal Tourism Properties by Destination Community*

With the exception of Micoud where there were no existing coastal tourism properties, all destination communities with coastal tourism properties faced challenges in applying a retreat adaptation strategy. In both Rodney Bay and Vieux-Fort, 100% of coastal tourism properties were restricted from inland retreat. Correspondingly, 83% and 50% of coastal tourism properties in Castries and Marigot Bay were constrained from inland retreat (Table 32). Rodney Bay was the most restricted destination community with both the highest number of coastal tourism properties and number of coastal rooms unable to retreat. The best suited destination communities for applying a retreat adaptation strategy was Gros-Islet and Soufriere where 30% and 40% of coastal tourism properties were unable to retreat. The location with the highest number of coastal tourism properties that were unable to retreat was Rodney Bay (10) and Castries (5). Vieux-Fort, Soufriere and Marigot Bay each had two coastal tourism properties that were restricted from inland retreat. The highest numbers of coastal rooms that are at risk to inundation and erosion impacts due to restrictions from inland retreat were in Rodney Bay (738, 100%), Gros-Islet (700, 40%) and Castries (648, 96%). The destination communities with lowest number of coastal rooms at risk to inundation and erosion impacts Marigot Bay (45, 26%) and Soufriere (202, 93%) (Table 32). There were four destination communities where the number of unable to retreat coastal rooms exceeded 90% (i.e. Castries (96%), Rodney Bay (100%), Soufriere (100%) and Vieux-Fort (100%).

Table 32: Evaluating Coastal 'Retreat' as a Potential Adaptation Strategy for Coastal Tourism Properties by Destination Community

Destination Communities	# of Coastal Tourism Properties from Total Tourism Properties	# of Tourism Properties Unable to Retreat	# of Coastal Rooms Unable to Retreat
Castries	6 of 18 (33%)	5 of 6 (83%)	648 of 678 (96%)
Gros-Islet	10 of 15 (67%)	3 of 10 (30%)	700 of 1745 (40%)
Marigot Bay	4 of 4 (100%)	2 of 4 (50%)	45 of 173 (26%)
Micoud	0 of 2 (0%)	0 of 0 (0%)	0 of 0 (0%)
Rodney Bay	10 of 14 (71%)	10 of 10 (100%)	738 of 738(100%)
Soufriere	5 of 14 (36%)	2 of 5 (40%)	202 of 218 (93%)
Vieux - Fort	2 of 6 (33%)	2 of 2 (100%)	258 of 258(100%)
Total	37 of 73 (51%)	24 of 37 (68%)	2591 of 2613 (99%)

4.5. Coastal Protection

Using Google Earth, this study identified coastal protection in the form of sea walls, breakwaters, revetments, jetties and groynes for 37 coastal tourism properties. All of the aforementioned coastal protection structures were included in the analysis for coastal protection of tourism properties. However, in the cases where sea walls were identified they were all located adjacent to properties and thus did not provide any protection for beach assets (e.g. Sandals Regency, Figure 13). As a result, tourism properties possessing sea walls that did not have any of the other forms of coastal protection structures (as listed above) were considered to be without coastal protection for beach assets. Notably, in some cases where coastal protection structures were identified, protection was observed to be limited. This was especially visible in the case of Rendezvous where despite an existing breakwater, erosion could be anticipated. Overall, only 14 (38%) of 37 coastal tourism properties had coastal protection while 23 (62 %) are currently left unguarded from erosion and flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise (Table 33).

4.5.1. Coastal Protection Case Studies:

(1) Rendezvous

In this case study of the Rendezvous beach tourism property the single break water, coastal protection for the tourism property and beach asset can be deemed inadequate (Figure 18 &19). While the break water helps with decreasing wave action and erosion to the frontal part of the beach and property the remainder of beach assets and the Rendezvous beach property remains unguarded to the left and right, as identified by the white arrows (Figure 18). This case study shows that despite the presence of coastal protection, sea-level rise, storm surges and wave heights remain a threat to this tourism property and its beach assets. The distances that waves can move inland is pinpointed by white arrows in Figure 18. The Rendezvous example demonstrates that additional coastal protection for coastal properties may be necessary to ensure a minimal impact from sea-level rise.

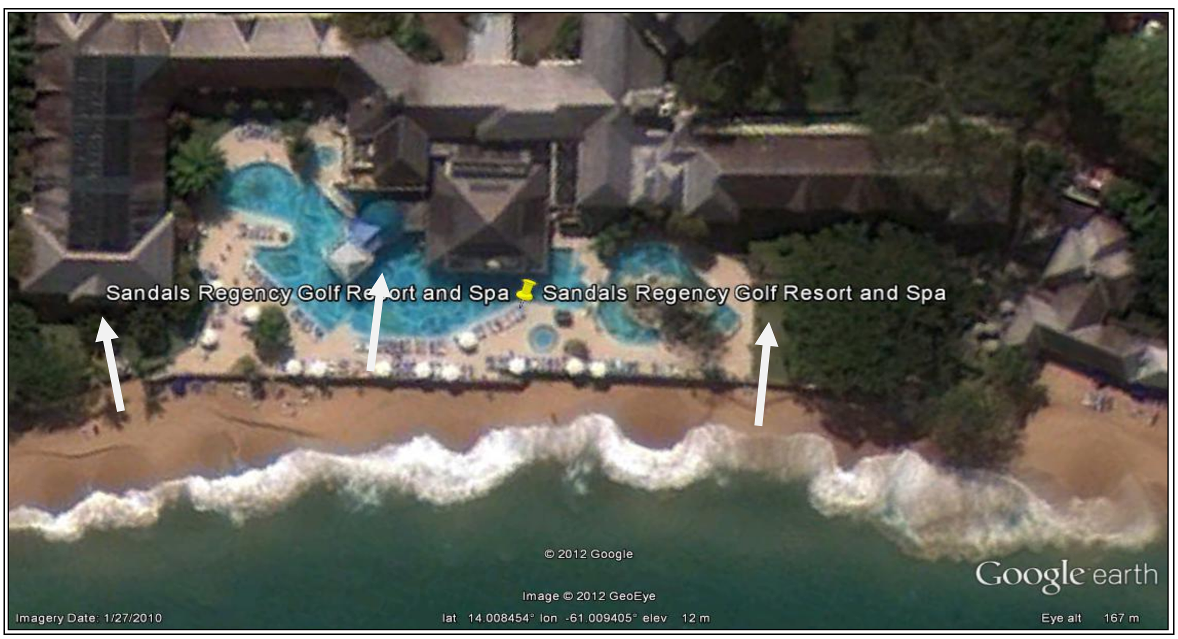
Figure 18: Coastal Protection at the Rendezvous Beach Tourism Property

Source: Google Image (modified by author)* white arrows show direction of erosion

(2) Sandals Regency and Spa

At Sandals Regency and Spa, a seawall provides protection against erosion and inundation of the tourism property, however the beach remains unshielded from sea-level rise, storm surge and wave action (Figure 19 &20). In addition, this tourism property is not entirely protected by a seawall and therefore flooding can be expected to begin from these unprotected areas. By a measure of total room capacity Sandals Regency and Spa is the second largest tourism property on the island with 331 rooms (Group E). Notably, this property is also one of the tourism properties at risk to flood impacts from 1 m of sea-level rise. In addition, seawalls are known to cause coastal squeeze over time as focus is not on protecting beach assets, but rather the tourism property from flood damages and erosion. As a result beach assets are likely to narrow over time requiring additional measures, such as beach nourishment, or face the eventual loss of beach assets. This case study demonstrates that seawalls only provide limited protection to tourism properties and leave~~s~~ beach assets unguarded from erosion due to waves, storm surge and sea-level rise.

Figure 19: Coastal Protection for Sandal Regency Resort & Spa



Source: Google Images (modified by author)* white arrows show the direction of erosion and inundation.

Figure 20: Topographical Map of the Castries Destination Community where Sandals Regency and Rendezvous is Located

Source: Government of St. Lucia

4.5.2. Coastal Protection for Tourism Properties and Beach Assets at Risk to Storm Surge and Waves, and Additional Exposed Risks by 1 m of Sea-level Rise

Of the 37 coastal tourism properties examined in this study, 22 (30%) were found to be at risk to flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise (Table 33). Only 10 (45%) of these 22 impacted coastal tourism properties currently had coastal protection in the form of sea walls, breakwaters, revetments, jetties and groynes .

Of the 22 coastal tourism properties with erodible beach assets at risk to inundation by 1 m of sea-level rise, 12 (55%) had no coastal protection (Table 33). However, coastal protection was identified at 5 (31%) tourism properties with erodible beaches assets that were at risk to flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise (Table 33).

4.5.3. Coastal Protection for Tourism Properties and Beach Assets Not Shown to be at Risk by Storm Surge and Waves , and Additional Exposed Risks by 1 m of Sea-level Rise.

For coastal tourism properties that were not found to be at risk to permanent inundation by 1 m of sea-level rise and temporary flooding risks by storm surge and waves (6 m), only 4 (27%) coastal tourism properties had coastal protection (Table 33).

For coastal tourism properties with beach assets that were not impacted by 1 m of sea-level rise or by storm surge and waves, two (20%) tourism properties had coastal protection while 8 (80%) did not have any form of coastal protection. There were a total of 19 (73 %) coastal tourism properties with beach assets that did not have coastal protection a while there were 23 (62%) of coastal tourism properties without coastal protection (Table 33).

Table 33: Coastal Protection for Tourism Properties and Beach Assets

	Coastal Tourism Properties with Protection	Coastal Tourism Properties without Protection	Coastal Tourism Properties with Beach Assets and Coastal Protection	Coastal Tourism Properties with Beach Assets without Coastal Protection
Impacted by 1 m of Sea-level Rise	10 (45%)	12 (55%)	5 (31%)	11 (69%)
Not Impacted by 1 m of Sea-level Rise	4 (27%)	11(73%)	2 (20%)	8 (80%)
Overall	14 (38%)	23(62%)	7 (27%)	19 (73%)

4.6. Sea-level Rise and Tourism Policy & Planning Review

Policy has been noted as an important tool for guiding adaptation planning towards climate change and sea-level rise (Government of St. Lucia, 2006a; Hall & Higham, 2005; Scott & Becken, 2010; Scott et al., 2012a). A total of 16 documents were included in this review.

4.6.1. Document Review

'Tourism' was mentioned in 13 (81%) of these 16 documents while both 'climate change' and 'tourism' where mentioned in only eight (50%) documents. 'Climate change', 'tourism' and 'sea-level rise' all appeared in only three (19%) of these documents with only two (13%) of these policies, the Natural Hazard Mitigation Policy & Plan (2006a) and the National Climate Change Policy and Adaptation Plan (2002b) having specific guidelines and recommendations for climate adaptation for the tourism sector.

In the more recent policy, the Natural Hazard Mitigation Policy & Plan (2006a) there are eight approaches to natural hazard risk reduction for the tourism sector:

(1) Conduct the necessary research and information gathering to support decision-making;
(2) Ensure that appropriate physical planning guideline such as coastal setbacks are enforced for new tourism developments;
(3) Work with stakeholders in the tourism sector to develop a strategic development plan which incorporates climate hazard considerations and appropriate measures such as water conservation programmes as well as general sustainability concerns;
(4) Prepare robust but adaptable disaster management plans that prepare for worse case scenarios;
(5) Establish clear restoration policies and plans with the full involvement of all key stakeholders and test these instruments;
(6) Retro-fit infrastructure based on an assessment of future risks;
(7) Ensure that corporate disaster plans are integrated into national disaster plans;
(8) Explore options for self-insurance and/or joint insurance. (pp.16-17)

In the National Climate Change Policy and Adaptation Plan (2002b) there are three approaches outlined for the tourism sector:

(1) Conduct the necessary research and information gathering in order to strengthen the basis for sound decision-making;

(2) Ensure that appropriate physical planning guideline such as coastal setbacks are enforced for new tourism developments;

(3) Work with stakeholders in the tourism sector to develop a strategic plan which incorporates climate change considerations and appropriate measures such as water conservation programmes as well as general sustainability concerns. (p. 15)

Notably, these two policies contain the exact same wording in their first three approaches. Although the two policies share similar guidelines on the involvement of relevant tourism stakeholders for designing effective policies and plans, setting physical planning for coastal setbacks on new tourism development and conducting research that will strengthen decision-making. The Natural Hazard Mitigation Policy & Plan (2006a) contains five additional approaches. These five additional specifications address broader adaptation strategies for the tourism sector and focus on preparation for worse case scenarios, tourism- inclusive disaster plans and risk insurance. The Natural Hazard Mitigation Policy & Plan and the National Climate Change Policy and Adaptation Plan will be further discussed in this chapter in subsections 4.6.3 and 4.6.4.

Although the Government of St. Lucia has recognized the need to improve policy and planning for sea-level rise in the tourism sector, after almost 10 years St. Lucia's National Tourism Policy (drafted, 2003) is still not implemented. Furthermore, this drafted policy does not include any recommendations for climate change adaptation within the tourism sector. At present, based on communications with government departments, there is currently no scheduled date for the enactment of the National Tourism Policy. Additionally, although the Fisheries Act, Coastal Zone Management Policy, National Environmental Policy and Management Strategy, Forest Policy and Sustainable Energy Plan are important policies that represent tourism-related sectors they did not contain any specific considerations for assisting adaptation within the tourism sector.

4.6.2. The National Tourism Policy (drafted, 2003)

The drafted National Tourism Policy has eight objectives:

(1) To establish tourism as a strategic economic development priority;
(2) To expand local participation directly or indirectly in the tourism sector;
(3) To continuously improve the quality of the tourism experience and product;
(4) To stimulate and facilitate additional investment in the upgrading, expansion and diversification of the tourism infrastructure and production base;
(5) To strengthen the backward and forward linkages between tourism and Agriculture and other sectors of the economy;
(6) To project a positive and unique identity of Saint Lucia in tourism generating markets
(7) To improve the public's perception of and attitude towards tourism;
(8) To participate actively in and take full advantage of regional and international initiatives.

As indicated by the above eight objectives, the drafted tourism policy is mainly based on an economic development agenda. This policy broadly makes provisions for environmental sustainability by including plans to work with other existing government agencies on formulating and implementing laws, policies and standards that would ensure adequate and sustainable protection and conservation of the physical environment. The policy does not make any mention of provisions or adaptation plans for the issues of climate change and sea-level rise for the tourism sector. However, since the drafted National Tourism Policy has not been adopted, there is the opportunity for reviews and amendments to reflect the climate change adaptation needs within the tourism sector.

4.6.3. Natural Hazard Mitigation Policy and Plan

Formally known as the Hazard Mitigation Plan of the Office of Disaster Preparedness (1995), the Hazard Mitigation Plan is the primary plan for disaster mitigation and response for St. Lucia (Government of St. Lucia, 2006a). This plan was revised in 1996, 2001, 2002 and then twice in 2006. The Hazard Mitigation Plan embodies the goals and objectives set forth by: the Disaster Preparedness and Response Act (2000), the Damage Assessment and Needs Analysis (DANA) Policy (2005), the Disaster Management Act (2006), and the Natural Hazard Mitigation

Policy (2006) which aim to improve disaster preparedness, prevention, and mitigation for St. Lucia.

The Natural Hazard Mitigation Plan outlines the most critical impacts from hazards and outlines some of the most anticipated effects for natural and man-made disasters. The Natural Hazard Mitigation Policy and Plan includes recommendations and plans for enhancing landslide inventory maps, and flood hazard and storm surge maps that will help in risk assessments. The plan stipulates that sea-level rise, beach erosion, storm surge, flooding and inundation in low-lying areas are all issues that should be closely monitored, but greater emphasis is placed on flooding from extreme storm events such as hurricanes. Although the Natural Hazard Mitigation Plan identifies sea-level rise as anticipated additional risk exacerbating the effect of hurricanes and tsunamis, there does not appear to be any specific adaptation planning considerations given to sea-level rise. However, Natural Hazard Mitigation Plan does establish the need for on-going assessments on population, infrastructure, shelter needs, evacuation plans and environmental impacts as it pertains to disasters.

In St. Lucia, presently there is no comprehensive systematic risk assessment process in the planning for hazard mitigation. Due to the absence of such relevant information adaptation planning remains noticeably absent on a national scale. Instead, Hazard Mitigation Plan projects are carried out mostly after storm- related events and often include repairs to infrastructure such as road networks and communication infrastructure (Government of St. Lucia, 2006a).

The Hazard Mitigation Plan is currently St. Lucia's overarching National Emergency Management Plan and includes; the hurricane, drought and flood plan. While the Hurricane Plan and Flood Plan make reference to flooding caused by tropical cyclones, they too omit the issue of inundation from sea-level rise.

4.6.4. National Climate Change Policy and Adaptation Plan

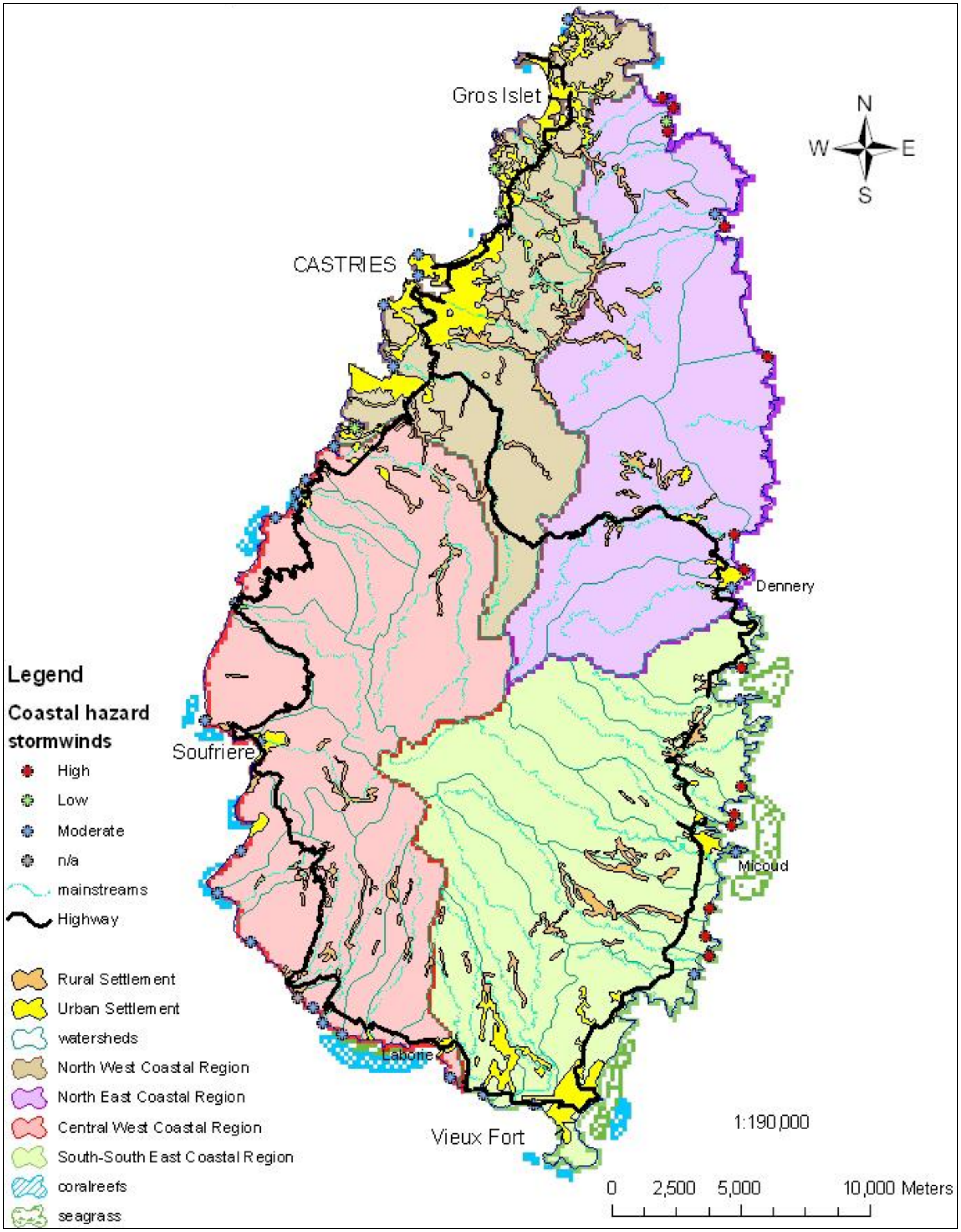
The National Climate Change Policy and Adaptation Plan was an outcome of the Caribbean Planning for Adaptation to Climate Change (CPACC) project which lasted from 1997-2001 as a joint effort between CARICOM nations, the OAS and the World Bank. The National Climate Change Policy and Adaptation Plan recognizes the impacts of climate change on St. Lucia and outlines three main objectives to meeting goals set by the UNFCCC. These three objectives focus on developing frameworks and strategies that aim at minimizing the negative impacts of climate change. This includes conducting systematic research that will improve forecasting and supply necessary planning approaches; and developing legal and institutional systems. The National Climate Change Policy and Adaptation Plan are amongst the very few policies and plans that address the impacts of sea-level rise for St. Lucia. The National Climate Change Policy and Adaptation Plan includes: the monitoring of coastal resources, the restoration of destroyed areas and increasing public knowledge and education on climate change issues. This policy advocates for climate change adaptation strategies for tourism, water resources, biodiversity, agriculture, human settlements, human health and the financial sector.

The main concerns for the tourism sector outlined in the National Climate Change Policy and Adaptation Plan are damage to tourism infrastructure from erosion, sea-level rise, degradation of coastal resources such as coral reefs and the economic loss from reduced visitors due to more severe weather patterns. For the tourism sector the policy identifies three approaches for climate change adaptation: research for better decision-making, enforcing physical planning guidelines such as coastal setbacks for new tourism development and engaging stakeholders in developing a strategic plan that considers climate change.

4.6.5. Coastal Zone Management Policy

When considering the issues of climate change and sea-level rise for the tourism sector the Coastal Zone Management Policy is perhaps one of the most important policies in St. Lucia. This policy addresses climate change impacts within coastal areas where the majority of St. Lucia's tourism properties and natural tourism resources are situated. The Coastal Zone Management Policy is aimed at achieving a holistic and integrated approach that will foster better management and use of coastal and marine habitats (Walker, 2006). The policy places focus on implementing institutional frameworks, securing financial resources, public awareness, and data collection for meeting its goals and objectives. The policy outlines three actions to address the degradation of beach assets: (1) identifying problematic and vulnerable areas; (2) mapping beach and sand resources; and (3) employing soft methods (e.g. beach replenishment and dune restoration) and where necessary, hard engineering methods. While these three actions were outlined within a 10 year timeframe, to the author's best knowledge, to date there are no known established guidelines, investment plans or implementation plans in support of these actions. However one of the key outcomes of coastal zone management efforts in St. Lucia has been a map for coastal zone regions (Figure 21). The map identifies crucial characteristics such as coastal hazard storm winds, coastal settlement, watersheds and coral reef habitats of various coastal regions around the island that are important to designing and employing coastal protection strategies and solutions to sea-level rise and storm surge from extreme storm events. The coastal zone regions' map identifies the north-west, west, south and south east coastlines as areas where moderate levels of storm winds occur. Noteworthy, these areas are particular important to coastal tourism properties and several beach assets as they are concentrated within these boundaries. Six of the seven locations in this study (i.e. Castries, Gros-Islet, Marigot Bay, Rodney Bay, Soufriere, and Vieux-Fort) which contain a total of 37 (51%) coastal tourism properties and 2613 (53%) coastal rooms are located within these coastlines.

Figure 21: Map of Coastal Zone Regions in St. Lucia



Source: Walker, 2006.

5. Discussion

5.1. Introduction

In Chapter 4, the outcomes for this research study were presented in three sections: (1) an inventory of tourism infrastructure at risk to the impacts associated with 1 m sea-level rise, (2) an adaptation analysis on the potential for coastal retreat as an adaptation strategy and evaluation of coastal protection; and (3) a sea-level rise and tourism policy and planning document review. These components were presented to help better understand the implications of sea-level rise for tourism in St. Lucia and possible adaptations strategies. This chapter will focus on the results of this study and discuss what they mean for sustainable tourism planning in St. Lucia.

Although global and regional scale impact assessments for sea-level rise (e.g. Nicholls et al., 2008 and Dasgupta et al., 2008) have provided some understandings on the consequences of sea-level rise for developing countries, they neglect one of the most coastal dependent and economically important sectors in those countries, tourism (Scott et al., 2012a). The Caribbean is one of the most tourism-dependent and climate-sensitive regions of the world, however there are few research studies about the impacts of sea-level rise on tourism for that region (Scott et al., 2012a).

In their recent study Scott et al. (2012b) found that 266 (29%) of 906 major coastal resort properties in 19 CARICOM countries would be partially or fully inundated by a 1 m of sea-level rise. In addition, between 440(49%) and 546 (60%) would be impacted by erosion of 50 m and 100 m associated with 1 m of sea-level rise. Notably, in that same study, St. Lucia ranked fifth among destinations with the lowest number of at risk coastal properties. Scott et al. (2012b) found that two (6.67%) of 30 resort properties in St. Lucia were at risk to partial or full inundation from 1 m of sea-level rise. In addition, the study showed that sea-level rise induced erosion of 50 m and 100 m would impact five and nine resorts properties, respectively.

This study improves on the findings by Scott et al. (2012b), by including 43 additional tourism properties and all room capacities. In addition to providing a more detailed inventory of tourism properties in St. Lucia, this research study also builds on findings and analysis by Scott et al. (2012b) by focussing on the implications of sea-level rise for individual destination communities in St. Lucia. Importantly, this study also estimated the new flood risks associated with 1 m of sea-level rise by using realistic storm impact projections that were specific to St. Lucia, instead of the regional average used by Scott et al. (2012b). Moreover, this study focusses on long-term future tourism planning in St. Lucia by including a 1 m sea-level rise flood risk analysis for six zoned future tourism development areas.

5.2. Impacts of Sea-level Rise on Tourism Properties in St. Lucia

Although sea-level rise is one of the main impacts of climate change that threatens the tourism sector, few studies have examined the implications it would have for that sector (Scott et al., 2012a). A 1 m in global sea-level rise represents a central estimate of recent studies that model the impacts of sea-level rise, and provides a realistic projection for 2100 (Tamisiae & Mitrovica, 2011; Scott et al., 2012b). To provide a realistic forecast for sea-level rise implications for tourism in St. Lucia, this study also adopted this 1 m projection.

This study estimated that flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise would cause a flood risk of 6 m for St. Lucia. Under this scenario, tourism properties, airports, cruise ports and zone areas for future tourism development are affected. Flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise impacted 22 (30%) of 73 tourism properties and 2672 (54%) of 4947 rooms on the island.

Notably, while a 30% at risk percentage for tourism properties might be considered small in comparison to the unaffected proportion of tourism properties in this study, it is important to note that the findings for at risk tourism properties present broader implications as they also affect room availability and the viability of destination communities. To better understand this issue there are three factors that should be highlighted:

(1) ASTER-SRTM showed that in the two highest room capacity groups, D and E, six of seven (~86%) tourism properties are at risk to inundation. Although only one of these tourism properties, a total of 254 (5%) rooms was found to be at risk to permanent flooding by 1 m of sea-level rise, with temporary flooding risks from storm surges and waves this number increased to a total of six tourism properties and 1818 (37%) rooms.

When discussing impacted tourism properties, it is important to consider their total room capacities. A higher room capacity means that these tourism properties can accommodate the highest numbers of visitors at any given time especially during peak tourism seasons and for annual events like the International Jazz Festival and Carnival. The unavailability of hotel rooms is likely to affect tourist arrivals during these periods and, more importantly, tourism expenditure.

(2) According to ASTER-SRTM analysis, all at risk tourism properties were either beach resorts or hotels that were in close proximity to beach assets. Beach front amenities are one of the attractive features for tourists when choosing a Caribbean destination (Zappino, 2005). Uyarra et al. (2005) found that tourists to Bonaire and Barbados were less willing to return to these sun destinations if beach resources had 'largely disappeared'. It is highly probable that if beach resources become unattractive or unavailable that St. Lucia's tourism market may be negatively affected.

Although beach resources are considered important to tourism in St. Lucia, their overall importance to the industry is largely unknown as the majority of tourists visit by cruise ships and do not require overnight accommodations. Nonetheless, beach tourism is an important aspect of St. Lucia's marketing image and, for this niche, it is important that beach properties and their assets remain aesthetically pleasing and readily available.

(3) The majority of at risk tourism properties, 18 (82%) of 22 are within popular destination communities that provide conveniences such as banking, restaurants and bars, shopping amenities and entertainment to tourists. In 2011, direct tourism GDP contributions for St. Lucia were US$0.1 billion with 96% generated from leisure spending (WTTC, 2012b). Flood and erosion damage to tourism properties in these prime areas will likely impact the number of tourists that can be accommodated in these exclusive destination communities and may also affect the overall tourist experience, thus a willingness to revisit.

Deslandes (2006) found that only 17% of tourists were repeat visitors to St. Lucia, signifying that the island had a low ability in retaining visitors and thus improving their level of 'destination loyalty'. While these findings are inconclusive due to limitations of sample size and type, it demonstrated that satisfaction and destination image by tourists were important factors in motivating a return visit to St. Lucia. Entertainment and leisure activities are an important part of the visitor experience in St. Lucia and appear in distinct varieties across various destination communities (St. Lucia Tourism Board). For tourists wanting to explore local communities and culture, the availability of tourism properties and amenities in various destination communities is important.

It should also be noted that a reduced tourist presence in destination communities may have negative economic implications for established local tourism businesses (e.g. tour operators, art vendors), as fewer tourists may mean less visitor spending in these areas. This is especially significant to the villages and towns (e.g. Vieux-Fort) where tourist presence is already minimal due to a lack of tourism properties for accommodation.

This study found that flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise would inundate both airports and cruise ports in St. Lucia. Airports and cruise ports are vital to tourism as they offer accessibility to destinations and ultimately determine the number of tourist arrivals. Notably, St. Lucia's airports are situated in close proximity to the coastlines and are prone to temporary flooding caused by storm surges. In 2010, Hurricane Tomas caused major flooding at critical transport infrastructures which resulted in losses of several thousand dollars in airport landing fees and cruise trips being cancelled (ECLAC, 2011b).

In addition, this study also found that five of six zoned future tourism development areas were at risk to inundation from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise. These six zoned future tourism development areas were part of a collaborated study with the Government of St. Lucia and the Florida based consulting company, IDEA, and was presented in the *2008 National Visions Plan* report. While many of the strategic plans for tourism development in the *2008 National Visions Plan* were based on land availability in undeveloped areas and revitalization of economically stagnant locations, these plans did not consider the implications of coastal flooding by storm surges and sea-level rise. The findings on the six zoned future tourism development areas unlike the other tourism-related infrastructures, offers the opportunity for future tourism planning that considers sea-level rise prior to the development of these envisioned tourism properties. Planning for sea-level rise in the six zoned future tourism development areas may help lessen or prevent investment losses for tourism stakeholders (e.g. resort owners and investors).

5.3. Impacts of Sea-level Rise on Coastal Resources

It is generally expected that sea-level rise will accelerate the rates of beach erosion (Daniel & Abkowitz, 2005a; Walsh et al., 2004; Nicholls, 2011). The impacts of sea-level rise induced erosion in addition to beach loss resulting from human interference, such as development of coastal areas, will have critical implications for coastal systems (e.g. coral reefs, mangroves, fisheries). In particular, the loss of beach assets will have important negative consequences for tourism in the Caribbean (Lewsey et al., 2004; Scott et al., 2012a; Wielgus et al., 2010).

Uyarra et al. (2005) surveyed two important destinations, Barbados and Bonaire and found that 77% and 43% of visitors would be unwilling to plan a return visit if 'beaches largely disappeared'. Wielgus et al. (2010) noted that a loss of 0.5 m in beach width could result in gross-revenue losses of about US$160,000 per year for an averaged size hotel (411 rooms) in the Dominican Republic. At this same destination, within a 10 year period beach erosion could cost the hotel industry alone US$52-100 million.

In another study, Mimura et al. (2007) found that 0.5 m of sea-level rise in Bonaire and the Netherlands was responsible for 38% of beach loss, a 35% decrease in turtle habitats and 29% reduction in fish production.

While there are no known studies on St. Lucia that have estimated the direct economic impact of losses to beach assets for tourism, studies on other islands within the Caribbean (such as Schleupner (2008a) in Martinque; Moore et al., 2010 in Barbados; Wielgus et al., 2010 in the Dominican Republic) indicate that beach loss would have a negative impact on tourism revenue.

In this study, between 12 (92%), and 13 (100%) coastal tourism properties with a total room capacity between 1323 (99%) and 1327 (100%) were impacted by 50 m and 100 m of erosion associated with 1 m of sea-level rise.

The findings of beach erosion in this study contribute to other studies (e.g. Belle & Bramwell, 2005; Coombes, Jones & Sutherland, 2008; Cambers, 2009) that have confirmed that reductions in beach widths would have negative implications for tourism. Furthermore, it highlights the need for more in-depth discussions on tourism adaptation for sea-level rise induced beach erosion.

5.4. The Implications for Coastal Adaptation in Tourism

Boateng (2008) noted that the impact of sea-level rise and severe storm events may be determined by local factors such as coastal geomorphology, geology, existing development and the capacity and affordability of coastal defence measures.

When examining coastal retreat as a potential adaptation strategy this study found that 24 (65%) of 37 coastal tourism properties were unable to implement a retreat adaptation strategy due to existing land uses (i.e. road networks, urban infrastructures, water surfaces or protected areas). Furthermore, 12 (55%) of 22 tourism properties at risk to inundation did not have any type of coastal protection. Of the 37 coastal tourism properties inventoried only 14 (38%) had some form of coastal protection, while 23 (62%) were left unprotected. Moreover, this study illustrated examples where coastal protection although in place, provided limited defence against storm surges and potential sea-level rise to beach assets and tourism properties (Figure 16 & 17).

Tol (2002) estimated that that 1 m of sea-level rise would cost the Caribbean and Latin American region US$2 billion per year. Several researchers including Nicholls (2011) and Daniel & Abkowitz (2005a) have highlighted the importance of using coastal protection strategies such as retreat, accommodation and protection to limit the impact of flooding events. Nicholls (2011) noted that sea-level rise will have wide-ranging global implications. However, the outcomes will be largely depending on the successes or failures of mitigation and adaptation responses. Small islands are extremely vulnerable to sea-level rise, whilst possessing the lowest implementation level of coastal protection (Nicholls et al., 2007). One of the main reasons why coastal protection is observed on this small scale is related to the high costs they require for implementation (Nicholls et al., 2010). By the 2040s, coastal adaptation for sea-level rise in developing countries is expected to be US$26-89 billion per year (Nicholls et al., 2010).

While this study found that a low implementation level of coastal protection and that many tourism properties were restricted from a retreat strategy, it does not conclude that any one coastal adaptation should or would supersede another as a more effective approach. The decision and applicability of various types and numbers of coastal protection in St. Lucia will largely depend on the availability of financial resources for this issue. In cases where the local government is unable to fund such projects, efforts will have to include regional and international assistance, as have been done with past projects on climate change.

The effectiveness of coastal adaptation planning in the long run will depend on its appropriate implementation (Nicholls, 2011). The application of coastal protection seems to vary on a case by case scenario and thus determining the most suitable method for any location is a challenging task. Schleupner (2008b) suggested that 18% of coastlines in Martinique would benefit from applying coastal structural protection (e.g. seawalls), while the conservation of mangrove forest could protect 15 % of coastal lines. In addition, Scott et al. (2012b) argued that while structural protection is often seen as a practical method for protecting coastal properties, they can be expensive to construct and lead to ‘coastal squeeze’- as beach assets are left unprotected.

In cases where hard-engineered coastal protection (sea walls and breakwaters) or soft-engineered coastal protection (e.g. beach nourishment) is not a feasible option, the only alternative may be to abandon impacted tourism properties or in a worst case scenario the entire impacted area. Due to the St. Lucia’s high dependency on tourism, its limited financial resources for addressing sea-level rise and the anticipated negative implications of sea-level rise for the tourism sector, it is important to critically assess the subject of coastal setbacks, as it may be the most affordable and practical long-term solution. Scott et al. (2012b) concluded that while “coastal retreat is a largely untested strategy for coastal tourism destinations” (p. 894) and that “the planning required for coordinated retreat would be highly complex, severely challenging local governments and planning authorities…” (p. 894) it is a more affordable adaptation response option than beach nourishment and structural protection for destinations already limited by financial resources.

Wielgus et al. (2010) also found that while beach nourishment is often considered a strategy for reducing the impacts of beach erosion for tourism, it can be extremely costly and only present a short-term solution (Wielgus et al., 2010). In 2007, the Dominican Republic government allocated US$18 million which had been generated from entry fees charged to international tourists to a beach restoration program in the coastal areas, Puerto Plata and Juan Dolio (Wielgus et al., 2010). Two years later, beach loss had become evident in these two areas, thus questioning the effectiveness of beach nourishment in these areas (Wielgus et al., 2010).

According to Walker (2006), coastal adaptation planning in St. Lucia requires an integrated approach that will require cooperation and collaboration among multiple departments to ensure that policies and strategies can be developed and implemented in an effective manner.

This study found that only 37 (51%) of 73 tourism properties inventoried were within coastal areas. However, of these 37 coastal properties, only 26 had beach assets. This means that only 26 (36%) of 73, less than half of all inventoried tourism properties had beach assets. From these findings three important questions emerge about St. Lucia's 3S tourism market: (1) how many tourists have a preference for accommodations with beach assets; (2) can St. Lucia thrive on a tourism market where tourism properties are away from coastlines and; (3) if so, what would be a suitable distance for tourists away from beach assets. While this matter will require further research and discussion by government and tourism stakeholders to determine the risks and benefits of expanding a tourism niche outside of beach tourism, it encourages the idea of coastal setbacks, a planning idea that has been emphasized by many researchers (e.g. Nicholls, 2011; Cambers; 1998; Cambers, 2009; Daniel & Abkowitz, 2005a) as a necessary planning approach that would lessen the severity of impacts of coastal hazards on beach properties. Lewsey et al. (2004) suggested that the impacts of sea level rise can be reduced by:

> Prohibiting the construction of protective structures in sensitive high-hazard areas, prohibiting the reconstruction of storm-damaged property in high-hazard areas; and conditioning land ownership in high-hazard areas to expire when a property owner dies or when sea levels reach a particular point along a map. (p. 400)

The implementation of coastal setback restrictions is expected to be a complex issue for St. Lucia. Simpson et al. (2012) reported that coastal setbacks in St. Lucia have been mainly based on 300 year old provisions made by colonial administrations that restricted various zones of backshore as Crown Lands. However, these areas are not protected by law and thus the can be legally sold by government to tourism developers who are usually eager to gain access to these lands (Mycoo, 2005). Moreover, Scott et al. (2012b) concluded that issues such as land use and ownership will prove very challenging for planning authorities when implementing retreat guidelines and enforcing them. These issues highlight the need for improvements in data collection for decision-making and policy guidelines with regards to land use and coastal protection from sea-level rise for the tourism sector.

5.5. Policy and Adaptation for the Tourism Sector

Hall (2011) noted that one of the factors that hinder sustainable tourism planning in many destinations is the lack of reliable tourism-specific data. The objectives of this study are guided by this understanding and provide relevant information that is necessary for effective tourism planning and policy development that hopes to improve sustainable tourism for St. Lucia.

The policy review conducted in this study showed that three of 16 national policies made mention of sea-level rise and tourism, while only two of these three policies had specific recommendations for adaptation within the tourism sector. It has been more than a decade since St. Lucia completed its first communication report on climate change as part of its commitment to the UN Framework Convention on Climate Change. While several adaptation measures were recommended for the tourism sector which including, relocation and retreat of coastal structures, restrictions on future development, sea-walls, coastal habitat protection and flood plain management, based on the policy review of this research study only two national policies have mentioned adaptation requirements for the tourism sector. While the aforementioned First Communication report highlighted major concerns of climate change and sea-level rise for the island's tourism sector and proposed a multi-sector approach to dealing with adaptation, to date St. Lucia has not implemented a national tourism policy, although a national tourism policy draft has existed since 2003. Despite the concerns outlined by the First Communications report, two years earlier, the drafted national tourism policy did not make mention of any provisions towards climate change and sea-level for the tourism sector.

Notably, although policy development is presented as an approach for implementing coastal setbacks, the enforcement of these setbacks can prove to be very challenging. For instance, in Nicaragua and Uruguay legislation has been successful in adopting a 248m and a 250m coastal setback respectively. However, these setbacks are often challenged and result in conflict with communities, government and developers that prevent these setbacks from being enforced. In islands such as Anguilla, Bahamas and Antigua and Barbuda where coastal setbacks have been developed they lack a legal framework. However, a legal framework does not guarantee that coastal setbacks will be enforced. Although coastal setbacks are a matter of law in Barbados, they are often challenged due to legal loopholes and thus have had little impacts on new development along coastal areas.

Making coastal setbacks a priority in legislation and ensuring its enforcement is of particular importance to the six zoned areas for future tourism development. Although only one of these six zoned areas were at risk to permanent inundation from 1 m of sea-level rise, the scenario for flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise showed that five of the six zoned areas for future development were at risk to flooding. Whereas existing tourism properties will have to find new ways to adapt to issues of sea-level rise be it by constructing hard-engineered coastal protection structures, beach nourishment and or retreat etc., future projects have the opportunity to apply better adaptation planning that will minimize the risk of inundation and erosion on tourism assets.

Another relevant factor that hinders long-term tourism planning and policy development in St. Lucia is the political process which includes a change of government and affects the categorization of various sectors. Gossling et al. (2009) noted that power struggles hinder the policy implementation process by all areas of government and that such forces are reflected by the changing agendas of governments and tourism stakeholders. This also leads to a lack of integration in sustainable tourism planning and development. The review of government documents for this study revealed that within the last 20-30 years St. Lucia's tourism ministry has been regrouped with various ministerial departments such as Ministry of Commerce, Tourism, Investment Affairs and Consumer Affairs; Ministry of Trade, Industry and Tourism and in more recent years the Ministry of Tourism and Civil Aviation which has now currently been changed to the Ministry of Tourism, Heritage and Creative Industries. Despite the importance of tourism to St. Lucia and change of power between the two main political parties United Worker's Party (UWP) and the St. Lucia Labour Party (SLP) over the last decade, the enactment of a tourism policy is still uncertain.

While opportunities for an integrated and comprehensive approach that includes tourism stakeholders and public participation exists in St. Lucia they have remained a complex process. Policy planning is never exclusively focused on tourism, but contains a mixture of various sectors that contributes to a disconnection between ideal policy goals and attainable outcomes (Gossling et al., 2009). Moscardo (2011) argued that tourism consists of numerous social and economic components that make it challenging to integrate numerous perspectives into a comprehensive framework.

Based on the findings of this research study and discourses from other climate change studies, sea-level rise will pose various challenges to St. Lucia's tourism sector. Research on sea-level rise is relevant in the development of tourism policy planning to help avoid maladaptation within the tourism sector. St. Lucia's drafted national tourism policy offers the opportunity for revisions that can include sea-level rise and improve long-term tourism policy and planning.

6. Recommendations and Conclusion

6.1. Introduction

Climate change is expected to cause GDP losses of 12.1% by 2025, 24.3% by 2050, 36.6% by 2075 and 49.1% by 2100 in St. Lucia, if no action is taken to reduce its impacts (Bueno et al., 2008). Although sea-level rise is identified by government officials and departments in St. Lucia as one of the main impacts of climate change that will have important consequences for tourism (Tulsie et al., 2001), research studies have not assessed the full extent of such threats to the tourism sector. This study improves on limited sea-level rise impacts studies for St. Lucia and Caribbean SIDS, by conducting a country-scale impact analysis for sea-level rise on tourism in St. Lucia. This study offers valuable information on the implications of sea-level rise for tourism that hopes to encourage an integrated policy agenda by government officials and all tourism stakeholders. Moreover, the research components of this study have contributed to the formulation of specific recommendations and understandings that are important to tourism adaptation planning in St. Lucia and provide opportunities for future research.

6.2. Recommendations for Tourism Adaptation and Climate Change Policy in St. Lucia

Using a geo-referenced database of 73 tourism properties located within seven destination communities, this study estimated that 22 (30%) properties consisting of 2672 (54%) rooms are at risk to flooding from storm surge associated with a 1/25 year storm event under 1 m of sea-level rise. Under this same scenario, the most impacted rooms were found in the destination communities of Vieux- Fort and Rodney Bay, 82 % and 80% respectively. These two areas should be made priority areas for adaptation because of their importance to tourism and vulnerability to sea-level rise. Additionally, both of St. Lucia's airports and cruise ports were found to be at risk to flooding. In addition, it was estimated that five of six areas zoned for future tourism development would be partially or fully inundated by storm surge associated with a 1/25 year storm event under 1 m of sea-level rise. Additionally, exacerbated erosion associated with 1 m of sea-level rise (i.e. 50 m and 100 m) impacted between 13 (93%) and 14 (100%) coastal tourism properties and a room capacity of 1343 (99%) and 1347 (100%) respectively. Most of

(24 of 37) coastal tourism properties and 2591 (99%) of 2613(100%) total coastal rooms were unable to implement retreat as an adaptation strategy. Moreover, of the 37 coastal tourism properties, 23 (62%) did not have 'hard-engineered' structural protection. Through a document review of 16 national policies and planning documents it was found that only two (13%) national policies outlined specific guidelines for adaptation for the tourism sector, the Natural Hazard Mitigation Policy & Plan (2006) and the National Climate Change Policy and Adaptation Plan (2002).

Overall, St. Lucia requires a more flexible process for the enactment and implementation of policies. As previously mentioned, policy development can undergo a lengthy process at the national level, as is the case with the drafted 2003 National Tourism Policy. Moreover, evidence shows that even when policies are enacted, the implementation of their guidelines can be stagnant for many years. For instance, the United Nations Convention to Combat Desertification did not appear in St. Lucia's national budget until nine years later of its enactment laws (Government of St. Lucia-NCSA, 2007). While it is imperative to develop adaptation policies for the tourism sector, it is also important that these policies are given priority for implementation.

A common conclusion in several national reports including Government of St. Lucia-NCSA (2007), Singh (2010), Tulsie et al. (2001), is that St. Lucia's adaptation capabilities are hindered by a range of limited resources. In St. Lucia domestic law remains unaffected by conventions unless it is transformed into an Act of Parliament. Where existing regional and international laws exist, their applicability relies on domestic laws (Government of St. Lucia-NCSA, 2007). Therefore, when transforming regional and international laws into national policies the Government of St. Lucia should not simply focus on mainly fulfilling regional and international membership obligations, but instead apply more consideration to national capabilities and available resources. By developing policies and plans that better consider obtainable physical, financial, human and technological resources, practical goals may be better designed and achieved in a timely manner.

Whereas policy development and their implementation can be a long and sometimes unsuccessful process, it is generally agreed that this component is one of the main steps in designing effective approaches for climate change adaptation planning for the tourism sector (Hall & Clayton, 2009). Based on the research outcomes in this study, the following recommendations are proposed for the purpose of improving sea-level rise adaptation for tourism in St. Lucia.

(1) Revision and implementation of the drafted National Tourism Policy to incorporate guidelines for climate change and sea-level rise adaptation to facilitate long-term adaptation planning in the tourism sector.

(2) To design a tourism policy that encourages tourism development outside of beach tourism. This could help reduce already intense competition among resort developers for coastal areas and minimising the impacts that sea-level rise and natural hazards can have on tourism infrastructure. Moreover, the expansion of a tourism market outside of beach tourism benefits St. Lucia's coastal habitats and resources which continue to be increasingly threatened mostly by coastal development.

(3) Review national policies and plans that pertain to tourism, such as the Fisheries Policy, Forest Policy and National Land Policy, and in particular, disaster risk management policies and plans, to ensure that pertinent areas of planning are clearly designed to support sustainable tourism. It is important to review individual national, regional and international policy guidelines and frameworks to make certain that they are not in conflict with each other and that are compatible for achieving sustainable tourism goals.

(4) Conduct an in-depth study on coastal areas and resources to ensure an up to date inventory exists for determining and implementing coastal setback specifications for new development and explore a cost benefit analysis on coastal protection options for existing infrastructure and resources.

(5) Conduct further research on sea-level rise using Light detection and Ranging (LiDAR) technology as a measure to help reduce the uncertainty of ASTER-SRTM. While this technology is expensive to obtain, over the last 20 years LIDAR has used laser light technology to improve the accuracy of distance measurements within 10 centimetres in coastal areas. LiDAR is particularly useful for regions with long shorelines, as it allows hundreds of kilometres to be surveyed speedily by a single GPS base station. This tool will help improve the data quality and geospatial analysis which is useful for increasing reliable information about the impacts of storm surge and sea-level rise on tourism in St. Lucia and guide more detailed planning within that sector.

(6) Pending further research, implement clear guidelines for coastal setbacks and policy or policies where necessary for enforcing these specifications.

6.3. Future Research

This study offers useful information about the associated impacts of 1 m of sea-level rise for tourism in St. Lucia using various approaches. However, it is important for government officials, policy makers and other tourism stakeholders to undertake further research that builds on present understandings of the implications of sea-level rise for tourism in St. Lucia. While the geospatial data in this study provides important information, it does not consider the limitations that land ownership and their physical characteristics present. There is a need for more in-depth geospatial research that includes such details in order to better understand the practical options (e.g. retreat) that can be used in the tourism planning for adaptation to sea-level rise.

In addition, an island-specific cost-benefit analysis is necessary when designing coastal adaptation for the tourism sector as it may help improve both short and long-term planning practical decisions in coastal regions. Although the cost of constructing coastal protection is expected to be a very expensive venture, a cost-benefit analysis will help determine and prioritize the most vulnerable coastal areas for adaptation. Moreover, in areas where coastal protection cannot be constructed, it will become increasingly important to find alternative cost-effective measures.

In particular, more research is needed on beach tourism in St. Lucia to better understand what the construction of tourism properties at further distances from shorelines would mean for the island's tourism image and markets. This study found that the majority of tourism properties did not have beach resources. More information on this area may also help guide the development of policy that can encourage tourism development away from coastal areas, thereby reducing urban development pressures in these areas and reducing the risks of losses to tourism infrastructure.

In addition, there is a need to engage tourism business owners and managers in tourism planning and adaptation to sea-level rise. Now that this study has identified the risks that 1 m of sea-level rise and its associated impacts of inundation and erosion will have on tourism infrastructure and beach assets in St. Lucia, it is worthwhile to improve communication and information sharing with the tourism business community on this issue. While resort owners and investors will likely incur some of the highest losses from damages due coastal flooding and erosion in tourism developed areas, little is known about the knowledge and adaptation strategies or plans of the tourism business community for sea-level rise. There is a need for more information on the perspectives of tourism stakeholders, in particular tourism investors and owners, to help better understand and design more meaningful ways to engage them in the discussion and planning of coastal adaptation. More in-depth information on ways to engage the tourism business community may also help strengthen capacity building efforts at the local level and encourage a broader, more agenda-focussed adaptation discussion for sea-level rise within St. Lucia's tourism sector.

The WTTC (2013) forecast indicates that St. Lucia has a growing tourism market, and thus proper tourism planning will become increasingly important due to limited coastlines. By understanding the importance of beach tourism to St. Lucia, better decisions and strategic planning approaches can be incorporated into future tourism development. Research studies in these areas will allow for better knowledge that may help improve on-going and future adaptation planning decisions.

6.4. Conclusion

Nicholl (2011) warn that even in the absence of storm surge and more adverse changes in extreme storm behaviour, sea-level rise will cause an increase in flooding frequency and severity for coastal regions. Sea-level rise is expected to impact coastal areas with flooding, that will exacerbate coastal erosion, degrade coastal habitats (e.g. wetlands , coral reefs) and increase salinization of surface and ground waters (Nicholls, 2011). Moreover, inundation by sea-level rise will cause greater challenges for coastal tourism such as damages to tourism properties and their beach assets (Cambers, 2009; Schwartz, 2005; Nicholls, 2011).

This study showed that in St. Lucia, the majority of coastal tourism properties and beach assets were at risk to inundation and erosion associated with 1 m of sea-level rise. Overall, adaptation strategy options for coastal tourism properties are currently limited. In most cases, there is inadequate land that would allow for 'retreat', and existing coastal protection structures are limited in number and, in some cases, provide insufficient protection for coastal tourism properties and their beach assets.

Furthermore, a review of policy and plans revealed that the tourism sector is greatly neglected in climate change-related agendas. To date, there are only two policies that have directly addressed climate change challenges within the tourism sector, the Natural Hazard Mitigation Policy & Plan (2006) and the National Climate Change Policy and Adaptation Plan (2002). Moreover, while these two national policies acknowledge the tourism sector in mitigation and adaptation plans, other pertinent polices such as the National Biodiversity Strategy & Action Plan and National Land Policy have not been amended to address sea-level rise challenges for the tourism sector. In St. Lucia, policy development within the tourism sector has been stagnant as a national tourism policy is yet to be enacted despite being drafted in 2003.

Hall (2011) noted that the growing contribution of tourism to environmental change and will further impact the resilience and adaptive capacity of destinations. The absence of policies that can guide an effective coastal adaptation planning process is likely to cause more complex scenarios especially in implementing retreat guidelines in the long-run as more coastal development occur (Simpson et al., 2012). Policy is an important aspect of improving sustainable tourism and will also help lessen the impact of sea-level rise and climate change on destinations (Hall, 2011). Policy gaps provide the opportunity to review and improve existing frameworks and, where necessary, implement new policies that are effective for the tourism sector (Hall, 2011).

To date much of the literature pertinent to the impacts of climate change on St. Lucia have focussed on the issue of warmer temperatures and how these temperatures affect coastal and natural habitats (e.g. coral reefs, fisheries and forestry). Moreover, numerous national studies have concentrated on the impacts of extreme weather events (e.g. tropical storm, hurricanes) for St. Lucia with little attention directed to understanding the consequences of sea-level rise for the tourism sector. Although there is some uncertainty about the time and scales at which sea-level rise will occur, sea-level rise is one of the most certain impacts of climate change that will occur (IPCC, 2007). Carew-Reid (2008) concluded that,

> Sea level rise does not happen overnight, and there is still some time to plan and develop adaptation initiatives. From now on, planning in all sectors needs to take sea level rise into account, and to avoid critical developments in areas susceptible to sea level rise and storm surges without adequate protection. (p. 58)

Importantly, while coastal adaptation strategies are a meaningful option to reducing the impact of sea-level rise on coastal infrastructure and resources, it is important to understand that there are various challenges for applying sea-level rise adaptation. Tobey et al. (2010) insist that national coastal adaptation strategies should be planned compatibly with the available national capabilities and human and financial resources of a particular country or area. There are key factors such as: (a) technical effectiveness: how effective will a particular adaptation option be (b) costs: what will it cost to implement the adaptation option? (c) benefits: what are the benefits of implementing a particular adaptation option and; (d) implementation considerations: the feasibility of implementing a particular design based on the available skill and resources.

Sea-level rise is projected to have a number of negative implications for tourism in St. Lucia. Although the importance of beach tourism to St. Lucia is unclear, many of the challenges facing this tourism market niche have been highlighted throughout this study and include inundation and flood damages to important tourism properties and loss of vital tourism beach resources on which tourism is heavily dependent. While the impacts of sea-level rise are better understood, the realistic challenges it poses for St. Lucia as a destination have not been assessed. Knowledge on sea-level rise impacts and the ability to identify the most at risk tourism properties, infrastructure and destination communities can assist the government of St. Lucia and pertinent stakeholders (e.g. resort managers and owners) improve adaptation strategies and policies that are primarily aimed at mitigating catastrophic outcomes for the tourism sector.

By examining a detailed inventory of tourism properties and assets that are sensitive to impacts of sea-level rise, coastal adaptation options and reviewing policy and planning regulations that are relevant for a response to sea-level rise, this study offers useful and important information to governments, planners and tourism stakeholders in St. Lucia that can assist in future tourism planning. The policy review demonstrated that tourism and sea-level rise remain absent from most tourism related policy instruments in St. Lucia and that much remains to be done to integrate sea-level rise risks into long-range tourism planning.

Importantly, this study provides methodologies that can be replicated for any other Caribbean SIDS. The small scale applicability of the methodologies can allow for a better understanding of the implications of sea-level rise on individual tourism destinations and their coastal environments, in particular SIDS that are considered most vulnerable to the impacts of sea-level rise.

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Appendix 1: IPCC SRES Emission Scenarios
Source: IPCC, 2007b, p.18

The Emission Scenarios of the IPCC Special Report on Emission Scenarios (SRES)[17]

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T) or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

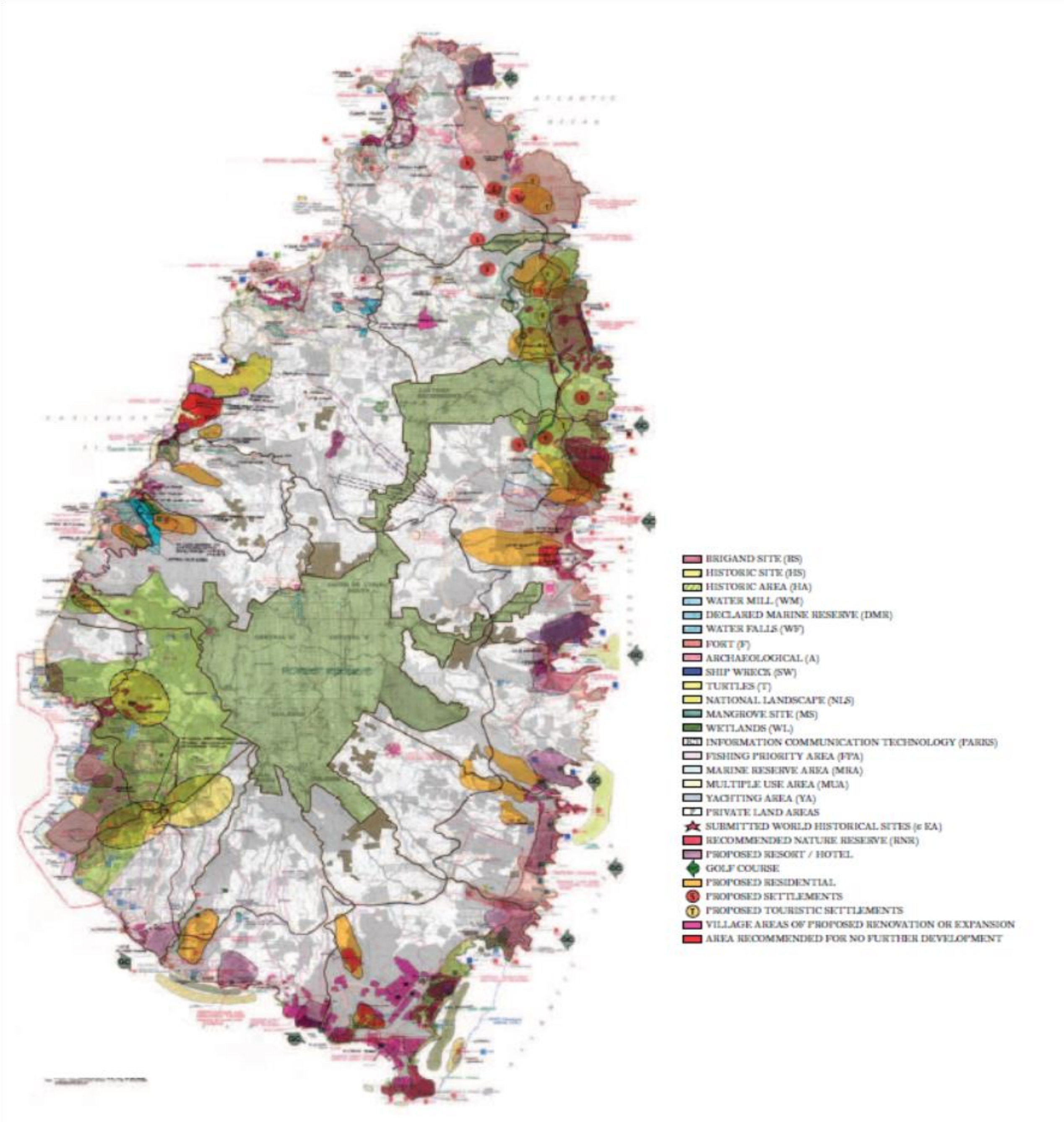
B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

An illustrative scenario was chosen for each of the six scenario groups A1B, A1FI, A1T, A2, B1 and B2. All should be considered equally sound.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.

[17] Emission scenarios are not assessed in this Working Group I Report of the IPCC. This box summarising the SRES scenarios is taken from the TAR and has been subject to prior line-by-line approval by the Panel.

Appendix 2: National Comprehensive Map for St.Lucia
Source: IDEA, 2008 http://www.finance.gov.lc/programmes/view/39.



Please Note: The information shown on this diagram was compiled utilising materials provided to IDEA. This diagram is a work in progress and is intended to demonstrate a comprehensive mapping approach. Initiatives by the Government of Saint Lucia are currently underway to create a digitised National Comprehensive Map.

Appendix 3a: Inventory of Tourism Properties in Group A (room capacity 1-50)

Group A	*Tourism Property*	*# of Rooms*
	Alize Inn Guest House	*12*
	Anse Chastanet Hotel	*49*
	Auberge Seraphine	*28*
	Bay Gardens Inn	*32*
	Bay Guest House	*7*
	Belle Kaye	*8*
	Blue Skies	*3*
	Cap Maison Ltd.	*49*
	Castles in Paradise Villa Resort	*19*
	Calabash Cove	*26*
	Charlery's Inn	*10*
	Cleopatra Villas	*6*
	Country Cottage Motel	*9*
	East Winds Inn	*30*
	Fond Doux Plantation	*10*
	Fox Grove Inn	*12*
	Ginger Lily Hotel	*11*
	Grandview Vacation Villas	*6*
	Habitat Terrace,Ltd	*10*
	Hummingbird Beach Resort	*11*
	JJ's Paradise Resort	*16*
	Jade Mountain	*30*
	Kabran Hotel	*14*
	Ladera Resort	*32*
	La Haut Resort	*13*
	Leisure Inn	*6*
	Mago Estate	*14*
	Mango Beach Inn	*4*
	Marigot Beach Club and Dive Resort	*25*
	Marina Haven Hotel	*8*
	MJI hotels	*52*
	Oasis at Marigot	*20*
	Palm Haven Hotel	*35*
	Poinsettia Apartments	*7*
	QR Quality Rooms	*14*
	Sea Grape Apartment	*6*
	The Down Town Hotel	*18*
	The Reef	*4*

Group A	*Tourism Property*	*# of Rooms*
	The Still Beach House	*5*
	Stonefield Estate Villas	*17*
	Sun West Villas	*8*
	Sweet Shaves Apartment	*4*
	Ti Kaye Village	*33*
	Tranquility Apartments	*7*
	Tropical Breezes Apts. & Guesthouse	*10*
	Tuxedo Villas	*10*
	Villa Beach Cottages	*20*
	Villa Capri	*9*
	Villa Serendipity	*4*
	Zamaca St. Lucia	*5*
	Zara Villas	*22*

Appendix 3b: Inventory of Tourism Properties in Group B (room capacity 51-100)

Group B	*Tourism Property*	*# of Rooms*
	Admiral Quay	*27*
	Bay Gardens Beach Resort	*72*
	Bay Gardens Hotel	*87*
	Bel Jou Hotel	*64*
	Cotton Bay Village	*74*
	Rendevous	*100*
	Royal St. Lucia	*96*
	Village Inn & Spa	*76*

Appendix 3c: Inventory of Tourism Properties in Group C (room capacity 101-200)

Group C	*Tourism Property*	*# of Rooms*
	The Body Holiday at Le Sport	*154*
	Coco Palm	*101*
	Discovery at Marigot	*124*
	Jalousie Plantation	*120*
	Sandals Halcyon	*169*
	The Landings	*122*
	Tropical Villas	*180*

Appendix 3d: Inventory of Tourism Properties in Group D (room capacity 201-300)

Group D	***Tourism Property***	***# of Rooms***
	Coconut Bay Resort & Spa	*254*
	Rex St. Lucia	*260*

Appendix 3e: Inventory of Tourism Properties in Group E (room capacity 301-350)

Group E	***Tourism Property***	***# of Rooms***
	Almond Morgan Bay	*340*
	Almond Smugglers Cove	*350*
	Sandals Grande	*301*
	Sandals Regency St. Lucia	*331*
	Windjammer Landing	*322*