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**AN ASSESSMENT OF THE ECONOMIC IMPACT OF CLIMATE CHANGE ON THE
AGRICULTURE, HEALTH AND TOURISM SECTORS IN SAINT LUCIA**

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EXECUTIVE SUMMARY

This report analyses the agriculture, health and tourism sectors in Saint Lucia to assess the potential economic impacts of climate change on the sectors. The fundamental aim of this report is to assist with the development of strategies to deal with the potential impact of climate change in Saint Lucia. It also has the potential to provide essential input for identifying and preparing policies and strategies to help advance the Caribbean subregion closer to solving problems associated with climate change and attaining individual and regional sustainable development goals. Some of the key anticipated impacts of climate change for the Caribbean include elevated air and sea-surface temperatures, sea-level rise, possible changes in extreme events and a reduction in freshwater resources.

The economic impact of climate change on the three sectors was estimated for the A2 and B2 IPCC scenarios until 2050. An evaluation of various adaptation strategies for each sector was also undertaken using standard evaluation techniques.

The key subsectors in agriculture are expected to have mixed impacts under the A2 and B2 scenarios. Banana, fisheries and root crop outputs are expected to fall with climate change, but tree crop and vegetable production are expected to rise. In aggregate, in every decade up to 2050, these sub-sectors combined are expected to experience a gain under climate change with the highest gains under A2. By 2050, the cumulative gain under A2 is calculated as approximately US\$389.35 million and approximately US\$310.58 million under B2, which represents 17.93% and 14.30% of the 2008 GDP respectively. This result was unexpected and may well be attributed to the unavailability of annual data that would have informed a more robust assessment. Additionally, costs to the agriculture sector due to tropical cyclones were estimated to be \$6.9 million and \$6.2 million under the A2 and B2 scenarios, respectively.

There are a number of possible adaptation strategies that can be employed by the agriculture sector. The most attractive adaptation options, based on the benefit-cost ratio are: (1) Designing and implementation of holistic water management plans (2) Establishment of systems of food storage and (3) Establishment of early warning systems. Government policy should focus on the development of these adaptation options where they are not currently being pursued and strengthen those that have already been initiated, such as the mainstreaming of climate change issues in agricultural policy.

The analysis of the health sector placed focus on gastroenteritis, schistosomiasis, ciguatera poisoning, meningococcal meningitis, cardiovascular diseases, respiratory diseases and malnutrition. The results obtained for the A2 and B2 scenarios demonstrate the potential for climate change to add a substantial burden to the health system in the future, a factor that will further compound the country's vulnerability to other anticipated impacts of climate change. Specifically, it was determined that the overall Value of Statistical Lives impacts were higher under the A2 scenario than the B2 scenario.

A number of adaptation cost assumptions were employed to determine the damage cost estimates using benefit-cost analysis. The benefit-cost analysis suggests that expenditure on monitoring and information provision would be a highly efficient step in managing climate change and subsequent increases in disease incidence. Various locations in the world have developed forecasting systems for dengue fever and other vector-borne diseases that could be mirrored and implemented. Combining such macro-level policies with inexpensive micro-level behavioural changes may have the potential for pre-empting the re-establishment of dengue fever and other vector-borne epidemic cycles in Saint Lucia. Although temperature has the probability of generating significant excess mortality for cardiovascular and respiratory diseases, the power of temperature to increase mortality largely depends on the education of the population about the harmful effects of increasing temperatures and on the existing incidence of these two diseases. For these diseases it is also suggested that a mix of macro-level efforts and micro-level behavioural changes can be employed to relieve at least part of the threat that climate change poses to human health. The same principle applies for water and food-borne diseases, with the improvement of sanitation infrastructure complementing the strengthening of individual hygiene habits.

The results regarding the tourism sector imply that the tourism climatic index was likely to experience a significant downward shift in Saint Lucia under the A2 as well as the B2 scenario, indicative of deterioration in the suitability of the island for tourism. It is estimated that this shift in tourism features could

cost Saint Lucia about 5 times the 2009 GDP over a 40-year horizon. In addition to changes in climatic suitability for tourism, climate change is also likely to have important supply-side effects on species, ecosystems and landscapes. Two broad areas are: (1) coral reefs, due to their intimate link to tourism, and, (2) land loss, as most hotels tend to lie along the coastline. The damage related to coral reefs was estimated at US\$3.4 billion (3.6 times GDP in 2009) under the A2 scenario and US\$1.7 billion (1.6 times GDP in 2009) under the B2 scenario. The damage due to land loss arising from sea level rise was estimated at US\$3.5 billion (3.7 times GDP) under the A2 scenario and US\$3.2 billion (3.4 times GDP) under the B2 scenario.

Given the potential for significant damage to the industry a large number of potential adaptation measures were considered. Out of these a short-list of 9 potential options were selected by applying 10 evaluation criteria. Using benefit-cost analyses 3 options with positive ratios were put forward: (1) increased recommended design speeds for new tourism-related structures; (2) enhanced reef monitoring systems to provide early warning alerts of bleaching events, and, (3) deployment of artificial reefs or other fish-aggregating devices. While these options had positive benefit-cost ratios, other options were also recommended based on their non-tangible benefits. These include the employment of an irrigation network that allows for the recycling of waste water, development of national evacuation and rescue plans, providing retraining for displaced tourism workers and the revision of policies related to financing national tourism offices to accommodate the new climate realities.

1. INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report (IPCC, 2007) provided conclusive scientific evidence that human activity in the form of greenhouse gas emissions (GHG) is responsible for many observed climate changes, but noted that use of this knowledge to support decision making, manage risks and engage stakeholders is inadequate.

The nations of the Caribbean Community (CARICOM)¹ contribute less than 1% to global GHG emissions (approximately 0.33%²; World Resources Institute, 2008), yet these countries are expected to be among the earliest and most severely impacted by climate change in the coming decades, and are least able to adapt to the impacts (Nurse et al., 2009). A global scale analysis of the vulnerability of developing nations to sea level rise (SLR) by the World Bank in 2007 (Dasgupta et al., 2007) found that Caribbean nations were among the most impacted nations from climate change in terms of land area lost, and the age of population and Gross Domestic Product (GDP) affected.

In the Caribbean more than half of the population lives within 1.5 km of the shoreline (Mimura et al., 2007). Saint Lucia is particularly vulnerable to sea level rise and other changes in the climate, since the island's lowest point reaches zero feet at the Caribbean Sea and 950m at the highest point (Mt. Gimie). It is estimated that the majority of persons live in areas near the flatter coastal regions and are more likely to be affected by coastal inundation, inland flooding, greater storm surge damage and increased erosion.

Climate change is impacting on a wide range of sectors and assets of the Caribbean including biodiversity (corals and fisheries), tourism, transportation and agriculture sectors, water resources, human health and disaster management planning (IPCC, 2007; Dulal et al., 2009; Simpson et al., 2009). This report attempts to assess the economic impact of climate change on the agriculture, health and tourism sectors in Saint Lucia as these were deemed most vulnerable to climate change and key contributors to the country's GDP.

2. BRIEF REVIEW OF THE SECTORS

A. AGRICULTURE

While the agricultural sector still has a significant role in the Saint Lucia's economy, tourism is now the main source of income (CIA Factbook 2009). Agriculture's total contribution to GDP fell significantly from 11% in 1995 to 4% in 2009. It was replaced largely by the construction and "Other Services" (transport and communications, banking and insurance, real estate and producers of government services) sectors. The value of the agricultural sector has not only fallen in terms of its percentage contribution to GDP, but also in terms of its absolute value. In 1995, this sector was worth approximately EC\$120 million, but by 2009, it was worth only approximately EC\$50 million. From 1995 the banana sub-sector accounted for about 67% of agricultural GDP (actual GDP values shown), followed by "Other Crops" (root, vegetable and tree crops) at approximately 20%, the Fishing, Livestock and Forestry, respectively. However, by 2009, banana's contribution fell to approximately 40% of agricultural GDP, replaced largely by fishing and other crops, which now accounts for approximately 23% each.

Annual growth rates of each of the agricultural sub-sectors also showed a large degree of variability, especially for bananas, which had the largest changes historically. This may be a reflection of production 'shocks' such as the occurrence of a tropical cyclone, or economic 'shocks', which may have affected investment in the sector. St Lucia is the largest of the Windward Islands banana exporters, and has historically had this dominance. In 2009, banana exports from Saint Lucia were 33,925 tonnes, which accounted for 71.39% of total Windward Islands banana exports (Ministry of Finance, Economic Affairs and

¹Antigua and Barbuda, The Bahamas, Saint Lucia, Belize, Dominica, Grenada, Saint Lucia, Haiti, Jamaica, Montserrat, Saint Lucia, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago.

²The Caribbean Islands contribute about 6% of the total emissions from the Latin America and Caribbean Region grouping and the Latin America and Caribbean Region is estimated to generate 5.5% of global CO₂ emissions in 2001 (UNEP, 2002).

National Development, Saint Lucia, 2010). With regard to the fisheries subsector, fish landings in Saint Lucia showed an overall decline in the 1980s, but during the 1990s, the quantity of landings increased sharply, as the government began to regard fisheries as an underexploited resource. Policies and other measures were subsequently put in place to spur investment in this sub-sector and improve the livelihoods of fishing communities. In the 2000s, fish landings fluctuated, but remained high since they were further enhanced by the introduction of Fish Aggregating Devices (FADs), which provide an easy way of “finding” fish, reducing search time and the associated costs.

B. HEALTH

Saint Lucia has a relatively low birth rate, long life expectancy, and appears to be advancing towards a stable population distribution (PAHO, 2007, 2009). Saint Lucia provides good vaccine coverage and although the health sector receives substantial donor support, it still suffers from a shortage of trained staff (PAHO, 2009).

The Ministry of Health, Family Affairs, and Gender Relations is responsible for the overall organization of resources and services for the health sector. Public sector health services are provided through a network of primary and secondary care facilities. Primary health care services are decentralized and mainly provided through 34 health centres spread throughout the island. Secondary care can be accessed at the main hospital, quasi-public, and privately owned institutions. In 2008, the crude birth rate was estimated at 18.8 live births per 1,000 population and the crude death rate at 6.71 deaths per 1,000 population. Life expectancy at birth was estimated at 72.0 years for males and 75.8 years for females. Total fertility rate was around 2.2 children per woman and infant mortality rate around 15.0 deaths per 1,000 live births.

C. TOURISM

Saint Lucia is one of the largest tourism destinations in the region. This sector emerged as the main engine of economic growth since the decline of the banana industry on the island. The island’s tourism product is based on the traditional Caribbean assets of sun, sea and sand. However, the island also benefits from being marketed as a leading destination for weddings and honeymoons. With 19,000 acres of rainforest acting as a habitat for rare birds and plants, the island also provides numerous activities for more adventurous tourists. There are also a number of dive sites scattered around the island. During the slower periods, the tourist industry also receives a significant boost from the Saint Lucia Jazz festival that is usually held in May and the Saint Lucia Carnival that occurs annually in July. As an indicator of the importance of the tourism industry to Saint Lucia, foreign exchange earnings generated by this sector are almost four times that of merchandise exports.

While total visitor arrivals increased in 2009, this was largely due to higher cruise-ship passengers, as stay-over arrivals registered declines in most major markets. Total visitor arrivals in 2009 were estimated at 1,014,761 compared to 947,445 in 2008 and 747,308 in 2005. Despite the increase in arrivals, earnings from the industry were down from the previous year. In 2009, total visitor expenditure was estimated at US\$297.8 million compared to US\$312.7 million in 2008 and US\$383.5 million in 2005. The majority of these visitors were cruise ship passengers, which were estimated at 699,306 in 2009 or 13% higher than the reported figure in 2008 and almost 77% higher than in 2005. The increase in cruise ship passengers was related to a rising number of cruise ships including the island on their ports of call. In 2009, an estimated 397 ships docked at the port in Saint Lucia, about 139 more than in 2005.

The tourism industry in Saint Lucia, like most of the Caribbean, reported a reduction in the number of stay-over visitors in 2009. During 2009, arrivals to the island were 278,491 or almost 6% lower than the previous year. The last five years has been particularly difficult for the island, as arrivals have declined to less than 300,000 after reaching as high as 317,939 in 2005³. The majority of visitors coming to the island are from the US, UK and the Caribbean. All three of these major markets have reported declines in the last five years due to increasing competition from other Caribbean destinations. The island is seeking to reposition itself away from the mass market, to appeal more to an up market/green clientele.

³ Statistics available at Caribbean Tourism Organisation website: <http://www.onecaribbean.org/statistics/tourismstats/>

3. FUTURE CLIMATE SCENARIOS

The IPCC has confirmed that global warming during the twentieth century has resulted from rising concentrations of anthropogenic GHG with a 90% level of confidence. The increase in average air and ocean temperatures, the melting of ice caps and snow fields and the rise in average sea levels are unequivocal evidence of climate system warming (IPCC, 2007).

ECLAC, in consultation with other key members of the Caribbean community, recommended the use of the IPCC emissions scenarios A2 and B2 for the assessment of the economic impact of climate change on Caribbean economies since these scenarios were deemed to be the most consistent with the type of development observed in the region. The general consensus of the global scientific committee, and a significant conclusion of the February 2007 report issued by the IPCC (2007), is that global temperatures are increasing and this increase is driving a number of phenomena. The Caribbean thus faces inevitable climate change during the 21st century, which may have long-term effects on the sustainable growth of the island states (table 1).

Table 1: Predicted climate scenarios for the Caribbean region by 2099

Parameter	Predicted Change
Air and sea surface temperature	Rise of 1.4 to 3.2°C
Sea Level Rise	Rise of 0.18 to 0.59* m
Ocean acidity	Reduction in pH of 0.14 – 0.35 units making the oceans more acid
Tropical Storms and Hurricanes	Likely (>66% certainty) increase in hurricane intensity with larger peak wind speeds and heavier precipitation
Precipitation	No clear predictions for the region, although most models predict a decrease in summer (June, July, August) precipitation in the Greater Antilles
Extreme weather events	Number of flood events expected to increase Picture for droughts is unclear regionally
*The prediction does not include the full effect of changes in the ice sheets in Antarctica and Greenland, therefore the upper values could increase.	

Source: Inter-Governmental Panel on Climate Change (2007)

4. METHODOLOGIES

While a largely similar approach was undertaken to analyse each sector on the whole (economic impact analysis, forecasting cost until 2050 and costing adaptation strategies), the unique characteristics and data availability for each sector necessitated the use of different methodologies with regard to the economic impact analysis.

1). Agriculture. An augmented production function was the general framework employed to model the effects of climate change on agricultural output in the sub-sectors of bananas and other crops (root, vegetable and tree). In an attempt to identify the effect of climate change, the analysis employed the temperature and precipitation variables and controls for price effects. The fisheries sub-sector was examined using existing information on fish landings.

Given the long-term nature of climate change impact assessments, it is common to calculate the present value of the impacts estimated over the 50- or 100-year horizon. This study uses 1%, 2%, and 4% social discount rates to better gauge the sensitivity of the economic impact estimates of climate change on the sectors under review, but recognizes the need to regularly review the appropriateness of this range of

interest rates in light of changing economic and capital market circumstances, both domestic and international.

Costing of the adaptation strategies in each of the sectors was undertaken by using benefit-cost analysis or multicriteria analysis.

2). Health. The nature of this sector required a different analytical approach to costing the economic impact of climate change. As a result a dose response-based rapid integrative assessment approach to the project was implemented to value the excess disease burden caused by climate change. An outline of the methodology is shown below:

- 1) Estimating climate variables under climate change;
- 2) Identifying the time line for the study;
- 3) Identifying potential areas of impact;
- 4) Identifying areas of impact that can be quantified;
- 5) Quantifying those impacts;
- 6) Comparing those impacts to a baseline representing a world without climate change;
- 7) Valuing this excess disease burden.

These steps are divided into stages relating to preliminary assumptions, baseline projections, climate change scenario projections and endpoint valuation.

3). Tourism. Three layers of economic impact analysis were employed to evaluate the tourism sector. The first focused on tourist arrivals, where climate (represented by temperature, humidity, precipitation, wind speed and duration of sunshine) and economic data were modeled using regression analysis. The second addressed climate related impacts on coral reef-related tourism and the third assessed the impact of SLR and related impacts, such as land and infrastructure loss.

5. ECONOMIC IMPACT ASSESSMENT OF CLIMATE CHANGE ON THE AGRICULTURE, HEALTH AND TOURISM SECTORS

A. AGRICULTURE

Analysis of the agriculture sector involved the analysis of three significant sub-sectors: bananas, other crops and fisheries. These key subsectors are expected to have mixed impacts under the A2 and B2 scenarios. Banana, fisheries and root crop outputs are expected to fall with climate change, but tree crop and vegetable production is expected to rise. In aggregate, in every decade up to 2050, these sub-sectors combined are expected to experience a gain under climate change, all scenarios, with the highest gains under the A2 scenario. By 2050, the cumulative gain under the A2 scenario is calculated as approximately US\$389.35 m and approximately US\$310.58 m under the B2 scenario (table 2).

Table 2: Present Value of Cumulative Losses for Agricultural Yield Relative to the Baseline (US\$ million)

Rate	2020		2030		2040		2050	
	A2	B2	A2	B2	A2	B2	A2	B2
1%	-11.08	57.04	-98.71	-54.56	-254.58	-187.23	-389.35	-310.58
2%	-7.11	51.97	-79.80	-44.27	-197.56	-144.97	-291.42	-229.40
4%	-0.77	43.36	-51.07	-28.60	-118.94	-87.27	-165.01	-127.31

Source: ECLAC, 2011

Based on the historical rates of tropical cyclones since 1981, there is, on average, a cyclone every four years. Based on these assumptions, the expected additional damage due to the increased intensity of tropical cyclones (not the total damage caused by the cyclone) is calculated and presented in table 3. The

results indicate that by 2050, additional losses due to an increased intensity of tropical cyclones is expected to be US\$6.9 million under the A2 scenario and US\$6.2 million under the B2 scenario, with a 1% discount rate.

Table 3: Present Value of Tropical Cyclone Cumulative Losses (US\$ mil)

Rate	2020		2030		2040		2050	
	A2	B2	A2	B2	A2	B2	A2	B2
1%	0.904	0.814	2.143	1.929	4.757	4.282	6.904	6.213
2%	0.836	0.752	1.882	1.694	3.881	3.493	5.371	4.834
4%	0.718	0.646	1.468	1.321	2.650	2.385	3.377	3.039

Source: ECLAC, 2011

B. HEALTH

The cumulative excess disease and mortality burden in 2050 for Saint Lucia is shown in table 4. Although the projected impact for Saint Lucia appears to be nontrivial, it must be noted that these numbers depend on the assumptions made in the study and are burdened by the uncertainties inherent to the data. Additionally, this projection of excess disease implicitly holds most socio-economic variables constant over the 2010-2050 period.

Table 4: The projected total excess disease burden 2010-2050

2010-2050 Total Mean Disease Burden Anomaly		Morbidity Anomaly		Mortality Anomaly	
Diseases		A2	B2	A2	B2
Malaria		4	4	52	52
Dengue Fever		209	168	3	3
Gastroenteritis	<5	24,237	19,180		
	>5	5,193	4,517		
	Total Pop				
Schistosomiasis		50	40		
Leptospirosis		0	0	0	0
Ciguatera Poisoning		0	0	0	0
Meningococcal Meningitis				29	23
Cardio. Diseases				4,306	3,623
Respiratory Disease		12,279	9,894		
Malnutrition		54	44	182	146
Extreme Events (# affected, deaths)		30,594	24,652	30	24

Notes: Values <1 show 2 decimal places. Values >1 are rounded to the nearest whole number. Unless otherwise indicated, the units are number of cases (morbidity) or deaths (mortality).

Source: ECLAC, 2011a

Table 5 provides an overview of the extra Value of Statistical Lives (VSL) burden resulting from climate change under each of the two scenarios considered. The results in the table show the maximum range of the mean extra VSL burden generated by climate change under two climate change scenarios. The top number in each cell shows the lower bound calculated for that particular category of impact. Each lower bound was calculated using the 4% discount rate. The bottom number in each cell shows the upper bound, which was calculated using the 1% discount rate. The overall VSL impacts are smaller under scenario B2 than A2. The values are summarised for the following diseases:

- Gastroenteritis

- Schistosomiasis
- Ciguatera Poisoning
- Meningococcal Meningitis
- Cardiovascular Diseases
- Respiratory Diseases
- Malnutrition

Table 5: VSL anomaly burden range 2010-2050

Mean Cumulative VSL Anomaly Burden 2010-2050	A2			B2		
	Morbidity	Mortality	Total	Morbidity	Mortality	Total
Range Type	4% DR	4% DR	4% DR	4% DR	4% DR	4% DR
	–	–	–	–	–	–
Cumulative PV Range	1% DR	1% DR	1% DR	1% DR	1% DR	1% DR
	35,534,534	3,807,482,630	3,843,017,164	29,259,230	3,259,432,047	3,288,691,276
Mean Annual Range	–	–	–	–	–	–
	68,830,440	7,411,196,574	7,480,027,014	55,009,417	6,180,799,493	6,235,808,910
Mean Annual Range per Capita	866,696	92,865,430	93,732,126	713,640	79,498,343	80,211,982
	–	–	–	–	–	–
Mean Annual Range per Capita	1,678,791	180,760,892	182,439,683	1,341,693	150,751,207	152,092,900
	4	449	453	4	396	400
Mean Annual Range per Capita	–	–	–	–	–	–
	8	874	882	7	751	758

Source: ECLAC, 2011a

The PPP-adjusted US\$ values shown in table 5, reveal a nontrivial impact, especially considering that the statistical life costs represent only the value of the indirect, nonmarket costs of human life part of the total economic costs that will be incurred by each of these fatalities or incidence of disease.⁴ It must be noted that the combination of underreported baseline health data and the assumptions made behind the disease projection efforts may have yielded results which represent lower bound economic costs. The extent to which they are actually lower bound figures, however, depends on several variables, including the VSL time series utilized in the projections.

C. TOURISM

Three distinct scenarios⁵ were considered in the context of tourist arrivals, namely the A2, B2 and BAU⁶. Forecasts of the change in tourist arrivals likely due to climate change are provided in table 6. The results suggest that under the A2 scenario cumulative arrivals are likely to be 33.6 million compared to 34.6 million for the B2 scenario relative to 38.2 million under the BAU scenario. Based on a discount rate of 1%, the projected earnings of the industry under the BAU scenario are US\$43.8 billion. Under the A2 scenario, however, the earnings from the industry fall to US\$38.6 billion, a cumulative loss of 5.2 billion or almost 5 times 2009 GDP.

⁴ Examples of the direct costs were found for a handful of the diseases considered here. See <http://www.dcp2.org/page/main/BrowseInterventions.html> & Ebi (2008), Markandya and Chiabai (2009). However, the dcp2.org data was mostly displayed in units of cost per DALY avoided, which made it unusable in this study. Also, as requests for data on the actual expenditures for these various conditions in Saint Lucia proved unsuccessful, and given that the Caribbean as a region contains countries with widely varying purchasing power, it was deemed that there wasn't enough information to justify transferring one set of the other direct costs to this study.

⁵ For an explanation of the IPCC climate scenarios see: <http://sedac.ciesin.columbia.edu/ddc/sres>

⁶ The BAU scenario is a linear extrapolation of the time series of tourist arrivals.

Table 6: Forecasted arrivals under various climate change scenarios

Arrivals	A2	B2	BAU
2008-2020	3802891	3912211	4240253
2021-2030	5696107	5871781	6420754
2031-2040	9215774	9492190	10458732
2041-2050	14895507	15354062	17036173
Total	33610278	34630244	38155912
Earnings (US\$ Millions)	A2	B2	BAU
2008-2020	4,826.30	4,965.04	5,381.36
2021-2030	7,229.01	7,451.96	8,148.67
2031-2040	11,695.87	12,046.67	13,273.32
2041-2050	18,904.10	19,486.06	21,620.85
Total	42,655.27	43,949.73	48,424.20

Source: ECLAC, 2011b

The results for the effect of climate change on coral reefs in Saint Lucia under the A2, B2 and BAU scenarios are provided in table 7. The value of damage for Saint Lucia were quite large due to the significant contribution made by coral reefs to the Saint Lucian economy: using a discount rate of 1%, the value of coral reefs affected by 2050 is likely to be US\$3.4 billion (3.6 times GDP in 2009) under the A2 scenario and US\$1.7 billion (1.6 times GDP in 2009).

Table 7: Value of coral reef damage

	Value (US\$ mil)		
	A2	B2	BAU
Nominal	5120	2560	3840

Notes: Coral reef contributions in Saint Lucia are taken from Burke et al. (2008).

Source: ECLAC, 2011b

The coastline in tourism destinations is a major part of the product. Beachfront properties, often sell for more than those further inland. In addition, most major aspects of the economy also tend to be located along the coastline (government offices and electricity generation plants). The estimated annual and capital costs of damage to infrastructure are provided in table 8. For Saint Lucia the annual costs of sea level rise was estimated at US\$41 million (4% of GDP) under the mid range scenario and US\$80 million (8.5% of GDP) in the high range scenario. In addition to these annual costs, the capital costs associated with sea level rise ranged between US\$367 million (39% of GDP) and US\$709 million (75% of GDP) under the two scenarios.

Table 8: Annual and capital costs of sea level rise

	GDP (US \$mil)	Annual Costs (US\$ mil)				Capital Costs (US\$ mil)								
		Tourism	Agriculture	Industry	Total Annual Costs (US \$mil)	Airports	Ports	Roads	Power Plants	Property	Tourist Resorts	Dry land loss	Wetland loss	Total
Mid range sea level rise	7438	41	0	0	42	42	57	0	n.a.	16	134	118	n.a.	367
High range sea level rise	8023	80	1	0	81	62	91	0	n.a.	39	300	217	n.a.	709

Source: Simpson et al. (2010) Note: n.a. indicates not available.

The estimated value of land loss in Saint Lucia is provided in table 9. The value of land loss due to sea level rise was US\$3.2 billion (3.4 times GDP) under the B2 scenario and US\$3.5 billion (3.7 times GDP) under the A2 scenario.

Table 9: Estimated value of land loss due to sea level rise

	A2	B2
Land Area (km)	616	616
Expected Land Loss (km)	6.16	6.16
Nominal Value of Land Loss (US\$ mil)	5,190.9	3,210.9
Present Value of Land Loss (US\$ mil); 1% discount rate	3,486.50	3,210.29
Present Value of Land Loss (US\$ mil); 2% discount rate	2,350.92	1,453.91
Present Value of Land Loss (US\$ mil); 4% discount rate	1,081.21	668.67

Source: ECLAC, 2011b

Given the above estimates, the total cost of climate change to the tourism product in Saint Lucia was estimated at US\$12.1 billion (12 times 2009 GDP) under the A2 scenario and US\$7.9 billion for the B2 scenario (3.6 times 2009 GDP) (table 10). Given the significant effects likely to arise due to climate change, adaptation to climate change must be viewed not just as a means of insurance but also as an imperative to ensure the viability of Caribbean economies.

Table 10: Total estimated impact of climate change on tourism (US\$ millions)

Estimated Value of Damage	1% discount rate		2% discount rate		4% discount rate	
	A2	B2	A2	B2	A2	B2
Tourism	(5222.53)	(4050.68)	(4732.53)	(3670.63)	(3897.28)	(3022.79)
Coral Reefs	(3438.86)	(1719.43)	(2318.80)	(1159.40)	(1066.44)	(533.22)
Land	(3486.50)	(2156.20)	(2350.92)	(1453.91)	(1081.21)	(668.67)
Total	(12147.90)	(7926.32)	(9402.25)	(6283.94)	(6044.93)	(4224.68)

Source: ECLAC, 2011b

6. ADAPTATION STRATEGIES

A. APPROACHES TO ADAPTATION IN SAINT LUCIA

Saint Lucia has begun to seriously address potential adaptation options. It is one of the few islands in the region to have a website⁷ specifically dedicated to the issue of climate change. Saint Lucia has already prepared a national climate change policy, which was tabled and approved by parliament (Government of Saint Lucia, 2005). The aim of the adaptation policy is to “foster and guide a national process of addressing the short, medium and long term effects of climate change in a coordinated, holistic and participatory manner in order to ensure that, to the greatest extent possible, the quality of life of the people of Saint Lucia, and opportunities for sustainable development are not compromised.” With regard to coastal and marine resources the document notes that the Government of Saint Lucia will adopt short, medium and long-term measures to protect coastal lands (coastal defence structures, enforcement of setbacks and restoration of coastal wetlands) as well as promote alternative fishery and resource use activities (mariculture). Given the importance of tourism to the national economy, the document also has a section on tourism. However, it was very weak on specific details: the main policy outlined in the document suggested that appropriate physical planning guidelines are adhered to (coastal setbacks). As it relates to institutional support, the document also called for the formation of a Coastal Zone Unit, which was set-up in 2005, as well as the incorporation of climate change considerations into Government’s budgetary process.

⁷ <http://www.climatechange.gov.lc/index.htm>.

Effective 1 February 2007, the Caribbean Community Climate Change Centre (CCCCC) began work on the Global Environment Fund (GEF) project entitled the Special Programme for Adaptation to Climate Change (SPACC). The objective of the project was to assist Caribbean islands with specific projects related to adaptation. In Saint Lucia, the project attempted to examine the potential impact of climate change on design wind speeds (Vickery, 2008). Given the likelihood of a greater number of category 4 and 5 hurricanes passing near the island, changes in the design of buildings and other structures are required. Assuming that the relative level of accepted risk remains unchanged, engineers will then need to increase their design wind speeds to compensate for the increased risk (estimated at 15%). These new building standards have been used to retrofit the Marchand Community Centre, which serves as a hurricane shelter.

Another key threat associated with climate change is the decreased availability of fresh water. As a result, Saint Lucia has instituted a pilot project in the Vieux Fort area. Under the SPACC, the Coconut Bay Beach Resort and Spa will be part of an initiative aimed at conserving water in the tourism industry as well as expanding the amount of water available to residents in the area (CCCCC, 2010). Some of the measures include the construction of two 25,000 L water storage tanks, with a pipe network to collect rainwater from the roofs of the resort that will be used for toilets and pool top-up as well as the construction of an irrigation network for the recycling of sewer wastewater for landscaping.

B. COSTING ADAPTATION STRATEGIES IN THE AGRICULTURE SECTOR

Eleven (11) potential adaptation options were identified for the agriculture sector and the present value of each option was calculated using a 4% discount rate (table 11). Based on the benefit-cost ratios, the information in table 6.3 indicates that the most attractive adaptation options are options 6, 3 and 10.

Table 11: Benefit-Cost Analysis of Adaptation Strategies for the Agriculture Sector (US\$ millions)

Options	Details	Cumulative Present Value of Benefits	Cumulative Present Value of Costs	Benefit-Cost Ratio	Net Benefits	Payback Period (years)
Option 1	Use water saving irrigation systems and water management systems e.g. drip irrigation	360.97	53.68	6.7	307.28	1.42
Option 2	Promote water conservation – install on-farm water harvesting off roof tops	144.38	16.61	8.7	127.77	0.07
Option 3	Design and implement holistic water management plans for all competing uses	28.09	\$1.00	28.0	27.09	0.14
Option 4	Repair/maintain existing dams	117.52	24.30	4.8	93.21	0.21
Option 5	Mainstream climate change issues into agricultural management	188.22	27.11	6.9	161.10	0.13
Option 6	Alter crop calendar for short-term crops	0.93	97.01	.96	0.93	0.00
Option 7	Adopt improved technologies for soil conservation	236.13	94.28	2.5	141.85	0.42
Option 8	Establish systems of food storage	167.49	7.18	23.3	160.30	0.04
Option 9	Establish early warning systems and disaster management plans for farmers.	97.53	7.23	13.5	90.29	0.60
Option 10	Build on-farm water storage (ponds, tanks etc)	31.83	60.99	0.5	(29.16)	1.91
Option 11	Installation of Greenhouses	37.33	7.35	5.1	29.98	0.13

Source: ECLAC, 2011

The final adaptation strategies chosen by the government should include these assessments, the omitted intangible benefits, as well as the provision of other social goals such as employment generation and enhanced food security.

C. COSTING ADAPTATION STRATEGIES IN THE HEALTH SECTOR

With regard to the diseases studied, if treatment of cases takes place under the A2 and B2 scenarios, the costs that are likely to be incurred are presented in table 12. While there are considerable differences in treatment methods for each of the relevant Internationally Classification of Diseases (ICD) codes, a conservative standard cost per case of \$300 (2010) rising by 10% per annum to 2050 has been adopted. Unsurprisingly, the highest aggregate treatment cost burdens are associated with gastroenteritis and cardio and respiratory complications.

Table 12: Estimated present value treatment cost for A2 and B2 relative to baseline present value 2010-2050 (US\$)

Discount Rate	A2				B2			
	Cardio and respiratory impacts	Malaria	Dengue	Gastro.	Cardio and respiratory impacts	Malaria	Dengue	Gastro
1%	592,155	31214	33,601	3,372,881	370,06	30449	9,494	2,070,204
2%	478,751	24664	28,051	2,729,161	310,460	23964	9,591	1,742,050
4%	324,759	16044	20,140	1,854,028	224,674	15447	8,888	1,266,987

Source: ECLAC, 2011a

An adaptation strategy based on monitoring and public information, i.e. relatively low cost “no regrets” interventions, is suggested for the health sector.

D. COSTING ADAPTATION STRATEGIES IN THE TOURISM SECTOR

Based on 10 evaluation criteria and feedback received from local experts, a short-list of potential adaptation options for the tourism sector was derived. Table 13 provides a summary of the benefit-cost analyses conducted for the study. Of the 9 options considered, 3 had benefit cost ratios above 1 over a 20-year horizon: options 1, 4 and 5. While some of the other options may have ratios below 1, once non-tangible benefits are included in the analysis it is quite likely that these ratios might easily rise above 1. For example, while retraining workers might not be cost effective, the option might still be considered viable in terms of the well being of the country’s citizens.

Table 13: Benefit-Cost Analysis of Selected Options for the Tourism Sector

US\$ Mil	Details	1 %		2%		4%	
		Benefit Cost Ratio	Payback Period (years)	Benefit Cost Ratio	Payback Period (years)	Benefit Cost Ratio	Payback Period (years)
Option 1	Increase recommended design wind speeds for new tourism-related structures	1.5	14	1.4	14	1.3	15

Option 2	Construction of water storage tanks	0.4	-	0.4	-	0.4	-
Option 3	Irrigation network that allows for the recycling of waste water	0.3	-	0.3	-	0.3	-
Option 4	Enhanced reef monitoring systems to provide early warning alerts of bleaching events	4.5	3	4.4	3	4.0	3
Option 5	Artificial reefs or fish-aggregating devices	1.9	6	1.8	7	1.7	7
Option 6	Develop national evacuation and rescue plans	0.9	-	0.9	-	0.8	-
Option 7	Introduction of alternative attractions	0.0	-	0.0	-	0.0	-
Option 8	Provide re-training for displaced tourism workers	0.4	-	0.4	-	0.4	-
Option 9	Revise policies related to financing national tourism offices to accommodate the new climatic realities	0.1	-	0.1	-	0.1	-

Source: ECLAC, 2011b

7. CONCLUSIONS AND POLICY RECOMMENDATIONS

Similar to other countries in the region, Saint Lucia is at risk from the economic impact of climate change on its tourism, health and agriculture sectors. It is one of the few islands in the region to have a website specifically dedicated to the issue of climate change and has already prepared a national climate change policy, which was tabled and approved by parliament.

The key subsectors in agriculture are expected to have mixed impacts under the A2 and B2 scenarios. Banana, fisheries and root crop outputs are expected to fall with climate change, but tree crop and vegetable production is expected to rise. In aggregate, in every decade up to 2050, these sub-sectors combined are expected to experience a gain under climate change, all scenarios, with the highest gains under A2. By 2050, the cumulative gain under A2 is calculated as approximately \$389.35 mil and approximately \$310.58 mil under B2, which represents 17.93% and 14.30% of the 2008 GDP. Additionally, costs to the agriculture sector due to tropical cyclones are estimated to be \$6.9 million and \$6.2 million under the A2 and B2 scenarios, respectively.

There are a number of possible adaptation strategies that can be employed by the agriculture sector. The most attractive adaptation options, based on the Benefit-Cost Ratio are: (1) Design and implement holistic water management plans (2) Establish systems of food storage and (3) Establish early warning systems. Government policy should focus on the development of these adaptation options where they are not currently being pursued, and strengthen those that have already been initiated, such as the mainstreaming of climate change issues in agricultural policy.

The analysis of the health sector focused gastroenteritis, schistosomiasis, ciguatera poisoning, meningococcal meningitis, cardiovascular diseases, respiratory diseases and malnutrition. The results obtained for the A2 and B2 scenarios demonstrates the potential for climate change to add a substantial

burden to the health system in the future, a factor that will further compound the country's vulnerability to other anticipated impacts of climate change. Specifically, it was determined that the overall Value of Statistical Lives impacts were smaller under the B2 scenario as compared to the A2 scenario.

A number of adaptation cost assumptions were employed to determine the damage cost estimates using benefit-cost analysis. The evaluation suggests that spending on monitoring and information systems would be highly efficient as a step to managing climate change and subsequent increases in disease incidence. Various locations in the world have developed forecasting systems for dengue fever and other vector-borne diseases that could be mirrored and implemented either nationally or regionally. Combining such macro-level policies with inexpensive micro-level behavioural changes has the potential to prevent the re-establishment of dengue fever and other vector-borne epidemic cycles in Saint Lucia. A number of adaptation cost assumptions were employed to determine the damage cost estimates using benefit-cost analysis. The benefit-cost analysis suggests that spending on monitoring and information provision would be a highly efficient step in managing climate change and subsequent increases in disease incidence. Various locations in the world have developed forecasting systems for dengue fever and other vector-borne diseases that could be mirrored and implemented. Combining such macro-level policies with inexpensive micro-level behavioural changes may have the potential for pre-empting the re-establishment of dengue fever and other vector-borne epidemic cycles on Saint Lucia. Although temperature has the probability of generating significant excess mortality for cardiovascular and respiratory diseases, the power of temperature to increase mortality largely depends on the education of the population on the harmful effects of increasing temperatures and on the existing incidence of these two diseases. For these diseases it is also suggested that a mix of macro-level efforts and micro-level behavioural changes can be employed to relieve at least part of the threat that climate change poses to human health. The same principle applies for water and food-borne diseases, with the strengthening of sanitation infrastructure complemented by improved individual hygiene habits.

The results regarding the tourism sector imply that the tourism climatic index was likely to experience a significant downward shift in Saint Lucia under the A2 as well as B2 scenarios, indicative of deterioration in the suitability of the island for tourism. It is estimated that this shift in tourism features could cost Saint Lucia about 5 times 2009 GDP over a 40-year horizon. In addition to changes in the climatic suitability for tourism, climate change is also likely to have important supply-side effects on species, ecosystems and landscapes. The damage related to coral reefs was US\$3.4 billion (3.6 times GDP in 2009) under the A2 scenario and US\$1.7 billion (1.6 times GDP in 2009). The damage due to land loss arising from sea level rise was US\$3.2 billion (3.4 times GDP) under the B2 scenario and US\$3.5 billion (3.7 times GDP) under the A2 scenario. The total cost of climate change to the tourism industry was projected to be US\$12.1 billion (12 times 2009 GDP) under the A2 scenario and US\$7.9 billion for the B2 scenario (8 times 2009 GDP).

Given the potential for significant damage to the industry a large number of potential mitigation measures were considered. Out of these a short-list of 9 potential options were selected using 10 evaluation criteria. Using benefit-cost analyses 3 options with positive ratios were put forward: (1) increased recommended design speeds for new tourism-related structures; (2) enhanced reef monitoring systems to provide early warning alerts of bleaching events, and; (3) deployment of artificial reefs or fish-aggregating devices. While these options had positive benefit-cost ratios, other options are also recommended based on their non-tangible benefits: irrigation network that allows for the recycling of waste water, development of national evacuation and rescue plans, providing retraining for displaced tourism workers and the revision of policies related to financing national tourism offices to accommodate the new climatic realities.

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