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

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EXECUTIVE SUMMARY

This report analyses the agriculture, health and tourism sectors in Jamaica 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 on Jamaica. It also has the potential to provide essential input for identifying and preparing policies and strategies to help move the Region closer to solving problems associated with climate change and attaining individual and regional sustainable development goals. Some of the key anticipated manifestations 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 was also undertaken for each sector using standard evaluation techniques.

The outcomes from investigating the agriculture sector indicate that for the sugar-cane subsector the harvests under both the A2 and B2 scenarios decrease at first and then increase as the mid-century mark is approached. With respect to the yam subsector the results indicate that the yield of yam will increase from 17.4 to 23.1 tonnes per hectare (33%) under the A2 scenario, and 18.4 to 23.9 (30%) tonnes per hectare under the B2 scenario over the period 2011 to 2050. Similar to the forecasts for yam, the results for escallion suggest that yields will continue to increase to mid-century.

Adaptation in the sugar cane sub-sector could involve replanting and irrigation that appear to generate net benefits at the three selected discount rates for the A2 scenario, but only at a discount rate of 1% for the B2 scenario. For yam and escallion, investment in irrigation will earn significant net benefits for both the A2 and B2 scenarios at the three selected rates of discount. It is recommended that if adaptation strategies are part of a package of strategies for improving efficiency and hence enhancing competitiveness, then the yields of each crop can be raised sufficiently to warrant investment in adaptation to climate change.

The analysis of the health sector demonstrates the potential for climate change to add a substantial burden to the future health systems in Jamaica, something that that will only compound the country's vulnerability to other anticipated impacts of climate change. The results clearly show that the incidence of dengue fever will increase if climate change continues unabated, with more cases projected for the A2 scenario than the B2. The models predicted a decrease in the incidence of gastroenteritis and leptospirosis with climate change, indicating that Jamaica will benefit from climate change with a reduction in the number of cases of gastroenteritis and leptospirosis.

Due to the long time horizon anticipated for climate change, Jamaica should start implementing adaptation strategies focused on the health sector by promoting an enabling environment, strengthening communities, strengthening the monitoring, surveillance and response systems and integrating adaptation into development plans and actions. Small-island developing states like Jamaica must be proactive in implementing adaptation strategies, which will reduce the risk of climate change. On the global stage the country must continue to agitate for the implementation of the mitigation strategies for developed countries as outlined in the Kyoto protocol.

The results regarding the tourism sector suggest that the sector is likely to incur losses due to climate change, the most significant of which is under the A2 scenario. Climatic features, such as temperature and precipitation, will affect the demand for tourism in Jamaica. By 2050 the industry is expected to lose US$ 132.2 million and 106.1 million under the A2 and B2 scenarios, respectively. In addition to changes in the climatic suitability for tourism, climate change is also likely to have important supply-side effects from extreme events and acidification of the ocean. The expected loss from extreme events is projected to be approximately US$ 5.48 billion (A2) and US$ 4.71 billion (B2). Even more devastating is the effect of ocean acidification on the tourism sector. The analysis shows that US$ 7.95 billion (A2) and US$ 7.04 billion is expected to be lost by mid-century.

The benefit-cost analysis indicates that most of the adaptation strategies are expected to produce negative net benefits, and it is highly likely that the cost burden would have to be carried by the state. The

options that generated positive ratios were: redesigning and retrofitting all relevant tourism facilities, restoring corals and educating the public and developing rescue and evacuation plans. Given the relative importance of tourism to the macroeconomy one possible option is to seek assistance from multilateral funding agencies. It is recommended that the government first undertake a detailed analysis of the vulnerability of each sector and, in particular tourism, to climate change. Further, more realistic socio-economic scenarios should be developed so as to inform future benefit-cost analysis.

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 (GHG) emissions 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). The IPCC report states that small islands are particularly vulnerable to the effects of climate change, including sea-level rise and extreme events (IPCC 2007). Climate change will expose Jamaica to rising sea levels, warmer temperatures, increased incidences of vector borne diseases, drought and possibly more intense, if less frequent, rainfall and more intense hurricanes. Deterioration in coastal systems will be exacerbated by inundation of storm surge, erosion and other coastal hazards (UNEP, 2002).

Climate change is impacting on a wide range of sectors and assets of the Caribbean including its' 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 Jamaica 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

In Jamaica, five parishes accounted for almost 57% of the cultivated farmland in 2007, according to the agricultural census of 2007 (Clarendon, St. Catherine, St. Ann, Westmoreland and St. Elizabeth), with the first two being geographically adjacent to the Kingston Metropolitan Area, the largest urban concentration in the country. Total acreage in production declined by 20% over the decade 1996-2007. Employment in agriculture has been in secular decline and was almost continuous after 1977. The FAO has constructed a production index for agriculture, and estimated it for the years 1961 to 2007. Production showed an average growth rate of 1.5% per annum for the entire sector. The decade of the 1990s had the highest growth rate, exactly twice the annual average for the entire period reviewed. Even as the production index suggested that the agricultural sector grew fairly steadily over the 45-year period after 1961, its contribution to GDP was in secular decline between 1970 and 2005.

The share of domestic agriculture in GDP has been larger than that of export agriculture since 1971, but the gap between the two has since increased. The pattern of decline of domestic agriculture mirrored, and probably accounted for, the decline in the contribution of the sector as a whole to GDP. The smaller sub-sector, export agriculture, declined at a slower rate, and remained stable at around 1% of GDP. About 45% of the contribution of domestic agriculture to GDP was due to production of root crops, and indeed the pattern of change over the review period is quite similar for domestic agriculture as a whole and root crops.

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

[2] The 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 CO_2 emissions in 2001 (UNEP, 2002).

B. Health

Jamaica is considered a lower middle-income developing country with medium human development and has generally good measures of "quality of life" indicators such as life expectancy, literacy, access to electricity and potable water. The country has a Human Development Index (HDI) of 0.766, ranking 100th among the 182 nations in the world (UNDP, 2009). The country is expected to achieve the Millennium Development Goals (MDGs) related to poverty, education, and health by 2015.

Jamaica has made positive developments in its health care system over the past few decades. Jamaicans are living longer - national life expectancy at birth has risen from 68 years in 1970 to the current 73.53 years (JASPEV, 2008). Jamaica has low rates of under-nutrition, infant mortality and fertility, relatively high immunization coverage and has eliminated polio and measles in the past several decades. As a tropical country, Jamaica's climate and weather are conducive to the transmission of vector‐borne, as well as food- and water-borne diseases. The rates of many of these diseases are increasing in small island states due to poor public health practices, inadequate infrastructure, and improper waste management practices (WHO, 2003).

C. Tourism

With the exception of remittances, tourism has become a default industry for bailing the ailing Jamaican economy out of its perpetual economic difficulty. Tourism is said to contribute, directly and indirectly, to over 30% of jobs in the Jamaican economy, and its share is expected to rise to 38% by 2014 (Clayton et al., 2004). According to Ramjeesingh et al. (2010, p.3), "tourist arrivals moved from 1.2 million in 1990 to 2.5 million in 2004 while tourism receipts jumped from US$ 739.9 million to US$ 1,438.8 million" during the corresponding period.

In the Caribbean, Jamaica has the fifth most tourism dependent economy (Clayton, 2004). As with many other Caribbean countries, fallout in the traditional sectors has resulted in a situation in which tourism has been increasingly seen as the engine of growth for the country (Boxill et al 2004). Tourist arrivals in Jamaica are dominated by the U.S market, which provides up to 60% of arrivals to the country. The other two important markets are Europe and Canada.

In addition to land tourism, Jamaica is also an important destination for cruise tourism in the world. Cruise tourism, which at the end of 2007 attracted in excess of 300,000 passengers, is an important segment of the Jamaican tourism product and efforts are being made with the construction of the Falmouth pier to attract the world's largest cruise ships to the country. The government intends that Jamaica will exponentially expand its cruise tourism sector within the next few years. Jamaica is one of the main ports of call for large cruise ships that ply the waters of the Caribbean Sea. At present, ships dock at the main resorts areas of Ocho Rios, Montego Bay and Port Antonio. The addition of Falmouth as a port will significantly increase the number of cruise passengers coming to the destination.

3. FUTURE CLIMATE SCENARIOS

The IPCC has confirmed that global warming during the twentieth century has resulted from rising concentrations of anthropogenic GHG emissions 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: Generalized least squares modeling was the general framework employed to model the effects of climate change on agricultural output in the sub-sectors of sugar, yam (a proxy for the root crop sub-sector) and escallion. In an attempt to identify the effect of climate change, the model included monthly average maximum temperature and precipitation for three periods (April-July, August-November and December-March). Other variables employed in the model include the price of cane, the cost of production, soil types and regional trend dummies.

2). Health: A predictive empirical statistical modeling approach was used to estimate the relationship between climate and disease. A Poisson regression model was estimated separately for dengue fever, gastroenteritis (under 5) and leptospirosis in order to obtain the historical relationship between each disease and climate variables such as rainfall, humidity and temperature as relevant to the particular disease. Other variables incorporated in the model include socioeconomic and other related environmental factors that were considered likely to influence the extent of disease incidence in Jamaica.

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 and precipitation) and economic data were modeled using regression analysis. The second evaluated the cost of extreme events to the tourism sector, while the third assessed the impact of SLR and ocean acidification.

Given the long-run nature of climate change impact assessments, it is common to estimate the present value of the impacts calculated over the 50- or 100-year horizon. This study uses three social discount rates – 1%, 2%, and 4% – 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.

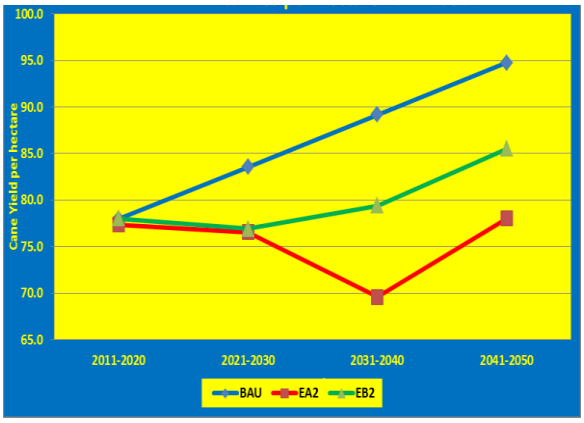
Costing of the adaptation strategies in each of the sectors was undertaken by using benefit-cost analysis or multicriteria analysis.

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

A. AGRICULTURE

Three crops were examined to analyse the impact of climate change on the agriculture sector in Jamaica: sugar cane, yam and escallion. Figure 1 shows the forecasts of the yield of sugarcane under the BAU, A2 and B3 scenarios. The forecasts show that sugar cane yields under both the A2 and B2 scenarios at first and then increase, with the yields on the B2 scenario beginning to increase in the 2020s, a decade before the yields on the A2 scenario begin to increase. Yields rise steadily through to 2050 on the BAU scenario.

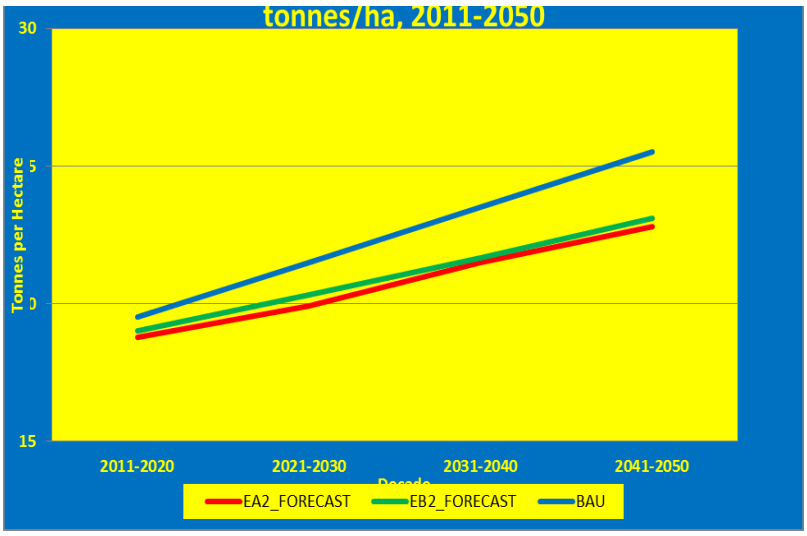
Figure 1: Projected Average Sugar Cane Yield



Source: ECLAC, 2011

Figure 2 shows the forecasts of the yield of yellow yam projected on the BAU, A2 and B2 scenarios. These results suggest that the yield of yam will be increasing but at a slower rate on both the A2 or B2 scenarios compared to the BAU. The forecast is for the yield to increase from 17.4 to 23.1 tonnes per hectare (33%) under the A2 scenario, and 18.4 to 23.9 (30%) tonnes per hectare under the B2 scenario over the period 2011 to 2050. This would be at an average annual rate of growth of less than 1%, somewhat slower than the annual average of 1.5% for the last 3 decades.

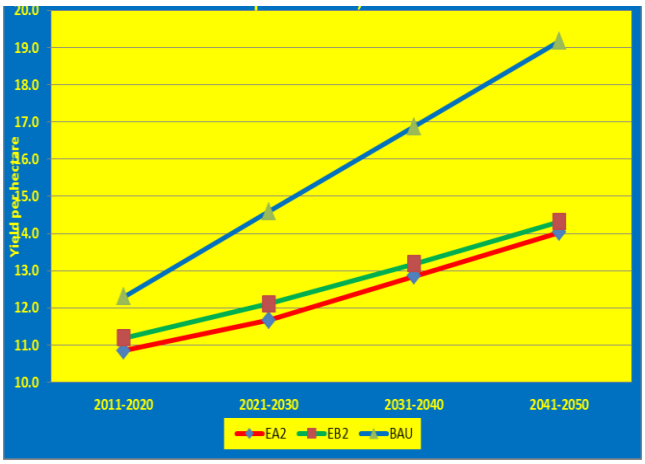
Figure 2: Projected Average Yam Yield



Source: ECLAC, 2011

Figure 3 shows the forecasts of the yield of escallion projected on the BAU, A2 and B2 scenarios. The model forecasts increases in yields by all three scenarios but slower on the A2 and B2 scenarios than on the BAU.

Figure 3: Projected Average Escallion Yield



Source: ECLAC, 2011

B. HEALTH

An economic impact analysis of climate change on the health sector was undertaken for three diseases: dengue fever, gastroenteritis in children under 5 and leptospirosis. Based on an examination of the impact of climate change on dengue fever, it was found that the A2 scenario produced the most expensive costing for each decade over the forty-year period (table 2). Using the 2008 GDP at the 2008 US$ rate, the cumulative cost of dengue fever under each scenarios account for approximately 0.19% (A2), 0.18% (B2) and 0.15% (BAU) of 2008 GDP (US$).

Table 2: Total Cost for Dengue Fever per decade (US$)

Total Cost	**2011-2020**	**2021-2030**	**2031-2040**	**2041-2050**
A2	5,276,110	6,280,520	6,972,731	8,016,270
B2	5,030,767	6,080,726	6,786,395	7,531,797

BAU	4,756,439	5,292,939	5,590,739	5,836,139
Discount rate 1%				
A2	5,223,349	6,217,715	6,903,004	7,936,108
B2	4,980,460	6,019,919	6,718,531	7,456,479
BAU	4,708,875	5,240,010	5,534,832	5,777,778
Discount rate 2%				
A2	5,170,587	6,154,910	6,833,277	7,855,945
B2	4,930,152	5,959,112	6,650,667	7,381,161
BAU	4,661,310	5,187,080	5,478,924	5,719,416
Discount rate 4%				
A2	5,065,065	6,029,299	6,693,822	7,695,620
B2	4,829,537	5,837,497	6,514,939	7,230,525
BAU	4,566,182	5,081,222	5,367,110	5,602,694

Source: ECLAC, 2011a

The total cost for each decade and scenario is presented in table 3. The cumulative cost of gastroenteritis under the A2 and B2 scenarios was US$ 242 and US$ 243 million, respectively. Using the 2008 GDP at 2008 US$ rates, the cumulative cost of gastroenteritis under the A2 and B2 scenarios account for approximately 1.7% of GDP (2008 US$).

Table 3: Total Cost of Gastroenteritis per decade in children under 5 years (US$)

Scenario	**2011-2020**	**2021-2030**	**2031-2040**	**2041-2050**
A2	64,148,949	61,755,559	60,096,052	56,016,455
B2	65,000,850	62,130,648	59,213,891	57,453,168
BAU	59,383,646	59,695,346	59,993,146	60,238,546
Discount rate 1%				
A2	63,507,460	61,138,004	59,495,091	55,456,291
B2	64,350,842	61,509,342	58,621,752	56,878,637
BAU	58,789,809	59,098,392	59,393,214	59,636,160
Discount rate 2%				
A2	62,865,970	60,520,448	58,894,131	54,896,126
B2	63,700,833	60,888,035	58,029,613	56,304,105
BAU	58,195,973	58,501,439	58,793,283	59,033,775
Discount rate 4%				
A2	61,582,991	59,285,337	57,692,210	53,775,797
B2	62,400,816	59,645,422	56,845,336	55,155,042
BAU	57,008,300	57,307,532	57,593,420	57,829,004

Source: ECLAC, 2011a

Table 4 shows the cost of leptospirosis per decade under the three scenarios with the highest cost being associated with the A2 scenario. The cumulative cost of leptospirosis in the A2 and B2 scenarios was US$ 19.4 and US$ 19 million, respectively. This cost is 0.14% of 2008 GDP.

Table 4: Total Cost Leptospirosis with Discount rates by Scenario and Decade (US$)

Scenario	2011-2020	2021-2030	2031-2040	2041-2050
A2	5,210,291	4,924,042	4,949,915	4,599,744
B2	5,071,055	4,794,265	4,615,955	4,572,820
BAU	2,813,988	3,125,688	3,423,488	3,668,888
Discount rate 1%				
A2	5,158,188	4,874,802	4,900,416	4,553,747
B2	5,020,344	4,746,323	4,569,796	4,527,092
BAU	2,785,848	3,094,431	3,389,253	3,632,199
Discount rate 2%				
A2	5,106,085	4,825,562	4,850,917	4,507,750
B2	4,969,634	4,698,380	4,523,636	4,481,364
BAU	2,757,708	3,063,174	3,355,018	3,595,510
Discount rate 4%				
A2	5,001,880	4,727,081	4,751,918	4,415,755
B2	4,868,213	4,602,495	4,431,317	4,389,907
BAU	2,701,428	3,000,660	3,286,548	3,522,132

Source: ECLAC, 2011a

C. TOURISM

Two scenarios[3] were considered in the context of tourist arrivals, namely the A2 and B2 scenarios. The projected and discounted cash flows are listed in table 5. These projections clearly indicate that the country is expected to incur significant levels of losses across the two scenarios based on the predicted changes in two climate features, temperature and rainfall. Prominent in terms of cost is the A2 scenario with a projected cumulative cost that is expected to marginally exceed US$132 million at the end of 2050, while in the event of a B2 scenario, losses are estimated to be in the region of US$106.1 million – this represents approximately 0.004% and 0.002% of GDP, respectively.

Table 5: Discounted Cash Flows of Cost to Tourism (US$ million)

Year	A2	B2	A2			B2		
			1%	2%	4%	1%	2%	4%
2010	12.98	12.01	12.98	12.98	12.98	12.01	12.01	12.01
2015	54.4	47.8	51.73	49.28	44.71	45.45	43.30	39.29
2030	98	91.06	80.36	65.95	44.68	74.66	61.28	41.52
2050	132.2	106.1	88.83	59.88	27.49	71.29	48.06	22.06

Source: ECLAC, 2011b

Table 6 shows the projected and discounted aggregate costing of extreme events to the tourism sector. As expected, the B2 option is the least cost approach (US$ 4.71 billion) while the A2 scenario generates a higher cost (US$ 5.49 billion).

Table 6: Discounted Cash Flow from Extreme Events to Tourism (US$ million)

[3] For an explanation of the IPCC climate scenarios see: http://sedac.ciesin.columbia.edu/ddc/sres

Year	A2			B2		
	1%	**2%**	**4%**	**1%**	**2%**	**4%**
2010	3952	3952	3952	4087	4087	4087
2015	5938.99	5657.97	5133.39	5444.47	5186.85	4705.95
2030	6563.28	5386.69	3649.82	4961	4071.65	2758.8
2050	5488.22	3699.65	1698.73	4713.40	3177.34	1458.91

Source: ECLAC, 2011b

The data in table 7 indicate the costs predicted for this supply-side effect of climate change are the highest of the three layers of cost. Although under both scenarios the sector is expected to incur huge losses due to sea level rise and ocean acidification, the least loss to the tourism industry will be incurred under the B2 scenario.

Table 7: Discounted Cash Flow of Sea Level Rise and Acidification for the Tourism Sector ($US million)

Year	**A2**			**B2**		
	1%	**2%**	**4%**	**1%**	**2%**	**4%**
2010	6372	6372	6372	5495	5495	5495
2015	9440.58	8993.86	8159.99	8444.88	8045.28	7299.36
2030	9594	7874.1	5335.2	8388.6	6884.79	4664.88
2050	7956.48	5363.52	2462.72	7041.22	4746.53	2179.42

Source: ECLAC, 2011b

6. ADAPTATION STRATEGIES

A. APPROACHES TO ADAPTATION IN JAMAICA

Jamaica is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol which mandates reductions in GHG emissions for certain countries. As a small island developing state, Jamaica has no specific targets for GHG reduction under the Protocol.

The Meteorology Service of Jamaica (MSJ) is the National Focal Point for the UNFCCC and is responsible for collecting and providing information to decision makers, policy makers and other stakeholders on climate change activities. The MSJ led the development of the draft Second National Communication on Climate Change for submission to the UNFCCC. This document includes information on the levels of national anthropogenic GHG emissions as well as mitigation and adaptation initiatives for the water resources, coastal resources, tourism, human health, human settlement and agricultural sectors based on the potential impacts of the years 2015, 2030 and 2050 (MSJ/UNDP, 2009).

Jamaica is involved in a number of regional climate change adaptation programmes, including the following:

- Mainstreaming Adaptation to Climate Change (MACC) – funded by GEF and CIDA –which is assisting countries in the Caribbean in ways to integrate climate change adaptation strategies into national development planning on issues such as tourism, health, agriculture, fisheries and infrastructure
- Caribbean Comprehensive Disaster Management Framework, which is helping to "strengthen regional, national and community level capacity for the mitigation, management and coordinated response to natural and anthropological hazards, and the effects of climate variability and change."

At the policy level, Jamaica has developed a draft National Climate Change Policy and Action Plan to provide a framework for the country's commitments to the UNFCCC and to guide mitigation and adaptation activities.

B. COSTING ADAPTATION STRATEGIES IN THE AGRICULTURE SECTOR

Table 8 summarises the adaptation strategies and the rates of return that have been adopted for each of the sub-sectors under analysis in the agriculture sector.

Table 8: Return on Investment in Adaptation

	Cost	**Benefit**	**Return on investment**
Climate variability			
Insurance	Private	Increased productivity because of reduced risk aversion to investments, risky choices of crops	
Climate Change			
Education	Public-private partnership	More attention to adaptation measures	
Warming			
Research, including accessing extant heat-resistant varieties	Public-private partnership	Increased yield	Benefit/cost ratio = 4
Change in precipitation pattern			
Irrigation per ha	Private cost	Increased yield	Internal rate of return = 15%
Terracing	Private (public) cost for private (public) hill-side lands	Manage erosion, protect top soil, reduce the potential and impact of flooding	Internal rate of return =12-22%
Water Management			
Individual catchment	Private cost	Increased yield, reduced mortality of plants and animals	
Public catchment	Public cost	Increased yield, counter drought	
Public drainage	Public cost	Flood management	
Hurricanes			
Windbreaks	Private cost	Manage the impact of winds on crops	Increase in yields of corn and soybeans = 7.6%-9.2% respectively, for an optimally spaced windbreak in the Great Plains of the USA

Source: ECLAC, 2011

The costs and benefits of investing in adaptation options to forecasted increases in temperature and changes in the pattern of precipitation were determined for each crop. The results are summarised in table 9.

Table 9: Net Benefit under each Climate Scenario

Sub-Sector	**Year**	**Scenario A2 - costs of adaptation**			**Scenario B2 - costs of adaptation**		
		1%	***2%***	***4%***	***1%***	***2%***	***4%***
Sugar cane	2012-20	-229.74	-223.47	-211.90	-245.16	-239.20	-228.06
	2021-30	67.27	59.37	46.53	59.72	51.37	38.27
	2031-40	246.72	197.52	127.62	100.28	79.19	49.84
	2041-50	209.34	151.03	79.64	109.06	78.12	40.55

	Total	**293.59**	**184.46**	**41.88**	**23.90**	**-30.51**	**-99.41**
Yam	2012-20	24.44	23.30	21.26	14.78	13.98	12.55
	2021-30	92.50	80.66	61.73	66.99	58.38	44.61
	2031-40	108.65	86.06	54.49	99.07	78.48	49.70
	2041-50	133.13	95.78	50.17	117.37	84.42	44.21
	Total	**358.72**	**285.80**	**187.65**	**298.20**	**235.27**	**151.07**
Escallion	2012-20	14.92	14.24	13.03	8.97	8.48	7.59
	2021-30	43.70	38.08	29.10	36.81	32.08	24.52
	2031-40	56.07	44.44	28.18	51.33	40.66	25.75
	2041-50	65.03	46.73	24.42	61.44	44.18	23.11
	Total	**179.72**	**143.50**	**94.72**	**158.55**	**125.39**	**80.97**

Source: ECLAC, 2011

C. COSTING ADAPTATION STRATEGIES IN THE HEALTH SECTOR

The adaptation strategies suggested for the health sector are outlined in table 10 along with the costing for the A2 and B2 scenarios. The table shows some of the direct measures that can be employed to reduce the cost effect of the disease burden. The approaches recommended are not exhaustive and represent some of the strategies that are feasible in the short to medium term.

Table 10: Summary Table of Adaptation Strategies (US$)

Projected Time (2011-2050)	**Adaptation Strategy**		**A2**	**B2**
Dengue Fever	Improve sanitation by 5%	Total number of Cases projected (model results)	14,481	13,403
		Total number of cases Averted	6,700	6,220
		Total Cost Saved (USD)	5,547,722	5,250,111
Gastroenteritis	Improve access to potable water by 5%	Total number of cases (model results)	759,358	765,233
		Total number of cases Averted	74,273	74,891
		Total Cost Saved (USD)	21,167,753	21,348,952
Leptospirosis	Improve sanitation by 5%	Total number of cases (model results)	40,495	37,268
		Total number of cases Averted	7,114	6,445
		Total Cost Saved (USD)	675,802	612,229

Source: ECLAC, 2011a

D. COSTING ADAPTATION STRATEGIES IN THE TOURISM SECTOR

Table 11 presents the benefit-cost ratios for adaptation strategies for the tourism sector. While, most of the adaptation strategies produce negative net benefits and the cost burden is likely to be carried by the state, at least three have positive net benefits: redesigning and retrofitting all relevant tourism facilities, coral restoration and educating the public, developing rescue and evacuation plans. These strategies are the ones that should be pursued as a first line of action against climate change.

Table 11: Benefit cost ratios for adaptation activities

Adaptation Activities	**Benefit**	**Cost**	**Net**

	Ratio	Benefits/Costs
Redesign and retrofit all relevant tourism facilities	1.2	0.2
Increase Storage facilities (i.e. build new dams, tanks and desalination plant)	0.3	-0.7
Build sea wall, raise land level, replant mangroves	0.3	-0.7
Put systems in place to restore corals	3.8	2.8
Educate public, develop rescue and evacuation plan	1.6	0.6
Provide resources to airlines, hotels for advertisement	0.7	-0.3
Introduce new attractions	0.1	-0.9
Retraining of tourism workers	0.4	-0.6
New tourism facilities	0.1	-0.9

Source: ECLAC, 2011b

It is suggested that initially government should undertake a detailed analysis of the vulnerability of the tourism sector to climate change. Additionally, it is recommended that realistic socio-economic scenarios be developed and potential adaptation strategies identified to inform any future benefit-cost analysis.

7. CONCLUSIONS AND POLICY RECOMMENDATIONS

Similar to other countries in the region, Jamaica is at risk from the economic impact of climate change on its tourism, health and agriculture sectors. Jamaica has started responding to climate change and at the policy level a draft National Climate Change Policy and Action Plan has been developed to provide a framework for the country's commitments to the UNFCCC and to guide mitigation and adaptation activities. These are initiatives that will benefit Jamaica since they will increase the resilience of the country to established risks, which are already taking place.

The outcomes from investigating the agriculture sector indicate that for the sugar-cane subsector the harvests under both the A2 and B2 scenarios decrease at first and then increase as the mid-century mark is approached. With respect to the yam subsector the results indicate that the yield of yam will increase from 17.4 to 23.1 tonnes per hectare (33%) under the A2 scenario, and 18.4 to 23.9 (30%) tonnes per hectare under the B2 scenario over the period 2011 to 2050. Similar to the forecasts for yam, the results for scallion suggest that yields will continue to increase to mid-century.

Adaptation in the sugar cane sub-sector indicate that replanting and irrigation appear to generate net benefits at the three selected discount rates for the A2 scenario, but only at a discount rate of 1% for the B2 scenario. For yam and escallion, investment in irrigation will earn significant net benefits for both the A2 and B2 scenarios at the three selected rates of discount. It is recommended that if adaptation strategies are part of a package of strategies for improving efficiency and hence enhancing competitiveness, then the yields of each crop can be raised sufficiently to warrant the investment in adaptation to climate change.

The analysis of the health sector demonstrated the potential for climate change to add a substantial burden to the future health systems on Jamaica, something that that will only compound the country's vulnerability to other anticipated impacts of climate change. The results clearly show that the incidence of dengue fever will increase if climate change continues unabated with more cases predicted for the A2 scenario than the B2. The models predicted a decrease in the incidence of gastroenteritis and leptospirosis with climate change, indicating that Jamaica will benefit from climate change with a reduction in the number of cases of gastroenteritis and leptospirosis.

Due to the long time horizon anticipated for climate change, Jamaica should start implementing adaptation strategies focused on the health sector by promoting an enabling environment, strengthening communities, strengthening the monitoring, surveillance and response systems and integrating adaptation into development plans and actions. Small-island developing states like Jamaica must be proactive in implementing adaptation strategies, which will reduce the risk of climate change. On the global stage the country must continue to agitate for the implementation of the mitigation strategies for developed countries outlined in the Kyoto protocol.

The results regarding the tourism sector suggest that the sector is likely to incur losses due to climate change, the most significant of which is under the A2 scenario. Climatic features, such as temperature and precipitation, will affect the demand for tourism in Jamaica. By 2050 the industry is expected to lose US$ 132.2 million and 106.1 million under the A2 and B2 scenarios, respectively. In addition to changes in the climatic suitability for tourism, climate change is also likely to have important supply-side effects from extreme events and acidification of the ocean. The expected loss from extreme events is projected to be approximately US$ 5.48 billion (A2) and US$ 4.71 billion (B2). Even more devastating is the effect of ocean acidification on the tourism sector - the analysis shows that US$ 7.95 billion (A2) and US$ 7.04 billion is expected to be lost by mid-century.

The benefit-cost analysis indicates that most of the adaptation strategies are expected to produce negative net benefits, and it is highly likely that the cost burden would have to be carried by the state. The options that generated positive ratios were: redesigning and retrofitting all relevant tourism facilities, restoring corals and educating the public and developing rescue and evacuation plans. Given the relative importance of tourism to the macroeconomy one possible option is to seek assistance from multilateral funding agencies. It is recommended that the government first undertake a detailed analysis of the vulnerability of each sector and, in particular tourism, to climate change. Further, some realistic socio-economic scenarios should be developed so as to inform future benefit-cost analysis.

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