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**AN ASSESSMENT OF THE ECONOMIC IMPACT OF CLIMATE CHANGE  
ON THE AGRICULTURE, ENERGY AND HEALTH SECTORS IN  
TRINIDAD AND TOBAGO**

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## EXECUTIVE SUMMARY

This report analyses the agriculture, energy, and health sectors in Trinidad and Tobago 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 Trinidad and Tobago. 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 exploration of various adaptation strategies was also undertaken for each sector using standard evaluation techniques.

The study of the impact of climate change on the agriculture sector focused on root crops, green vegetables and fisheries. For these sectors combined, the cumulative loss under the A2 scenario is calculated as approximately B\$2.24 and approximately B\$1.72 under the B2 scenario by 2050. This is equivalent to 1.37% and 1.05% of the 2008 GDP under the A2 and B2 scenarios, respectively.

Given the potential for significant damage to the agriculture sector a large number of potential adaptation measures were considered. Out of these a short-list of 10 potential options were selected by applying 10 evaluation criteria. All of the adaptation strategies showed positive benefits. The analysis indicate that the options with the highest net benefits are: (1) Building on-farm water storage, (2) Mainstreaming climate change issues into agricultural management and (3) Using drip irrigation. Other attractive options include water harvesting. The policy decisions by governments should include these assessments, the omitted intangible benefits, as well as the provision of other social goals such as employment.

The analysis of the energy sector has shown that the economic impact of climate change during 2011-2050 is similar under the A2 (US\$142.88 million) and B2 (US\$134.83 million) scenarios with A2 scenario having a slightly higher cost (0.737% of 2009 GDP) than the B2 scenario (0.695% of 2009 GDP) for the period. On the supply side, analyses indicate that Trinidad and Tobago's energy sector will be susceptible to the climate change policies of major energy-importing countries (the United States of America and China), and especially to their renewable energy strategies. Implementation of foreign oil substitution policy by the United States of America will result in a decline in Trinidad and Tobago's Liquefied Natural Gas (LNG) export (equivalent to 2.2% reduction in 2009 GDP) unless an alternative market is secured for the lost United States of America market. China, with its rapid economic growth and the highest population in the world, offers a potential replacement market for Trinidad and Tobago's LNG export. In this context the A2 scenario will offer the best option for Trinidad and Tobago's energy sector.

The cost-benefit analysis undertaken on selected adaptation strategies reveal that the benefit-cost ratio of replacing electric water heaters with solar water heaters is the most cost-effective. It was also found that the introduction of Compact Fluorescent Light (CFL) and Variable Refrigerant Volume (VRV) air conditioners surpasses the projected cost of increased electricity consumption due to climate change, and provides an economic rationale for the adoption of these adaptation options even in a situation of increased electricity consumption occasioned by climate change. Finally, the conversion of motor fleets to Compressed Natural Gas (CNG) is a cost-effective adaptation option for the transport sector, although it has a high initial cost of implementation and the highest per capita among the four adaptation options evaluated.

To investigate the effect of climate change on the health sector dengue fever, leptospirosis, food borne illnesses, and gastroenteritis were examined. The total number of new dengue cases for the period 2008 to 2050 was 204,786 for BAU, 153,725 for A2 and 131,890 for the B2 scenario. With regard to the results for leptospirosis, A2 and B2 seem to be following a similar path with total number of new cases in the A2 scenario being 9,727 and 9,218 cases under the B2 scenario. Although incidence levels in the BAU scenario coincided with those of A2 and B2 prior to 2020, they are somewhat lower post 2020. A similar picture emerges for the scenarios as they relate to food-borne illnesses and to gastroenteritis. Specifically for

food-borne illnesses, the BAU scenario recorded 27,537 cases, the A2 recorded 28,568 cases and the B2 recorded 28,679 cases.

The focus on the selected sources of morbidity in the health sector has highlighted the fact that the vulnerability of the country's health sector to climate change does not depend solely on exogenously derived impacts, but also on the behaviour and practices among the population. It is clear that the vulnerability which became evident in the analysis of the impacts on dengue fever, leptospirosis and food-borne illnesses is not restricted solely to climate or other external factors. The most important adaptation strategy being recommended targets lifestyle, behaviour and attitude changes. The population needs to be encouraged to alter their behaviours and practices so as to minimise their exposure to harmful outcomes as it relates to the incidence of these diseases.

## 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)<sup>1</sup> contribute less than 1% to global GHG emissions (approximately 0.33%<sup>2</sup>; 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 climate change 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.

According to a report from the Government of Trinidad and Tobago (2009, p.2) “As a small island developing state, Trinidad and Tobago is particularly vulnerable to the adverse impacts of climate change such as those related to temperature increases, changes in precipitation and sea level rise. Specific sectors that are likely to be impacted on are the agriculture sector, human health, human settlements, coastal zones, and water resources as well as cross-sectional socio-economic systems”.

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 energy sectors in Trinidad and Tobago as these were deemed most vulnerable to climate change and key contributors to the country’s GDP, whether directly or indirectly.

## 2. BRIEF REVIEW OF THE SECTORS

### A. AGRICULTURE

In 1980, the largest components of the agricultural sector were the sugar sub-sector, followed by domestic agriculture and then export agriculture. However, following the closure of the main sugarcane-producing farm (Caroni (1975) Ltd) in the mid 2000s, the Sugar Manufacturing Company continued to operate at a loss and therefore had a negative contribution to GDP in 2008. The value of the agricultural sector improved slightly over the past 2 decades (in absolute terms), but this occurred with a very high degree of variability in the growth rate.

While the economy of Trinidad and Tobago has become more and more dependent on revenue from the petroleum sector, the contribution of the agricultural sector fell from 2% of total GDP in 1997 to just 0.4% of total GDP in 2009. Further, between 1990 and 2008 the forested area in Trinidad and Tobago fell by 5.3%, arable land availability fell by 35.6% over that time, and the available agricultural land fell by 29.9%.

In 2008, the labour force in the agricultural sector accounted for 3.8% of all industries (Central Bank of Trinidad and Tobago, 2009). While this is a small number, which represents direct employment, there is anecdotal evidence that the local agricultural sector supports a very large informal or indirect sector, particularly of the rural population. Therefore, agricultural employment is still very critical, despite its low contribution to national GDP, in terms of supporting rural livelihoods, and providing employment to many

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

<sup>2</sup>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<sub>2</sub> emissions in 2001 (UNEP, 2002).

unskilled workers. Agricultural output is also increasingly significant as global food prices continue to increase and the Trinidad and Tobago government looks to increasing food security amidst a spiraling food import bill.

## **B. ENERGY**

The energy sector plays an important role in Trinidad and Tobago's economy. In 2008, the energy sector's share of the Gross Domestic Product (GDP) amounted to approximately 48% while contributing 57% of the total government revenue. In the same year, the sector's share of merchandise export was 88%, made up mainly of refined oil products including petroleum, LNG and natural gas liquids (Central Bank of Trinidad and Tobago, 2009).

The United States of America has historically been a major importer of Trinidad and Tobago's gas products. The percentage of Trinidad and Tobago's gas products exported to the United States of America grew from 18% in 2000 to about 44% in 2004, representing a 26% point gain within a five-year period. The share of natural gas production exported to the United States of America has, however, declined since 2004 reaching a low of 15% in 2009. Trinidad and Tobago is the dominant exporter of LNG to the market in the United States of America. Between 2002 and 2006, imports from Trinidad and Tobago represented more than 66% of all LNG imports by the United States of America. The highest share of approximately 76% was recorded in 2008 but by the following year, Trinidad and Tobago's share of imports by the United States of America had declined sharply to 52%.

Given the importance of the energy sector in Trinidad and Tobago's economy, and with the United States of America serving as a major export market for its LNG exports, domestic energy policy in the United States of America as well as global trend in the world oil market are expected to impact on the country's energy sector export earnings.

## **B. HEALTH**

The epidemiological profile of Trinidad and Tobago is not different from that of the countries of the developed world, with chronic diseases such as heart disease, cancer, diabetes and hypertension being very high on the mortality list. Data for the period 1990 to 2003 from PAHO (2008) show that mortality rates were the highest for diseases of the circulatory system followed by malignant neoplasms, external causes, communicable diseases, and acquired immune deficiency syndrome (AIDS). Although ranked fourth in the region, the mortality rate per 1,000 population for communicable diseases (such as diarrhoeal disease, dengue fever, leptospirosis and malaria) assumed an increasingly important role in the burden of mortality over the period 1990-2003. The increase in the mortality rate for communicable diseases may be linked to a number of factors, one of which may be climate change.

Climate change, via changes in weather patterns can impact the spread of some communicable diseases through changes in water, air and food quality and vector populations. It is worth noting that the percentage of population living in urban areas is significantly lower than that for other countries in the subregion. Further, more than 85% of the population lives in rural areas and so they may be more exposed to the risk of contracting diseases such as dengue fever, malaria and leptospirosis and gastroenteritis.

## **3. FUTURE CLIMATE SCENARIOS**

The IPCC has confirmed that global warming during the twentieth century has resulted from rising concentrations of anthropogenic greenhouse gases (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 21<sup>st</sup> 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 root-crops, green vegetables and fisheries. In an attempt to identify the effect of climate change, the analysis controls for price effects and typical agricultural inputs such as area harvested, capital inputs and price of output. The climate variables employed in the analysis are temperature and rainfall. The fisheries sub-sector was analysed by utilizing data on the landings of all commercial species worldwide and a temperature preference profile was created for each species, which showed the regions that each species prefers to inhabit based on historical temperatures.

**2). Energy.** The methodological approach adopted in this model examines the economic impact of climate change on the energy sector by investigating both energy demand and energy supply. On the demand side an econometric approach was adopted to estimate the relationship between economic and climate variables and energy demand. On the supply side, a scenario building approach that investigates a number of factors and how they might affect the production and supply of fossil fuels in the future was adopted. Key among these is how climate change adaptation and mitigation strategies pursued by major energy consuming nations could impact the world energy market. Other important factors include short-run supply limitation due to refinery capacity restriction, long-run supply limitation constrained by energy reserve, and disruption in supply due to sea level rises and extreme weather events

Given the long-run nature of climate change impact assessments, it is common to calculate the present value of the impacts calculated 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 net cost-benefit analysis or multicriteria analysis.



**3). Health.** The Engle-Granger Two-Step Algorithm Testing procedure along with Error Correction Modeling was used to investigate the relationship between climate and disease. Models were estimated separately for dengue fever, leptospirosis, food-borne illnesses and gastroenteritis 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 Trinidad and Tobago.

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

### A. AGRICULTURE

Relative to the baseline case (Business as Usual – BAU), the key subsectors (root-crops, green vegetables and fisheries) in agriculture are likely to be subject to mixed impacts under the A2 and B2 scenarios<sup>3</sup>. Fisheries outputs are expected to fall with climate change, but root crop and vegetable production are expected to rise until the optimal temperature and rainfall levels for growing these crops are exceeded. However, relative to the baseline, the values of yield will be worse under the A2 and B2 scenarios for both root crop and fisheries outputs, but better under these two scenarios for vegetable production, since most of the key vegetables have a relatively high temperature range for optimal production. In aggregate, in every decade up to 2050, these three key sub-sectors combined are expected to experience a loss under climate change, all scenarios, with the highest losses under A2. By 2050, the cumulative loss under A2 is calculated as approximately B\$2.24 and approximately B\$1.72 under B2 (table 2). These values as a percentage of the 2008 nominal GDP are shown in table 3.

**Table 2: Present Value of Cumulative Losses for Agricultural Yield Relative to the Baseline (TT \$mil)**

	2020		2030		2040		2050	
	A2	B2	A2	B2	A2	B2	A2	B2
<b>1%</b>	98.66	60.83	358.52	255.48	953.02	638.16	2,244.27	1,720.19
<b>2%</b>	90.81	55.85	309.37	218.90	760.97	508.74	1,647.02	1,249.39
<b>4%</b>	77.31	47.26	233.00	162.33	495.31	329.59	915.25	678.30

Source: ECLAC, 2011

**Table 3: Estimate of the Cumulative Cost of the Impact of Climate Change (in 2008 GDP\* % of the Net Present Value)**

	2020		2030		2040		2050	
	A2	B2	A2	B2	A2	B2	A2	B2
<b>1%</b>	0.06%	0.04%	0.22%	0.16%	0.58%	0.39%	1.37%	1.05%
<b>2%</b>	0.06%	0.03%	0.19%	0.13%	0.47%	0.31%	1.01%	0.76%
<b>4%</b>	0.05%	0.03%	0.14%	0.10%	0.30%	0.20%	0.56%	0.42%

\*Central Bank of Trinidad and Tobago (2009)

Source: ECLAC, 2011

### B. ENERGY

For the entire 40-year period, the economic impact of climate change results in a cost to the economy for both the A2 and B2 scenarios and for all discount rates (table 5). The economic impact ranges from US\$70.32 million under the A2 scenario with a 4% discount rate to US\$142.88 million under the A2

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

scenario when no discounting is applied. In the case of the B2 scenario, economic impact ranges from US\$40.40 million with a 4% discount rate to US\$134.83 million when no discounting is applied. As a proportion of GDP, these economic impact estimates represent 0.737% of 2009 GDP for the case of no discounting and 0.363% of 2009 GDP for the case of a 4% discount rate under A2. Similarly for the B2 scenario, the economic impact estimates represent 0.695% of 2009 GDP for the case of no discounting and 0.208% when a 4% discount rate is applied. When economic impact estimates under the A2 and B2 scenarios are compared, A2 results in higher cost over the entire period of 2011-2050 and for all discount rates considered.

**Table 4: Economic Impact of Climate Change on Electricity Consumption**

Period	Economic Impact at Different Discount Rates (US\$ million*) (Percentage of 2009 GDP)							
	A2				B2			
	0%	1%	2%	4%	0%	1%	2%	4%
2011-2020	1.727 (0.009)	3.195 (0.016)	4.538 (0.023)	6.895 (0.036)	-8.841 (0.046)	-11.204 (0.058)	-13.377 (0.069)	-17.217 (0.089)
2021-2030	78.841 (0.407)	67.987 (0.351)	58.829 (0.303)	44.485 (0.230)	101.82 (0.525)	86.451 (0.446)	73.616 (0.380)	53.839 (0.278)
2031-2040	-11.331 (0.058)	-8.167 (0.042)	-5.923 (0.031)	-3.190 (0.016)	-59.077 (0.305)	-47.143 (0.243)	-37.817 (0.195)	-24.689 (0.127)
2041-2050	73.643 (0.380)	54.262 (0.0280)	40.111 (0.207)	22.129 (0.114)	100.93 (0.520)	73.154 (0.377)	53.215 (0.274)	28.464 (0.147)
<b>2011-2050</b>	<b>142.88</b> <b>(0.737)</b>	<b>117.28</b> <b>(0.605)</b>	<b>97.55</b> <b>(0.503)</b>	<b>70.32</b> <b>(0.363)</b>	<b>134.83</b> <b>(0.695)</b>	<b>101.26</b> <b>(0.522)</b>	<b>75.64</b> <b>(0.390)</b>	<b>40.40</b> <b>(0.208)</b>

\* Using the monthly average selling rate of US\$1=TT\$6.40 by the Central Bank of Trinidad and Tobago for December 2010.

Source: ECLAC, 2011a

On the supply side, the A2 scenario provides the best situation for Trinidad and Tobago's energy sector. In contrast, however, the B2 scenario does not augur well for Trinidad and Tobago. Under the B2 scenario, China is expected to pursue a climate change mitigation strategy that emphasizes renewable energy and devotes resources to developing renewable energy technology. This implies that growth in the use of natural gas will remain steady, at or below the growth level under the BAU. However, with emphasis on renewable energy and marginal increase in consumption of natural gas, China will not offer an alternative market for Trinidad and Tobago's lost United States of America export market. In addition, a shift to renewable energy has the potential of depressing the price of natural gas on the world oil market. This implies that under the B2 scenario, LNG export volume and unit price would fall. The consequence is a decline in export revenue for Trinidad and Tobago.

### C. HEALTH

Despite the mixed results for impact of the individual diseases on the health sector across scenarios, when the overall picture is taken the analysis shows that the most costly impact on the health sector is expected to be the in the BAU scenario (table 4). This was seen when the cost of treating the respective diseases was considered. The least cost impact was experienced in the B2 scenario.

**Table 4: The Treatment Costs under BAU, A2 and B2 Scenarios for the period 2008 to 2050**

Scenarios	DENGUE FEVER (US\$ M)	LEPTOSPIROSIS (US\$ M)	FOOD-BORNE ILLNESSES (US\$ M)	GASTROENTERITIS (US\$M)	TOTAL (US\$ M)
BAU	326.8	2.4	8	84.4	<b>421.6</b>
A2	245.3	3.2	8.3	95	<b>351.8</b>
B2	210.5	3.1	8.3	124.6	<b>346.5</b>

Source: ECLAC, 2011b

## 6. ADAPTATION STRATEGIES

### A. APPROACHES TO ADAPTATION IN TRINIDAD AND TOBAGO

Trinidad and Tobago is a ratified signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol. In 2001, the country submitted its First National Communication on Climate Change to the UNFCCC and is in the process of finalizing the Second National Communication. On a regional level, Trinidad and Tobago has participated in a number of projects on climate change presided over by CARICOM. The Government of Trinidad and Tobago recognizes that there is “no-one-size-fits-all” policy for countries or even sectors in the context of climate change and that climate change policies are tailored based on national circumstances, development objectives and sectoral and cross sectoral interactions. A Draft National Climate Change Policy was developed for Trinidad and Tobago in 2009 after a comparison of climate change policies for countries similar in development aspirations, size and geographical location. Currently, climate change is not specifically addressed in existing sectoral and national policies although broad reference to mitigation and adaptation is made in the National Environmental Policy (2006) (GOVTT, 2009).

The Draft National Climate Change Policy is expected to have implications for other sectoral policies and there is a need for it to be revised to integrate and contextualize issues relating to climate change<sup>4</sup>. The objective of the draft policy are to reduce or avoid GHG emissions from all emitting sectors, to enhance carbon sinks, to protect the natural environment and human health, to conserve and build resilience of human and natural systems to adapt to the adverse impacts of climate change and to enhance agricultural production and food security (GOVTT, 2009).

Trinidad and Tobago’s response to climate change is guided by the concept of sustainability. All Government Ministries are expected to be involved in the implementation of the policy. It was recognized that the response will require consultative and a multi-partite approach and will be both evidence-based and precautionary in nature. Trinidad and Tobago’s response to climate change focuses on both adaptation and mitigation. In the context of mitigation, the government proposes to utilize low greenhouse gas emission economic development pathways across sectors.

### B. COSTING ADAPTATION STRATEGIES IN THE AGRICULTURE SECTOR

The present value of each adaptation option was calculated using a 4% discount rate and is shown in table 5. The estimations indicate that the most attractive adaptation options, based on the Benefit-Cost Ratio are: (1) Build on- farm water storage such as ponds and tanks (2) Mainstreaming climate change issues into agricultural management and (3) Water harvesting. However, the options with the highest net benefits are, (in order of priority): (1) Build on- farm water storage such as ponds and tanks), (2) Mainstreaming climate change issues into agricultural management and (3) Use of drip irrigation. The final policy choice by governments should take into considerations these assessments, as well as the omitted intangible benefits and the provision of other social goals such as employment.

**Table 5: Benefit-Cost Analysis of the Highest-Ranked Proposed Adaptation Strategies for the Agriculture Sector (TT\$ Millions) (4% Discount Rate)**

Options	Details	Cumulative Present Value of Benefits	Cumulative Present Value of Costs	Benefit Cost Ratio	Net Benefits	Payback Period (years)

<sup>4</sup> Currently there are some national policies and legislation in which climate change may have some significance Draft National Protected Areas Policy (2009), National Tourism Policy (2009), Draft National Forest Policy (2008), Draft Waste Management Rules (2008), Water Pollution Management Programme (2005), Environmentally Sensitive Areas Rules (2001), National Policy and Programme on Wetland Conservation for Trinidad and Tobago (2001)

Option 1	Use water saving irrigation systems and water management systems e.g. drip irrigation	7,573.79	593.73	12.8	6,980.05	0.64
Option 2	Mainstream climate change issues into agricultural management	28,521.60	167.32	170.5	28,354.27	0.01
Option 3	Repair/maintain existing dams	67.87	25.96	2.6	41.91	0.18
Option 4	Adopt improved technologies for soil conservation	341.83	124.26	2.8	217.56	0.00
Option 5	Establish systems of food storage	236.54	15.77	15.0	220.76	0.00
Option 6	Water conservation - Water Harvesting	3,029.5	34.20	88.6	2,995.30	0.18
Option 7	Water Management Plans	58.77	1.20	48.9	57.57	0.06
Option 8	Build on- farm water storage (ponds, tanks)	121,235.16	150.12	807.6	\$121,085.03	1.96
Option 9	Agricultural Drainage	210.21	233.34	0.9	(23.12)	0.00
Option 10	Installation of Greenhouses	20.38	20.38	1.0	\$0.00	0.28

Source: ECLAC, 2011

### C. COSTING ADAPTATION STRATEGIES IN THE ENERGY SECTOR

A cost-benefit analysis was done on the adoption of Compact Fluorescent Bulbs (CFL) by residential electricity consumers, introduction of solar water heaters to replace electric water heaters by residential consumers, introduction of Variable Refrigerant Volume (VRV) air conditioner (AC) to replace split ACs in the hospitality industry, and introduction of CNG to replace gasoline as a transport fuel. The results are presented in table 6.

**Table 6: Cost-Benefit Analysis of Climate Change Adaptation Options for the Energy Sector**

Adaptation Option	Measure of Net Benefit at Different Discount Rates								CO <sub>2</sub> Abated	
	Net Present Value (NPV) <sup>1</sup> (US\$ million*)				Benefit-Cost Ratio (BCR)				Quantity (kt)	Value (US\$ million*)
	0%	1%	2%	4%	0%	1%	2%	4%		
CFL Bulbs	345.20	277.51	226.38	157.01	1.83	1.80	1.77	1.72	7,735.36	116.03
SWH	344.09	278.71	228.85	160.30	4.66	4.29	3.97	3.43	6,194.39	92.92
VRV AC	1.58	0.95	0.50	-0.10	1.06	1.04	1.03	0.99	170.09	2.55
CNG	97.60	75.70	59.33	37.50	1.98	1.90	1.83	1.68	131.26	1.97

\* Using the monthly average selling rate of US\$1=TT\$6.40 by the Central Bank of Trinidad and Tobago for December 2010.

Source: ECLAC, 2011a

The results revealed that the benefit-cost ratio of replacing electric water heaters with solar water heaters was the most cost-effective. The adaptation option of replacing mini split air conditioners in hotels and guest houses with VRV air conditioners is only marginally cost-effective when the discount rate is below 4%. This is a reflection of the small number of hotel and guest-house rooms in Trinidad and Tobago, their low occupancy ratio, and the cheap price of electricity in Trinidad and Tobago. The conversion of motor fleets to

CNG is a cost-effective adaptation option for the transport sector, although it has a high initial cost of implementation and the highest per capita among the four adaptation options evaluated.

#### D. COSTING ADAPTATION STRATEGIES IN THE HEALTH SECTOR

The adaptation measures identified in table 7 are all expected to contribute in some way to the reduction of disease incidence in Trinidad and Tobago. The adaptation measures recommended relate largely to increasing access to improved water sources and sanitation facilities and influencing behaviour changes since these were found to be major drivers of the selected diseases in Trinidad and Tobago.

**Table 7: Adaptation Costs of Measures Identified for the Health Sector**

Adaptation Measures	Cost per annum (2008)	Cost to 2050	Cost to 2050 (1%)	Cost to 2050 (2%)	Cost to 2050 (4%)
Replace sanitation facilities	0.2	8.4	5.53	3.66	1.62
Strengthening the sanitation drive of the Municipal Corporations	1.85	77.2	50.83	33.61	14.87
Expanding CEPEP	0.46	19.32	12.72	8.41	3.72
Enhancing capacity of the Solid Waste Management Company (SWMCOL)	0.11	4.62	3.04	2.01	0.89
Improving water supply, especially to the rural area	2.06	86.52	56.97	37.66	16.66
Enhancing Environmental Awareness	0.43	18.06	11.89	7.86	3.48
Health Promotion - to reduce risky behaviour	2.06	86.52	56.97	37.66	16.66
Strengthening the work of the Environmental Management Agency	0.10	4.2	2.77	1.83	0.81
Forestry preservation	0.10	4.2	2.77	1.83	0.81
<b>TOTAL</b>	<b>7.17</b>	<b>309.04</b>	<b>203.48</b>	<b>134.53</b>	<b>59.51</b>

Source: ECLAC, 2011b

Table 8 shows the options available for reducing the high cost of treatment that is associated with increased disease incidence following investments in adaptation measures.

**Table 8: Comparison of Cost of Treatment and Cost of Adaptation for the Health Sector (\$USM)**

Scenario	Total Cost	Total Cost (1%)	Total Cost (2%)	Total Cost (4%)
<u>BAU</u>				
Cost of Treatment	422	278	183	81
Cost of Adaptation	309	203	135	60
<u>A2</u>				
Cost of Treatment	352	232	153	68
Cost of Adaptation	309	203	135	60
<u>B2</u>				
Cost of Treatment	347	228	151	67
Cost of Adaptation	309	203	135	60

Source: ECLAC, 2011b

The implications represented in table 6.3 are unambiguous - in the face of the incidence of disease that can be expected, it is practical to undertake adaptation measures, mainly because of the welfare benefits of less morbidity amongst the population, even if in all instances savings are not achieved.

## 7. CONCLUSIONS AND POLICY RECOMMENDATIONS

Trinidad and Tobago is under considerable threat from the economic impact of climate change on its agriculture, energy, and health sectors. In terms of development policy and planning, the country has begun addressing the impact of climate change on the country and has in place a Draft National Climate Change Policy. Trinidad and Tobago's response to climate change focuses on both adaptation and mitigation strategies. In the context of mitigation, the government proposes to utilize low greenhouse gas emission economic development pathways across sectors and for adaptation the policy in its present form outlines broad options to integrate adaptation planning into national policy

The study of the impact of climate change on the agriculture sector focused on 3 leading sub-sectors: root crops, green vegetables and fisheries. For these sectors combined, the cumulative loss under A2 is calculated as approximately TT\$2.24 billion and approximately TT\$1.72 billion under B2 by 2050. This is equivalent to 1.37% and 1.05% of the 2008 GDP under the A2 and B2 scenarios, respectively.

Given the potential for significant damage to the agriculture sector, a large number of potential adaptation measures were considered. Out of these a short-list of 10 potential options were selected by applying 10 evaluation criteria. All of the adaptation strategies showed positive benefits. The analysis indicate that the options with the highest net benefits are: (1) Building on-farm water storage; (2) Mainstreaming climate change issues into agricultural management; and (3) Using drip irrigation. Other attractive options include water harvesting and water management plans. The policy decisions by governments should include these assessments, the omitted intangible benefits, as well as the provision of other social goals such as employment.

The analysis of the energy sector has shown that the economic impact of climate change during 2011-2050 is similar under the A2 (US\$142.88 million) and B2 (US\$134.83 million) scenarios with A2 scenario having a slightly higher cost (0.737% of 2009 GDP) than the B2 scenario (0.695% of 2009 GDP) for the period. On the supply side, analyses indicate that Trinidad and Tobago's energy sector will be susceptible to the climate change policies of major energy-importing countries (the United States and China), and especially to their renewable energy strategies. Implementation of foreign oil substitution policy by the United States of America will result in a decline in Trinidad and Tobago's LNG export (equivalent to 2.2% reduction in 2009 GDP) unless an alternative market is secured for the lost United States of America market. China, with its rapid economic growth and the highest population in the world, offers a potential replacement market for Trinidad and Tobago's LNG export. In this context the A2 scenario will offer the best option for Trinidad and Tobago's energy sector.

The cost-benefit analysis undertaken on selected adaptation strategies reveal that the benefit-cost ratio of replacing electric water heaters with solar water heaters is the most cost-effective. It was also found that the introduction of CFL and VRV air conditioners surpasses the projected cost of increased electricity consumption due to climate change, and provides an economic rationale for the adoption of these adaptation options even in a situation of increased electricity consumption occasioned by climate change. Finally, the conversion of motor fleets to CNG is a cost-effective adaptation option for the transport sector, although it has a high initial cost of implementation and the highest per capita among the four adaptation options evaluated.

To investigate the effect of climate change on the health sector, four diseases (dengue, leptospirosis, food borne illnesses, and gastroenteritis) were examined. The total number of new dengue cases for the period 2008 to 2050 was 204,786 for BAU, 153,725 for A2 and 131,890 for B2. With regard to the results for leptospirosis, A2 and B2 seem to be following a similar path with total number of new cases in A2 being 9,727 and 9,218 cases in B2. Although incidence levels in the BAU scenario coincided with those of A2 and B2 prior to 2020, they became somewhat lower post 2020. A similar picture emerges for the scenarios as they relate to food-borne illnesses and to gastroenteritis. Specifically for food-borne illnesses, the BAU scenario recorded 27,537 cases, the A2 recorded 28,568 cases and the B2 recorded 28,679 cases.

The focus on the selected sources of morbidity in the health sector has highlighted the fact that the vulnerability of the country's health sector to climate change does not depend solely on exogenously derived impacts, but also on the behaviours and practices among the population. It is clear that the vulnerability

which became evident in the analysis of the impacts on dengue fever, leptospirosis and food-borne illnesses is not restricted solely to climate or other external factors. The most important adaptation strategy being recommended targets lifestyle, behaviour and attitude changes. The population has to be encouraged to alter their behaviours and practices so as to minimise their exposure to harmful outcomes as it relates to the incidence of these diseases.

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