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ANALYSIS OF EXTREME EVENTS IN THE CARIBBEAN 1990 - 2008

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FOREWORD

Caribbean countries, by virtue of their geographical characteristics, resource constraints and limited adaptive capacity, are vulnerable to natural hazards, especially hydro-meteorological events such as tropical storms, hurricanes and heavy rainfall. Haiti has demonstrated that threats of a geological nature also exist, as the tragic event of the 12 January 2010 earthquake have revealed. Previous volcanic activity in Montserrat and several other islands underscores this fact. Fragile ecosystems and infrastructure will be increasingly challenged by climate change.

This study presents an analysis of extreme events in the Caribbean subregion for the period 1990 to 2008, and forms part of a similar, wider study focused on the Latin America and the Caribbean region (Central America and South America being the other two subregional components). It explores the economic costs of climate change through an examination of adaptation costs to extreme events. ECLAC, through its Subregional Headquarters for the Caribbean, is pleased to have been able to undertake this study with the financial support of DFID and to have ensured its successful execution in collaboration with technical expertise from the University of the West Indies.

The primary data on which this study is based comes, in the main, from disaster evaluations undertaken by ECLAC using its Damage and Loss Assessment (DALA) methodology. This methodology was developed by ECLAC in collaboration with other partners and is now used widely in other regions as the standard method for evaluating disaster impacts. It is hoped that the findings of this study will add to the stock of knowledge on the impact of disasters in the region and assist in informing policymaking to reduce risk.

There is concurrence by ECLAC with the literature on disasters and development that disasters are not simply the result of potent natural hazards, but are often manifestations of unresolved problems of development. The study reiterates the important notion that the analysis of the impact of disasters should not be limited to the stark evidence on economic costs or lost lives but should also address the possible impact on the developmental trajectory of a particular country.

Disasters often aggravate macroeconomic problems. The study suggests that declines in real GDP and employment in some sectors following disasters temporarily set back living standards in affected countries. It argues that a most serious challenge relates to external debt and notes that for all of the countries reviewed, their external debt increased in the year of the disaster (compared to the year prior to the disaster). This is an important concern, as the expansion of debt is also triggered by normal infrastructure and development needs and other economic shocks. Moreover, the loss of foreign exchange from debt servicing costs is an important constraint on development growth in the Caribbean.

Regardless of the extent of damage to social, economic, environmental or infrastructural resources, a country has to engage in post-disaster rehabilitation and reconstruction in an effort to return economic activity and life of its citizens to some level of normalcy. The urgency of this rehabilitation process is particularly acute when, as in many of the countries reviewed in this study, housing and human settlements as well as vital infrastructure (water, roads, communication and energy) have been affected by the impact of a disaster. However, disasters often present opportunities to build back better, for instance, by upgrading shanty settlements, applying building codes and diversifying the production base. Such opportunities must be properly grasped.

Finally, ECLAC wishes to encourage countries of the Caribbean subregion to budget and programme for disaster planning and climate change through integration of risk reduction measures into medium and long term development planning, in the same manner as for other vital public goods.

Neil Pierre
Director

CONTENTS

TABLES

FIGURES

BOXES

EXECUTIVE SUMMARY

This study presents an analysis of extreme events in the Caribbean subregion, and forms part of a similar, wider study focused on the Latin America and the Caribbean region (Central America and South America being the other two subregional components).

Chapter I of this study analyses the cost of disasters in the Caribbean for the period 1990 to 2008 using the ECLAC Damage and Loss Assessment or DALA methodology, which classifies the total impact of a natural disaster on a country according to damage, losses and secondary impacts.[1] Chapter II then uses historical data to project possible changes in the frequency and intensity of extreme events using the PRECIS (Providing Regional Climates for Impacts Studies) tool to generate shaded-isopleth maps. Chapter III identifies existing and potential climate change adaptation actions and strategies, and estimates their cost based on the valuation of disaster prevention and reduction interventions. Finally, the study presents some conclusions and policy recommendations. Maps and indicators are provided in the Appendices.

Between 1990 and 2008, the Caribbean experienced 165 natural disasters, of which 61% were windstorm-related events – hurricanes, floods and tropical storms. Haiti, the Dominican Republic and Jamaica were the countries most affected, having each experienced 49, 34 and 21 natural events, respectively.

The total impact on the subregion (in damage and losses) was estimated at US $ 136 billion[2] over the period. Damage refers to the impact on immovable assets and stock, while losses stem from disruption to the flow of goods and services that will not be produced or rendered over a period of time due to the disaster, such as the loss of crop harvests or industrial production.

The evaluation, further broken down into economic, social, infrastructural and environmental damage, found economic impacts to be the highest, most heavily felt in productive sectors such as agriculture, tourism and manufacturing. Economic damage in agriculture-dependent economies such as Saint Lucia and Dominica was concentrated on the banana crop and subsistence agriculture, in Guyana in the sugar and rice industries, and in Belize in the sugar, bananas, citrus and papaya crops. In tourism-dependent economies such as Anguilla, the Bahamas, Cayman Islands and Grenada, the tourism sector bore the brunt of the infrastructural impact, most of the tourism plant being located along the coastline exposed to wind and wave damage. The social impact was generally concentrated in housing and human settlements. With the exception of Suriname, direct damage to housing and human settlements ranged between 35% and 99% of total national damage costs.

The breakdown of total damage by economic, social, infrastructural and environmental damage is as follows:

- The total economic impact (damage and losses) of natural disasters in the Caribbean between 1990 and 2008 was US$ 63 billion (46% of total impact)
- The social cost of disasters was US$ 57 billion (42% of total impact)
- The total infrastructural damage from natural disasters was approximately US$ 12 billion (9% of total impact)
- Damage to the environment from disasters was US$ 3.5 billion (3% of total impact)

Countries experienced differential impacts depending on their level of resilience. Haiti experienced the highest total damage cost, estimated to be 39% of the regional damage costs or

[1] ECLAC (2003), and Annex 1.
[2] Constant 2008 dollars.

approximately US$ 53 billion. Suriname was a second behind Haiti, with an estimated US$ 51 billion in total damage costs which accounted for 38% of the subregional damage costs. The total subregional rehabilitation costs from natural disasters were estimated at US$ 1.3 trillion. Haiti alone accounted for 99% of this sum.

Secondary impacts refer to the fallout in the main macro-economic variables, including gross domestic product, investment, prices, public finances and the balance of payments. The negative impact on real GDP and employment in some sectors, and declines in exports and higher imports for reconstruction, has tended to widen the structural balance of payments deficit in many countries. The external debt of some of the countries reviewed showed sharp and significant increases. Indeed, hurricanes have been an important contributor to the growth of debt in OECS countries in the last two decades.

Chapter II of the analysis provides projections of the frequency, intensity and severity of impacts of natural disasters in the Caribbean and responses in terms of climate change adaptation strategies, using the PRECIS (Providing Regional Climates for Impacts Studies) modelling tool to generate shaded-isopleth maps. Making reasonable projections was challenged by the lack of acceptable and published projections of extreme events in the Caribbean. The variables projected were temperature, surface temperature, wind speed and sea level pressure at surface level.

The main findings point to declining precipitation in the Bahamas and severe increases in surface temperatures in Haiti, the Dominican Republic and Belize in the decades up to 2050, compared with the benchmark period of 1961 to 1990. These projected conditions could exacerbate droughts that could subsequently lead to flooding due to increased overland flows during periods of intense rainfall, as has been experienced in Haiti in the past. Moreover, fluctuations in temperature and precipitation could affect the water table and fragile water resources of affected countries, leading to water deficits as temperatures rise.

The differential impacts of climatic and environmental changes on countries in the subregion were measured using the environmental vulnerability index (EVI) and the adjusted prevalent vulnerability index (PVI).

The Environmental Vulnerability Index (EVI) measures the “precariousness of States, arising from their economic exposure, lack of protection and peripherality.” Three of the fourteen countries included in the analysis —Dominica, Jamaica and Saint Lucia— were categorized as extremely vulnerable. Five countries —Cayman Islands, the Dominican Republic, Grenada, Haiti and the Netherlands Antilles— were ranked as highly vulnerable, while two countries —Anguilla, and Turks and Caicos Islands— were categorized as vulnerable. The Bahamas and Belize were deemed at risk, while Guyana and Suriname were resilient. Vulnerability reflected the nature of the hazards and the development of resilience and response capacities by individual countries. Jamaica was the most vulnerable with respect to the frequency and intensity of hazards, while Anguilla was the least vulnerable, not often impacted by hazards.

Importantly, with respect to coping capacity, Turks and Caicos Islands emerged as the most vulnerable, and Anguilla and Cayman Islands were also highly vulnerable. This suggests the need to build resilience by improved building codes and construction setback limits from coastlines in these tourism dependent economies. Belize was the least vulnerable with respect to coping. With respect to susceptibility to the impacts of climate change, Saint Lucia was deemed most vulnerable, due to potential impacts on water resources, agriculture and fisheries, while Suriname was least vulnerable.

The prevalent vulnerability index (PVI) measures socio-economic fragility and a lack of social resilience. The index is based on two sets of indicators. One set includes variables such as population density, investment to GDP ratio and debt service to GDP ratio, among others, while the other set includes the Gini coefficient of income inequality, exposure of capital assets, and levels of education and employment, among other factors. The PVI showed that Grenada had the highest level of vulnerability between 1990 and 2007, while Suriname had the lowest. Haiti, Saint Lucia and the Dominican Republic also had relatively high indices of vulnerability.

Chapter III undertakes an evaluation of country level climate change adaptation and disaster risk reduction strategies. The analysis is based on individual national communications on greenhouse gas emissions, and supporting information on the existence of natural disaster preparedness and response agencies and capacities.

Almost all countries have developed national communications on disasters and natural disaster preparedness and mitigation plans. Each country in its national communications has identified specific priority sectors that are most vulnerable to climatic events. For most countries, health, coastal zones, tourism and agriculture make up the most sensitive sectors, depending on production specialization and the extent of health and coastal zone management. Nevertheless, all sectors were important for adaptation since they are linked to human communities and fallout in them affects employment, poverty, government expenditure and public debt.

There has been a strong emphasis on re-enforcement of physical infrastructure to withstand minimum category events in pre-event plans. These involved improving design of causeways, bridges and housing. Similarly, the majority of coastal zones pre-event adaptation entailed the constructing sea walls, dykes, levees and floodwalls. The upgrading of physical infrastructure was also an adaptation strategy in tourism.

Nevertheless, policymakers recognized the need to move beyond reinforcement of physical infrastructure to focus on safeguarding other productive sectors. Therefore, the agriculture preparedness plans focused on introducing crops that were most tolerant to changes in climatic conditions, sought to improve irrigation, drainage and other farming practices, and to use new technology such as hydroponics, soil conservation and other practices to limit losses from disasters. Guyana has designed an Impact and Vulnerability Assessment for the forestry sector, while Saint Lucia has a comprehensive adaptation plan for agriculture. Water resources management was centred on water conservation, and the development of good knowledge in safety precautions and preparedness in the event of floods and other disasters.

In recognition of the importance of community buy-in and participation, all countries are seeking to increase education and awareness of disaster risk management. Several workshops have been held to discuss civil society participation in disaster risk management.

- The July 2005 workshop on "Reporting on the Mauritius Strategy Implementation in Saint Vincent and the Grenadines" targeted schools and communities to get them more involved in sand watch and other environmental activities.
- The United Nations Environmental Programme (UNEP) workshop was held in Mexico in October, 2007. This led to the Latin America and the Caribbean Regional Statement to the Ninth Global Civil Society Forum and the Tenth Special Session of the Governing Council /Global Ministerial Environment Forum. The workshop identified the responsibility of each stakeholder to mitigate climate change, and to strengthen alliances amongst organizations through joint climate change prevention, mitigation and adaptation policy and projects.

The Caribbean Natural Resource Institute (CANARI) proposed national follow-up activities for several countries focused on collaboration among governments, civil society, schools, conservation organizations, NGOs, the media and artists.

A vital area of assessment was the cost of funding for adaptation. Using constant 2008 dollars to assess current adaptation costs, it was found that a substantial amount of funding went into rehabilitation and reconstruction in response to disasters. Countries also requested funding to compile their National Communications to the United Nations Framework Convention on Climate Change (UNFCCC). The bulk of the funding went to Haiti, Guyana and Jamaica, while countries like the Cayman Islands and Dominica received less funding. It is anticipated that despite their budget constraints, countries would have to budget counterpart resources to increase adaptation and mitigate the impacts of climate change. Such adaptation and mitigation is a critical public good in the Caribbean.

In order to provide an effective and proactive response to climate change and extreme events it was recommended that Caribbean governments and citizens take action on a number of fronts. Given the high socio-economic fall-out from natural disasters, countries should undertake practical measures, including adequate setback limits for hotel construction, use of more disaster resistant varieties of crops, and the strengthening of livelihoods assets and social capital to raise resilience.

To mitigate the impact of climate change, there is a need for increased investment in more detailed hurricane/climate change projections. The PRECIS model provides a partial tool for projecting, but needs further elaboration to make it more effective. More detailed studies on natural environmental impacts are needed, in terms of bio-physical and socio-economic impacts. Specific studies should be undertaken to improve the ex ante valuation of natural assets across the Caribbean to provide benchmark data for evaluation of damage and loss to these assets in the event of a disaster.

A thorough review of best practices in terms of preparedness, resilience building and climate change adaptation should be undertaken. This would entail sharing of best practices from countries such as Cuba and the active involvement of civil society.

Crucially, development planning needs to give due weight to climate change in an environment of increasing uncertainty. Climate change mitigation should be mainstreamed into development plans, with a focus on priority investments that could yield multi-dividend returns. This should include a focus on diversification into more resilient activities where possible.

Given the heavy losses in housing and other buildings, construction standards should be based on the Caribbean Unified Building Code (CUBIC). One way to encourage this would be to link compliance with the code with insurance and tax incentives.

Finally, there is a need for emphasis on public and professional education and participation of civil society in resilience building activities. Disaster preparedness and risk reduction should be programmed into multiple activities in the society to reinforce the message. Importantly, education and awareness should be started in the early school system. This should include practical field trips to vulnerable sites and the use of role playing to solve environmental challenges.

CHAPTER I

A HISTORICAL ANALYSIS OF THE IMPACT OF NATURAL DISASTERS ON CARIBBEAN ECONOMIES FROM 1990 TO 2008

The results of an historical analysis of impact of natural disasters on Caribbean economies between 1990 and 2008 are summarized in Tables 1 to 3. Table 1 tracks natural disasters by country between 1990 and 2008. In summary, the data show that the Caribbean countries are most vulnerable to natural disasters in terms of their economic and social vulnerability. The former refers to sectoral impacts in tourism, manufacturing, industry and commerce, and the latter to impacts in the social sector which includes housing stock and settlements, health, education and infrastructure. Table 2 summarizes the share of total regional impact borne by individual Caribbean countries. Table 3 disaggregates the share of regional costs borne by countries across economic, social, infrastructural and environmental damage.

A. GENERAL OVERVIEW

The following are some of the salient results of that analysis.

(a) Table 1 shows that between the period 1990 and 2008 the Caribbean countries under review experienced 165 natural disasters, of which 61% were windstorm-related events – hurricanes, floods and tropical storms. Haiti, the Dominican Republic and Jamaica were the most affected by these natural disasters over the period, having each experienced 49, 34 and 21 natural events, respectively.

(b) Incomplete data reveal that some 2.5 million people were affected over the study period.

(c) Total impact on the Caribbean subregion (damage and losses) from natural disasters was estimated to be US$ 136 billion[3] over the period 1990 to 2008, as follows:

- Total damage and loss to the economic sector was US$ 63 billion (46%)
- The impact on the social sector was US$ 57 billion (42%)
- Total damage and loss to infrastructure was US$ 12 billion (9%)
- The impact on the environment was valued at US$ 3.5 billion (3%)

(d) Haiti suffered the highest total impact - estimated to be 39% of the regional impact or approximately US$ 53 billion. Suriname was close behind Haiti, with total impact estimated at US$ 51 billion, 38% of the regional impact.

(e) Total regional rehabilitation costs from natural disasters were estimated at US$ 1.3 trillion. Haiti alone accounted for 99% of these rehabilitation and reconstruction costs.

(f) A common thread among all the Caribbean countries was the impact on the social sector, and more specifically on the housing and human settlements subsector. With the exception of Suriname, all other countries reviewed had direct damage to the housing and human settlements subsector, ranging between 35% and 99% of total national damage costs incurred as a result of natural disasters.

[3] Constant 2008 dollars.

(g) At the disaggregated sectoral level, in many of the tourism-dependent economies such as Anguilla, the Bahamas, Cayman Islands and Grenada where most of the tourism plant is located along the coastline, much of the damage and loss was attributed to the tourism sector. Likewise, in agriculture-dependent economies such as Saint Lucia and Dominica, the majority of the impact was felt in the agricultural sector.

(h) The behaviour of some key macroeconomic variables also highlights the vulnerability of the subregion to disasters. The external debt of some of the countries reviewed showed sharp and significant increases in the period immediately before and immediately after the occurrence of the disaster. In Haiti, external debt before and after the disaster at 234% and 118% of GDP in 2004 and 2008 corroborates the EMDAT[4] definition of a disaster as"that which outstrips the capacity of a country to cope…" Table 1 highlights the extraordinary vulnerability of Haiti relative to other Caribbean countries. The data show that Haiti had the highest share of costs due to economic, infrastructural and environmental damage. Suriname bore the highest share of costs to the social sector.

Table 1
Natural disasters by type and country: 1990 to 2008

Country	Drought	Earthquake (seismic activity)	Epidemic	Extreme Temperature	Flood	Mass movement wet	Storm	Total
Belize				1	3		8	12
Guyana	1				4	1		6
Suriname					2			2
Anguilla	0	0	0		0	0	1	1
Bahamas	0	0	0		0	0	12	12
Cayman Islands	0	0	0		0	0	7	7
Dominica	0	1	0		0	0	5	6
Dominican Rep	0	1	3		13	0	16	34
Grenada	0	0	0		0	0	4	4
Haiti	3	0	1		22	0	23	49
Jamaica	1	0	2		4	0	14	21
Netherlands Antilles	0	0	0		0	0	1	1
St Lucia	0	1	0		0	1	4	6
Turks and Caicos Is	0	0	0		0	0	5	5
Total	**5**	**3**	**6**	**1**	**48**	**2**	**100**	**165**

Source: "EM-DAT: The OFDA/CRED International Disaster Database
www.emdat.be - Université Catholique de Louvain - Brussels - Belgium"

[4] http://www.emdat.be/database

Table 2
Share of total natural disaster damage costs borne by individual Caribbean economies, 1990-2008

Country	Total National impact from Disasters as a % of Total Regional impact from Disasters (1990 – 2008)
Anguilla (1995)	0.06%
Bahamas, the (2004)	0.39%
Belize (2007)	0.08%
Belize (2000)	0.24%
Cayman Islands (2004)	3.78%
Cayman Islands (2008)	0.20%
Dominica (2007)	0.09%
Dominican Republic (2004)	1.01%
Grenada (2004)	1.32%
Guyana (2005)	12.70%
Haiti (2004)	14.05%
Haiti (2008)	25.36%
Jamaica (2001)	0.14%
Jamaica (2001)	1.55%
Netherlands Antilles (1995)	1.15%
Saint Lucia (2007)	0.02%
Suriname (2006)	37.64%
Turks and Caicos (2008)	0.22%

Table 3
Impacts of natural disasters on Caribbean economies 1990-2008

Country	Disaster event	Total national impact to infrastructure as a % of total subregional infrastructure damage	Total national impact to economic sector as a % of total subregional economic sector impact	Total national social sector impact as a % of total subregional social sector Impact	Total national environmental impact as a % of total subregional environmental impact
Anguilla	Hurricane Luis (1995)	0.2%	0.1%	0.0%	0.00%
Bahamas, the	Hurricane Frances and Jeanne (2004)	1.3%	0.4%	0.3%	0.00%
Belize	Hurricane Dean (2007)	0.1%	0.1%	0.0%	0.13%
Belize	Hurricane Keith (2000)	0.4%	0.3%	0.1%	0.81%
Cayman Islands	Hurricane Ivan (2004)	6.1%	2.6%	4.8%	0.53%
Cayman Islands	Hurricane Paloma (2008)	0.2%	0.1%	0.3%	0.36%
Dominica	Hurricane Dean (2007)	0.5%	0.1%	0.0%	0.00%
Dominican Republic	Hurricane Frances & Jeanne (2004)	3.5%	1.4%	0.1%	0.04%
Grenada	Hurricane Ivan (2004)	1.6%	0.6%	2.1%	0.00%
Guyana	Floods (2005)	14.2%	8.1%	18.3%	0.08%
Haiti	Hurricane Jeanne (2004)	9.8%	21.3%	7.7%	0.69%
Haiti	Tropical Storm Fay, Gustav, Hanna, Ike (2008)	50.8%	26.0%	15.1%	92.10%
Jamaica	Hurricane Michelle (2001)	1.1%	0.1%	1.3%	0.00%
Jamaica	Hurricane Ivan (2004)	3.8%	1.2%	1.3%	4.16%
Netherlands Antilles	Hurricane Luis, Marylyn (1995)	0.8%	1.8%	0.6%	0.00%
Saint Lucia	Hurricane Dean (2007)	0.1%	0.0%	0.0%	0.01%
Suriname	Floods (2006)	4.8%	35.8%	49.0%	0.00%
Turks and Caicos Islands	Hurricane Hanna, Ike (2008)	0.7%	0.0%	0.3%	1.09%

Source: Derived from ECLAC Assessments, 1990 – 2008

Box 1
Methodological issues

The report is based primarily on the ECLAC methodology for estimating the socio-economic impacts of disasters. In order to facilitate a subregional comparison among the case study countries, it was necessary to convert the damage costs in the year of the natural disaster to constant 2008 values. This conversion was done using a GDP Deflator Index obtained from the International Monetary Fund World Economic Outlook Database. The following should be noted:

- Deflators were obtained for Antigua and Barbuda, The Bahamas, Belize, Dominica, the Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Saint Lucia and Suriname.

- In the absence of deflators for the Cayman Islands, the Netherlands Antilles and the Turks and Caicos Islands, the deflator for the Bahamas was used as a proxy.

B. THE IMPACT OF NATURAL HAZARDS AND CLIMATE CHANGE ON ECONOMIES

Wisner and others (1976) remind us that there is nothing 'natural' about 'natural disasters'. Wisner's caution is intended to distinguish between the trigger event, the hazard, and its consequences, some of which are disastrous.

The analysis of the impact of disasters is not limited to the stark evidence on economic costs or lost lives, but also needs to address the possible impact on the developmental trajectory of a particular country. On this score, the literature on disasters and development has increasingly recognized that disasters are not simply extreme events created entirely by natural forces but rather, they are sometimes manifestations of unresolved problems of development.[5] For example, poverty may lead to unsustainable livelihood practices – high population densities in high risk areas that exacerbate inherent vulnerability – the result being disasters that outstrip the capacity of individuals or governments to cope with the consequences (Anderson and Woodrow, 1998; Wisner, 2001).

The United Nations Development Programme (UNDP) calculates that while only 11% of persons exposed to droughts, earthquakes, floods and windstorms live in developing countries, they simultaneously constitute an estimated 53% of the people who lose their lives (UNDP, 2004). Poorer countries also suffer to a greater extent when economic loss is measured as a proportion of GDP (World Bank, 2004).

Benson and Clay (2004) noted that, "…Economic vulnerability is not a static condition that reflects location-specific environmental hazards. The scale and nature of the economic impacts of a natural hazard event depend, as well, on influences that are time specific." They highlight five basic factors that determine the macroeconomic vulnerability to natural hazards:

1. **The type of natural hazard** –the frequency and intensity of some hazards could be more debilitating on an economy. Table 3 shows that for some countries, the cost of the disaster was in excess of the national output (GDP).

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[5] Former United Nations Secretary General, Kofi Annan said, "...poverty and population pressure force growing numbers of poor people to live in harm's way—on flood plains, in earthquake-prone zones and on unstable hillsides." See Opening Remarks by Kofi Annan at the 4th Forum on the International Decade for Natural Disaster Reduction. Available at www.unisdr.org.

2. **The overall structure of an economy, including natural resource endowments** – interpreted to include the level of diversification. Many of the economies reviewed are heavily dependent on one main economic activity – mainly tourism or agriculture.

3. **The geographic size of a country** – this is particularly important for smaller Caribbean countries where the impact of any hazard puts the entire country at risk.

4. **The country's income level and stage of development** – which affects the country's ability to engage in effective pre-disaster risk reduction, post disaster rehabilitation and resilience-building. Some of the countries reviewed are considered medium development countries according to the HDI. Guyana and Haiti are exceptions, low development countries and the only two HIPC[6] countries in the Caribbean. This combination means that any hazard that occurs in these two countries may inevitably result in a disaster.

5. **Prevailing socioeconomic conditions, including the policy environment and the state of the economy** – Most Caribbean countries do not have effective hazard mitigation measures in place. Historical evidence suggests that disaster response is just that – reactive. The complexity of socio-economic challenges and resource constraints impedes the implementation of proactive disaster risk reduction measures, with sometimes catastrophic consequences.

1. Climate change and disasters in Caribbean small island developing States (SIDS)

Apart from the inherent vulnerability to windstorm related events, the threat of climate change as an exacerbating factor looms large. The Fourth Assessment Report (FAR) of the Intergovernmental Panel on Climate Change (IPCC) (2007) has documented the following likely impacts of climate change on small island developing States, including those of the Caribbean:

1. There is a high confidence that sea level rise will affect livelihoods in SIDS as well as coastal settlements and vital infrastructure

2. Water resources are likely to be seriously compromised

3. Climate change could have an overall negative impact on regional tourism, direct in terms of loss of tourism plant and indirect in terms of loss of employment, reduction of economic linkages between agriculture and other economic activities.

Box 2 provides some further details on the anticipated impacts of climate change on SIDS.

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[6]Heavily (Highly) Indebted Poor Countries Initiative or the HIPC Initiative was started in 1996 and is funded by a number of multilaterals including the IMF and the World Bank. The Initiative is meant to allow a number of countries to qualify for debt relief. The objectives of the Initiative include reducing external debts owed by HIPC governments and financing increases in government spending on poor people.

Box 2
Anticipated Impact of Climate Change on SIDS

Specific climate change impact	Probability of occurrence	Socio-economic Impact
Sea level rise	Very high	• exacerbate inundation, storm surge, erosion and other coastal hazards • threaten the livelihood and well-being of island communities given than approximately 50% of the population live within 1.5 km of the shore • settlements, facilities and vital infrastructure compromised.
Water resources	Very high	• water resources in these islands are especially vulnerable to future changes and distribution of rainfall. • many islands in the Caribbean likely to experience increased water stress as a result of climate change.
Extreme events	Very high	• Increase in frequency and intensity of windstorm related events – hurricanes and tropical storms
Overall developmental impact		
The three climate change impacts identified will have a significant developmental impact on sustainable livelihoods, housing and settlements, and the tourism sector. Sea-level rise and increased sea water temperature will cause accelerated beach erosion,[7] degradation of coral reefs, and bleaching. A warmer climate could reduce the number of people visiting small islands. Water shortages and increased incidence of vector-borne diseases may also deter tourists.		

Source: FAR, IPCC 2007, Chapter 16

C. Contextual Overview of Disasters in the Caribbean

The Caribbean subregion, defined to include Guyana and Suriname in the south to the Dominican Republic, Haiti, Cuba and Belize in the north, is characterized by great diversity, in terms of population size and per capita GDP, among others.[8] Notwithstanding this diversity, the subregion holds in common the challenges of size and inherent susceptibility to disasters, particularly windstorm-related events such as hurricanes and tropical storms. The impact of these windstorm events is sometimes so significant that the passage of one event can undo years of progress towards the achievement of developmental objectives. The cost of such disasters – measured as the sum of damage and losses from the event– can be substantial.

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[7] See Cambers (1995) on this score.
[8] For a recent review and discussion of Caribbean economies see Pantin and Attzs (2009) in Understanding the Contemporary Caribbean edited by Richard S. Hillman and Thomas J D'Agostino.

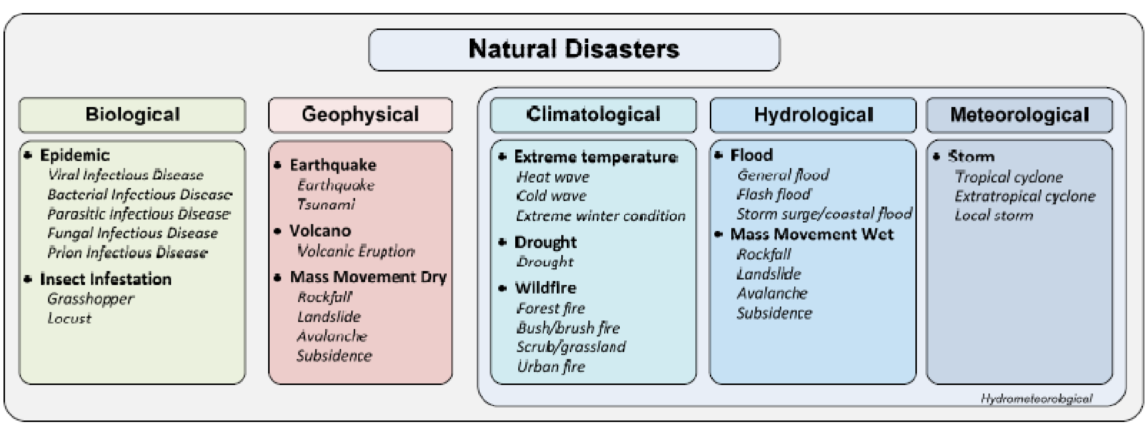
Map 1: The Caribbean

©1992 Magellan Geographix[SM] Santa Barbara, CA (800) 929-4627

Hydrological and meteorological (hydro-meteorological) disasters - hurricanes and tropical storms and other windstorm related events - are the most common in the subregion. Box 3 provides a typology of natural disasters. Hydro-meteorological disasters account for an estimated 60% of all natural disasters affecting the Caribbean, but in damage impact the share is even larger. Significant flooding is one of the after-effects of hurricanes, estimated to cause 29% of the disasters; wind storms and heavy rainfall are caused by tropical weather systems (including El Niño). Unlike ECLAC member countries in Central America, for which earthquakes are a significant natural hazard, in Caribbean countries earthquakes accounted for approximately 2% of the disasters which the subregion faced between 1990 and 2008.

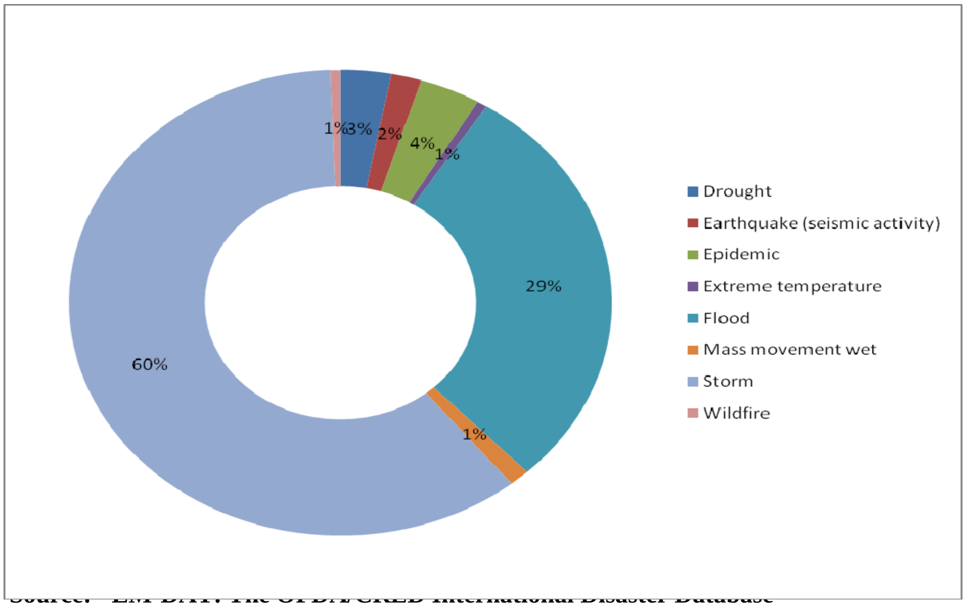
Generally, the larger countries of the northern Caribbean (in terms of geographic space covered), that is, the Bahamas, Haiti, the Dominican Republic and Jamaica, have been the most affected in terms of frequency of natural disasters. (See figures 2 and 3, and tables 1 and 2).

Box 3
Typology of natural disasters



Source: CRED Crunch, "Disaster Data: a balanced perspective". Issue no. 13, July 2008. Brussels, Belgium: Centre for Research on the Epidemiology of Disasters (CRED). http:// www.cred.be

Figure1
Total number of disasters by type of disaster



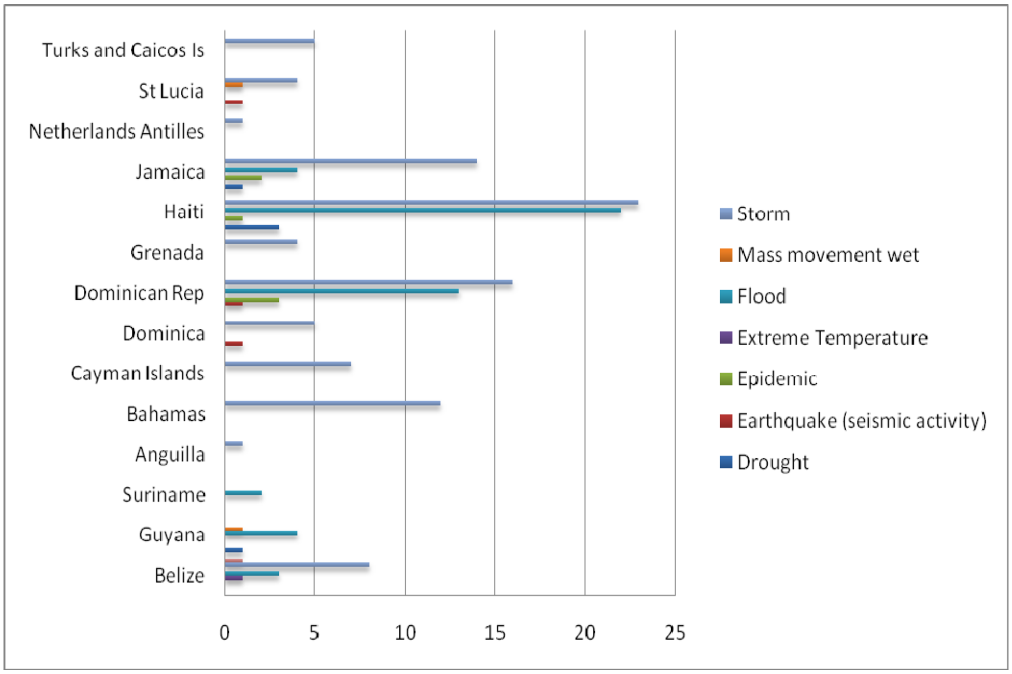
Source: EM-DAT: The OFDA/CRED International Disaster Database
Source: www.emdat.be - Université Catholique de Louvain - Brussels - Belgium"

Figure 2 shows the number of natural disasters[9] by type and country for the period 1990 to 2008. The figure illustrates that, of the 14 Caribbean countries under review in this study, Haiti, the Dominican Republic, Jamaica and the Bahamas have experienced a disproportionately greater number of storms. Flooding also has severely affected several of the countries.

Figure 2 is complemented by table 1 and figure 3 which shows the total number of natural disasters that have occurred by country. Of an estimated 166 natural hazards affecting the subregion between 1990 and 2008, Haiti again has emerged as the country most vulnerable to these hazards – this country was affected by 29% of the total number of disasters that occurred during 1990 and 2008. The Dominican Republic and Jamaica were affected by 20% and 13%, respectively.

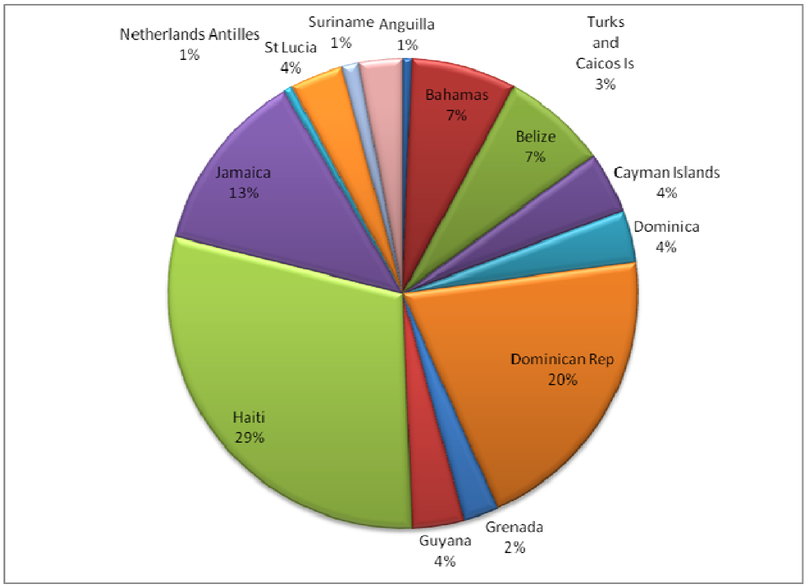
[9] Drought, earthquake, epidemic, extreme temperature, flood, insect infestation, mass movement dry, mass movement wet, storm, volcano

Figure 2a
Natural Disasters by type and country: 1990 - 2008



Source: "EM-DAT: The OFDA/CRED International Disaster Database
www.emdat.be - Université Catholique de Louvain - Brussels - Belgium"

Figure 3
Total Number of Natural Disasters that occurred by country: 1990 - 2008



Source: "EM-DAT: The OFDA/CRED International Disaster Database
www.emdat.be - Université Catholique de Louvain - Brussels - Belgium"

D. SOCIO-ECONOMIC ASSESSMENT OF HAZARDS ON CARIBBEAN ECONOMIES

Apart from the floods which had catastrophic impacts on Guyana and Suriname in January 2005 and April/May 2006, respectively, the subregion experienced fourteen named events over the 18-year period under consideration. Table 2 provides a snapshot of the impact of windstorm-related natural hazard events that have affected the Caribbean subregion between 1990 and 2008. Of these fourteen named events, there were three Category 1 events (Dean[10] and Gustav), one Category 2 event (Marilyn), two Category 3 events (Ivan and Jeanne), six Category 4 events (Ike, Luis, Ivan, [11] Keith, Paloma and Francis), and two Category 5 events (Dean and Ivan).

The socio-economic impacts of these hazards were manifested in economic impacts (national output and GDP), infrastructural impacts (roads and bridges, electricity, telecommunication and water), social impacts (populations affected) and environmental impacts (loss of ecosystems and natural resources).

1. Economic impacts of disasters on Caribbean Economies 1990 – 2008

Between 1990 and 2008, the subregion suffered an estimated US$ 63 billion[12] in damage and losses as a result of disasters. This impact was suffered in the tourism, agriculture, forestry and fisheries, manufacturing and industry and commerce sectors. In each country, the impact was greatest in the leading economic subsector. For example the economic impact suffered in the Bahamas was primarily to that country's tourism sector whereas for Saint Lucia, the economic impact was primarily to that country's agricultural sector.

Table 4 shows the disasters responsible for causing the impact to the various economic sectors across the Caribbean between 1990 and 2008. The table shows damage to single or multiple sectors (where such data were available) and cumulative regional impact from disasters. The data reveal the following:

(a) In terms of overall economic impact of disasters on Caribbean economies, Haiti, with its complexity of socio-economic challenges, ranked first, accounting for 47% of the total regional damage from disasters. Suriname was ranked second, accounting for approximately 36% of the total regional effect from disasters – calculated as the respective country's total national economic impact from disasters as a share of total regional economic impact. Subsequent tables also point to the overall vulnerability of the Haitian economy to natural disasters.

(b) For Belize, Dominica, the Dominican Republic, Guyana, Haiti, Jamaica, Saint Lucia and Suriname the agricultural sector was most affected by windstorm related natural disasters. This finding is not surprising since agriculture is the primary economic activity in many of the aforementioned countries. In Belize (in the aftermath of Hurricane Dean, 2007), Dominica, Haiti, Saint Lucia, Jamaica (in the aftermath of Hurricane Michelle, 2001) and Suriname, direct damage as and losses accounted for between 80% and 85% of the total national impact of natural disasters.

(c) In Anguilla, the Bahamas, Cayman Islands, Dominican Republic, Grenada and the Netherlands Antilles, all tourism-dependent economies, their tourism sectors were heavily impacted (as a share of total impact of the natural disaster).

(d) Industry and Commerce did not emerge as having suffered a significant economic impact in many of the countries. The exceptions were the Cayman Islands, for which 46% of total

[10] Hurricane Dean developed from a Category 1 to a Category 5 event.
[11] Hurricane Ivan affected Grenada as a Category 3 then hit Jamaica and Cayman Islands as a Category 4 and finally a Category 5 hurricane.
[12] Constant 2008 United States dollars

costs in the economic sector from natural disasters was to damage and losses in industry and commerce, Guyana for which 37% of total cost to the sector was accounted for by damage and losses to industry and commerce, and the Turks and Caicos Islands, for which both damage and losses to the economic sector totalled 72% of total national impact to the economic sector.

Table 4
Total damage and loss to the economic sector by subsectors and across countries, 1990 – 2008

Country	Disaster Event	Damage to Agriculture, Forestry and Fisheries as a % of total effect to ES	Losses to Agriculture, Forestry and Fisheries as a % of total effect to ES	Damage to Tourism as a % of total effect to ES	Loses to Tourism as a % of total effect to ES	Damage to Industry and Commerce as a % of total effect to ES	Losses to Industry and Commerce as a % of total effect to ES	Damage to Manufacturing as a % of total effect to ES	Losses to Manufacturing as a % of total effect to ES	Total National Effect as a % of Total Regional effect to ES
Anguilla	Hurricane Luis (1995)	4.60%	4.40%	75.69%	13.30%	1.28%	0.73%	0.00%	0.00%	0.08%
Bahamas	Hurricane Frances and Jeanne (2004)	6.87%	22.17%	18.91%	52.04%	0.00%	0.00%	0.00%	0.00%	0.37%
Belize	Hurricane Dean (2007)	33.94%	58.58%	1.06%	6.43%	0.00%	0.00%	0.00%	0.00%	0.12%
Belize	Hurricane Keith (2000)	23.43%	14.18%	37.54%	10.98%	9.27%	4.59%	0.00%	0.00%	0.31%
Cayman Islands	Hurricane Ivan (2004)	0.04%	0.56%	30.27%	19.38%	46.06%	3.69%	0.00%	0.00%	2.64%
Cayman Islands	Hurricane Paloma (2008)	0.16%	0.59%	39.77%	26.13%	21.12%	12.24%	0.00%	0.00%	0.06%
Dominica	Hurricane Dean (2007)	34.49%	46.18%	2.11%	2.63%	9.32%	5.27%	0.00%	0.00%	0.07%
Dominican Republic	Hurricane Frances & Jeanne (2004)	30.12%	8.82%	25.54%	19.20%	0.00%	16.32%	0.00%	0.00%	1.39%
Grenada	Hurricane Ivan (2004)	10.13%	8.48%	56.54%	18.73%	0.00%	2.04%	3.30%	0.80%	0.64%
Guyana	Floods (2005)	36.49%	3.19%	0.17%	3.93%	37.19%	15.53%	2.43%	1.08%	8.10%
Haiti	Hurricane Jeanne (2004)	38.02%	58.06%	0.00%	0.00%	2.34%	1.57%	0.00%	0.00%	21.30%
Haiti	Tropical Storm Fay, Gustav, Hanna, Ike (2008)	15.68%	3.36%	1.32%	4.58%	4.08%	25.44%	4.22%	14.28%	25.99%
Jamaica	Hurricane Michelle (2001)	85.61%	8.56%	5.83%	0.00%	0.00%	0.00%	0.00%	0.00%	0.07%
Jamaica	Hurricane Ivan (2004)	25.47%	38.45%	3.49%	8.41%	0.37%	7.33%	1.57%	14.91%	1.21%
Netherlands Antilles	Hurricane Luis, Marilyn (1995)	0.00%	0.00%	35.96%	28.42%	10.36%	25.26%	0.00%	0.00%	1.80%
St. Lucia	Hurricane Dean (2007)	36.09%	46.37%	17.00%	0.54%	0.00%	0.00%	0.00%	0.00%	0.03%
Suriname	Floods (2006)	83.25%	2.07%	4.74%	4.16%	0.71%	5.07%	0.00%	0.00%	35.82%
Turks and Caicos	Hurricane Hanna, Ike (2008)	12.94%	14.44%	0.00%	0.00%	43.77%	28.84%	0.00%	0.00%	0.02%

Source: Derived from ECLAC Assessments

Tables 5 (a) and 5(b) provide data on the economic impact of disasters on imports, exports, external debt and external balance on goods and services, in Caribbean countries for which such data were available. The following summarizes some of the more salient findings:

(a) For most of the countries considered, there was a marginal increase (less than 10%) in imports between the year prior to and the year of the natural disaster – in the Bahamas there was a 4% increase, in Belize and Grenada a 7% increase, and in Jamaica a 2% increase between 2003 and 2004 when hurricane Ivan occurred. In the other countries, the increase was either more than 10% or there was a decrease in imports. In Dominica, the increase in imports was 13% between 2006 and 2007, in Guyana the increase was 18% between 2004 and 2005, and in Haiti the increase was 26% between 2003 and 2004.

(b) For some of the countries reviewed, there were significant declines in imports in the year after the disaster – as much as 29% in Dominica, 14% and 4% in Belize (for the disasters of 2007 and 2000, respectively), 10% in the Bahamas, 11 % in the Dominican Republic; imports declined by 1% in each of the other countries.

(c) Not surprisingly, in the year of the disaster the external debt as a share of GDP in all the countries reviewed increased compared to the year prior to the disaster. In this regard, the countries which stand out has having the most significant increases in external debt as a share of GDP as a result of natural disasters are: the Bahamas (43%); Belize (50%) as a result of the disaster which occurred in 2000); Grenada (22%) and Haiti (119%).

(d) A comparison of countries' external debt in the year prior to the disaster and the year after immediately after the disaster shows (a) declines in external debt as a share of GDP in Belize, Dominica and Saint Lucia, by 41%, 56% and 34%, respectively. In Guyana and Haiti, the change in external debt as a share of GDP in the year immediately before and immediately after the disaster revealed staggering increases of 405% for Guyana and 234% and 118% for Haiti in the years 2004 and 2008, respectively.

The extent to which hazards manifest themselves as disasters depends, inter alia, on the pre-existing vulnerability (and level of resilience) and the country's capacity to engage in post-disaster rehabilitation and recovery. In an effort to improve national resilience to disasters, the Government of Grenada has imposed a National Reconstruction Levy[13] meant to provide a catastrophe fund to buffer the impact, especially the financial impact, of disasters.[14]

[13] For more information on the Levy see the downloadable information booklet at http://www.grenadaworld.com/

[14] In 2007, in collaboration with the World Bank and other multilateral agencies, several CARICOM countries adopted a regional response to transferring the risk associated with annual windstorm related events that affect the Caribbean, and the Caribbean Catastrophe Risk Insurance Facility (CCRIF) was formed. The decision to formalize the CCRIF was informed in part by the annual economic impact of disasters and the more recent 2004 devastation of the Grenada economy by Hurricane Ivan.

Table 5a
External debt as a % of GDP in years immediately before and after occurrence of natural disaster for selected Caribbean countries

Country	External debt year immediately prior to disaster year (% of GDP)	External debt in year of disaster occurrence (% of GDP)	External debt in year immediately after disaster occurrence (% of GDP)	% change in external debt year of disaster relative to year immediately prior of disaster	% change in external debt year after disaster relative to year of disaster
Bahamas, the	**2003**	**2004**	**2005**		
	7	10	n.d.	43%	n.d.
Belize	**1999**	**2000**	**2001**		
	34	52	n.d.	50%	n.d.
	2006	**2007**	**2008**		
	70	79	42	13%	-41%
Dominica	**2006**	**2007**	**2008**		
	70	72	31	3%	-56%
Dominican Republic	**2003**	**2004**	**2005**		
	30	32	33	7%	11%
Grenada	**2003**	**2004**	**2005**		
	89	109	91	22%	2%
Guyana	**2004**	**2005**	**2006**		
	31	34	159	9%	405%
Haiti	**2003**	**2004**	**2005**		
	34	33	114	-3%	234%
	2007	**2008**	**2009**		
	40	89	88	119%	118%
Jamaica	**2000**	**2001**	**2002**		
	49	n.d.	n.d.	n.d.	n.d.
	2003	**2004**	**2005**		
	66	75	75	14%	14%
Saint Lucia	**2006**	**2007**	**2008**		
	51	52	34	1%	-34%

Table 5b
Natural disaster effect as a % of key macroeconomic variables for selected Caribbean countries

COUNTRY	Imports year before disaster(% of GDP)	Imports year of disaster (% of GDP)	Imports year after disaster(% of GDP)	Exports year before disaster(% of GDP)	Exports year of disaster (% of GDP)	Exports year after disaster(% of GDP)	External Debt (% of GDP)	External Debt (% of GDP)	External Debt (% of GDP)	External balance on goods and services (% of GDP)	External balance on goods and services (% of GDP)	External balance on goods and services (% of GDP)	External Debt ($US mil)	External Debt ($US mil)	External Debt ($US mil)	External Debt (% change)	External Debt (% change)
Bahamas, the	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003-2004**	**2004-2005**
	54	58	68	42	44	60	7	10	n.d.	-12	-15	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Belize	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**	**1999-2000**	**2000-2001**
	66	73	69	57	53	51	34	52	n.d.	-10	-20	-11	254.5	423.7	n.d.	40	n.d.
	2006	**2007**	**2008**	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2006-2007**	**2007-2008**
	62	62	46	61	60	44	70	79	42	-1	-2	n.d.	1063	1099	1050	3	-5
Dominica	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2006-2007**	**2007-2008**
	64	77	48	45	41	34	70	72	31	-19	n.d.	n.d.	203.5	217.5	220.1	6	1
Dominican Republic	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003-2004**	**2004-2005**
	54	49	38	53	50	34	30	32	33	-1	1	1	6295	6965	7756	10	10
Grenada	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003-2004**	**2004-2005**
	69	76	76	40	44	33	89	109	91	-29	-32	-43	376.9	433	406	13	-7

Table 5b (cont'd): Natural disaster effect as a % of key macroeconomic variables for selected Caribbean countries

COUNTRY	Imports year before disaster(% of GDP)	Imports year of disaster (% of GDP)	Imports year after disaster(% of GDP)	Exports year before disaster(% of GDP)	Exports year of disaster (% of GDP)	Exports year after disaster(% of GDP)	External Debt (% of GDP)	External Debt (% of GDP)	External Debt (% of GDP)	External balance on goods and services (% of GDP)	External balance on goods and services (% of GDP)	External balance on goods and services (% of GDP)	External Debt ($US mil)	External Debt ($US mil)	External Debt ($US mil)	External Debt (% change)	External Debt (% change)
Guyana	**2004**	**2005**	**2006**	**2004**	**2005**	**2006**	**2004**	**2005**	**2006**	**2004**	**2005**	**2006**	**2004**	**2005**	**2006**	**2004-2005**	**2005-2006**
	106	124	123	96	88	200	31	34	159	-10	-36	-48	236.6	251.6	1141	6	78
Haiti	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003-2004**	**2004-2005**
	47	43	42	15	14	14	34	33	114	-22	-31	-28	1309	1225	1323	-7	7
	2007	**2008**	**2009**	**2007**	**2008**	**2009**	**2007**	**2008**	**2009**	**2007**	**2008**	**2009**	**2007**	**2008**	**2009**	**2007-2008**	**2008-2009**
	34	60	n.d.	11	23	n.d.	40	89	88	-23	n.d.	n.d.	1598	1026	1071	-56	4
Jamaica	**2000**	**2001**	**2002**	**2000**	**2001**	**2002**	**2000**	**2001**	**2002**	**2000**	**2001**	**2002**	**2000**	**2001**	**2002**	**2000-2001**	**2001-2002**
	54	54	55	43	38	36	49	n.d.	n.d.	-11	-16	-20	3375.3	n.d.	n.d.	n.d.	n.d.
	2003	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**	**2003-2004**	**2004-2005**
	58	60	61	40	43	41	66	75	75	-18	-17	-20	5574	6399	6557	13	2
Saint Lucia	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**	**2006-2007**	**2007-2008**
	70	81	82	48	47	85	51	52	34	55	n.d.	n.d.	401.1	417.6	349.8	4	-19

n.d. – no data

Sources: derived from World Development Indicators available from http://www.worldbank.org ; Central Intelligence Agency World Fact book available from www.cia.gov ; Caribbean Development Bank available from www.caribank.org ; CARICOM Regional Statistics available from www.caricomstats.org ; World bank Global Development Finance Reports available from http://www.publications.workbank.org/GDF

2. Infrastructure impacts of disasters on Caribbean economies 1990 – 2008

The total impact on infrastructure in the Caribbean over the period 1990 to 2008 was estimated at US$ 12 billion. This value reflected primarily damage and losses to water, electricity, ports and airports, communication, roads and transportation, drainage and irrigation, coastal zone and fire services and government buildings.

.Table 6a below provides data on the various infrastructural damage costs. As in the case of the economic sector, Haiti also ranked first among countries suffering the impact of disasters on infrastructure. Haiti's national infrastructure damage and loss from disasters was 51% of the total regional impact on infrastructure.

A breakdown by country performance, and within each infrastructural sector as defined by the ECLAC methodology, is as follows:

(i) **Water:** Damage and loss to water infrastructure from natural disasters was greatest in Guyana and Haiti – approximately 43% of total national cost in infrastructure in both countries.

(ii) **Electricity**: The impact to electricity infrastructure caused extensive destruction in Suriname where 46% of total national costs were from this particular sector. For Grenada the sum was 36%, for Anguilla 26% and for the Cayman Islands roughly 22% in the aftermath of both hurricanes Ivan and Paloma.

(iii) **Ports and airports**: Turks and Caicos Islands suffered extensive damage to ports and airports when Hurricane Ike struck in 2008. The effect from this hurricane (damage and loss) was estimated at 45% of total impact of the disaster. The Netherlands Antilles also suffered damage amounting to 36% of total cost.

(iv) **Communication**: Communication in a number of countries was heavily affected, directly and indirectly. The total impact on the communication sector, as a share of total cost was estimated at 66% in the Netherlands Antilles as a result of Hurricanes Luis and Marilyn. In Grenada, communication costs were approximately 55% of total national costs while in Anguilla, the Bahamas and the Cayman islands (post Hurricane Paloma), the communication damage costs were 49%, 35% and 30% of their respective total national costs from disasters.

(v) **Roads and transportation**: Destruction of roads and transportation was significant in practically all Caribbean countries. Costs from this sector as a share of total national costs ranged between 40% and 93% in Jamaica (from two disaster events) to 68% in Haiti and 71% in Dominica.

(vi) **Government buildings**: Government buildings were less affected by disasters.

Table 6a
Total damage and loss to infrastructure across countries, 1990 - 2008

Country	Disaster Event	Damage to Water as a % of total infrastructure damage	Losses to Water as a % of total national infrastructure damage	Damage to Electricity as a % of total national infrastructure damage	Losses to Electricity as a % of total national infrastructure damage	Damage to Ports/Airports as a % of total national infrastructure damage	Losses to Ports/Airports as a % of total national infrastructure damage	Damage to Communications as a % of total national infrastructure damage	Losses to Communications as a % of total national infrastructure damage	Damage to Roads and Transportation as a % of total national infrastructure damage	Losses to Roads and Transportation as a % of total national infrastructure damage	Damage to Drainage and Irrigation as a % of total national infrastructure damage	Losses to Drainage and Irrigation as a % of total national infrastructure	Damage to Coastal Zone and Fires Services as a % of total national	Losses to Coastal Zone and Fires Services as a % of total national	Damage to Government Buildings as a % of total national infrastructure damage	Losses to Government Buildings as a % of total national infrastructure	Total National Infrastructure Damage and loss as a % of Total Regional Infrastructure Effect
Anguilla	Hurricane Luis (1995)	0.31%	0.00%	13.54%	11.99%	9.57%	1.34%	35.58%	13.15%	14.53%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.17%
Bahamas, the	Hurricane Frances and Jeanne (2004)	0.52%	2.66%	2.68%	5.75%	0.00%	0.00%	35.58%	0.00%	42.57%	3.25%	0.00%	0.00%	0.00%	0.00%	6.99%	0.00%	1.30%
Belize	Hurricane Dean (2007)	1.28%	0.64%	7.27%	0.94%	0.00%	0.00%	4.28%	1.07%	80.53%	3.98%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%
Belize	Hurricane Keith (2000)	1.86%	0.23%	3.51%	1.26%	0.00%	0.00%	1.73%	1.00%	52.58%	37.84%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.43%
Cayman Islands	Hurricane Ivan (2004)	1.17%	0.19%	8.25%	8.52%	2.36%	1.46%	11.71%	7.72%	35.59%	11.85%	0.00%	0.00%	0.00%	0.85%	10.32%	0.00%	6.13%
Cayman Islands	Hurricane Paloma (2008)	0.30%	0.11%	18.86%	4.76%	15.68%	2.01%	13.51%	15.87%	0.00%	1.47%	0.00%	0.00%	5.74%	0.00%	21.69%	0.00%	0.20%
Dominica	Hurricane Dean (2007)	5.24%	0.19%	0.00%	1.41%	1.25%	0.00%	19.42%	1.83%	70.14%	0.52%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.46%
Dominican Republic	Hurricane Frances & Jeanne (2004)	1.28%	0.59%	3.73%	0.21%	0.00%	0.00%	0.00%	0.00%	31.81%	62.38%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.52%
Grenada	Hurricane Ivan (2004)	2.81%	0.40%	28.07%	8.42%	0.00%	0.00%	30.67%	25.02%	4.13%	0.48%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.56%

Source: Derived from ECLAC Assessments

Table 6a (cont'd): Total damage and loss to infrastructure across countries, 1990 - 2008

Country	Disaster Event	Damage to Water as a % of total infrastructure damage	Losses to Water as a % of total national infrastructure damage	Damage to Electricity as a % of total national infrastructure damage	Losses to Electricity as a % of total national infrastructure damage	Damage to Ports/Airports as a % of total national infrastructure damage	Losses to Ports/Airports as a % of total national infrastructure damage	Damage to Communications as a % of total national infrastructure damage	Losses to Communications as a % of total national infrastructure damage	Damage to Roads and Transportation as a % of total national infrastructure damage	Losses to Roads and Transportation as a % of total national infrastructure damage	Damage to Drainage and Irrigation as a % of total national infrastructure damage	Losses to Drainage and Irrigation as a % of total national infrastructure damage	Damage to Coastal Zone and Fires Services as a % of total national infrastructure damage	Losses to Coastal Zone and Fires Services as a % of total national infrastructure	Damage to Government Buildings as a % of total national infrastructure damage	Losses to Government Buildings as a % of total national infrastructure	Total National Damage and Loss as a % of Total Regional Infrastructure Effect
Guyana	Floods (2005)	41.16%	1.97%	0.58%	1.68%	0.00%	0.00%	1.00%	0.67%	36.63%	1.97%	2.13%	12.21%	0.00%	0.00%	0.00%	0.00%	14.22%
Haiti	Hurricane Jeanne (2004)	30.99%	0.00%	0.00%	0.21%	0.00%	0.00%	0.00%	0.00%	68.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	9.81%
Haiti	Tropical Storm Fay, Gustav, Hanna, Ike (2008)	8.27%	3.99%	3.53%	1.31%	0.00%	0.00%	0.00%	0.38%	43.34%	39.19%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	50.84%
Jamaica	Hurricane Michelle (2001)	5.69%	0.00%	0.37%	0.01%	0.00%	0.00%	0.41%	0.00%	93.12%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.09%
Jamaica	Hurricane Ivan (2004)	2.40%	6.15%	7.42%	10.18%	1.35%	0.16%	2.50%	16.83%	30.97%	10.02%	0.00%	0.00%	0.00%	0.00%	12.03%	0.00%	3.80%
Netherlands Antilles	Hurricane Luis, Marilyn (1995)	8.73%	13.28%	8.73%	13.28%	18.16%	18.49%	38.36%	29.11%	2.98%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.83%
St. Lucia	Hurricane Dean (2007)	0.25%	0.62%	3.58%	2.91%	7.93%	0.00%	11.00%	0.21%	52.72%	5.03%	0.00%	0.00%	15.75%	0.00%	0.00%	0.00%	0.08%
Suriname	Floods (2006)	0.00%	0.00%	46.10%	0.00%	0.00%	0.00%	0.00%	0.00%	53.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.81%
Turks and Caicos	Hurricane Hanna, Ike (2008)	0.54%	0.07%	6.93%	4.05%	33.82%	11.27%	4.68%	1.21%	19.76%	0.00%	0.00%	0.00%	9.34%	0.00%	0.00%	0.00%	0.69%

Source: Derived from ECLAC Assessments

3. Social sector impacts of disasters on Caribbean economies 1990 – 2008

Social sector impacts focus on the impacts of disasters on health, housing and human settlements, education and culture. In all case study countries, the impact of natural disasters was most heavily felt in the housing subsector. Table 7a provides details of damage to housing and human settlements, while Table 7b provides a breakdown by subsector of the social sector.

Damage to housing infrastructure, Hurricane Ivan, Grenada: September 2004

Table 7a shows the spate of devastation in housing and human settlements across the Caribbean in the wake of windstorm-related disasters. In several of the countries, destruction incurred to the housing subsector amounted to more than 90% of their total costs to the social sector. The only country to have avoided this housing dilemma was Suriname, in which only 20% of total costs were due to destruction to the housing subsector.

Other summary observations in terms of the impact of disasters to the social sector of Caribbean countries are:

(a) Total national cost to the social sector for Suriname was approximately 50% of the total regional damage costs to the social sector.

(b) The education and culture subsector damage costs were highest in Suriname – accounting for 79% of the national social damage costs.

(c) The health subsector costs in Dominica as a share of its national costs to the social sector were 21%, the highest compared to other Caribbean countries.

(d) The cost of the impact on the housing and human settlements subsector at the national level was highest in Guyana (99%).

Table 7a
Impacts of disasters on housing and human settlements in the Caribbean, 1990 – 2008

Country	Disaster event	Damage to housing and human settlements as a % of total social sector effect	Losses to housing and human settlements as a % of total social sector effect	Total damage and loss to housing and human settlements subsector as a % of total social sector effect
Anguilla	Hurricane Luis (1995)	90%	0%	**90%**
Bahamas, the	Hurricane Frances and Jeanne (2004)	73%	0%	**73%**
Belize	Hurricane Dean (2007)	98%	0%	**98%**
Belize	Hurricane Keith (2000)	91%	0%	**91%**
Cayman Islands	Hurricane Ivan (2004)	87%	8%	**96%**
Cayman Islands	Hurricane Paloma (2008)	89%	6%	**95%**
Dominica	Hurricane Dean (2007)	68%	1%	**68%**
Dominican Republic	Hurricane Frances & Jeanne (2004)	60%	13%	**72%**
Grenada	Hurricane Ivan (2004)	86%	1%	**87%**
Guyana	Floods (2005)	99%	0%	**99%**
Haiti	Hurricane Jeanne (2004)	92%	0%	**92%**
Haiti	Tropical Storm Fay, Gustav, Hanna, Ike (2008)	70%	10%	**80%**
Jamaica	Hurricane Michelle (2001)	86%	0%	**87%**
Jamaica	Hurricane Ivan (2004)	82%	5%	**88%**
Netherlands Antilles	Hurricane Luis, Marilyn (1995)	83%	6%	**89%**
Saint Lucia	Hurricane Dean (2007)	35%	1%	**36%**
Suriname	Floods (2006)	20%	0%	**20%**
Turks and Caicos Islands	Hurricane Hanna, Ike (2008)	53%	16%	**69%**

Source: Derived from ECLAC Country Assessments, 1990 - 2008

Table 7b: Economic impacts of disasters to the social sector in the Caribbean, 1990 – 2008

Country	Disaster event	Damage to health as a % of total social sector impact	Losses to health as a % of total social sector impact	Damage to housing and human settlements as a % of total social sector impact	Losses to housing and human settlements as a % of total social sector impact	Damage to education and culture as a % of total social sector impact	Losses to education and culture as a % of total social sector impact	Total National SS Effect as a % of Total Regional SS Effect
Anguilla	Hurricane Luis (1995)	2.59%	1.07%	90.11%	0.00%	6.02%	0.20%	0.02%
Bahamas, the	Hurricane Frances and Jeanne (2004)	2.93%	2.28%	72.52%	0.20%	22.05%	0.02%	0.26%
Belize	Hurricane Dean (2007)	0.00%	0.89%	97.58%	0.09%	1.35%	0.09%	0.04%
Belize	Hurricane Keith (2000)	3.39%	1.76%	90.62%	0.21%	3.03%	0.99%	0.08%
Cayman Islands	Hurricane Ivan (2004)	0.64%	0.62%	87.50%	8.28%	2.85%	0.12%	4.76%
Cayman Islands	Hurricane Paloma (2008)	0.41%	0.39%	88.59%	6.05%	4.06%	0.50%	0.34%
Dominica	Hurricane Dean (2007)	20.48%	7.39%	67.72%	0.64%	3.49%	0.29%	0.04%
Dominican Republic	Hurricane Frances & Jeanne (2004)	1.01%	17.61%	59.72%	12.55%	8.91%	0.20%	0.13%
Grenada	Hurricane Ivan (2004)	0.67%	0.00%	86.46%	0.54%	12.26%	0.08%	2.10%
Guyana	Floods (2005)	0.09%	0.22%	98.52%	0.50%	0.63%	0.04%	18.30%
Haiti	Hurricane Jeanne (2004)	3.74%	0.07%	91.82%	0.00%	4.44%	0.06%	7.68%
Haiti	Tropical Storm Fay, Gustav, Hanna, Ike (2008)	4.44%	2.32%	70.27%	10.00%	12.46%	0.51%	15.11%
Jamaica	Hurricane Michelle (2001)	2.77%	2.69%	86.44%	0.15%	6.61%	1.34%	1.29%
Jamaica	Hurricane Ivan (2004)	5.64%	0.32%	82.29%	5.41%	6.24%	0.09%	1.29%
Netherlands Antilles	Hurricane Luis, Marylyn (1995)	1.89%	1.97%	83.08%	5.80%	6.21%	1.05%	0.57%
Saint Lucia	Hurricane Dean (2007)	4.55%	13.44%	34.78%	0.82%	8.22%	38.18%	0.01%
Suriname	Floods (2006)	0.13%	0.15%	20.48%	0.00%	79.22%	0.01%	48.95%
Turks and Caicos Islands	Hurricane Hanna, Ike (2008)	2.94%	23.74%	52.67%	16.12%	2.13%	2.40%	0.29%

Source: Derived from ECLAC Assessments

4. Environmental impacts of disasters on Caribbean economies 1990 – 2008

There is a paucity of data on the environmental impact of hazards on Caribbean economies. Where such data may be available, these are usually not accompanied by any pre-disaster benchmark from which hazard-specific impact can be easily identified. Notwithstanding this caveat, the data that are available on the economic impact of natural disasters on natural ecosystems are captured in table 8 and illustrated in figure 10.

Environmental/Infrastructural damage, Hurricane Dean, Jamaica: June 2007

The available data again show that Haiti has sustained the greatest amount of damage to its environmental assets than any other Caribbean countries. The cost of environmental destruction in Haiti accounted for an estimated 92% of the total regional environmental costs over the review period. Environmental harm in Jamaica following hurricane Ivan accounted for 4% of total regional environmental value.

Flooding in Guyana: January 2005

Table 8
National economic impact of natural disasters on the environmental sector as a percentage of the subregional impact, selected Caribbean countries: 1990 – 2008

Country	Disaster event	National environmental impact as a percentage of total subregional environmental impact
Anguilla	Hurricane Luis (1995)	0.00%
Bahamas, the	Hurricane Frances and Jeanne (2004)	0.00%
Belize	Hurricane Dean (2007)	0.13%
Belize	Hurricane Keith (2000)	0.81%
Cayman Islands	Hurricane Ivan (2004)	0.53%
Cayman Islands	Hurricane Paloma (2008)	0.36%
Dominica	Hurricane Dean (2007)	0.00%
Dominican Republic	Hurricane Frances & Jeanne (2004)	0.04%
Grenada	Hurricane Ivan (2004)	0.00%
Guyana	Floods (2005)	0.08%
Haiti	Hurricane Jeanne (2004)	0.69%
Haiti	Tropical Storm Fay, Gustav, Hanna, Ike (2008)	92.10%
Jamaica	Hurricane Michelle (2001)	0.00%
Jamaica	Hurricane Ivan (2004)	4.16%
Netherlands Antilles	Hurricane Luis, Marylyn (1995)	0.00%
Saint Lucia	Hurricane Dean (2007)	0.01%
Suriname	Floods (2006)	0.00%
Turks and Caicos Islands	Hurricane Hanna, Ike (2008)	1.09%

Source: ECLAC Disaster Assessment Reports – 1995-2008: www.eclac.org

5. Population impacts of natural disasters in the Caribbean, 1990 - 2008

The following definitions are used in this section based on the ECLAC methodology:

(a) The terms **victim** and **affected person** are used synonymously; the methodology notes that the affected population may be **primarily** or **secondarily** affected.

(b) **Primary victims** and **homeless persons** are those in the population affected by the direct effects of the disaster, for example the dead, injured or disabled. Also included in this category are persons who suffered material loss as a direct and immediate consequence of the disaster. Partial details are available in table 7(b) but there are many data gaps.

(c) **Secondarily affected persons** in a disaster are those who experience a deterioration in their living conditions or for whom the physical environment changes, impoverishing and affecting other dimensions – their network of social contacts, work relationships, communications, culture and recreation, normal access to education, health and food services.

Table 9a details the impacts of disasters on Caribbean populations, where such data were available. It shows that approximately 2.5 million persons were affected, and that the population affected far exceeds the number of persons dead, injured or disabled.

Table 9a
Population affected by natural disasters in the Caribbean 1990 – 2008

Country	Total population affected by natural disasters between 1990 and 2008 (absolute figures)	Total population affected by natural disasters between 1990 and 2008 as a % of total population in year natural disaster (relative population impact)
Anguilla	n.d.	n.d.
Bahamas, the	28 500	9%
Belize	95 106	35%
Cayman Islands	37 681	22%
Dominica	44 000	62%
Dominican Republic	n.d.	
Grenada	81 553	78%
Guyana	629 492	85%
Haiti	1 097 926	13%
Jamaica	385 661	15%
Netherlands Antilles	n.d.	
Saint Lucia	23 167	14%
Suriname	48 351	6%
Turks and Caicos Islands	10 270	33%
	TOTAL = 2 481 707	AVERAGE = 34%

n.d. : no data available

Table 9a shows that in Guyana and Grenada, approximately 80% of the total population was affected by natural disasters. Given the definition of population affected, it may be deduced that there is some correlation between this finding and the earlier reported finding that there was extensive social damage in Guyana and Grenada, particularly to the housing sectors.

There are stark differences in population and country sizes. Haiti has a population of more than 8 million people; therefore, it is not surprising that the number of persons affected should also be greater, as shown in table 9b. The larger the population affected the greater impact on human capital and on the overall development prospects for the country in question, in terms of poverty and educational levels.

Table 9b
Population affected by natural disasters in the Caribbean 1990 – 2008

	Anguilla	Bahamas	Belize	Belize	Cayman Islands	Cayman Islands	Dominica	Dominican Republic	Grenada	Guyana	Haiti	Haiti				Jamaica	Jamaica	Netherlands Antilles	Netherlands Antilles	St Lucia	Suriname	Turks and Caicos Is	Turks and Caicos Is
Historical Series																							
Type of Event	Hurricane	Hurricane	Hurricane	Hurricane	Hurricane	Hurricane	Hurricane	Hurricane	Hurricane	Floods	Tropical Storm	Tropical Storm	Hurricane	Hurricane	Hurricane	Hurricane	Hurricane	Hurricane	Hurricane	Hurricane	Floods	Hurricane	Hurricane
Name of Event	Luis	Frances and Jeanne	Dean	Keith	Ivan	Paloma	Dean	Frances and Jeanne	Ivan		Jeanne	Fay	Gustav	Hanna	Ike	Michelle	Ivan	Luis	Marylyn	Dean		Hanna	Ike
Year of Event (Month)	1995 (September)	2004 (September)	2007 (August)	2000 (Sep-Oct)	2004 (Sept)	2008 (Nov)	2007 (August)		2004 (September)	2005 (January)	2004 (Sept)	2008 (Aug)	2008 (Aug)	2008 (Sept)	2008 (Sept)	(2001) Oct	2004 (Sept)	1995 (Sept)	1995 (Sept)	2007 (August)	2006 (April-May)	2008 (Sept)	2008 (Sept)
Intensity of the Event	Category 4	Category 4 (Frances); Category 3 (Jeanne)	Category 5	Category 4	Category 5	Category 4	Category 1		Category 3				Category 1				Category 4	Category 4	Category 2	Category 1		Category 1	Category 4

Impact on Population																							
Deaths		2		10	2	0	3		28	34	3000	793				5	17			1			
Injuries		3				1	26		680		2600	548					14						
Displaced				5335	6000						14000	310					493						
Severely Affected Population			6140			179	13283			274774	297926									429		10270	
% of Severely affected population wrt total pop			2%			0.33%	19%			37%											6%		
Moderately Affected Population						2304				354718													
% of Moderately affected population wrt total pop										48%													
Affected population - Agricultural Sector			20878																	22738			
Affected population - Tourism Sector			10685																				
Total Affected population		28,500	37,703	57,403	35,198	2,483	44,000		81,553	629,492	297,926	800,000				15,976	369,685			23,167	48,351	10,270	
% of Total Population					17.00%	4.60%	62%				4%									14%	6%	33%	
Population		319333	276896						104533	739472	8924553					2621444							

6. Rehabilitation costs from natural disasters in the Caribbean, 1990 - 2008

Regardless of the extent of damage to social, economic, environmental and infrastructural resources, a country has to engage in post-disaster rehabilitation and reconstruction in an effort to return economic activity and the life of its citizens to some level of normality. The urgency of this rehabilitation process is particularly acute when, as in many of the countries reviewed in this study, housing and human settlements and vital infrastructure (such as water, roads, communication) have been affected by the passage of a disaster.

The process and associated cost of rehabilitation for countries such as Haiti is exacerbated when the prevailing socio-economic and environmental circumstances heighten national vulnerability to disasters. Based on available data for reconstruction costs, it is not surprising that Haiti accounted for almost 98% of those costs. Table 10 provides details.

Several questions arise from such a scenario:

(a) How does a country such as Haiti, given its HIPC status, finance such reconstruction costs[15]

(b) Can the costs, incurred by disasters on an economy such as Haiti, be sustained? What real prospects are there for sustainable development in an economy such as Haiti given its apparent high vulnerability to disasters?

Though Haiti stands out as an extreme case, the above questions are also relevant to other Caribbean SIDS, especially given, inter alia, the lack of economic diversification of their economies.

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[15] Geopolitical priorities often determine that donors distribute funds across the poorer countries. With that in mind, it seems unlikely that Haiti would receive all regionally allocated donor funds for rehabilitation.

Table 10
Total national rehabilitation costs as a percentage of total subregional rehabilitation costs

Country	Total national rehabilitation costs as a percentage of total subregional rehabilitation costs
Anguilla (Hurricane Luis)	0.01%
Bahamas, the	0.00%
Belize (Hurricane Dean)	0.00%
Belize (Hurricane Keith)	0.01%
Cayman Islands (Hurricane Ivan)	0.00%
Cayman Islands (Hurricane Paloma)	0.00%
Dominica	0.10%
Dominican Republic	0.00%
Grenada (Hurricane Ivan)	0.13%
Guyana (Floods)	0.46%
Haiti (Hurricane Jeanne)	98.16%
Haiti (Hurricanes Fay, Ike, Gustav , Hanna)	1.12%
Jamaica (Hurricane Michelle)	0.00%
Jamaica (Hurricane Ivan)	0.00%
Netherlands Antilles (Hurricane Luis)	0.00%
Netherlands Antilles (Hurricane Marilyn)	0.00%
Saint Lucia (Hurricane Dean)	0.00%
Suriname (floods)	0.00%
Turks and Caicos (Hurricanes Hanna, Ike)	0.00%

Source: Derived from ECLAC Assessments, 1990 – 2008

CHAPTER II

PROJECTIONS OF FREQUENCY AND INTENSITY OF EXTREME EVENTS

The process of determining changes in the frequency and intensity of extreme events in the Caribbean was fraught with uncertainty. The mismatch, between the optimal scale at which the Global Climate Models work and the extremely small scale over which the Caribbean countries included in the study are located, posed the principal challenge.

Research by Webster and others (2005) focused, for example, on the frequency and intensity of tropical cyclones (hurricanes) over the past 35 years in an environment of increasing sea surface temperature (SST). The largest increase in cyclonic activity was seen in the North Pacific, Indian and South West Pacific Oceans, and the smallest percentage increase occurred in the North Atlantic Ocean. The authors note that, given their "basic conceptual understanding of hurricanes… there could be a relationship between hurricane activity and SST." They also point out that "… it is well established that SST >26^{o}C is a requirement for tropical cyclone formation in the current climate. There is also a hypothesized relationship between SST and the maximum potential hurricane intensity." Other factors, such as El Niño and the North Atlantic Oscillation, make it "…difficult to discern any trend relative to background SST increases with statistical veracity…"

In the context of this study, perhaps the most pertinent observation by Webster and others is that "…Global modelling results for doubled CO_2 scenarios are contradictory with simulations showing a lack of consistency in projecting an increase or decrease in the total number of hurricanes, although most simulations project an increase in hurricane intensity…"

As a summary concluding note, Webster and others point out that "… careful analysis of global hurricane data shows that, against a background of increasing SST, no global trend has yet emerged in the number of tropical storms and hurricanes. Only one region, the North Atlantic, shows a statistically significant increase, which commenced in 1995. However a simple attribution of the increase in numbers of storms to a warming SST environment is not supported, because of the lack of a comparable correlation in other ocean basins where SST is also increasing. The observation that increases in North Atlantic hurricane characteristics have occurred simultaneously with a statistically significant positive trend in SST has led to the speculation that the changes in both fields are as a result of global warming."

A. METHODOLOGICAL APPROACH TO CLIMATE CHANGE SCENARIOS FOR CARIBBEAN REGION

At present, ongoing research on climate change scenarios for the Caribbean subregion is using the PRECIS (Providing Regional Climates for Impacts Studies) tool (See box 4 for details). Using PRECIS, it is possible to obtain projected changes in temperature, surface temperatures, precipitation, wind speed and sea level pressure for the Caribbean and its subregions. These preliminary projections provide the basis on which the following discussion on the temporality of trends is made, in terms of changes of event recurrence in the short, medium and long term. The preliminary projections also seek to distinguish the countries of the subregion geographically by which possible changes will be more noticeable.

(a) Methodological approach to projections for temperature, surface temperature, precipitation, wind speed, and sea level pressure for the Caribbean region and subregions using PRECIS[16]

The projection maps for the Caribbean and its subregions were generated using the PRECIS-Caribe online tool: http://precis.insmet.cu/eng/datos.html which generates climate models for Central America, Mexico and the Caribbean. Projections can be made for a variety of variables, such as surface pressure, humidity and geo potential height. Firstly, the geographical areas for which the projections were being made were specified by the input of longitudes and latitudes. Projections were generated for the entire Caribbean subregion and the following geographical subdivisions: Haiti and the Dominican Republic, the Bahamas and Turks and Caicos Islands, OECS, Jamaica, Belize, Suriname and Guyana.[17]

The variables projected were: temperature, surface temperature,[18] precipitation, wind speed and sea level pressure at surface level. These projections are based on two possible future greenhouse gas scenarios: A2- Medium- High emission scenario and B1- Low emission scenario. The B1 scenario was chosen to reflect a “best case scenario” rather than A2 which reflects medium-high emissions.

Projections were made for both August and September, considered the most active period for hurricanes, with specified years of 2011, 2020, 2029, 2038 and 2047 for the Caribbean subregion, and 2050 for the geographical subdivisions. The option for output format was shaded-isopleth maps[19] such that variations could be easily identified.

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[16] The completion of this study was fraught with a major challenge of data paucity. Secondary data was the primary source of information for Chapter II. To elaborate, in the scientific community there do not currently exist published and acceptable projections of extreme events for the Caribbean, particularly on the frequency and intensity of such events. Due to this absence of data, assessments on the future vulnerability of countries, and the related climate change adaptation or disaster risk reduction measures that may be employed, were somewhat compromised. Notwithstanding this major data deficiency, efforts were made to use the PRECIS modelling tool.

In determining future vulnerability of the Caribbean to extreme events, two approaches were employed:

(i) using an Environmental Vulnerability Index which focuses primarily on the environmental factors that could exacerbate a country’s vulnerability to disasters

(ii) An Adjusted Prevalent Vulnerability Index which seeks to identify socio-economic and developmental factors that could affect a country’s vulnerability to disasters, including the threat of climate change.

The paucity of data at the country-specific level is evident. In some cases data were not available from national sources, and tertiary sources of data had to be utilized. The specific instances where these sources were used are identified at the appropriate points in the study.

[17] The tool specification does not allow for a Longitude beyond 60° East and latitude below 5° South. Thus, only a small section of Guyana is covered.

[18] Mean temperature is projected at a level of 850 m, to be distinguished from surface temperature. Surface temperature is mainly utilized to observe changes in temperature over the seas.

[19] Isopleths are lines that join areas with equal temperature values. An isopleth map will consist of several isopleths representing different values. For visual purposes, the areas between each isopleth are shaded to allow changes in values to be discernible.

Box 4- Information note on PRECIS

PRECIS is a PC-based regional climate model developed by the Hadley Centre of the Meteorological Office of the United Kingdom for use by non-Annex I Parties to the United Nations Framework Convention on Climate Change. The results available on the Web page represent a contribution of the Cuban Meteorological Institute (INSMET) to the activities that are being undertaken in the Caribbean to evaluate the impacts of climate change and to identify adaptation measures. This contribution was supported financially by the UNDP-CIDA Project "Development and Adaptation to Climate Change", and the UNDP-GEF RLA/01/G31 Project, "Enhancing the Capacity for Stage II Climate Change Adaptation in Central America, Mexico and Cuba", also known as ACCII. Available from http://precis.insmet.cu/eng/Precis-Caribe.htm

The scenarios available on the web page were generated by simulations developed with PRECIS for two time periods, 1961-1990 and 2071-2100. For the second period, the run was made using the SRES A2 Greenhouse Gas emission scenario. Once the results were obtained, the differences in output were calculated between the control period (1961-1990) and the period simulated (2071-2100).

Noting that the actual results refer only to the SRES A2 scenario and for the period 2071-2100, climate change signals were estimated for the B1 emission scenario and for the period between 2010 and 2070. It was not possible to calculate these directly using the Regional Climate Model because of the substantial computer resources and time required. It was therefore impossible to provide that information in a short time period.

To obtain projections for other periods and scenarios, the signals were scaled using factors from the Global Climate Model. This procedure is described in the PRECIS Manual, including the scaling factors used in our estimations.

Essentially, the application of scaling factors is quite simple. The original output fields of variables of the PRECIS run for 2071-2100 were divided by the value of global warming of the HadAM3P and were multiplied by the blue values in the table. The fields were calculated in that way for the previous period and for the B1 scenario.

Two factors influenced the decision to estimate the signals for the B1 scenario. First, SRES B1 is a scenario with less global warming and its use can permit the consideration of an extreme level of projections. In addition, the projections for B2 will soon be available. Thus, it would not be wise to present indirect estimations.

More information on the generation of climate scenarios using PRECIS is available in the PRECIS Manual (filename: Handbook.PDF). To obtain more information about PRECIS visit http://www.precis.org.uk

B. SPECIFIC CLIMATE CHANGE SCENARIOS FOR THE CARIBBEAN REGION

Maps 2 to 9 illustrate projections in temperature, mean surface temperature, precipitation, wind speed and sea level pressure for various years for the Caribbean subregion and geographical subdivisions. These variables are the most important factors in the formation and potential intensity of hurricanes which form from tropical cyclones fed by heat from moist warm air over oceans (reflected by high surface temperatures over the sea) such as the Atlantic and Pacific Oceans. Hurricanes are also characteristic of low pressure systems. The maps are also generated for both August and September – the most active months for hurricanes in the Caribbean.[20]

The Caribbean subregion consists of countries that vary in size with locations spanning from 5° North to approximately 28° North of the Equator, and 60° West to 90° West of the Greenwich meridian. The maps generated are therefore based on longitudes and latitudes within this range. The sub-regional impacts of hurricanes are therefore expected to vary. Among the most prominent observations made from the maps are the extreme projections for declining precipitation in the Bahamas, and the severity of projected surface temperature increases in Haiti, the Dominican Republic and Belize. These projected conditions may have the potential to exacerbate droughts which may result later in flooding because of increased overland flows during periods of intense rainfall, especially in areas that experience severe erosion of the topsoil and/or are naturally prone to land slippage when water-soaked. Other possible consequence of a worsening situation may be landslides

[20] Projections for September for the Caribbean can be viewed in Annex1.

and mudslides. Fluctuations in temperatures and precipitation affect the water table and fragile water resources of countries, leading to water deficits where increased temperatures contribute to greater evapotranspiration losses. An imbalance in such scenarios can therefore affect the hydrological cycles within countries.

A review of the possible variations in the variables included in Maps 2 to 9 is therefore important in creating a framework of what the future holds for the Caribbean subregion. The continued projected trends, although for a low-emission greenhouse gas scenario, suggest that, in general, the main climatic factors of precipitation and temperature will change significantly as compared to 1961-1990, as will the other variables.

Box 5. Guidelines to maps

1. Each map represents a particular variable, for a projected year, as compared to the mean of the variable from 1961 to 1990.

2. Each map is accompanied by a coloured key. Each colour represents a specific value rpresenting the projected change in value of the variable compared to the baseline period 1961-1990. It should be noted however, that the same colour DOES NOT represent the same value throughout the maps even for the same variable. For example, in 2011, green might represent a value of 2.0 degrees (if temperature is the variable under consideration) but in 2038, green might represent a value of 4.0 degrees. Each map contains a note: “GHG: Scenarioghg_sresb1” which outlines the selection of a greenhouse gas scenario for Low Emissions.

3. The units of analysis are as follows:

^{o}C: degrees Celsius.
mm/día (mm/day): millimetres per day.
m/s: metres per second.
hPa: hectopascals. [21]

4. The reader is therefore duly cautioned when interpreting the maps.

(a) Projected changes in temperature

Maps 2 (a) to 2 (e) shows the mean temperature projected for the Caribbean subregion during the month of August in the years 2011, 2020, 2029, 2038 and 2047, compared to the mean temperature between 1961 and 1990. With respect to changes in temperature for the Caribbean subregion and geographical subdivisions, the general observations that may be discerned from the maps are as follows:

(a) There is likely to be an increased temperature throughout the Caribbean when compared to the period 1961 to1990.

(b) The increases in temperature are likely to be between 0.5^{o} C and 1.9^{o}C, in 2011 and 2047, respectively.

(c) In 2011, the countries of the northern Caribbean, including Bahamas, Haiti, the Dominican Republic, OECS countries and Jamaica, are projected to have temperature increases by 0.5^{o}C and 0.7^{o}C. In the southern Caribbean, the projected change in temperature is between 1 ^{o} C and 1.1 ^{o} C for countries such as Guyana and Suriname

(d) The projection for 2020 shows a similar disparity in temperature ranges for the northern and southern Caribbean with the area from the Bahamas to Haiti, including Jamaica, showing a

[21] Meteorologists use hectopascals (hPa) to measurer air pressure: equivalent to millibars

projected increase in temperature of 0.65 ^{o}C to 0.85 ^{o}C. The southern Caribbean area extending from OECS countries to Guyana is likely to experience an increase in temperature by 0.7 ^{o}C to 0.9 ^{o}C.

(e) By 2029 the projected increases are projected to be by 0.7 ^{o}C to 0.8 ^{o}C for the northern Caribbean and 0.8 ^{o}C to 1 ^{o}C for the southern Caribbean.

(f) August 2038 shows expected increases in the northern Caribbean temperature by 0.7 ^{o}C to 1 ^{o}C and even a maximum of 1.05 ^{o}C in Haiti and the Dominican Republic. Temperatures are expected to increase by 0.75 ^{o}C to 1 ^{o}C in the southern Caribbean.

(g) In the year 2047 there is likely to be an increase in temperature by 1.2 ^{o}C to 1.6 ^{o}C in the northern Caribbean and an increase by 1.2 ^{o}C to 1.3 ^{o}C in the southern Caribbean.

(b) Projected changes in mean surface temperatures

The general projections in MSTs observed are detailed in maps 3 (a) to 3 (e). The projections from the map simulations are:

(a) There is likely to be an increase in mean surface temperature throughout the Caribbean when compared to the mean of the period 1961 to 1990.

(b) MST is likely to vary by 0.6 ^{o}C to 1^{o}C in 2011 and vary by 1 ^{o}C to 1.5 ^{o}C and even a maximum of 2.5 and 3 ^{o}C in some northern geographical subdivisions such as Haiti and the Dominican Republic in 2047.

(c) In 2020, the projection shows likely increases in MST from 0.4 ^{o}C to 1.4 ^{o}C throughout the Caribbean.

(d) Greater increases in temperature are projected for larger Caribbean countries by approximately 1 ^{o}C to 1.4 ^{O}C and even 1.6 ^{o}C in 2020.

(e) By 2029, MST increases are projected to increase between 0.6 ^{o}C and 0.8 ^{o}C throughout the Caribbean. Larger geographical subdivisions such as Haiti and the Dominican Republic show increases in MST by 1 ^{o}C to 1.2 ^{o}C.

(f) In 2038, MSTs are projected to increase by 0.6 ^{o}C to 1^{o} C, showing similar subregional increases in by 1.2 ^{o}C and even 1.6 ^{o}C as in 2029.

(g) In 2047, MST increases are projected to be by 1 ^{o}C to 1.5 ^{o}C and 2.5 ^{o}C and 3 ^{o}C in extreme cases for geographical subdivisions such as Jamaica and central Haiti and Dominican Republic.

(c) Projected changes in pressure at mean sea level

The general projections in subregional and geographical subdivision observations on the projections in mean sea level pressure are detailed in maps 4 (a) to 4 (e). The projections from the simulations are:

(a) In 2011, pressure at mean sea level is expected to decrease by 0.1 to 0.4 hPa as compared to the mean pressure between 1961 and 1990.

(b) In 2020, changes in pressure become more positive (as compared to 2011) as projections show likely increases by a maximum of 0.8 hPa with values becoming greater as one moves from the southern Caribbean toward the northern Caribbean.

(c) Changes in pressure in 2029 also become more positive as projections show likely increases to a maximum of 1.6 hPa from the southern Caribbean toward the northern Caribbean.

(d) Changes in pressure become smaller in 2038, with declines in the extreme southern Caribbean of -0.3 hPa and smaller increases in the northern Caribbean by 0.1 to 0.7 hPA.

(e) Pressure at mean sea level in 2047 increases by as much as 1.6 hPa, with significant increases observed for the northern Caribbean including Haiti and the Dominican Republic, Jamaica, and the Bahamas.

(d) Projected changes in wind speed

The discernable observations from the maps 5 (a) to 5 (e) illustrating projections in wind speed are:

(a) As compared to the mean wind speed between 1961 and 1990, the mean wind speed in 2011 is expected to generally increase by 0.2 m/s to 0.6 m/s for the Caribbean subregion including the area over the Atlantic Ocean. The Caribbean Sea, however, is projected to experience relatively small declines in wind speed.

(b) In 2020, wind speed is likely to increase by 0.2 m/s to 0.5 m/s throughout the Caribbean.

(c) Wind speeds are likely to increase by 0.3 m/s in 2029, for the majority of the Caribbean subregion with geographical subdivisions increases of up to 0.5 m/s to 1.2 m/s for the lower OECS countries and northern Haiti.

(d) In 2038, the Caribbean is likely to experience an increase 0.2 m/s to 0.7 m/s, with greater increases observed closer to the Caribbean landmasses/ countries as opposed to the seas (Caribbean and Atlantic).

(e) In 2047, wind speeds are projected to increase by 0.5 m/s to 1 m/s.

(e) Projected changes in total precipitation rate

Precipitation changes illustrated in maps 6 (a) to 6 (e) are projected for the period between 2011 and 2047 as follows:

(a) In 2011 the precipitation rate is likely to increase by 1 mm/ day in the Atlantic Ocean above the Caribbean archipelago including the Turks and Caicos Islands and the Bahamas area which is likely to experience an increase by as much as 2 mm /day. The rest of the Caribbean shows no expected changes in the precipitation rate when compared to that of 1961- 1990.

(b) 2020 appears to be slightly drier when compared to 1960-1990. Precipitation rates either remain unchanged or decline by 0.5 mm / day.

(c) There is likely to be no change in 2029 as compared to the precipitation rate between 1960 and1990. Some extreme variations however show increases by 2 mm/ day around OECS, Jamaica and Belize.

(d) 2038 projections are similar to those for 2029 showing no significant changes in the precipitation rates, with some scattered increases by 1mm/ day around Jamaica and Belize.

(e) In 2047, precipitation rate changes vary throughout the Caribbean with the Bahamas showing a likely drastic decline by 4 mm/ day. Other areas such as the northern OECS show smaller declines of 1 mm/ day.

(f) Subregional projections for August 2050

(i) Haiti and the Dominican Republic

Projected changes in total precipitation rates, mean surface temperature and wind speed for the year 2050 observed from maps 7 (a) to 7 (c) are as follows:

(a) In 2050, the precipitation rate for Haiti and the Dominican Republic is likely to decline by 0 mm/ day to 1.8 mm/ day. Greater declines are observed over the Dominican Republic (by 1.5 mm/ day in central Dominican Republic and an extreme decrease by 2.1 mm/day for the south-western part of the Dominican Republic) as compared to smaller expected declines over Haiti (0.3 mm/ day).

(b) There is a projected general increase in mean surface temperature over Haiti and the Dominican Republic by 1^{o} C and 2.8^{o} C. There are significant increases towards the interior of this area with a maximum expected increase of 2.8 ^{o}C over the Dominican Republic.

(c) The observed wind speed changes over Haiti and the Dominican Republic range between 0.2 m/s and 0.6 m/s. The northern part of this area is likely to experience an increase in wind speed by 0.8 m/s.

(ii) The Bahamas and Turks and Caicos Islands

Projected changes in total precipitation rates, mean surface temperature and wind speed for the year 2050 observed from maps 8 (a) to 8 (c) are as follows:

(a) There is expected to be a general decline in precipitation rates by 0 to 1.5 mm/ day. Greater decreases are observed closer toward the Atlantic Ocean.

(b) Mean surface temperatures are expected to increase by 0.6^{o} C to 1.8^{o} C. The MST for the greater Bahamas is likely to increase by 1.6 ^{o} C, while the lower Turks and Caicos Islands shows the probability of a smaller increase in MST of 0.6 ^{o}C to 0.8 ^{o}C.

(c) Wind speeds are expected to increase by 0.2 to 1.2 m/s, more significantly towards the Turks and Caicos Islands.

(iii) OECS including the: Netherlands Antilles, Anguilla, Dominica, Grenada and Saint Lucia

Projected changes in total precipitation rates, mean surface temperature and wind speed for the year 2050 observed from maps 9 (a) to 9 (c) are as follows:

(a) The precipitation rate is likely to decline by 0 mm to 1 mm/ day. Most of the individual countries are expected to have no significant changes in precipitation rate.

(b) The MST is likely to increase by 0.7 ^{o}C to 0.9 ^{o} C in 2050. Greater increases are observed for the southernmost OECS countries.

(c) Wind speeds are likely to increase by 0.2 to 0.7 m/s.

(iv) Guyana and Suriname

Projected changes in total precipitation rates, mean surface temperature and wind speed for the year 2050 observed from maps 10 (a) to 10 (c) are as follows:

(a) Precipitation rates for Guyana (western) are likely to increase by 0 to 0.5 mm. day.

(b) MST is likely to increase by 1.5 ^{o} C to 2.1 ^{o} C.

(c) There is a small projected increase in wind speed by 0.1 m/s to 0.2 m/s.

(v) Jamaica

Projected changes in total precipitation rates, mean surface temperature and wind speed for the year 2050 observed from maps 11 (a) to 11 (c) are as follows:

(a) Jamaica is expected to be drier in 2050, with a general decrease in precipitation rates by 0.4 mm/ day to an extreme of 1.2 mm / day. Significant declines are observed to be greater toward the centre of the island.

(b) In 2050, the MST for Jamaica is observed to likely increase from 1^{o} C to 2.8 ^{o} C. Significant increases are also observed toward the centre of the island.

(c) Wind speed projections are greater south of the island with the western and eastern coasts likely to experience smaller increases in wind speed.

(vi) Belize

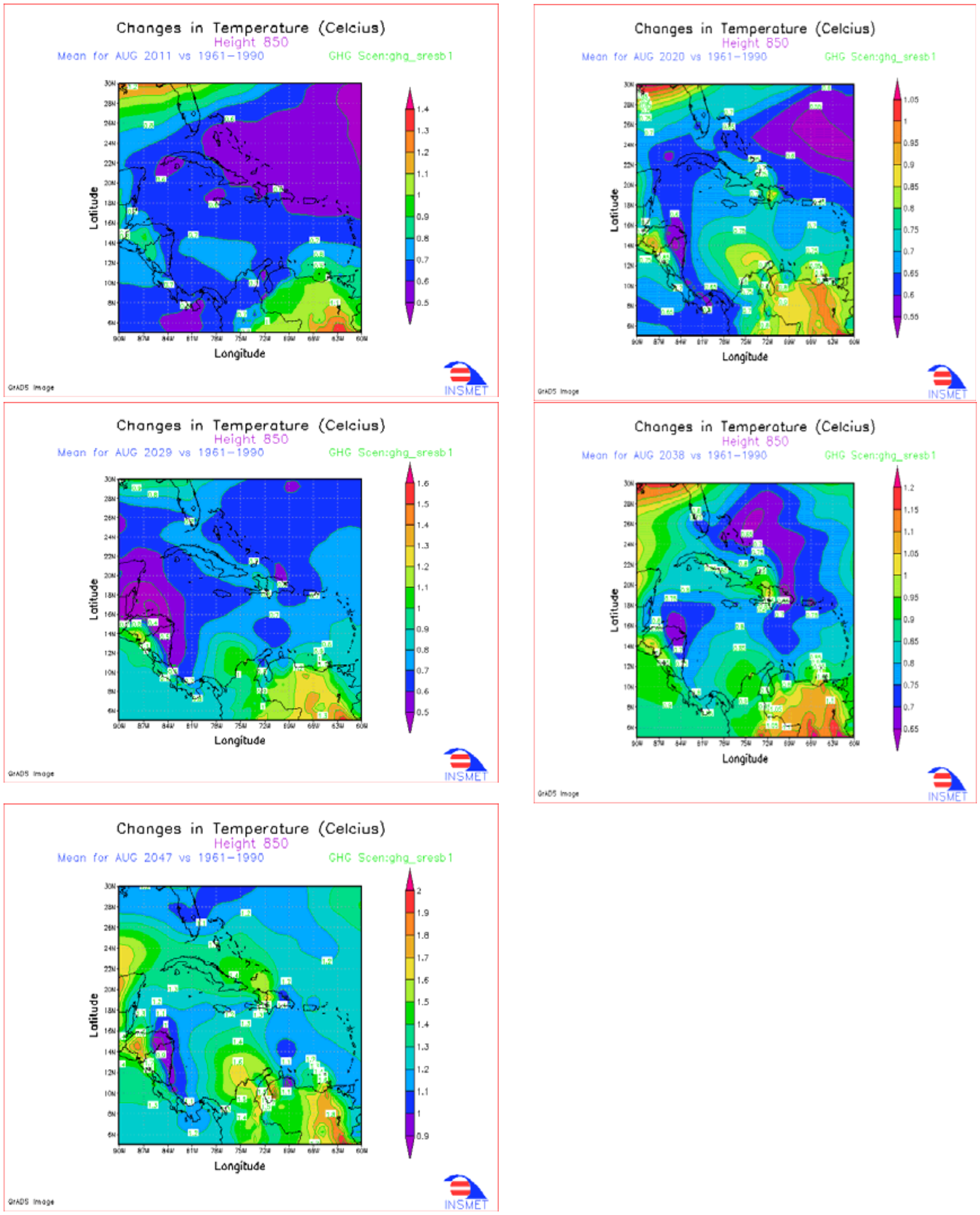
Projected changes in total precipitation rates, mean surface temperature and wind speed for the year 2050 observed from maps 12 (a) to 12 (c) are as follows:

(a) Belize is projected to be drier in 2050 with a decline in precipitation rates by 0 to an extreme 2.4 mm/ day. The declines are significant toward the interior of the country.

(b) MST is also likely to increase significantly by 1.2 ^{o} C to 2.4 ^{o} C indicating a hotter 2050 for Belize.

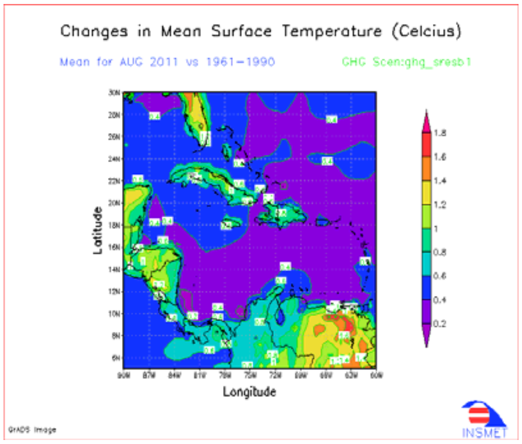
(c) Wind speed for the country is projected to increase by 0.5 m/s to 0.8 m/s.

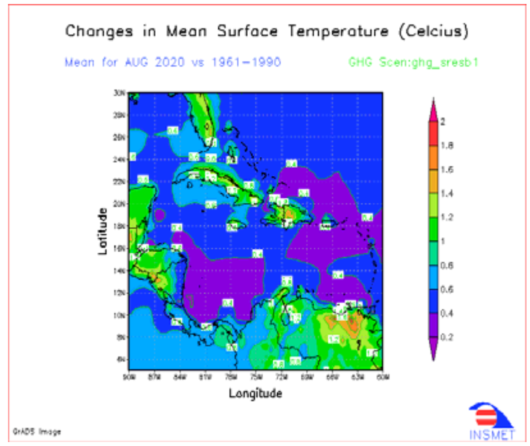
Maps 2 (a) to 2 (e): Projected temperature variations in the Caribbean for various years (August, under B1 Scenario: Low Emissions)

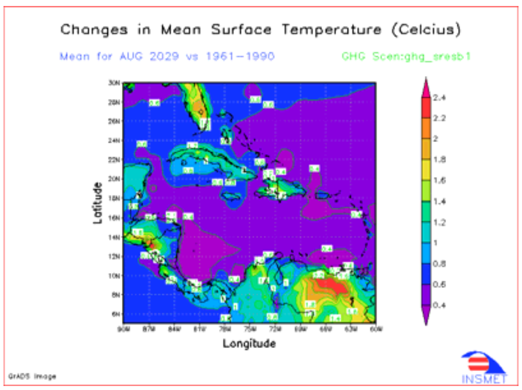


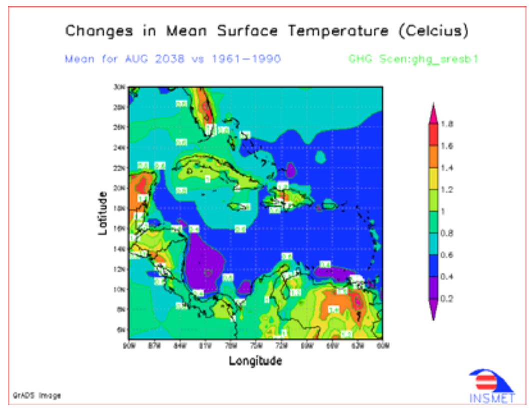
Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

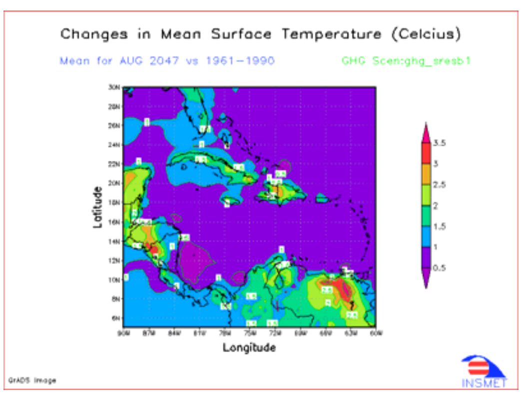
Maps 3 (a) to 3 (e): Projected changes in mean surface temperature in the Caribbean for various years (August, under B1 Scenario: Low Emissions)









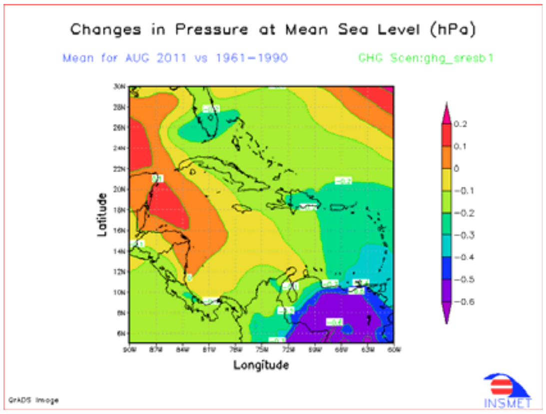


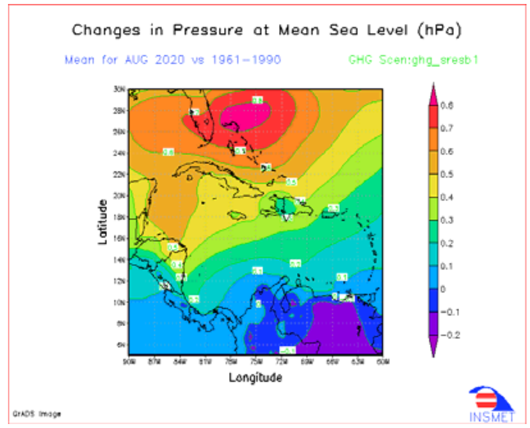
Maps show the mean surface temperature for August of various years (projected) as compared to the mean surface temperature between 1961 and 1990.

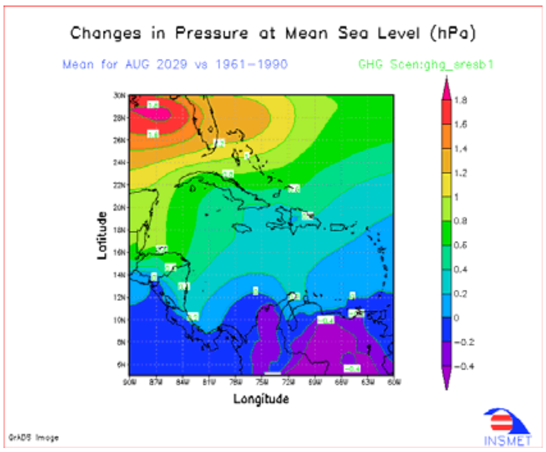
Observations: Surface temperature has great significance when considered over the sea (sea surface temperature). The SST from the maps show a gradual increase in surface temperatures mainly from a variation of 0.4 degrees in 2011, to mainly 0.6 degrees in 2029 and then by 1 degree by 2047.

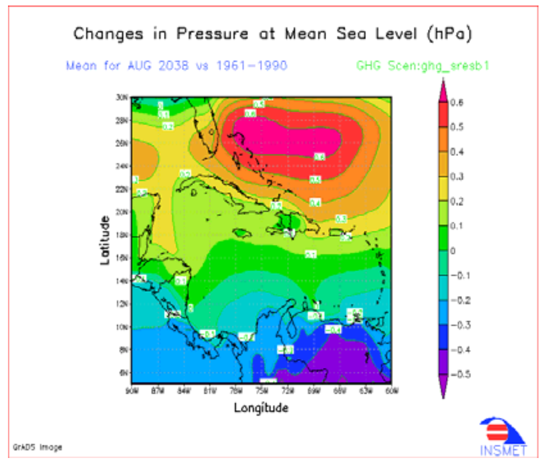
Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

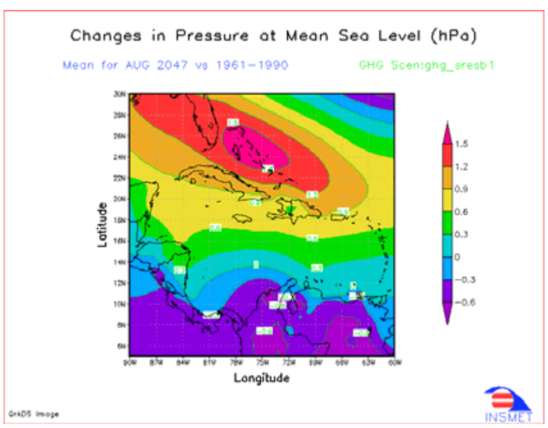
Maps 4 (a) to 4 (e): Projected changes in pressure at mean sea level in the Caribbean for various years(August, under B1 Scenario: Low Emissions)







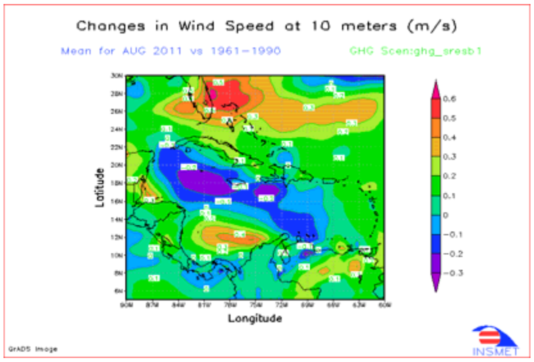


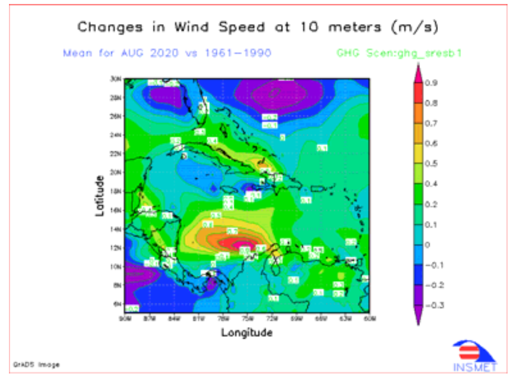


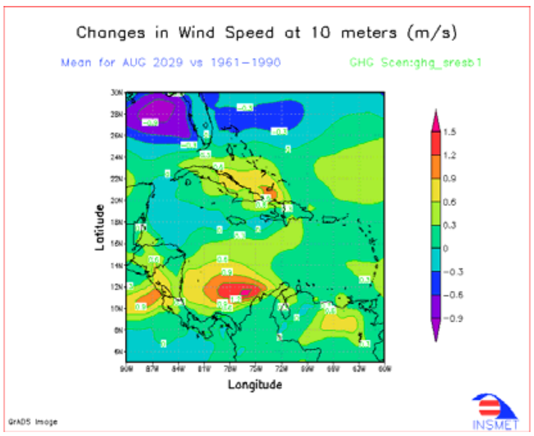
Maps show the mean Sea Level Pressure for August of various years (projected) as compared to the mean sea level pressure between 1961 and 1990. Observation: Sea Level pressure contributes to the formation of hurricanes with lower pressure levels being conducive to such formations. The maps however show that variations are generally positive increasing from a variation of mainly -0.1 hPa in 2011 to more positive variations ranging between 0-1.5 hPa in 2047

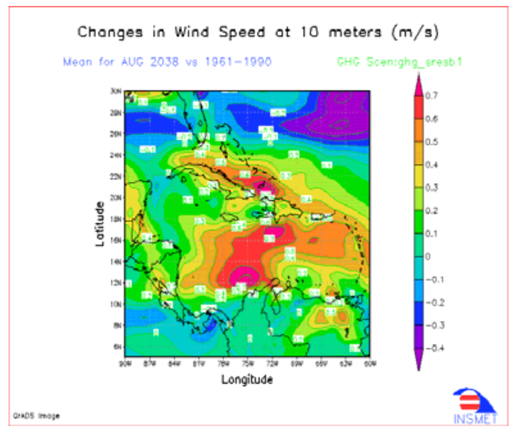
Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

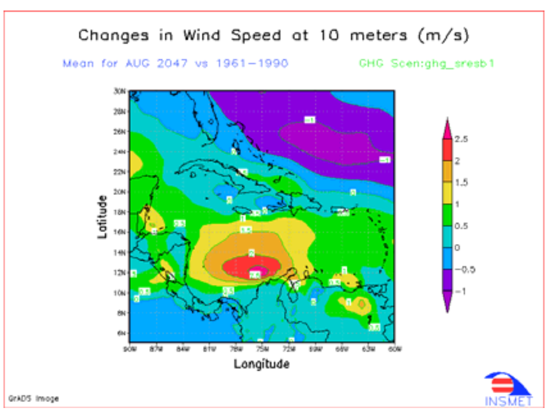
Maps 5 (a) to 5 (e): Projected changes in wind speed in the Caribbean for various years (August, under B1 Scenario: Low Emissions)







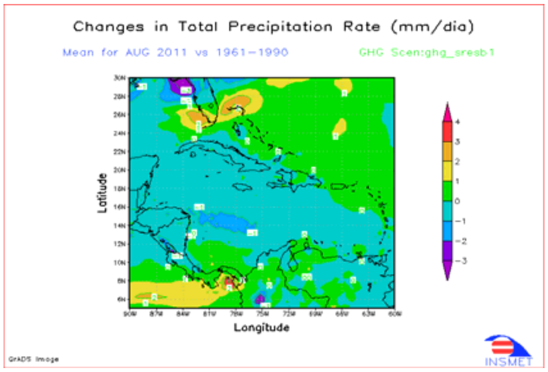


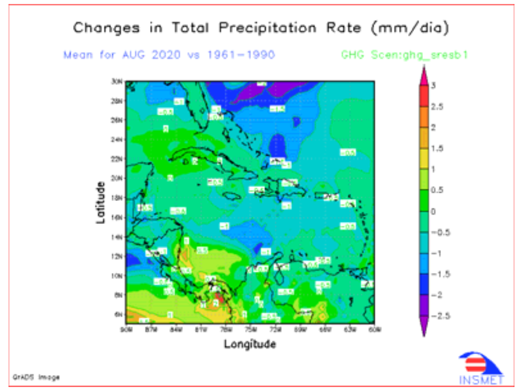


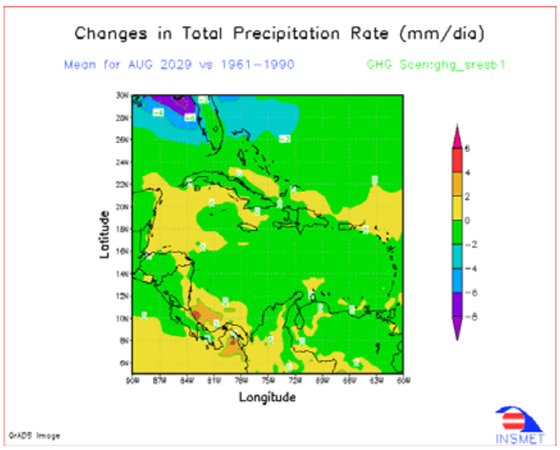
Maps show the mean Wind Speed for August of various years (projected) as compared to the mean Wind Speed between 1961 and 1990. Observations: The projected maps show that wind speed will -vary mainly by 0.2-0.3 m/s over the Atlantic Ocean in 2011 to - 0.5 to -1 m/s in 2047.

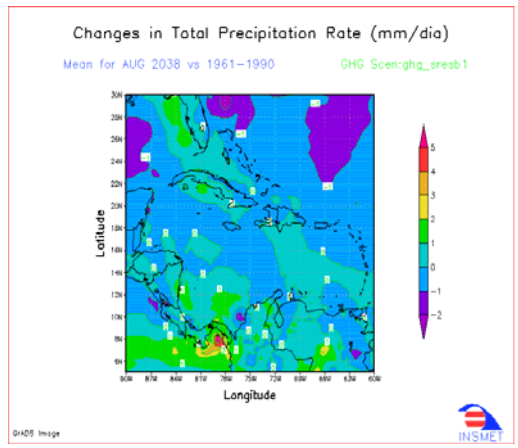
Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

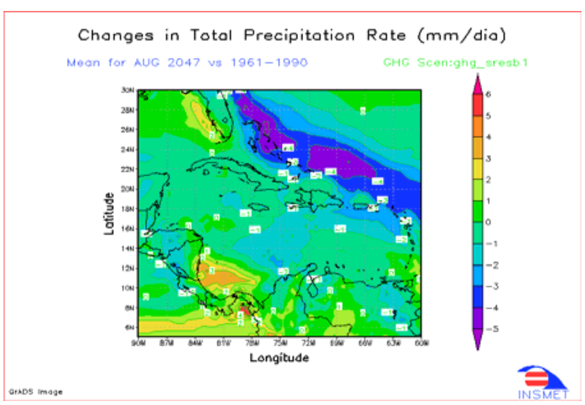
Maps 6(a) to 6(e): Projected changes in total precipitation rate in the Caribbean for various years (August, under B1 Scenario: Low Emissions)









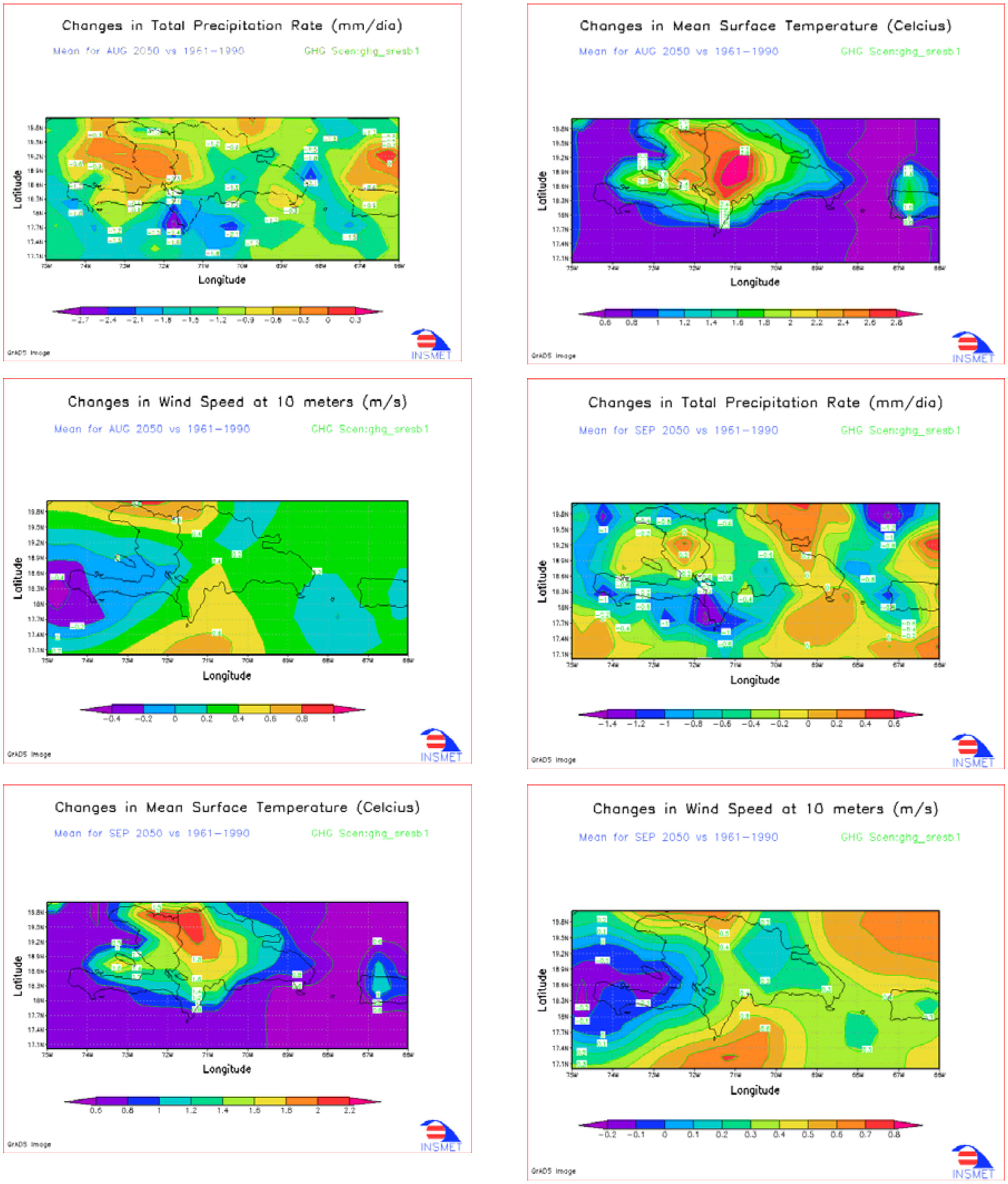


Maps show the mean precipitation for August of various years (projected) as compared to the mean precipitation between 1961 and 1990.

Observations: Precipitation seems to be varying with subregional geographical locations. Increases in precipitation are projected mainly the south-western Caribbean, with the Caribbean Sea and part of the adjacent islands showing the potential for a gradual decline in precipitation. Severe declines by -4 mm/day are projected more toward the north-western Caribbean around the Bahamas and Turks and Caicos archipelago.

Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

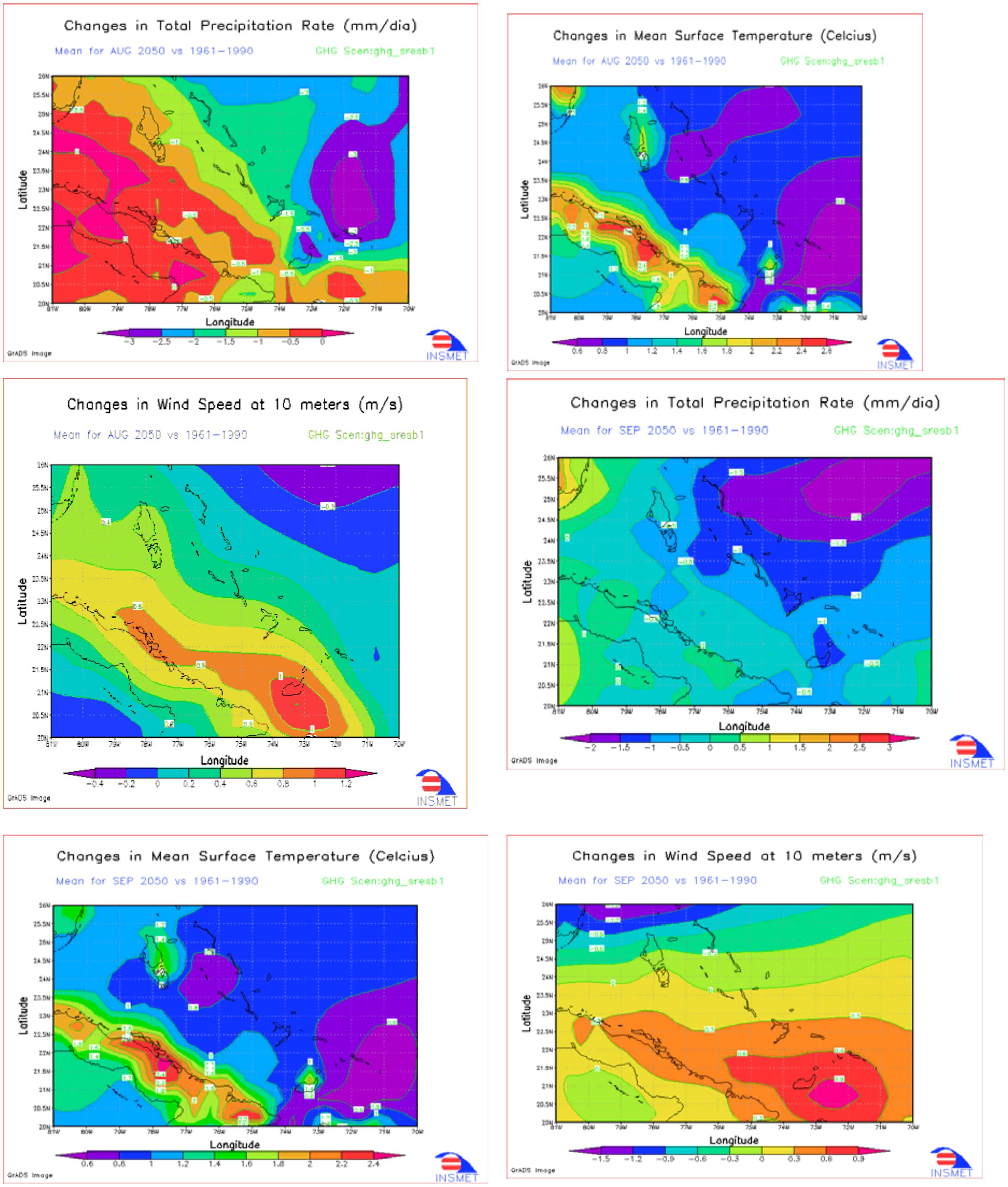
Maps 7 (a) to 7 (f): Projected precipitation changes in Haiti and the Dominican Republic for 2050 (August and September, under B1 Scenario: Low Emissions).



Maps show 2050 projections in changes in total precipitation, mean surface temperature, and wind speed for the months of August (a) to (c) and September (d) to (g) for Haiti and the Dominican Republic.
Observations: At a sub regional level, Haiti and the Dominican Republic are projected to experience lower precipitation rates (mm/day) in both August and September. Mean surface temperature is also projected to increase significantly especially at the interior of the country. Wind speed does not show any significant changes, with variations ranging from -0.2 to 0.4 m/s.

Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

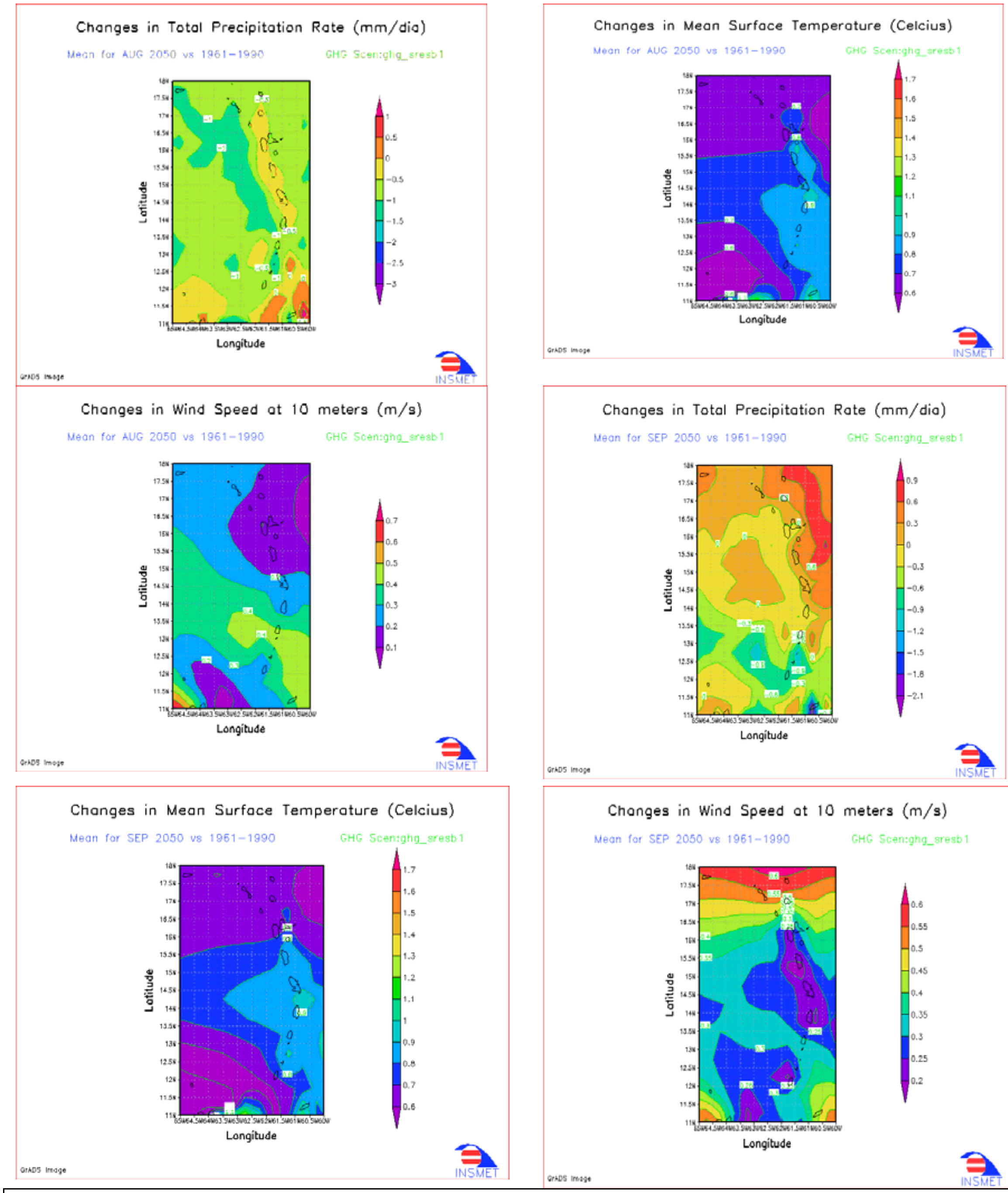
Maps 8 (a) to 8 (f): Projected precipitation, surface temperature and wind speed changes in the Bahamas and Turks and Caicos Islands for 2050 (August and September, under B1 Scenario: Low Emissions)



Maps show 2050 projections in changes in total precipitation, mean surface temperature, and wind speed for the months of August and September for the Bahamas and Turks and Caicos Islands.
Severe declines in precipitation rates are projected in 2050 for the Bahamas and Turks and Caicos Islands, by approximately 2 mm/ day. SSTs in the area are projected to increase by a maximum of 1.2 degrees. Wind speed changes are generally positive for the area

Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

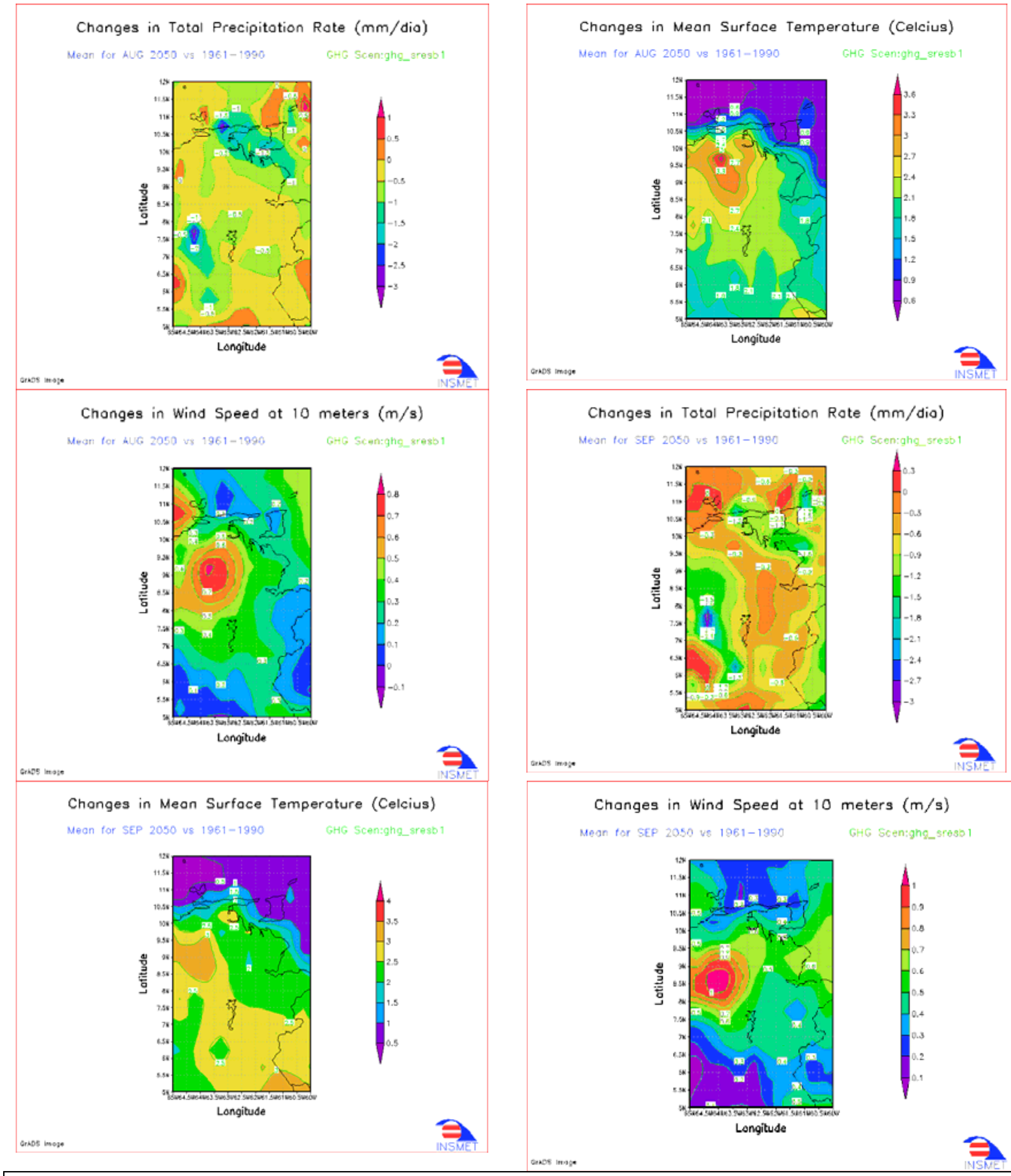
Maps 9 (a) to 9 (f): Projected precipitation, surface temperature and wind speed changes in the Netherlands Antilles, Anguilla, Dominica, Grenada and Saint Lucia for 2050 (August and September, under B1 Scenario: Low Emissions)



Maps show 2050 projections in changes in total precipitation, mean surface temperature, and wind speed for the months of August and September for OECS.
Observations: Changes in the precipitation rates are negligible either ranging from -0.3 to +0.3 mm/day. Surface temperatures however project clear increases by 0.6 to 1 degree Celsius in 2050. In addition wind speeds, in a similar manner show that there would be increases in wind speeds in the area in 2050.

Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

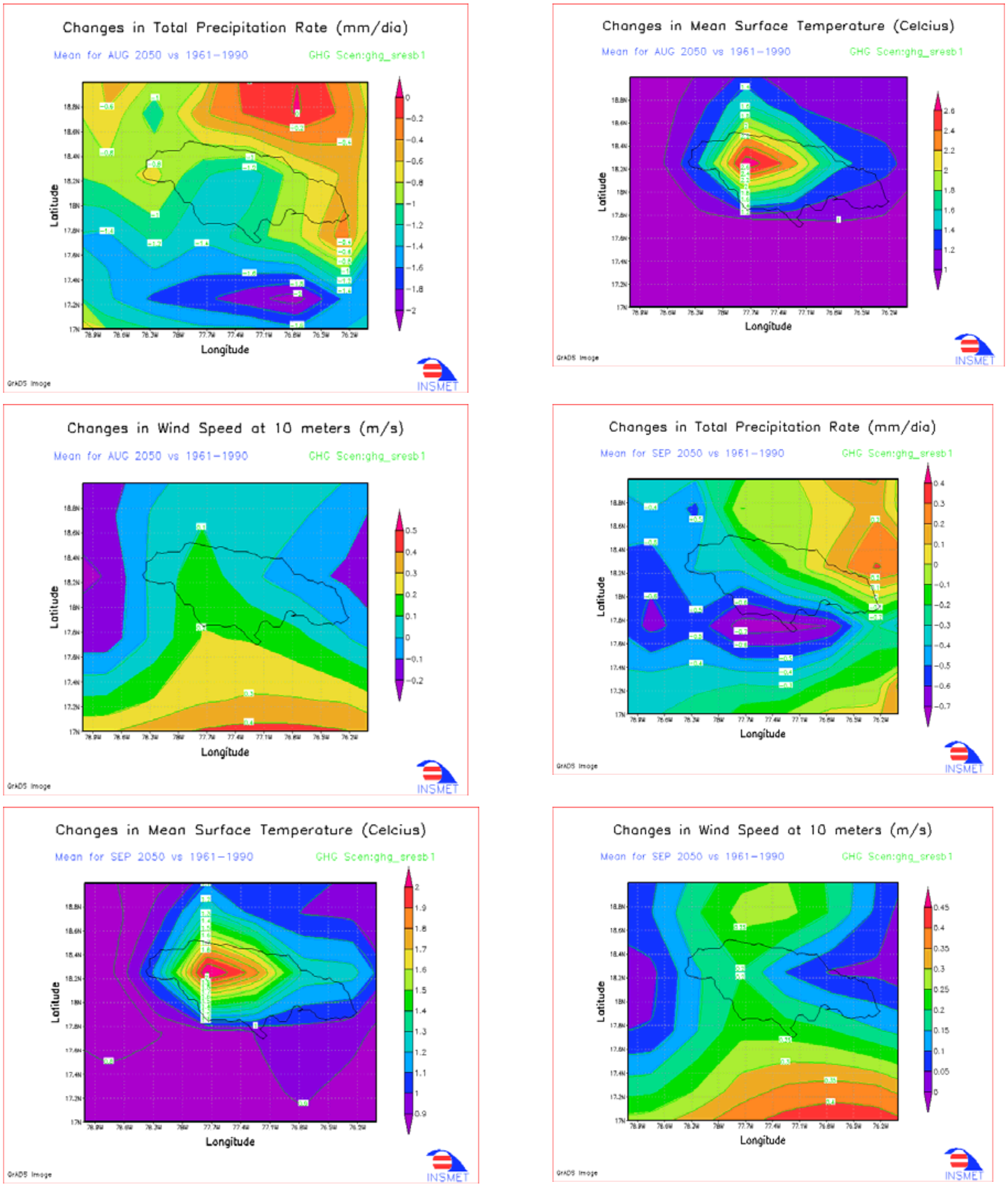
Maps 10 (a) to 10 (f): Projected precipitation, surface temperature and wind speed changes in Guyana and Suriname for 2050 (August and September, under B1 Scenario: Low Emissions)



Maps show 2050 projections in changes in total precipitation, mean surface temperature, and wind speed for the months of August and September for Guyana.
Observation: The maps do not reflect the entire Guyana/Suriname name. From the availability of the projections however, in 2050 precipitation rates show that there may be a decline in the westernmost part of Guyana. Surface temperatures however, are projected to increase as are wind speeds.

Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

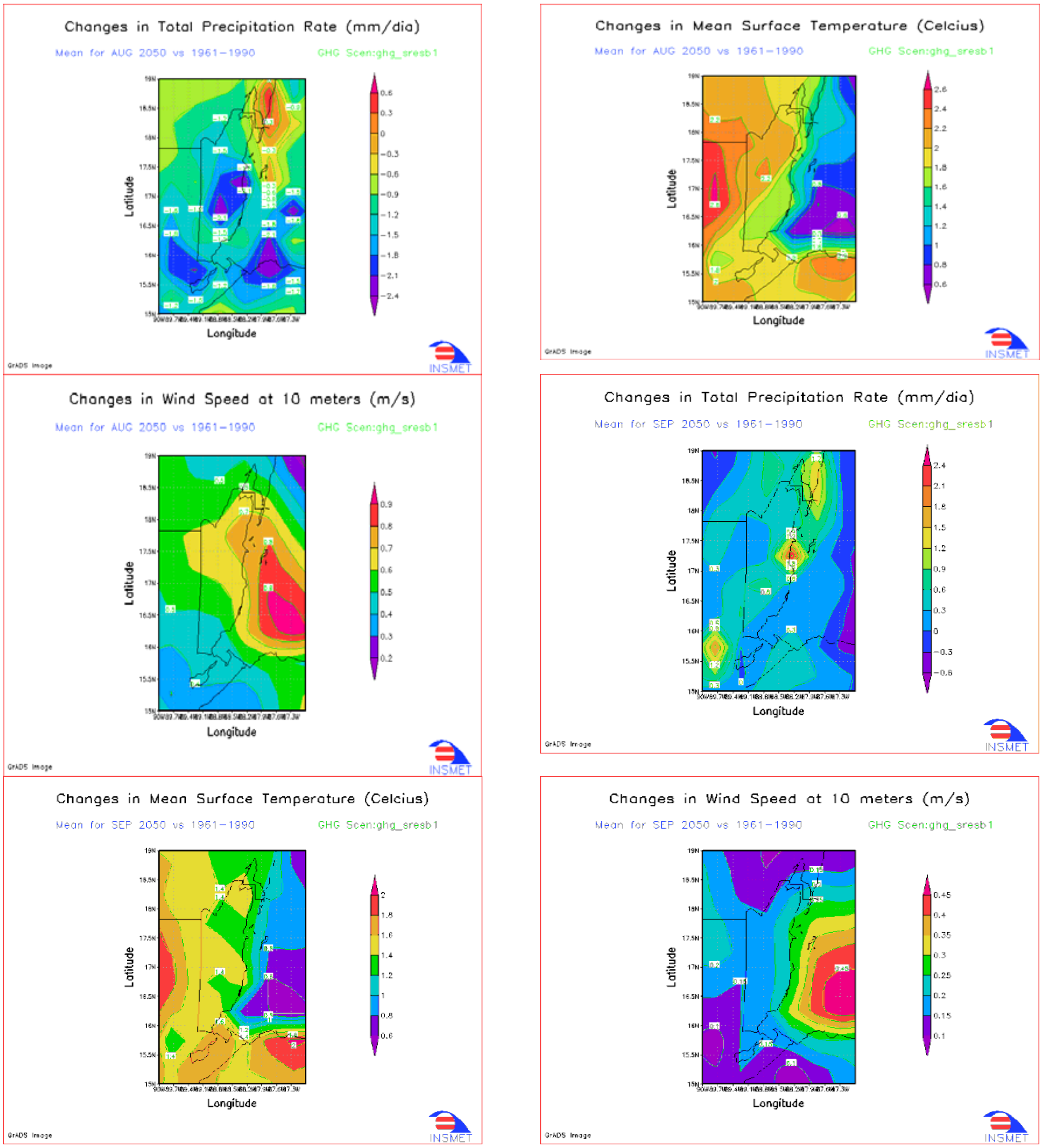
Maps 11 (a) to 11 (f): Projected precipitation, surface temperature and wind speed changes in Jamaica for 2050 (August and September, under B1 Scenario: Low Emissions)



Maps show 2050 projections in changes in total precipitation, mean surface temperature and wind speed for the months of August and September for Jamaica.
Observations: The projected precipitation maps for Jamaica predict a decline in precipitation rates, and a significant increase in surface temperatures. Wind speeds are also anticipated to increase.

Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

Maps 12 (a) to 12 (f): Projected precipitation, surface temperature and wind speed changes in Belize for 2050 (August and September, under B1 Scenario: Low Emissions)



Maps show 2050 projections in changes in total precipitation, mean surface temperature, and wind speed for the months of August and September for Belize.

Observations: While August is predicted to have a decline in precipitation rates, the projected map for Belize suggests that precipitation will increase significantly in September (possible flooding). Mean surface temperatures are projected to increase by 1.6 to 2.4 degrees Celsius in August, and by 1.4 to 1.6 degrees Celsius in September. There are also projected increases in wind speeds.

Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

C. SUBREGIONAL ANALYSIS OF THE SEVERITY OF IMPACTS

This section deals with the "…identification of the different geographical zones in the subregions in terms of areas in which possible changes will be more severe." As noted earlier, the methodology that underlies the analysis in this section of the report involves use of two indices:

(a) The Environmental Vulnerability Index

(b) The Adjusted Prevalent Vulnerability Index[22]

1. The environmental vulnerability index

The Environmental Vulnerability Index (EVI) is an index which measures the "precariousness of states, arising from their economic exposure, lack of protection and peripherality." [23] Box 5 provides a brief background to the EVI as well as a description of the terminology used in the calculation of the EVI. Annex 2 (a) and 2 (b) provides further elaboration on the EVI.

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22 The original PVI is designed by Cardona et al (2003a) in The Notion of Disaster Risk: Conceptual Framework for Integrated Management. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. http://idea.unalmzl.edu.co

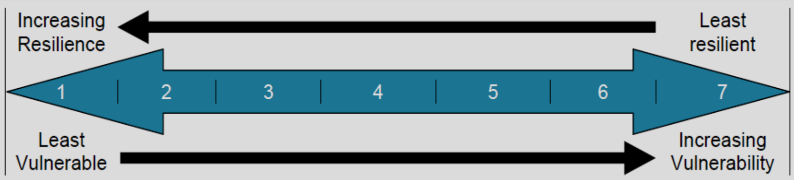
23 Briguglio, as cited in the Pratt et al, (2004)

Box 5: An overview of definitions used in the EVI

The Environment Vulnerability Index was developed to fill a need that small island developing States (SIDS) had in terms of the disadvantage they faced due to their small size and susceptibility to disturbances. The issue was first identified in the Global Summit on Small Island Developing States in Barbados, 1994. In the Barbados Programme of Action (BPoA) it was identified by SIDS and the United Nations that a vulnerability index that integrates ecological fragility and economic vulnerability should be developed in order to reflect the situation in these countries.

The Environmental Vulnerability Index (EVI) was undertaken through a partnership by the South Pacific Applied Geoscience Commission (SOPAC), United Nations Environment Programme (UNEP), and small island developing States, collaborating countries, institutions and experts with a view at examining the issue of environmental vulnerability.

The EVI uses Specific, Measurable, Attainable, Realistic and Time Based (SMART)[24] indicators to measure different issues of environmental vulnerability and, as a result, requires the compilation of environmental vulnerability data for fifty (50) indicators.[25] The indicators are combined by averaging[26] and then reported simultaneously as a single index. These indicators are selected on the basis of the "best scientific understanding currently available,"[27] and in collaboration with international experts, country experts, other agencies and interest groups. Due to the heterogeneity of the indicators which include variables (in which responses are numerical, qualitative and on different scales), these indicators can then be mapped onto a1-7 vulnerability scale. This scale ranges from 1 – least vulnerable (most resilient) to 7 – most vulnerable (least resilient)."



(1) **Vulnerability** is the tendency for an entity to be damaged.

(2) **Entities** can be physical (such as people, ecosystems, coastlines) or abstract concepts (such as societies, communities, economies, countries) that can be damaged (responders).

(3) **Resilience** is the opposite of vulnerability and refers to the ability of an entity to resist or recover from damage.

(4) **Hazards** are things or processes that can cause damage, but can only be defined in terms of the entity (responder) being damaged.

(5) **Natural resilience** (also known as intrinsic resilience) is the natural ability of an entity (responder) to resist damage.

(6) **Acquired vulnerability** (also known as extrinsic resilience) is vulnerability gained from damage in the past.

(7) **Overall vulnerability** (OV) is the result of many vulnerability factors working together, for example, the OV of a country. It includes information on the risk of hazards, natural resilience and acquired vulnerability.

Source: Pratt and others (2004)

[24] The term 'smart indicators' has been used to define EVI indicators which aim to capture a large number of elements in a complex interactive system while simultaneously showing how the value obtained relates to some ideal condition." (Pratt and others, 2004)

[25] For a complete listing of the indicators see annex 3.

[26] According to the EVI Technical Report (2004), "simple averages across indicators are used because they can be easily understood and more complex models do not appear to offer any advantages to the expression or utility of the index."

[27] Pratt and others (2004)

(a) EVI scores for case study countries

Using the methodology for calculating the EVI, the case study countries have been ranked into the five categories of **extremely vulnerable**, **highly vulnerable**, **vulnerable**, **at risk** and **resilient**, based on whether the individual country had more than 80% data versus those countries that are data deficient. The categorization is shown in table 13 (a). Table 13(b) shows the actual EVI score obtained per country, the percentage of data held for the 50 indicators that constitute the EVI, and the resulting vulnerability status of the respective country, based on the EVI categorization.[28]

The data in table 13(b) show the following:

(a) Of the 14 countries included in this analysis, three countries (Dominica,[29] Jamaica and Saint Lucia) scored high on the EVI resulting in their categorization as extremely vulnerable.

(b) Five countries (the Cayman Islands, the Dominican Republic, Grenada, Haiti and the Netherlands Antilles) were categorized as highly vulnerable.

(c) Two countries, Anguilla and Turks and Caicos Islands, were categorized as vulnerable.

(d) The Bahamas and Belize were deemed to be at risk

(e) Guyana and Suriname were resilient.

Table 13a
EVI classification for case study countries

EVI classification for countries with valid scores (>80% data)	EVI trends for countries that are data deficient
Extremely Vulnerable	***Extremely Vulnerable***
Jamaica	Saint Lucia Dominica[30]
Highly Vulnerable	***Highly Vulnerable***
Dominican Republic Haiti	Cayman Islands Grenada Netherland Antilles
Vulnerable	***Vulnerable***
	Anguilla Turks and Caicos
At Risk	***At Risk***
Belize	Bahamas
Resilient	***Resilient***
Guyana Suriname	

Source: Adapted from EVI Technical Report (2004)

[28] For a classification of case study countries with valid scores and those that are data deficient see Annex 1.
[29] The EVI was not calculated for Dominica, however, Saint Lucia was used as a proxy.
[30] See Footnote 4

Table 13(b): EVI Scores for Case Study Countries

Country	EVI	DATA%	STATUS
Anguilla	312	52	Vulnerable
Bahamas, the	248	62	At Risk
Belize	258	90	At Risk
Cayman Islands	343	60	Highly Vulnerable
Dominica[31]	393	59	Extremely Vulnerable
Dominican Republic	324	90	Highly Vulnerable
Grenada	316	62	Highly Vulnerable
Guyana	207	90	Resilient
Haiti	343	92	Highly Vulnerable
Jamaica	381	94	Extremely Vulnerable
Netherlands Antilles	323	60	Highly Vulnerable
Saint Lucia	393	59	Extremely Vulnerable
Suriname	211	88	Resilient
Turks and Caicos Islands	292	52	Vulnerable

Source: http://vulnerabilityindex.net/EVI_Country_Profiles.htm

(b) Case study country analysis using the EVI

Table 14 shows the EVI analysis for the case study countries in 2005. The salient points revealed by the analysis are as follows:

(a) With respect to hazards (frequency and intensity of events) Jamaica is the most vulnerable/least resilient country of the fourteen reviewed in this study. Saint Lucia is ranked as the second most vulnerable among the case study countries. The most resilient and least vulnerable is Anguilla.

(b) In the context of inherent characteristics for coping with hazards, the Turks and Caicos Islands emerged as the most vulnerable/least resilient in terms of resistance. Anguilla and the Cayman Islands were second and third, respectively, as the most vulnerable among the case study countries. The least vulnerable/most resilient was Belize.

(c) External forces affecting the national environment is the third area captured in table 14 and in this category Jamaica is also the most vulnerable/least resilient country. Saint Lucia ranks second. The least vulnerable/most resilient case study country is that of Suriname.

(4) Climate change is a factor which can exacerbate a country's vulnerability and Saint Lucia is the most vulnerable/least resilient country in this regard while Suriname is the least vulnerable/most resilient according to the EVI scale. Figure 5 shows that with respect to exposure to natural disasters, Saint Lucia is also the most vulnerable and least resilient while Anguilla is the least vulnerable/most resilient according to the EVI scale. It should be noted that Saint Lucia is also the most vulnerable/least resilient in terms of desertification, water, agriculture and fisheries while the Netherlands Antilles is the most vulnerable with respect to biodiversity and human health impacts.

The indicators used in the calculation of the EVI are "signals are based on average levels observed over the past 5 years, but may include data for much longer periods for geological events."[32] The EVI is representative of the period 1999 to 2004; however, significant climate change events have occurred ex post this period for several case study countries, especially for Haiti and Suriname. As a result, the EVI is used as an illustration of the vulnerability of the case study countries for the period from 1999 to 2004.

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[31] Data for Dominica were unavailable. Data for Saint Lucia were used a proxy.
[32] Pratt and others (2004)

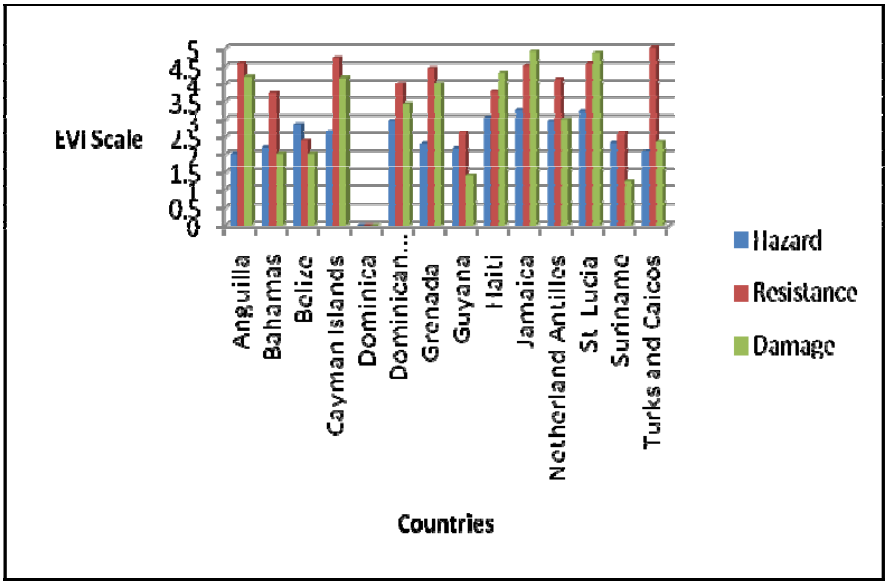
Table 14
EVI details for case study countries

	Anguilla	Bahamas	Belize	Cayman Islands	Dominica	Dominican Republic	Grenada	Guyana	Haiti	Jamaica	Netherlands Antilles	Saint Lucia	Suriname	Turks and Caicos Islands
Hazard	2.00	2.18	2.85	2.65	n.d.	2.96	2.29	2.15	3.04	**3.24**	2.94	3.20	2.31	2.08
Resistance	4.57	3.71	2.38	4.71	n.d.	4.00	4.43	2.63	3.75	4.50	4.14	4.57	2.63	**5.00**
Damage	4.20	2.00	2.00	4.17	n.d.	3.40	4.00	1.40	4.30	**4.90**	3.00	4.86	1.20	2.33
Climate Change	3.75	3.60	2.85	4.50	n.d.	3.92	3.90	2.69	3.62	3.62	4.00	**4.88**	2.46	4.13
Exposure to natural disasters	1.50	2.20	2.55	2.80	n.d.	3.00	2.50	2.18	2.82	2.73	2.50	**4.14**	1.82	2.29
Biodiversity	4.45	3.00	2.47	4.50	n.d.	3.32	4.08	2.39	4.11	4.58	**6.37**	4.62	2.58	3.92
Desertification	2.40	3.43	3.36	3.86	n.d.	4.09	2.86	3.27	3.55	3.64	3.00	**5.00**	2.64	4.25
Water	5.00	3.67	3.83	5.33	n.d.	4.91	5.67	2.91	4.92	4.64	4.80	**6.00**	3.09	4.00
Agriculture/Fisheries	2.60	2.40	3.39	3.56	n.d.	3.65	4.10	2.41	3.78	3.78	3.30	**4.50**	2.44	2.88
Human health aspects	**7.00**	1.00	2.60	4.00	n.d.	3.50	3.00	1.25	2.80	4.25	**7.00**	2.00	1.75	3.00

Source: Adapted from: http://www.vulnerabilityindex.net/EVI_Country_Profiles.htm

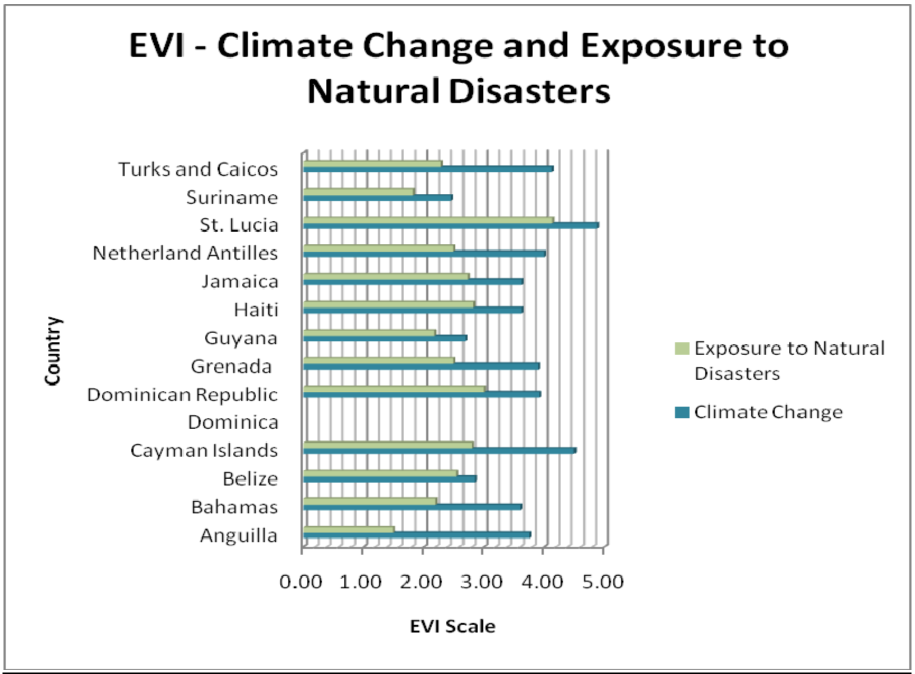
Further, the figure 4 below graphically depicts the situation of the case study countries in terms of the sub indicators hazards, resistance and damage.

Figure 4
EVI –Hazard, Resistance and Damage



Source: Dderived from http://www.vulnerabilityindex.net/EVI_Country_Profiles.htm

Figure 5
EVI –Climate change and exposure to natural disasters



2. The Adjusted Prevalent Vulnerability Index (PVI)

Box 6 provides a brief background and details on the Prevalent Vulnerability Index (PVI).

Box 6: The Prevalent Vulnerability Index

The PVI seeks to depict the main vulnerability conditions by measuring exposure in prone areas, socio-economic fragility and lack of social resilience on the basis that measuring these areas provides a measure of direct, indirect and intangible impacts of hazard events. The index is a composite indicator that provides a comparative measure of a country's pattern or situation. Inherent vulnerability conditions underscore the relationship between risk and development (UNDP, 2004). Vulnerability, and therefore risk, are the result of inadequate economic growth, and deficiencies that may be corrected by means of adequate development processes. Although the indicators proposed are recognized as useful for measuring development (Holzmann and Jorgensen, 2000; Holzmann, 2001) their use here is intended to capture favourable conditions for direct physical impacts (exposure and susceptibility), as well as indirect and, at times, intangible impacts (socio-economic fragility and lack of resilience) of potential physical events (Masure, 2003; Davis, 2003). The PVI is an average of these three types of composite indicators.

Indicators of Exposure and Susceptibility - The best indicators of exposure and/or physical susceptibility (PVIES) are the susceptible population, assets, investment, production, livelihoods, historic monuments, and human activities (Masure, 2003; Lavell, 2003b). Other indicators include population growth and density rates, and agricultural and urban growth rates. These variables reflect the national susceptibility to dangerous events, whatever their nature or severity. Exposure and susceptibility are necessary conditions for the existence of risk.

Indicators of Socioeconomic Fragility - Socioeconomic fragility (PVISF) may be represented by indicators such as poverty, lack of personal safety, dependency, illiteracy, income inequality, unemployment, inflation, debt and environmental deterioration. These indicators reflect relative weaknesses that increase the direct effects of dangerous phenomena (Cannon, 2003; Davis, 2003; Wisner, 2003). Even though these effects are not necessarily cumulative (and in some cases may be superfluous or correlated), their influence is especially important at the social and economic levels (Benson, 2003b)

Indicators of (Lack of) Resilience - Lack of resilience (PVILR), seen as a vulnerability factor, may be represented by means of the inverse relationship of a number of variables that measure human development, human capital, economic redistribution, governance, financial protection, community awareness, the degree of preparedness to face crisis situations, and environmental protection. These indicators are useful to identify and guide actions to improve personal safety (Cannon, 2003; Davis, 2003; Lavell, 2003a; Lavell, 2003b; Wisner, 2003).

Source : Cardona and others (2005)

For the purposes of this study, and given the paucity of data based on the original PVI, an effort was made to harmonize data on the 14 case study countries and develop an adjusted PVI. This adjusted PVI is based on two sets of indicators:

Indicator 1 seeks to capture those variables which, in the context of the Caribbean, are deemed important factors in a country's economic exposure and susceptibility. Variables included in this indicator are:

Population density (people per sq. km)
Exports of goods and services (% of GDP)
Imports of goods and services (% of GDP)
Gross fixed capital formation (% of GDP)
Agriculture, value added (% of GDP)
Debt Service as a % of GDP
Tourism as a % of GDP

Indicator 2 reviews variables that are considered important in determining a country's socio-economic fragility and resilience. The variables in this indicator include:

GINI index
Poverty levels
Unemployment, total (% of total labour force)
Inflation, consumer prices (annual %)
Human Development Index, HDI [Inv]
Gender Related Development Index, GDI [Inv]
Social expenditure: health % of GDP[Inv]
Social expenditure: education as % of GDP
Level of sensitivity to CC/DRM
Government effectiveness

(a) Methodology for calculating the adjusted PVI

Equal weights were applied for each of the variables identified for the indicators **Economic Exposure and Susceptibility** (EES) and **Socio-Economic Fragility and Resilience** the (SEFR). Given that there were seven variables for the EES, the weight applied was 0.143 while for the SEFR the ten variables attracted equal weighting of 0.1. Sufficient data were not readily available for the dependent countries, Anguilla, the Cayman Islands, the Netherlands Antilles and Turks and Caicos Islands. As a result, they were omitted from the PVI analysis.

(b) Results of the analysis for the Adjusted PVI for the case study countries

The data in table 15 show the results of the Adjusted Prevalent Vulnerability index for Caribbean countries, 1990 – 2007.[33] The results show that Grenada has the highest level of vulnerability for the period 1990 to 2007 ranging from 23.33 to 36.07 while Suriname has the lowest level of vulnerability ranging from 2.03 to 18.55.[34]

[33] There were difficulties in obtaining data for 2008 and, as such, it was excluded from the calculation.
[34] A composite indicator consists of a mathematical combination of a set of indicators. However, according to Cardona and others (2003b), "composite indicators are based on sub-indicators that have no meaningful unit of

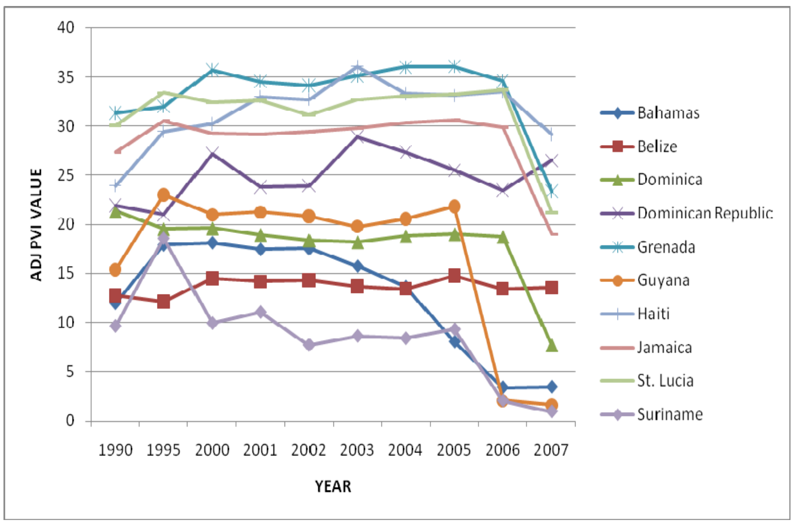
Table 15
Adjusted Prevalent Vulnerability Index for Caribbean countries, 1990- 2007

Country	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
Bahamas, the	11.97	17.92	18.15	17.46	17.54	15.76	13.65	8.05	3.38	3.43
Belize	12.74	12.15	14.49	14.18	14.30	13.68	13.43	14.76	13.44	13.54
Dominica	21.33	19.54	19.61	18.96	18.38	18.20	18.81	19.02	18.74	7.70
Dominican Republic	21.93	20.96	27.18	23.81	23.94	28.92	27.33	25.49	23.46	26.48
Grenada	31.30	32.00	35.68	34.52	34.12	35.09	35.99	36.07	34.60	23.33
Guyana	15.41	22.98	20.97	21.23	20.80	19.78	20.56	21.83	2.05	1.60
Haiti	23.94	29.45	30.25	32.98	32.72	36.05	33.28	33.09	33.45	29.13
Jamaica	27.35	30.47	29.21	29.18	29.42	29.78	30.35	30.57	29.89	18.97
Saint Lucia	30.04	33.36	32.43	32.61	31.13	32.67	33.04	33.24	33.69	21.21
Suriname	9.63	18.55	9.92	11.04	7.69	8.61	8.38	9.29	2.03	0.94

Source: Compiled by the authors

Figure 6 further illustrates the trends in the Adjusted PVI for the case study countries. It shows that Grenada, Haiti, Saint Lucia and Jamaica are the countries with the highest vulnerability.

Figure 6
Adjusted Prevalent Vulnerability Index for Caribbean countries, 1990 – 2007



measurement and there is no obvious way of weighting these sub-indicators." For the purposes of this study, the PVI ranges from 0 (lowest vulnerable) to 100 (highest vulnerability).

CHAPTER III

CLIMATE CHANGE ADAPTATION AND DISASTER RISK REDUCTION IN CARIBBEAN COUNTRIES

This section draws on two sets of information available at the national level: first, the respective country's first National Communication to UNFCCC on greenhouse gases and second, complementary information on the existence of natural disaster preparedness and response agencies. The results of the analysis of these two sources are summarized in Table 16. In their National Communications, each country identified specific priority sectors most vulnerable to climatic events. For most countries, health, coastal zones, tourism and agriculture were the more sensitive sectors. However, all sectors were important for adaptation because they were tied to social aspects such as employment, poverty, public debt and increased government expenditure.

Most adaptation pre-event plans involved reinforcement of physical infrastructure to withstand the actual event. These involved improving designs of causeways, bridges and housing. The majority of coastal zones pre-event adaptation involved constructing sea walls, dykes, levees and floodwalls. This also extends to the tourism sector since adaptation plans rely on physical infrastructure for the safety of tourism before and after a disaster.

Second, apart from reinforcement of physical infrastructure, there was further investment into development of several sectors. The agricultural sector preparedness plans in several countries looked at crops that were most tolerant to changes in climatic conditions. Proper irrigation, farming practices and use of new technology, soil conservation techniques and practices that could make a difference in limiting losses in these sectors were also addressed. Emphasis in the water resources sector was on water conservation and on developing a good knowledge base in safety, precautions, and preparedness in dealing with disasters, and in preventing physical and human losses.

Third, all countries are seeking to have increased education and awareness of disaster risk management. Table 10 lists several workshops held to discuss civil society participation in Disaster Risk Management. With the 2009 Copenhagen Summit, civil society organizations are now being given the opportunity to provide their input into major environmental issues related to climate change and disaster prevention. Table10 also highlights workshops held in Saint Vincent and the Grenadines in July 2005 on Reporting on Mauritius Strategy Implementation, which targeted schools, communities and government agencies to collaborate and become more in involved in Sand watch activities.

Another workshop conducted by CANARI was held in Saint Lucia in October, 2007 on "Enhancing the role of civil society in raising awareness and building capacity for adaptation to climate change." This workshop targeted schools, artistes, government agencies and civil society organizations. It sought to promote awareness about climate change adaptation.

UNEP hosted a workshop held in Mexico from 12 to 14 October, 2007 on "Latin America and the Caribbean Regional Statement to the Ninth Global Civil Society Forum and the Tenth Special Session of the Governing Council/Global Ministerial Environment Forum" which targeted groups such as the international community, environmental and socio-economic sector organizations and government. This workshop sought to identify the importance to climate change of holding each shareholder responsible. It also sought to strengthen alliances amongst organizations through joint climate change prevention, mitigation and adaptation policy and projects.

The last section included in the table is proposed national follow-up activities by CANARI for several countries. The main focus groups for these activities are governments, civil society organizations, schools, conservation organizations, NGOs, media and artists.

It was also important to show the cost of, or funding for, adaptation for these aforementioned countries, using constant 2008 dollars. Thus, a substantial amount of funding went into rehabilitation cost and response to disasters. Countries also asked for funding to compile their National Communications to the UNFCCC. Most of the funding went to Haiti, Guyana and Jamaica, while less funding was channelled to countries such as Cayman Islands and Dominica.

Table 16: Disaster management plans and cost of funding for adaptation

Country	Disaster management plans	Cost of funding for adaptation (Funding Agency) Constant 2008 US$
Anguilla	Comprehensive Disaster Management Strategy (CDMS)	Received **US$ 14,939** for humanitarian assistance (Canada)
Bahamas, the	Caribbean: Planning for Adaptation to Climate Change (CPACC)	Prepare its First National Communication in the amount of **US$ 276,825 (**UNDP) Additional financing for capacity-building in priority areas in the amount of **US$ 142,670** (UNDP) Promoting sustainable energy in the Bahamas grant in the amount of **US$ 1,493,930 (**IDB)
Belize		Funding for preparation of its Initial National Communication in response to its commitments to UNFCCC in the amount of **US$215,847** (UNDP) Bridge rehabilitation in the amount of **US$10.2 million** (CDB) Immediate response loan for tropical storm Arthur in the amount of **US$ 603,777** (CDB)
Dominica		Implementation of pilot adaptation measures in coastal areas in the amount of **US$ 4,313,694** **(**World Bank) Rehabilitation of sea defences for Hurricane Omar in the amount of **US$ 18.8 million** (CDB) National disaster management for Hurricane Omar in the amount of **US$ 1,027,070** (CDB)
Dominican Republic		Research in solar energy for electricity in the amount of **US$ 5,048,426** (IDB)

Grenada	National Disaster Management Strategy of Grenada (NDMSOG)	Funding for preparation of its Initial National Communication in response to its commitments to UNFCCC in the amount of **US$ 374,372** (UNDP) Additional financing for capacity-building in priority areas in the amount of **US$ 203,055** (UNDP) Disaster mitigation and restoration Grenada in the amount of **US$ 7,513,035** (CDB) Hurricane reconstitution in the amount of **US$ 22.3 million** (CDB)
Guyana	(i) More accurate flood risk Information that incorporates the effects of climate and sea level rise (ii) improved public education on disaster risk and its reduction (iii) an updating of the national disaster risk management system to more effectively implement integrated disaster risk management. The overall objective of the programme is to design and implement an Integrated Disaster Risk Management Plan, within the framework of Comprehensive Disaster Management. The specific objectives are to: (i) evaluate climate-related disaster risk (ii) strengthen national and local capacity for IDRM (iii) support the future implementation of the IDRM plan through the design of an investment programme in flood prevention and mitigation	Grant to support the design and implementation of an integrated disaster risk management Guyana in the amount of **US$ 13,534,764** (IDB) GEF Projects Integrated and Sustainable Management of Trans-boundary Water Resources. (World Bank) Project grant approved **US$ 2,000,000**

Haiti	USAID Preparedness and Mitigation Assistance to Haiti in FY 2009. Since 2006, USAID/OFDA has provided training and technical assistance to improve the ability of local Haitians to prepare for and respond to disasters. To further plan for and implement preparedness and mitigation programs in Haiti, USAID/OFDA is formulating a comprehensive country strategy that incorporates elements to more effectively coordinate the humanitarian response to tropical storm including through increased involvement in early recovery projects.	USAID/OFDA HUMANITARIAN FUNDING: Preparedness and Mitigation Funding **US$ 1,100,045.** Disaster Response Funding **US$ 14,567,691.** Project Enabling activities to facilitate the preparation of a National Adaptation Plan of Action (NAPA) GEF Grant **US$198,665**
Jamaica	The Comprehensive Disaster Management (CDM) cycle illustrates the ongoing process by which governments, businesses and civil society plan for and reduce the impact of disasters, and take steps to recover after a disaster has occurred. The CDM framework is multi-hazard and multisectoral in its application and is concerned primarily with integrating vulnerability assessment and risk reduction into development planning and management (CDERA, 2001) through four major phases: Mitigation, Preparedness, Response, and Recovery.	GEF projects. 1) Demand Side Management Demonstration. Focal area: Climate change Agency: IBRD GEF Grant: US$3,800,000 2) Enabling Jamaica to prepare its First National Communication in response to its commitments to UNFCCC. Focal area: Climate change Agency: UNDP. GEF Grant: US$232,780 3) Climate change enabling activity (Additional Financing for Capacity Building in Priority Areas). Focal area: Climate change

		Agency: UNDP. GEF Grant: US$100,000 Post Hurricane Dean rehabilitation. Agency: Ministry of Transport and Works (MTW) through its National Works Agency (NWA). Loan amount: **US$20.5mn**
Saint Lucia	The objective of Second Saint Lucia Disaster Management Project (DMP II) is: (a) to further reduce the country's vulnerability to adverse natural events (such as hurricanes and floods) through investing in risk management activities (b) to strengthen the institutional management and response capacity of the respective ministries and agencies for disaster management through the provision of facilities, critical equipment, technical assistance and training.	GEF Projects 1) Implementation of pilot adaptation measures in coastal areas of Saint Lucia. Agency: World Bank. Project grant approved: **US$2,100,000** 2) Enabling Saint Lucia to prepare its First National Communication in response to its commitments to UNFCCC Focal area: Climate change Agency: UNDP GEF Grant: **US$169,900**

Suriname		GEF Projects 1) Integrated and Sustainable Management of Trans-boundary Water Resources. Agency: World Bank Project grant approved. (2008) **US$2,000,000** 2) Enabling Suriname to prepare its Initial National Communication in response to its Commitments to the UNFCCC.(1998) Focal area: Climate change Agency: UNDP GEF Grant: US$350,000
Turks and Caicos Islands		Immediate Response Loan. Agency: Ministry of Communications, Works and Utilities. LOAN AMOUNT: **US $0.520 million**

A. ADAPTATION STRATEGIES FOR PRIORITY SECTORS

Further details are now provided below on adaptation strategies which have been proposed and/or are being implemented across the case study countries. This section compares cross-country policies for the same priority sector. However, it should be noted that there was a paucity of data for the non-independent territories of Cayman Islands, Netherlands Antilles, Turks and Caicos Islands, and Anguilla.

1. Agriculture, Forestry and Fisheries

There has been a paucity of data and information for the non-independent territories. From table 17 it can be concluded that most of the countries have readily available pre-adaptation strategies for the sectors addressed. Most countries looked at introducing crops more tolerant to the changing climatic conditions, and new production technologies, for example, hydroponics. Guyana has approached the forestry sector and with some urgency, using the Impact and Vulnerability Assessment as a starting tool, continues to carry out detailed studies in the interior. Saint Lucia has a comprehensive breakdown on sectoral plans to adapt to climate change.

Table 17
Adaptation Strategies for case study countries – Agriculture, Forestry and Fisheries

Bahamas, the	**PRE EVENT** 1) Develop agricultural production systems adapted to soil salinization, atmospheric CO_2 enrichment, increased temperatures. **POST EVENT** Assess vulnerability to soil salinization, loss of agricultural lands due to year-round and seasonal high water tables, salt water flooding
Belize	**PRE EVENT** 1)Accelerate diversification in production and exports; relocate agricultural activity away from the coastal zone; introduce changes to the traditional planting and sowing dates; introduce new varieties or species; reduce tillage. 2) Develop a comprehensive land use policy; introduce forest management plans; promote agro forestry; restore abandoned agricultural lands; establish tree plantations; develop national forest fire management plan. **POST EVENT** Increase food production; strengthen intersectoral linkages; increase the competitiveness of the agricultural sector
Dominica	**PRE EVENT** 1) Strengthen legislation and regulations governing forest management on government and private property; find creative fiscal measures to encourage private lands to remain under forest cover; reforestation of critical watersheds; protecting wetland ecosystems. 2) Enforce legislation and policy concerning land use; food security and health; large scale watershed management projects; education / public awareness; on farm water storage capabilities. 3) Encouragement of use of fishing boats able to target offshore fisheries; enforcement of fishing controls within national exclusive economic zone; raising the level of coastal structures (docks and piers); fisheries plan.
Grenada	**PRE EVENT** **AGRICULTURE AND FISHERIES** 1)Greater demand for irrigation; reduced available arable lands decreasing crop yields; reduced livestock productivity particularly chicken; increased likelihood of crop failures.
Guyana	**PRE EVENT** **AGRICULTURE** 1) Promote changing use or activity in most vulnerable areas, if necessary. 2) Substitution of crops 3) Improvement in farm level management and productivity 4) Identify inland and interior areas for promotion of large scale agriculture. **Fisheries** 1) Promote aquaculture and large scale farming in inland and interior areas. 2) Continue to address policy directions on export markets, insurance, transfer of technology, introduction of new species of crops and fish (salt tolerant) into Guyana **Forestry**. 1) cleared forest (from mining/forestry activities) and parts of savannah regions to be utilized for human settlement/industry. Using the Impact and Vulnerability Assessment as a starting tool, continue to carry out detailed studies in the interior region on: 3) soil fertility, changes in temperature, rainfall, and other climatic variables, spatial shift in vegetation and species mix.

Haiti	**PRE EVENT** **AGRICULTURE** 1)Soil conservation techniques and practices 2) The use of new agricultural technology. 3) Development of educational programmes for farmers about the possibilities of climate change. 4) Development of crop varieties that are temperature resistant and more tolerant to changes to moisture content in the soil.
Jamaica	**PRE EVENT** **AGRICULTURE** 1) More efficient use of the water resources for agriculture. 2) Research on traditional crops to determine tolerance to climate change and to determine how to maintain productivity by manipulating certain factors within the environment and the crops themselves.
Saint Lucia	**PRE EVENT** **AGRICULTURE** 1) Introduction of salt-tolerant species 2) Hydroponics 3) Public awareness 4) Introduction of heat and drought-tolerant crops 5) Crop research 6) Use of greenhouses protection of forested areas 7) Farm relocation 8) Improved pest and disease management 9) Restoration of degraded lands 10) Agricultural diversification 11) Reduced livestock stocking rates **Forestry**. 1) Development and enforcement of land use policy 2) Legislation and regulations 3) Promotion of agro forestry 4) Preservation of watersheds including compulsory acquisition 5) Reforestation 6) Public awareness 7) Wetlands protection 8) Urban forestry **FISHERIES** 1) Resource and ecosystem monitoring 2) Public awareness 3) Strengthening environmental legislation 4) New fishing technologies 5) Efficient processing facilities 6) Regional and international cooperation 7) Development of a Fisheries Management Plan incorporating climate change

Suriname	**PRE EVENT** **AGRICULTURE** 1)Development of rice varieties for brackish water 2) Development of high yielding rice varieties 3) Introduction of farming techniques based on agro forestry principles. 4) Establishment of artificial lakes in the interior of the country for irrigation.

2. Health and the environment

Both Anguilla and Suriname have specific Health and the Environment adaptation policies. In Suriname, health policies are targeted at specific aspects of human health, while for Anguilla the policies are more general in nature. This is shown in table 18 below.

Table 18
Adaptation strategies for case study countries - Health and the Environment

Anguilla	**Suriname**
(1) Health Sector Plan	1)Disease prevention activities, control and surveillance programmes have to be put in place
(2) Evacuation of schools	2) Existing surveillance programmes will be increased to a higher level
(3) Annual Disaster Response Plan	3) Pertinent and permanent programmes will be put in place to effectively suppress malaria, dengue and yellow fever.
(4) Flood plan	
(5) Air accident and sea transport anticipation plans	
(6) Health Sector Plan	

3. Tourism

From table 19, it was observed that for several countries (such as Anguilla), the tourism sector was vulnerable to the effects of climate change, but no clear policy was identified for adaptation. However, for all others, adaptation policies included improvement of physical infrastructure and reallocation and protection measures to control flooding and coastal erosion. Greater research and education measures about disasters were also proposed.

Table 19
Adaptation strategies for case study countries – Tourism

Bahamas, the	1) Emphasis on eco-tourism 2) Improve design of sea wall, cause ways, bridges 3) Improve coastal infrastructure 4) Hazard mapping
Cayman Islands	1) External intervention 2) Include climate scientists in decision making e.g. coastal settlements 3) Longer term tourism planning; Public education/ raising awareness; engagement with the private sector 4) Putting regional pressure on the insurance industry to provide incentives for more sustainable building design.
Dominica	1) Establishment of a reliable quantitative database in support of widespread observations of the impacts of current climate variability 2) Conduct of research into appropriate traditional knowledge and skills 3) Creation of new, or revision of existing, hazard maps which will define the extent of impact prone areas.
Grenada	1) Higher costs for power and air conditioning services 2) Greater threats from tourists withdrawal due to diseases threats 3) Reduced coastal and quays attraction; greater expenditure for tourist advertising.
Saint Lucia	1)Relocation of structures 2)Strengthened development controls 3)Economic diversification 4)Hard and soft coastal engineering protection measures 5)Flood control

4. Fresh water, water resources, coral reefs and coastal zone resources

Pre-event adaptation strategies have been undertaken by the selected countries (see table 20) mainly for the water resources sector and the coastal zone sector. The Bahamas is the only country that has been identified to specify a strategy directed toward coral reefs. From the available information, Anguilla, Cayman Islands and Turks and Caicos Islands have no specified strategies of adaptation for these sectors. Most strategies involve proper management of water resources and the use of conservation practices. Sea level monitoring and sea wall construction are also main strategies employed for the coastal zone sector of countries such as Belize and Guyana.

Table 20: Adaptation strategies for case study countries – Freshwater, water resources, coral reefs and coastal zone resources

	Belize	Dominica	Guyana	Jamaica	Saint Lucia	Suriname
Coastal Zones/ Ecosystems	**Pre event:** 1) Establish setbacks for undeveloped coastal areas; 2) Construct and improve seawalls; 3) Beach nourishment; 4) Relocate vulnerable coastal Communities; 5)Monitor relative sea level rise and local wave climate	**Pre event:** 1)Use of traditional knowledge and skills 2) Shore protection measures; setback strategies; 3) Public education; environmental impact assessments.	1) Hard structural options 2) Dykes, levees and floodwalls 3) Seawalls, revetments and bulkheads 4) Detached breakwaters 5) Floodgates and tidal barriers 6) Saltwater intrusion barriers 7) Wetland restoration and creation	**Pre event:** 1) Advanced planning to avoid worst impacts. 2) Modification of building styles and codes. 3) Water sector policy 4) Flood forecasting and risk mapping, 5) Flood management control plan, Inclusion of hazard assessment in the development approval process, inclusion of hazard assessment in environmental impact assessments. **Post event:** (1) Construction of sea defences to protect the Palisadoes tombolo which links Norman Manley International Airport (NMIA) with the mainland via the Norman Manley Highway (NMH). Works include construction of stone revetments groynes, and replenishment of protective dunes. (1) Repairs to main roads, including rehabilitation of pavement, drainage works, river training and sea defences.(CDB)	**Pre Event:** 1) Relocation and retreat of structures and activities. 2) Restrictions on future development. 3) Sea-walls, levees Reinforcing existing structures e.g. docks. 4) Flood plain management plan. 5) Building codes. 6) Mangrove habitat protection and reforestation. 7) Raising coastal bridges and roads.	**Pre Event:** 1) Building dykes and dams to prevent further erosion of the coast, land loss and flooding consequently. 2) Retreat. 3) Integrated coastal zone management. 4)Breakwaters to build groynes, which are hard structures, used the wave energy reaching the coastline. The Suriname Red Cross, in collaboration with Inter-American Institute for Cooperation on Agriculture (IICA), conducted community risk reduction activities in the worst flood-affected villages during January through April 2009.

5. Human settlement, energy, transportation

Other sectors with adaptation polices include human settlements, energy and transportation., however, it should be noted that the policies are limited to only a few of the case study countries as identified in the table 21 below.

Table 21: Adaptation strategies for case study countries – Human settlement, energy and transportation

	Dominica	Saint Lucia	Belize	Guyana
Human Settlements	1) Relocation; 2) Effective Enforcement 3) Environmental Impact Assessments; 4) Physical Planning; 5) Use of Traditional Knowledge; 6) Education and Public Awarenes	1) Inland relocation. 2) Upgrading planning legislation (building codes, EIA etc). 3) Community based resource management. 4) Public awareness 5) Use of traditional knowledge. 6) Development of climate change database. 7) Hazard mapping.		
Transportation			1) Ban visible emission of fumes; Improve infrastructure; 2) Prioritize mass transport in urban areas; 3) Ensure access to public transportation.	

Table 22: Adaptation strategies for case study countries – Human settlement, energy and transportation

DATE\LOCATION OF WORKSHOP or REPORT	TITLE or THEME	ORGANISATION CONDUCTING WORKSHOP	PROPOSALS\RECOMMENDATIONS
5 to 7 October 2007 Skyway Hotel, Vieux Fort, Saint Lucia.	Enhancing the Role of Civil Society in Raising Awareness and Building Capacity for Adaptation to Climate Change Source: CANARI Publication: http://www.canari.org/docs/St%20Lucia%20climate%20change%20workshop.pdf	Caribbean Natural Resource Institute (CANARI) **Target Groups:** Schools, conscious artistes, government, civil society	i) Collaboration between organizations to promote message in schools. (e.g. Sandwatch and UNESCO) ii) Artistes Weathering Climate Change: using 'conscious' artistes as the medium to convey messages about climate change and adaptation. iii) Continuation of constructive workshops throughout the region to bring government focal points and key civil society organizations at the national level to discuss adaptation strategies. iv) Youth debates and/or Parliaments
12 to 14 October 2007 Monterrey, Mexico.	Latin America and the Caribbean Regional Statement to the Ninth Global Civil Society Forum and the Tenth Special Session of the Governing Council/Global Ministerial Environment Forum SOURCE: UNEP: http://www.unep.org/Civil_Society/GCSF9/pdfs/ROLACstatement.pdf	UNEP **Target Groups:** International community, the environmental and socioeconomic sectors, government	i) Importance for the international community responsibility with regards to climate change, so those generating the most GHG's will change their production and consumption patterns, assess compensatory measures and facilitate mechanisms to favor the prevention, mitigation and adaptation to the impacts of those most vulnerable. ii) Essentially generate and strengthen alliances among the environmental and socioeconomic sectors in the framework of the National Strategies for Sustainable Development in order to implement climate change prevention, mitigation and adaptation policies and projects. iii) The need to introduce and implement political, economic, institutional, and legal reforms that will translate into improvements in energy efficiency and the development of alternative energies. iv) Addressing the problem barriers that prevent this theme, will generate benefits that are not only environmental, but also economic and social, in terms of job creation, improved

			balance of payments and incentives for local industry and communities. v) Recognizing that climate change can be addressed not only in the framework of an environmental proposal but also from the perspective of development. Consequently, we declare it necessary to identify and make use of mechanisms that are alternatives to environmental compensations to finance projects to address climate change
Date not available	CANARI Proposed National Follow-up Activities by country: SOURCE: CANARI: http://www.canari.org/Annex%2025%20Proposed%20national%20followup%20activities.doc Raise awareness of climate change and its impacts.	Anguilla Anguilla National Trust **Target groups**: Government, civil society, schools, the media, Anguilla Tourist Board	Stimulated discussion, community projects on mitigation. Introduce climate change as a subject for discussion in school debates. National dialogue on and review of climate change policy. Introduce climate change issues for expression in schools and drama programmes.
	Integrate information on Global Climate Change and its impacts into school curricula.	Bahamas **Target Groups**: Friends of the Environment, National Conservation Organizations	Use the existing system of Environmental Clubs to develop and disseminate messages (80% of schools have clubs). High-school song competition. Arrange for discussions on climate change to be carried on the Delvoy radio program.
	Environment Teachers forum and media information workshop	Dominica **Target Groups :** Environnemental Clubs, High schools	Use the existing system of Environmental Clubs to develop and disseminate messages (80% of schools have clubs). High-school song competition. Arrange for discussions on climate change to be carried on the Delvoy radio program.
	Training session for media on climate change	Grenada **Target Groups** : NGOs, CBOs, GRENCODA	Hold a training session to awareness among media practitioners f the phenomenon of global climate change and the threats that it poses to Grenadian communities. Linda (freelance media representative) and Dale (GRENCODA) will work together to initiate these plans.
	Develop a climate change information package that provides the media with	Guyana **Target Groups:** NGOs, Media, Artists, WWF,	Practitioners in the electronic media are less responsive and need to be mobilized. A

	accurate and culturally relevant information on global climate change	EPA	comprehensive climate change information package would probably be more effective in developing awareness and initiating engagement.
	A two-day forum for civil society is already planned for November 2009	Jamaica **Target Groups:** NEEC, EFJ, CF	The activities of this Workshop are ongoing.
11 to 16 July 2005 Bequia, Saint Vincent and the Grenadines.	Report on Mauritius Strategy Implementation: Small Islands Voice Planning Meeting. SOURCE:http://www.unesco.org/csi/smis/siv/interreg/SIVplanmeet-svg3.htm	Small Islands Voice (SIV) Target Groups: Schools, communities,	Sandwatch activities that include expansion of Sandwatch to other schools and communities. ii) Expansion of Sandwatch to more Family Islands. iii) Expansion of the SIV Youth Internet Forum to primary schools. iv) SIV Global Forum with emphasis on expanding SIV Youth Forum to primary schools.

CONCLUSION AND POLICY RECOMMENDATIONS

Caribbean economies, by virtue of their geography, resource constraints and limited adaptive capacity, are vulnerable to the impacts of natural hazards, especially hydro-meteorological events such as tropical storms, hurricanes and heavy rainfall.

The extensive damage to infrastructure during disasters points to limited resilience in a number of countries. Infrastructure is a major catalyst for economic development. Its damage is a major setback in the development process. The literature suggests that infrastructure (defined to include the sectors of transport, water and sanitation, power, telecommunications and irrigation) has the capacity to impact on economic development in two main ways: (a) infrastructure contributes to economic growth via, for example, infrastructure developments (such as improved sewerage treatment plants) that can improve the health profile of a community or country. The efficient production and financing of infrastructure services can also reduce wasteful consumption of water and contribute to the protection of natural resources; (b) infrastructure can raise the quality of life of a community or country. Kessides (1993) cites as an example, the creation of amenities in the physical environment such as cleaner water, land and air.

Although sometimes ignored, the social costs of disasters in terms of their impact on housing and human settlement, health and education systems and the livelihoods of the most vulnerable groups are quite significant. Disaster management and mitigation plans must include clear actions to reduce fall-out in the social sectors through sustainable livelihood approaches that seek to build up livelihood assets and capital that could lessen the impact of disasters on the society.

As expected, vulnerability to natural disasters varies across countries in the Caribbean, depending on frequency of impacts and resilience capacities. Haiti stands out as the country with the greatest social vulnerability to natural disasters. This is useful information from a policy perspective in terms of any comprehensive disaster risk management policy, that may be considered for the Caribbean subregion but, particularly, for that country. Indeed, the recent catastrophic earthquake in Haiti points to the manifest need for a comprehensive reconstruction and disaster mitigation and management strategy that is focused on reducing risk and building back much better than before the event. Moreover, environmental vulnerability in Haiti also stood out as alarming and is underscored by the perennial and sometimes catastrophic flooding experienced by that country.

In addition, the tourism-dependent economies, including Antigua, the Bahamas and Cayman Islands, are prone to disruption of activity in the sector and employment due to windstorm events. The vulnerability of these countries is compounded by the damage to fragile coastal ecosystems that are important to the overall quality of the tourism product. In order to reduce the socio-economic and environmental impacts of these hazards, these economies will need to abide by improved building codes, including proper setback limits from the coastline, the care and management of the coastal environment, and the use of proper catastrophic risk insurance to ensure the speedy resumption of business after a disaster.

The following policy recommendations are proposed to assist the Caribbean subregion in designing a more effective and proactive response to the socio-economic and environmental impact of climate change and extreme events.

(1) Investment in more detailed hurricane/climate change impact projections at the national and subregional levels

Efforts to project likely implications of climate change in terms of hurricanes in the Caribbean are constrained by the fact that existing models are at a larger scale. The PRECIS model provides some partial solution, but itself requires further elaboration in order to be able to make more categorical projections. The proposal therefore is for Caribbean countries, with international support as available and required, seek to remedy this basic constraint to climate change adaptation strategies.

(2) More detailed studies on natural environmental impacts specifically in terms of bio-physical and socio-economic impacts

Post facto assessments of the impact of natural disasters are relatively easy, in the case of roads and other infrastructure and productive assets, in terms of loss of income, employment and foreign exchange earnings. This is less obvious in the instances where natural capital is negatively impacted, except in instances where there is a significant evidence of impact on market derived ecosystem goods or services. As a result, there is likely to be a tendency to under-value negative environmental impacts. As one example, a hurricane some years ago led to major reef fishing grounds in Belize becoming covered by sand. Fishermen complained about loss of livelihood, but this was not easily documented. The proposal therefore is for specific studies which enhance the capacity to have ex ante valuation of key natural assets across Caribbean countries to facilitate detailed post disaster evaluation studies .

(3) Review of best practices to date in terms of preparedness, resilience building and climate change adaptation e.g. Cuba

Differing Caribbean countries have shown relatively greater or lesser capacity to prepare for and build resilience against natural disasters and the related issue of adaptation to climate change. There is therefore room for sharing of best practices across the Caribbean including involvement of civil society organizations. In fact, given the geographic scale of the Caribbean subregion, there may be an opportunity to treat the issue of climate change adaptation and disaster risk reduction as a Caribbean public good – where the benefits that accrue to one country redound to the benefit of the entire subregion.

(4) Further analysis of development planning in the context of growing climate change uncertainty

There is a distinction made in the literature between disasters as a ‘problem for development’ or disasters as a ‘problem of development’. The proposal here is that the latter interpretation be embraced and now mainstreamed into overall development planning. One suggested dimension would be to look for multidividend returns from priority investments which simultaneously seek to address current socio-economic and environmental concerns while adding to resilience, preparedness and adaptation.

(5) Construction and other related standards to be specifically based on resilience to natural disasters and adaptation climate change

CARICOM has long ago agreed on introducing the CUBIC, Caribbean Unified Building Code.[35] However, perhaps perversely, CUBIC is being honoured more in the breach. One way to

[35] In 1985 CARICOM Governments agreed to standardize building codes to strengthen the resistance of homes, commercial buildings and factories to hurricanes, earthquakes and other natural hazards. The Council of Caribbean Engineering Organisations (CEEO) subsequently developed this standardized building code, the Caribbean Uniform Building Code, CUBIC. The Code is a set of technical standards which should be used by all building professionals, builders and Government regulators to ensure that buildings constructed will be

assist the process would be to link compliance with CUBIC (or some similar code) to insurance and tax incentives. An example of such a private sector -led initiative is to be found in Antigua where the United Insurance Company has provided financial incentives (catastrophe insurance discounts) to its customers (residential and commercial) if these customers comply with, inter alia, some of the risk reduction measures identified in CUBIC.

(6) Public and professional education and participation by civil society organizations in preparedness and resilience building.

At the end of the day, public awareness and education is critical in times of actual response to the occurrence of natural disasters. An early warning system that expects public response to a 24- or 48-hour warning is unlikely to be effective in reducing disaster risk. The public cannot be prepared in 24 or 48 hours for an event they have spent their lives not thinking about. Therefore, there is need to introduce public and professional awareness from as early on as in the school system.

In summary, the analysis of the Caribbean countries reinforces the view that natural disasters are a substantial challenge to development. Repeated natural hazards highlight the vulnerability of fragile ecosystems and inadequate provision for resilience in the built environment. Nevertheless, disasters often present the opportunity to build back much better and to include structured programmes for building long-term resilience, such as building codes, relocation of vulnerable communities and abiding by proper setback limits in constructions close to the coast.

Moreover, major change is often more politically feasible after a disaster, as citizens acknowledge that without significant change, similar impacts can be repeated in the future. The challenge for the Caribbean in the past has been how to invert the challenges to realize such opportunities. However, in the face of mounting evidence of the impact of climate change and the rising frequency of catastrophic events, the time for the Caribbean to act, to safeguard development progress so far and to build a platform for the future, is now.

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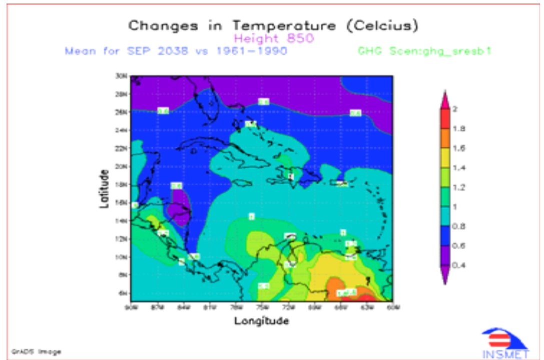
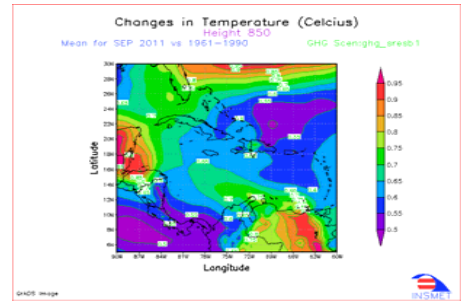
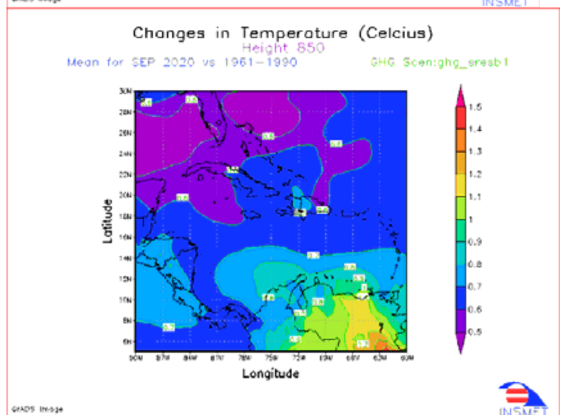
resistant to the natural hazards of high winds, heavy rainfall, earthquakes and the environmental pressures of the Caribbean. The Code was produced in eleven volumes, in which each volume treats with a separate aspect of natural hazard management – for example, Wind or Earthquake Loads. The Code was produced in this format to facilitate purchase by building professionals of any specific or all of the volumes, depending on the needs if the building professional. The main objective of CUBIC is to provide technical guidelines for all new construction and for the upgrading of existing construction, which can be used or referred to by CARICOM countries without the need for further research into the nature and use of the building materials and construction methods. One advantage of conforming to the guidelines set out in CUBIC is that the cost of repairs to buildings which have been built according to CUBIC guidelines but which may have suffered from the effect of high winds, is much lower.

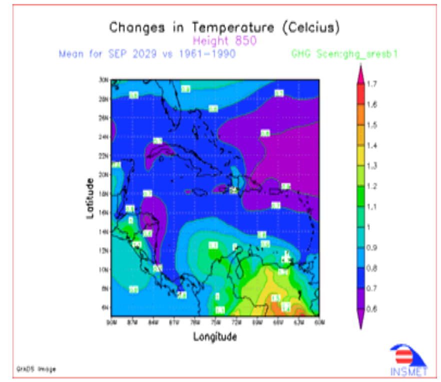
MAPS

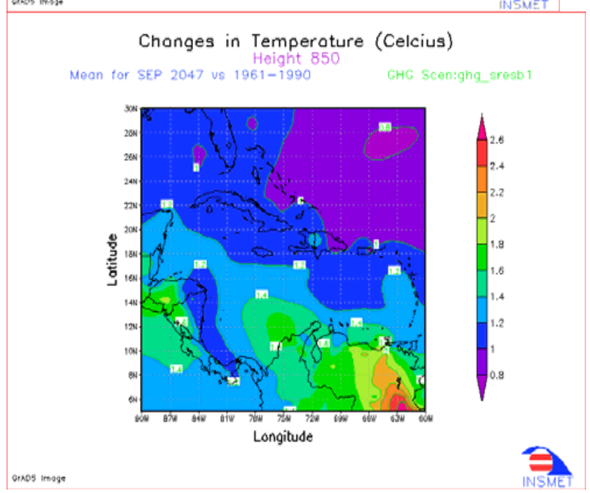
Projected changes in temperature in the Caribbean for various years (September) under B1 Scenario: Low Emissions)







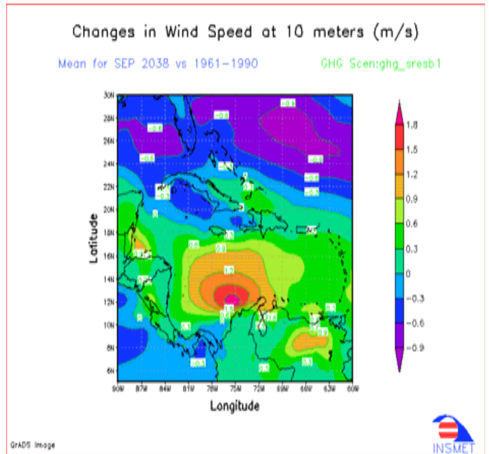


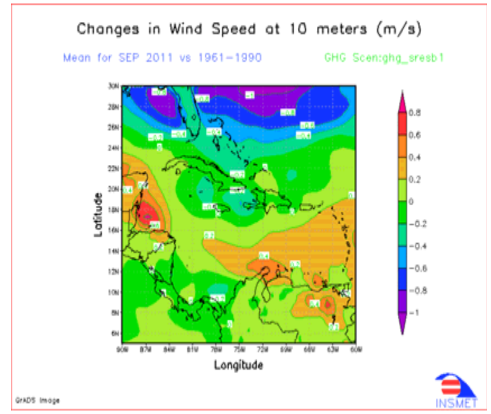


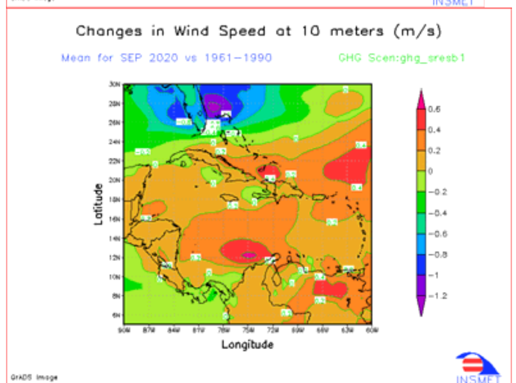
Maps show the mean temperature for September of various years (projected) as compared to the mean temperature between 1961 and 1990.
Observations: Increased temperature variations are more significant closer to larger land masses eg Florida and South America. All maps show a projection of increased temperatures as compared to 1961-1990, this means that from 2011 (map a) onwards, temperatures are projected to generally increase.

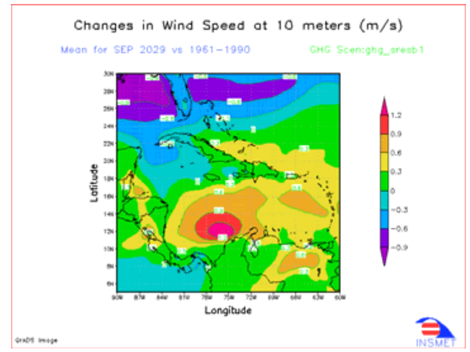
Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

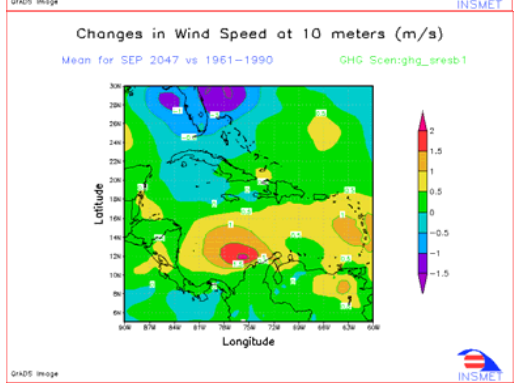
B1 Scenario: Low Emissions)







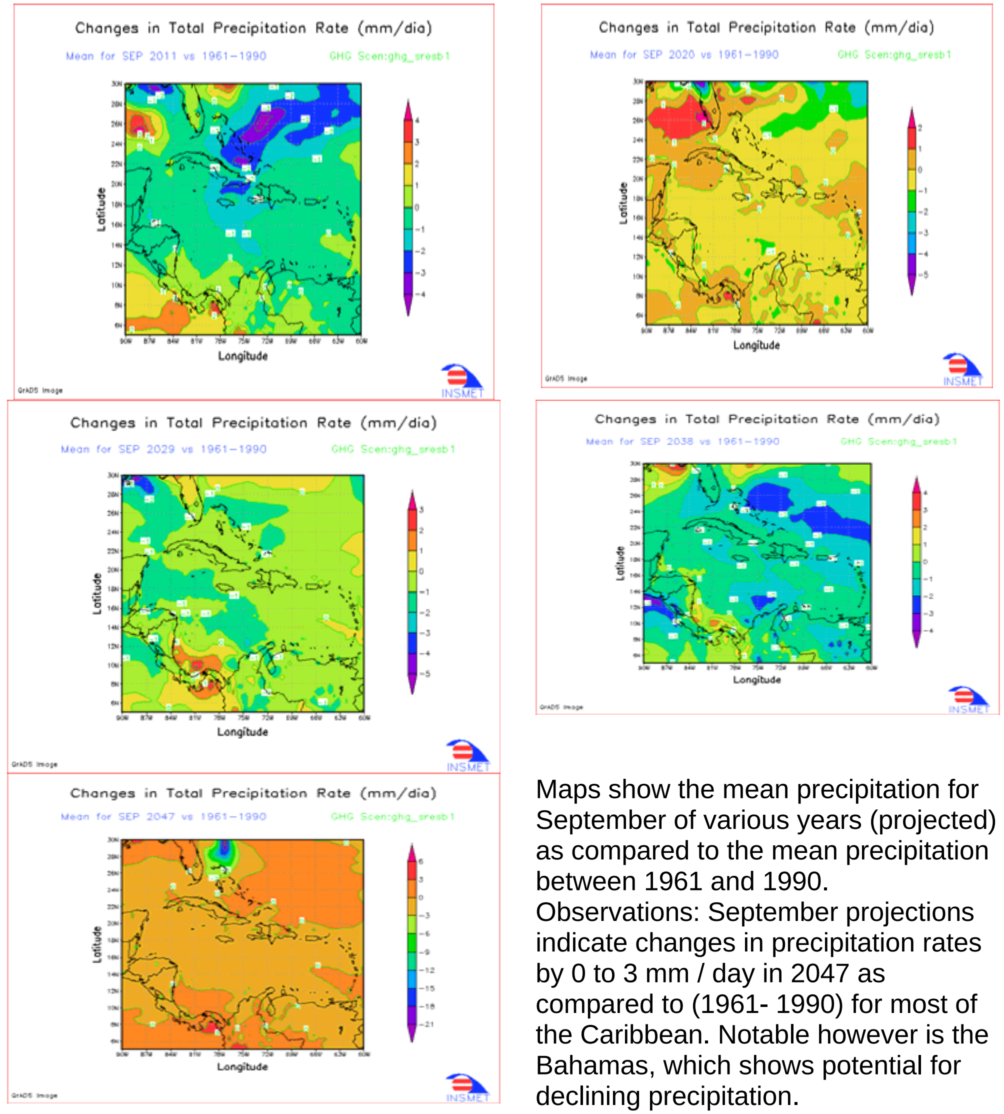




Maps show the mean Wind Speed for September of various years (projected) as compared to the mean Wind Speed between 1961 and 1990.
Observations: The projected maps show that wind speed will increase as changes are mainly positive.

Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

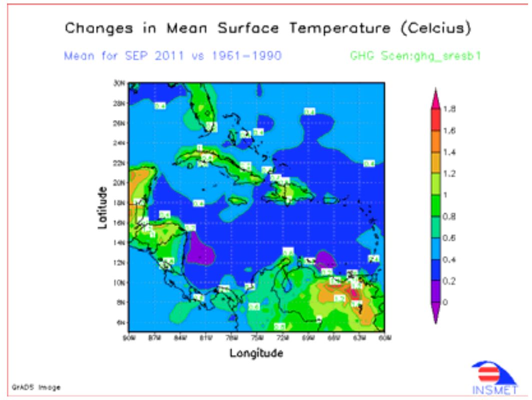
Caribbean for various years (September, under B1 Scenario: Low Emissions)

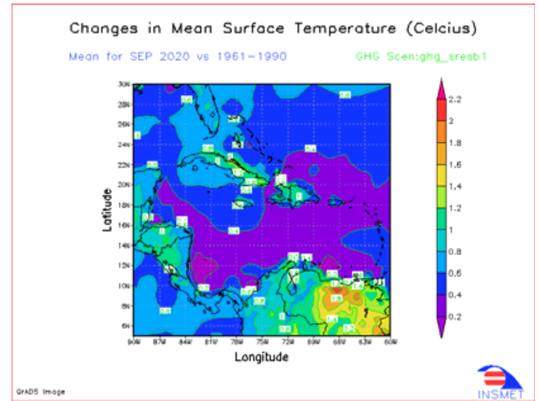


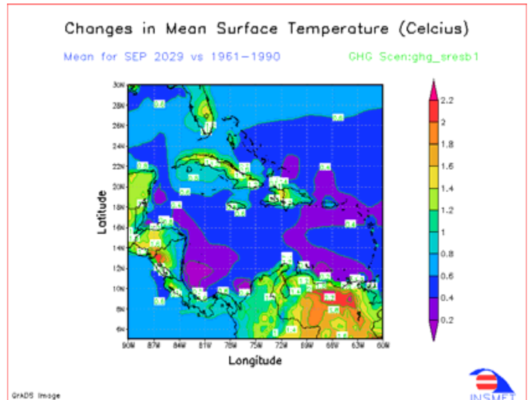
Maps show the mean precipitation for September of various years (projected) as compared to the mean precipitation between 1961 and 1990.
Observations: September projections indicate changes in precipitation rates by 0 to 3 mm / day in 2047 as compared to (1961- 1990) for most of the Caribbean. Notable however is the Bahamas, which shows potential for declining precipitation.

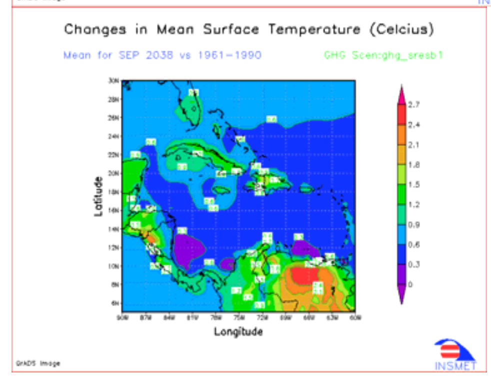
Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

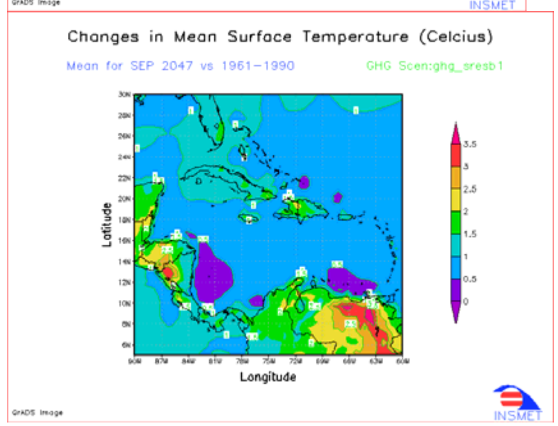
(September, under B1 Scenario: Low Emissions).







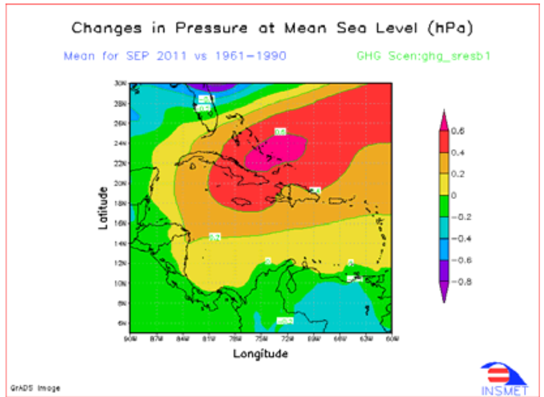


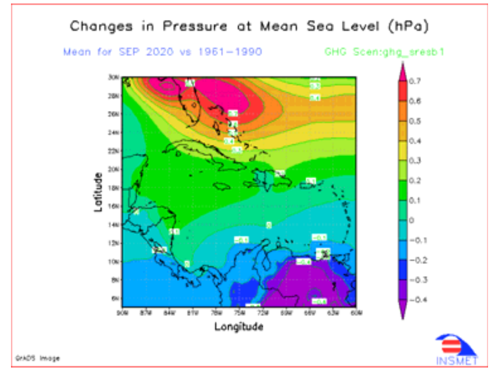


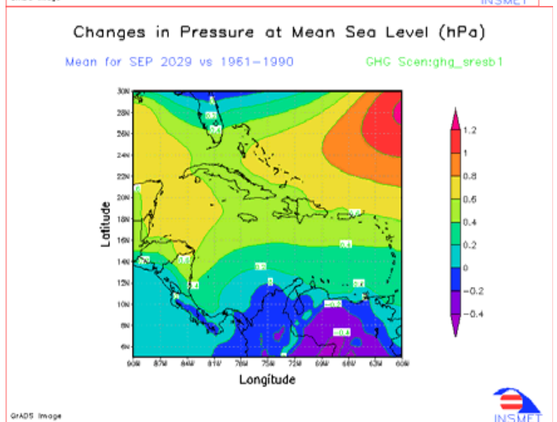
Maps show the mean surface temperature for September of various years (projected) as compared to the mean surface temperature between 1961 and 1990. Observations: Surface temperature has great significance when considered over the sea (sea surface temperature). The SST from the maps show a gradual increase in surface temperatures mainly from a variation of 0.4 degrees in 2011, to mainly 0.6 degrees in 2029 and then by 1.0 to 1.5 degrees by 2047.

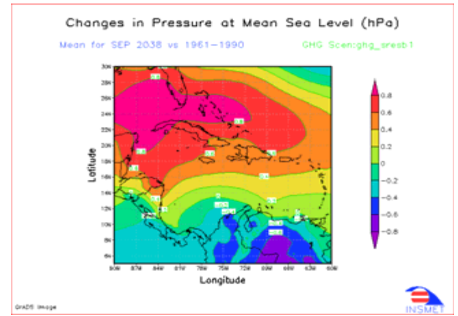
Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

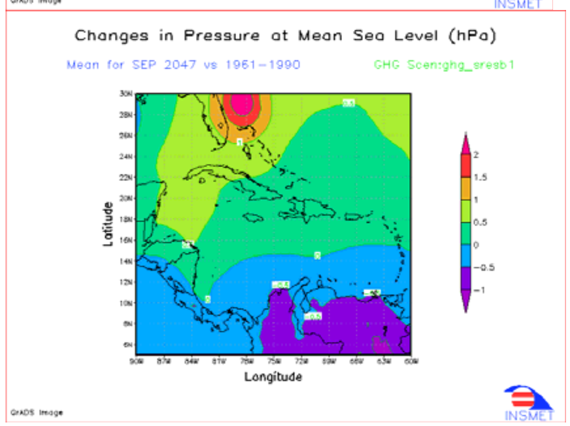
(September, under B1 Scenario: Low Emissions).











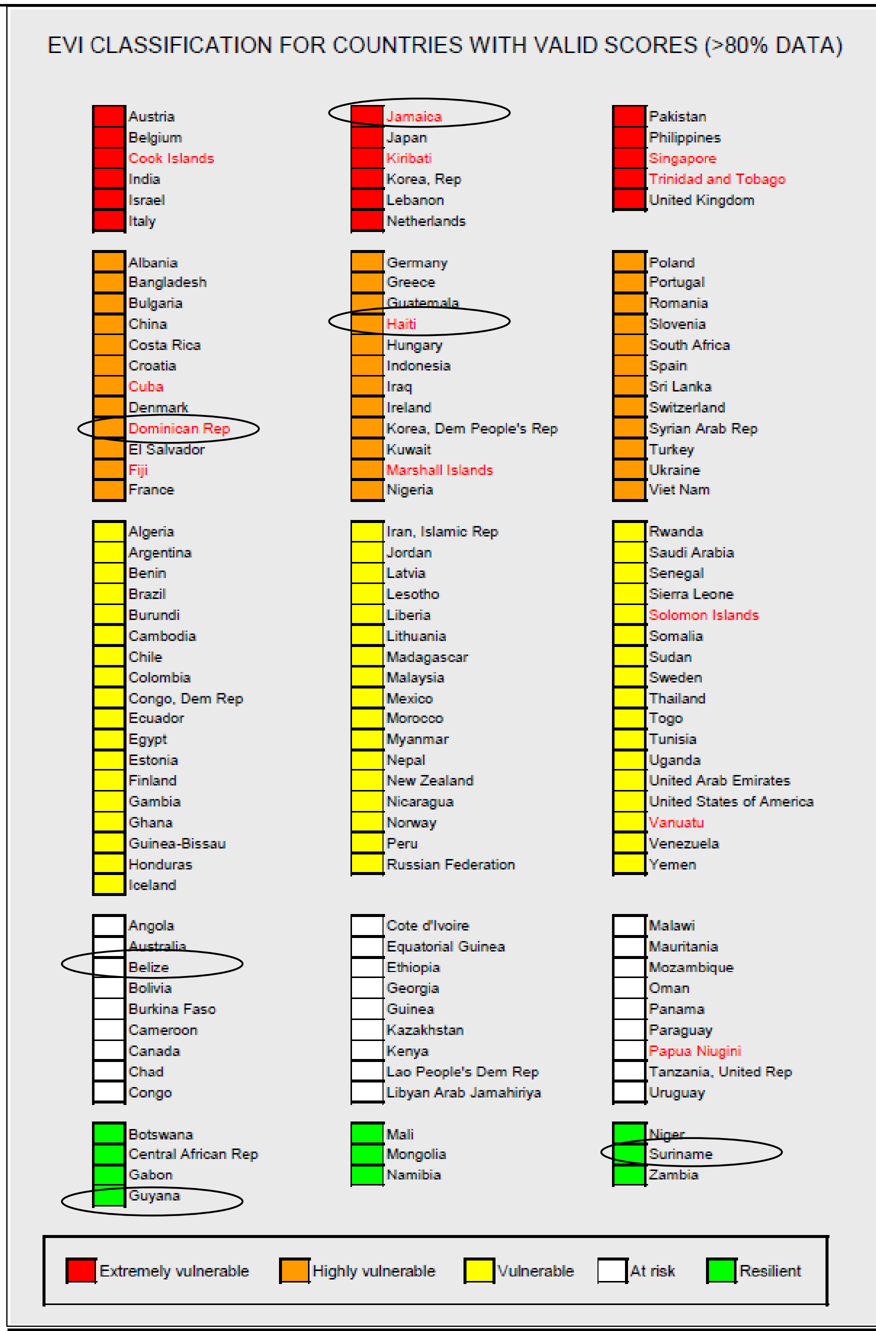
Maps show the mean sea level pressure for September of various years (projected) as compared to the mean sea level pressure between 1961 and 1990.
Observations: Mean sea level pressure is projected to increase by greater and greater amounts during the selected years.

Source: Generated by author using PRECIS-Caribe tool: http://precis.insmet.cu/eng/datos.html

Annex 2(A)

EVI CLASSIFICATION OF COUNTRIES RE: VULNERABILITY

Red countries are **SIDS**; the classifications are: Extremely Vulnerable (EVI of 365+); Highly Vulnerable (315-365); Vulnerable (265-315); At Risk (215-265) and Resilient (<215).

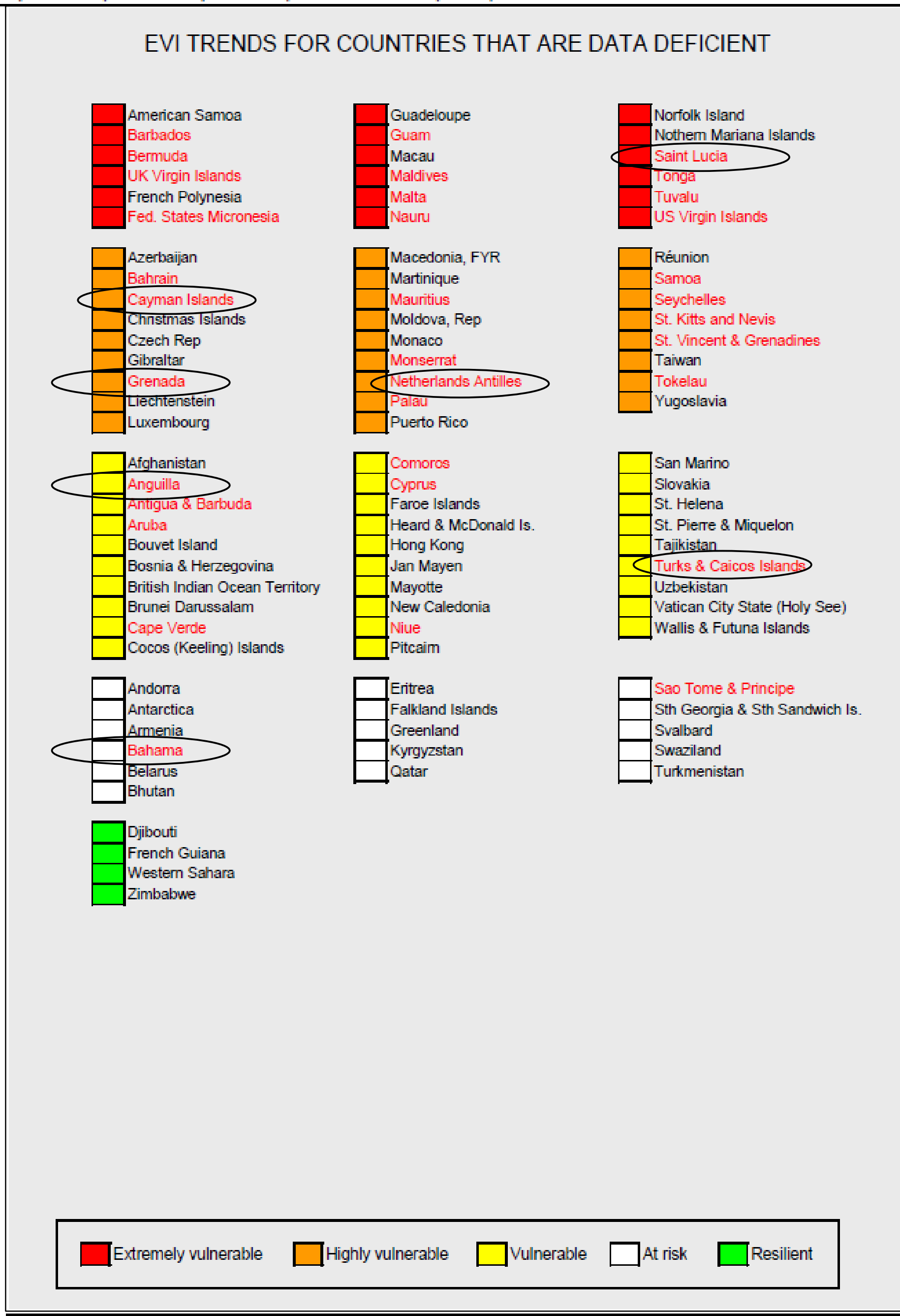


Source: EVI Technical Report (2004)

Annex 2(B)

EVI CLASSIFICATION OF COUNTRIES RE: VULNERABILITY

Red countries are **SIDS**; the classifications are: Extremely Vulnerable (EVI of 365+); Highly Vulnerable (315-365); Vulnerable (265-315); At Risk (215-265) and Resilient (<215).



Source: Pratt and others (2004)

Annex 3
EVI CATEGORIZATION OF INDICATOR

INDICATORS	TYPES	ASPECTS	SUB-INDICES						
1 Wind	W&C	Hazards	CC	D				CCD	
2 Dry	W&C	Hazards	CC	D		AF	W	CCD	
3 Wet	W&C	Hazards	CC	D		AF	W	CCD	
4 Hot	W&C	Hazards	CC	D				CCD	
5 Cold	W&C	Hazards		D				CCD	
6 SST	W&C	Hazards	CC			AF			CBD
7 Volcano	G	Hazards		D					
8 Earthquake	G	Hazards		D					
9 Tsunami	G	Hazards		D					
10 Slides	G	Hazards		D					
11 Land	Gph	Resistance	CC						CBD
12 Dispersion	Gph	Resistance	CC						CBD
13 Isolation	Gph	Resistance							CBD
14 Relief	Gph	Resistance	CC					CCD	CBD
15 Lowlands	Gph	Resistance	CC					CCD	CBD
16 Borders	Gph	Resistance							CBD
17 Imbalance	R&S	Damage				AF			CBD
18 Openness	R&S	Hazards				AF			CBD
19 Migratory	R&S	Resistance				AF			CBD
20 Endemics	R&S	Resistance							CBD
21 Introductions	R&S	Damage				AF			CBD
22 Endangered	R&S	Damage							CBD
23 Extinctions	R&S	Damage							CBD
24 Vegetation	R&S	Damage	CC			AF	W	CCD	CBD
25 Loss Veg	R&S	Hazards				AF	W	CCD	CBD
26 Fragmentation	R&S	Damage				AF			CBD
27 Degradation	R&S	Damage				AF	W	CCD	
28 Reserves	R&S	Hazards					W		CBD
29 MPAs	R&S	Hazards				AF			CBD
30 Farming	R&S	Hazards				AF			
31 Fertilisers	R&S	Hazards			HH	AF	W		
32 Pesticides	R&S	Hazards			HH	AF	W		
33 Biotech	R&S	Hazards				AF			
34 Productivity overfishing	R&S	Hazards				AF			
35 Fishing Effort	R&S	Hazards				AF			
36 Water	R&S	Hazards	CC		HH	AF	W	CCD	
37 SO2	R&S	Hazards			HH				
38 Waste	R&S	Hazards							
39 Treatment	R&S	Hazards			HH		W		
40 Industry	R&S	Hazards							
41 Spills	R&S	Hazards							
42 Mining	R&S	Hazards							
43 Sanitation	R&S	Hazards			HH		W		
44 Vehicles	R&S	Hazards							
45 Density	H	Damage	CC	D			W		
46 Growth	H	Hazards					W		
47 Tourists	H	Hazards							
48 Coastal	H	Damage	CC	D					
49 Agreements	H	Hazards							
50 Conflicts	H	Damage							

Indicator number and short name is shown with general types, aspects of vulnerability and sub-index to which each indicator is included. **General Types**: W&C=Weather & Climate; G=Geological; Gph=Geographical; R&S=Resources & ecosystem services; H=Human populations. **Aspects of vulnerability**: Hazards, Resistance and Damage. **Sub-indices**: CC=Climate Change; D=Exposure to natural disasters; HH=Human health aspects; AF=Agriculture & Fisheries; W=water; CCD=Desertification; CBD=Biodiversity.

Source: Pratt and others (2004)

Annex 4

ADAPTATION STRATEGIES AND COST OF FUNDING

Country	Disaster prevention project	Adaptation strategy by priority sector	Status of proposed action		Cost of funding for adaptation (Funding agency) Constant 2008 US$
			Pre-event	**Post-event**	
Anguilla	Comprehensive Disaster Management Strategy (CDMS)	**HEALTH**	Evacuation of schools; Annual Disaster Response Plan; Health Sector Plan; Flood plan; Air accident and sea transport anticipation plans.	Identify areas that require long term priority action.	Received **US$14,939** for Humanitarian assistance (Canada)
		ENVIRONMENT			
Bahamas, the	Caribbean: Planning for Adaptation to Climate Change (CPACC)	**TOURISM**	Emphasis on eco-tourism; improve design of sea wall, cause ways, bridges; improve coastal infrastructure; hazard mapping.		Prepare its First National Communication in the amount of **US$276,825 (**UNDP) Additional Financing for Capacity Building in Priority Areas in the amount of **US$142,670** (UNDP) Promoting Sustainable Energy in the Bahamas Grant in the amount of **US$1,493,930** (IADB)
		WATER RESOURCES	Monitoring of competing use of resources e.g. non-registered private wells public education on water conservation; use of reverse osmosis in desalination processes; sewerage schemes.		
		CORAL REEFS	Establish additional sea level monitoring stations.		
		AGRICULTURE	Develop agricultural production systems adapted soil salinization, atmospheric CO_2 enrichment, increased temperatures.	Assess vulnerability to soil salinization, loss of agricultural lands due to year-round and seasonal high water tables, salt water	

Country	Disaster prevention project	Adaptation strategy by priority sector	Status of proposed action		Cost of funding for adaptation (Funding agency) Constant 2008 US$
			Pre-event	**Post-event**	
Anguilla	Comprehensive Disaster Management Strategy (CDMS)	**HEALTH**	Evacuation of schools; Annual Disaster Response Plan; Health Sector Plan; Flood plan; Air accident and sea transport anticipation plans.	Identify areas that require long term priority action.	Received **US$14,939** for Humanitarian assistance (Canada)
		ENVIRONMENT			
				flooding.	
Belize		**COASTAL ZONES**	Establish setbacks for undeveloped coastal areas; construct and improve seawalls; beach nourishment; relocate vulnerable coastal communities; monitor relative sea level rise and local wave climate		Funding for preparation of its Initial National Communication in Response to its Commitments to UNFCCC in the amount of **US$215,847** (UNDP) Bridge Rehabilitation in the amount of **US$10.2mn** (CDB) Immediate Response Loan for Tropical Storm Arthur in the amount of **US$603,777** (CDB)
		AGRICULTURE	Accelerate diversification in production and exports; relocate agricultural activity away from the coastal zone; Introduce changes to the traditional planting and sowing dates; Introduce new varieties or species; reduce tillage.	Increase food production, strengthen intersectoral linkages; increase the competitiveness of the agricultural sector.	
		WATER RESOURCES	Develop a national water management system; Promote effective and efficient use of water; Develop local		

Country	Disaster prevention project	Adaptation strategy by priority sector	Status of proposed action		Cost of funding for adaptation (Funding agency) Constant 2008 US$
			Pre-event	**Post-event**	
Anguilla	Comprehensive Disaster Management Strategy (CDMS)	**HEALTH**	Evacuation of schools; Annual Disaster Response Plan; Health Sector Plan; Flood plan; Air accident and sea transport anticipation plans.	Identify areas that require long term priority action.	Received **US$14,939** for Humanitarian assistance (Canada)
		ENVIRONMENT			
			management and technical expertise; Relocate waste disposal sites above influence of sea level rise; Adopt agricultural practices based on availability of water.		
		LAND USE	Develop a comprehensive land use policy; Introduce forest management plans; Promote agro forestry; Restore abandoned agricultural lands; establish tree plantations; develop national forest fire management plan.		
		BIODIVERSITY	Adopt National Protected Areas System Plan (NPASP) officially; establish and consolidate four proposed national biological corridors into the Mesoamerican Biological Corridors Project; establish and maintain protected areas; Actively manage wild populations outside protected		

Country	Disaster prevention project	Adaptation strategy by priority sector	Status of proposed action		Cost of funding for adaptation (Funding agency) Constant 2008 US$
			Pre-event	Post-event	
Anguilla	Comprehensive Disaster Management Strategy (CDMS)	**HEALTH** **ENVIRONMENT**	Evacuation of schools; Annual Disaster Response Plan; Health Sector Plan; Flood plan; Air accident and sea transport anticipation plans.	Identify areas that require long term priority action.	Received **US$14,939** for Humanitarian assistance (Canada)
			areas.		
		ENERGY	Develop a comprehensive national energy policy incorporating climate change; establish a multidisciplinary energy committee; identify potential indigenous sources of energy; relocate power plants, substations and distribution lines above low lying coastal zones; switch electrical distribution system from above ground to below ground.		
		TRANSPORTATION	Ban visible emission of fumes; improve infrastructure; prioritize mass transport in urban areas; ensure access to public transportation.		

		WASTE MANAGEMENT	Implement methane recovery at landfill; expand sewage system in Belize City; expand sewer treatment lagoons for Belize City; encourage residents to connect to sewer system in Belize City and San Pedro; create economic and commercial activities away from coastal areas.		
Cayman Islands		**TOURISM** **INTERNATIONAL FINANCE**	External intervention; include climate scientists in decision making; Longer term planning; public education/ raising awareness; political consensus; engagement with the private sector; putting regional pressure on the insurance industry to provide incentives for more sustainable building design.	Education and communication to all; environmental governance; regional cooperation; sound science in environmental monitoring	
Dominica		**FORESTRY AND TERRESTRIAL RESOURCES**	Development and implementation of a land use policy; Strengthen legislation and regulations governing forest management on government and private property; find creative fiscal measures to encourage private lands to remain under forest cover; reforestation of critical watershe Protecting wetland ecosystems.		Implementation of pilot adaptation measures in Coastal Areas in the amount of **US$ 4,313,694** (World Bank) Rehabilitation of Sea Defences for Hurricane Omar in the amount of **US$ 18.8 million** (CDB) National Disaster Management for Hurricane Omar in the amount of **US$ 1,027,070 (**CDB)

		COASTAL ECOSYSTEMS	Use of Traditional Knowledge and Skills; shore protection measures; setback strategies; public education; environmental impact assessments.		
		FRESHWATER RESOURCES	Refurbishment of DOWASCO Fa Revision of the pricing mechanism; restoration and rehabilitation of watersheds, riverbanks and wetlands; establishment of a National Water Commission; integrate watershed conservation into national planning and decision-making.		
		HUMAN SETTLEMENT	Relocation; setbacks; effective enforcement; environmental impact assessments; physical planning; use of traditional knowledge; education and public awareness.		
		AGRICULTURE	Enforce legislation and policy on land use; food security and health; large scale watershed man projects; education / public awareness; on-farm water storage capabilities.		

		FISHERIES	Encouragement of use of fishing boats able to target offshore fisheries; enforcement of fishing controls within the national exclusive economic zone; raising the level of coastal structures (docks and piers); fisheries plan.		
		TOURISM	Establishment of a reliable quantitative database in support of widespread observations of the impacts of current climate variability; conduct of research into appropriate traditional knowledge and skills; creation of new, or revision of existing, hazard maps which will define the extent of impact prone areas.		
Dominican Republic		**WATER**			Research in Solar Energy for Electricity in the amount of **US$5,048,426** (IDB)
		COASTAL MARINE			
		AGRICULTURE			
		HEALTH			
Grenada	National Disaster Management Strategy of Grenada (NDMSOG)	**WATER RESOURCES**	Reduced available domestic water supplies - surface water and ground Water; Reduced water quality through salt water intrusion, and/or increased cost of purification; Increased cost of water.		Funding for preparation of its Initial National Communication in response to its commitments to UNFCCC in the amount of **US$ 374,372** (UNDP) Additional financing for Capacity Building in Priority Areas in the amount of **US$ 203,055**
		AGRICULTURE AND	Greater demand for irrigation;		

		FISHERIES	reduced available arable lands Decreasing crop yields; reduced livestock productivity particularly chicken; increased likelihood of crop failures.		(UNDP) Disaster Mitigation and Restoration Grenada in the amount of **US$ 7,513,035** (CDB) Hurricane Reconstitution in the amount of **US$ 22.3million** (CDB)
		COASTAL ZONES	Beach erosion; lowland inundation; inundation of Sandy islands and Keyes; Reduced fish stock.		
		TOURISM	Higher costs for power and air conditioning services; Greater threats from tourist withdrawal due to disease threats; reduced coastal and Keyes attraction; greater expenditure for tourism advertising.		
		HUMAN HEALTH	Increased incidence of water related diseases, malaria, dengue; increased malnutrition among lower income group due to less available local foods; increased per capita cost of health services.		
Guyana	(i) More accurate flood risk information that incorporates the effects of climate and sea level rise; (ii) improved public education on disaster risk and its reduction; and (iii) an updating of the national disaster risk management system to more effectively	**COASTAL ZONE**	1) hard structural options 2)dikes, levees and floodwalls 3)seawalls, revetment and bulkheads 4)detached breakwaters 5)floodgates and tidal barriers 6)saltwater intrusion barriers 7)wetland restoration and creation		The Inter-American Development Bank (IDB) approved **a US$1 million** dollar grant to support the design and implementation of an integrated disaster risk management plan for Guyana.

	implement integrated disaster risk management. The overall objective of the programme is to design and implement an Integrated Disaster Risk Management Plan, within the framework of Comprehensive Disaster Management. The specific objectives are to: (i) evaluate climate-related disaster risk; (ii) strengthen national and local capacity for IDRM; and (iii) support the Future implementation of the IDRM plan through the design of an investment programme in flood prevention and mitigation	**AGRICULTURE AND FISHERIES**	**Agriculture** 1) Promote changing use or activity in most vulnerable areas, if necessary. 2) Substitution of crops 3) Improvement in farm level management and productivity 4) Identify inland and interior areas for promotion of large scale agriculture. **Fisheries** 1) Promote aquaculture and large scale farming in inland and interior areas. 2) Continue to address policy directions on export markets, insurance, transfer of technologies, introduction of new species of crops and fishes (salt tolerant etc) into Guyana		GEF Projects Integrated and Sustainable Management of Trans-boundary Water Resources. (World Bank) Project grant approved **US$2,000,000**
		WATER RESOURCES	Short term options. 1) water conservation (metering, time-runs, etc) 2) implement monitoring and inventory of water availability while continuing the development of new artesian wells. Long term options. Domestic/Industry 1) stricter water conservation techniques and management 2) rainwater collection 3) development of inland and interior conservancies		

			Agriculture and Fisheries 1) stricter control and management of supply network 2) drainage re-use 3) artificial recharge of reservoirs from nearby rivers etc. 4) removing sediments and weeds from reservoirs for more storage capacity 5) low water use crops 6) high value per water use crops 7) salt-tolerant crops and fish species 8) relocation of fishing ponds Energy 1) keeping reservoirs at maximum storage to reduce evaporation effects 2) changing releases to match other water uses 3) taking plants off in low flow times		
		Forestry and Land Use Adaptation Options	**Human Settlement and Industry** 1) cleared forest (from mining/forestry activities) and parts of savannah regions to be utilized for human settlement/industry ..Using the Impact and Vulnerability Assessment as a starting tool, continue to carry out detailed studies in the interior region on:		

			3) soil fertility, changes in temperature, rainfall, and other climatic variables, spatial shift in vegetation and species mix		
		Energy Adaptation Options	. **Commercial/residential/ public buildings** 1) conservation techniques: reduce lighting in buildings not in use **Machines/Equipment/Vehicles** 1) purchase of fuel-efficient machines/equipment/vehicles 2) efficiency/maintenance of machines/equipment . transportation 3) implementation of a more efficient transportation plan **Alternative energy sources** 1) hydropower (to be promoted especially Microsystems and mini-scales) 2) co-generation from use of bio-mass to be pursued in the sugar, rice and forestry industry		
Haiti	USAID Preparedness and Mitigation Assistance to Haiti in FY 2009. Since 2006, USAID/OFDA has provided Training and technical assistance to improve the ability of local Haitians to prepare for and respond to disasters. To further plan for and implement preparedness and mitigation programmes in	**AGRICULTURE**	1)Soil conservation techniques and practices 2) The use of new agriculture technologies. 3) development of education programmes for farmers about the possibilities of climate change. 4) Development of crop varieties that are temperature resistant and more tolerant to		USAID/OFDA HUMANITARIAN FUNDING: Preparedness and Mitigation Funding,**US$ 1,100,045**. Constant 2008 value = $42175175 Disaster Response Funding, **US$14,567,691**. Constant 2008 value = $558517.98

	Haiti, USAID/OFDA is formulating a comprehensive country strategy that incorporates elements to more effectively coordinate the humanitarian response to tropical storms, including through increased involvement in early recovery projects.		changes to moisture content in the soil.		Project Enabling Activities to Facilitate the Preparation of a National Adaptation Plan of Action (NAPA) GEF Grant **US$ 198,665**
		WATER RESOURCES	1)reforestation specifically directed to water resources and underground water resources 2)technical capacity to monitor changes in the hydrological cycle. 3) Efficient Management and Protection of water resources. 4) Development of artificial water resources and new dams.		
Jamaica	The Comprehensive Disaster Management (CDM) cycle illustrates the ongoing process by which governments, businesses and civil society plan for and reduce the impact of disasters, and take steps to recover after a disaster has occurred. The CDM framework is multi-hazard and multi-sectoral in its application and is concerned primarily with integrating vulnerability	**COASTAL ZONES**	1)Advanced planning to avoid worst impacts. 2)Modification of building styles and codes. 3)Water Sector Policy, 4)Flood forecasting and risk mapping, 5)Flood management control plan, Inclusion of hazard assessment in the development approval process, inclusion of hazard assessment in environmental impact assessment	Post Hurricane Dean rehabilitation. (1) Construction of sea defences to protect the Palisadoes tombolo which links Norman Manley International Airport (NMIA) with the mainland via the Norman Manley Highway (NMH). Works include construction of stone revetments, groynes, and replenishment of	GEF projects. 1) Demand Side Management Demonstration. Focal area: Climate change Agency: IBRD GEF Grant: **US$ 3,800,000** 2) Enabling Jamaica to Prepare its National Communication in response to its commitments to UNFCCC. Focal area: Climate change Agency: UNDP. GEF Grant**: US$ 232,780**

	assessment and risk reduction into development planning and management (CDERA, 2001) through four major phases: Mitigation, Preparedness, Response, and Recovery.	**WATER RESOURCES**	1)Reduction of unaccounted for water. 2)Promote industrial water conservation 3) Promote agricultural use conservation *National Irrigation Development plan provides specific planning recommendations for this area 4) Increase storage capacity 5) Development of infrastructure	protective dunes. (1) Repairs to main roads, including rehabilitation of pavement, drainage works, river training and sea defences. (CDB)	3) Climate Change Enabling Activity (Additional Financing for Capacity Building in Priority Areas). Focal area: Climate change Agency: UNDP. GEF Grant: **US$100,000** Post Hurricane Dean rehabilitation Agency: Ministry of Transport and Works (MTW) through its National Works Agency (NWA). Loan amount**: US$20.5mn**
		AGRICULTURE	1)More efficient use of the water resources with respect to agriculture. 2) Research on traditional crops to determine tolerance to climate change and to determine how to maintain productivity by manipulating certain factors within the environment and the crops themselves.		
Netherlands Antilles					
Saint Lucia	The objective of Second Saint Lucia Disaster Management Project (DMP II) is: (a) to further reduce the country's vulnerability to adverse natural events (such as hurricanes, floods etc.) through investing in risk management activities; and (b) to strengthen the institutional management and response capacity of the	**COASTAL ZONE**	1) Relocation and retreat of structures and activities. 2) Restrictions on future development. 3) Sea-walls, levees etc Reinforcing existing structures e.g. docks. 4) Flood plain management plan. 5) Building codes. 6) Mangrove habitat protection and reforestation.		GEF Projects (All amounts in US$) 1) Implementation of Pilot Adaptation Measures in Coastal Areas of St. Lucia. Agency: world bank. Project grant approved: **US$2,100,000** Constant 2008 value = $3562608

	respective ministries and agencies for disaster management through the provision of facilities, critical equipment, technical assistance and training.		7)Raising coastal bridges and roads.		2) Enabling St. Lucia to Prepare its First National Communication in Response to its Commitments to UNFCCC Focal area: Climate change Agency: UNDP GEF Grant: **US$169,900** Constant 2008 value = $288231.952
		HUMAN SETTLEMENTS	1) Inland relocation. 2) Upgrading planning legislation (building codes, EIA etc). 3) Community based resource management. 4) Public awareness 5) Use of traditional knowledge. 6) Development of climate change database. 7) Hazard mapping.		
		FRESHWATER	1) Reductions in line losses Accurately reflecting costs of water. 2) Restoration of riverbanks and wetlands. 3) Water conservation 4) Public awareness 5) Improved management of forest resources including private forests Strengthening data collection 6) Development of a national wat management plan		
		AGRICULTURE	1)Introduction of salt-tolerant species 2)Hydroponics 3)Public awareness 4)Introduction of heat and drought-tolerant crops 5)Crop research 6)Use of greenhouses Protection of forested areas 7)Farm relocation 8)Improved pest and disease		

			management 9)Restoration of degraded lands 10)Agricultural diversification 11)Reduced livestock stocking rat		
		FORESTRY	1)Development and enforcement of land use policy 2)Legislation and regulations 3)Promotion of agro forestry 4)Preservation of watersheds including compulsory acquisition 5)Reforestation 6)Public awareness 7)Wetlands protection 8)Urban forestry		
		FISHERIES	1)Resource and ecosystem monitoring 2)Public awareness 3)Strengthening environmental legislation 4)New fishing technologies 5)Efficient processing facilities 6)Regional and international cooperation 7)Development of a Fisheries Management Plan incorporating climate change		
		TOURISM	1)Relocation of structures 2)Strengthened development controls 3)Economic diversification 4)Hard and soft coastal engineering protection measures 5)Flood control		

Suriname		**COASTAL ZONE**	1)Building dykes and dams to prevent further erosion of the coast, land loss and flooding consequently. 2) Retreat. 3) Integrated coastal zone management. 4)Breakwaters: to build groynes, which are hard structures, used to reduce the wav reaching the coastline. The SRC, in collaboration with Inter-American Institute for Cooperation on Agriculture (IICA), conducted community risk reduction activities in the worst flood affected villages during January through April 2009.		GEF Projects (All amounts in US$) 1) Integrated and Sustainable Management of Trans-boundary Water Resources. Agency: world bank Project grant approved. (2008) **US$2,000,000** Constant 2008 value = $2548079400 2) Enabling Suriname to Prepare its Initial National Communication in Response to its Commitments to the UNFCCC.(1998) Focal area: Climate change Agency: UNDP GEF Grant: **US$350,000** Constant 2008 value = $445913895
Turks and Caicos Islands				Specific activities have included include clearing communication acce and reinstatement of disrupte utilities and services so that social and economic activities can r	Immediate Response Loan. Agency: Ministry of Communicati Works and Utilities. **LOAN AMOUNT: US** $.520 mn Constant 2008 value = 776843.6

Appendix Table 2: Direct and indirect economic damage by sector and by country, 1990 - 2008

	Anguilla	Bahamas	Belize	Belize	Cayman Islands	Cayman Islands	Dominica	Dominican Republic	Grenada	Guyana	Haiti	Haiti	Jamaica	Jamaica	Netherlands Antilles	St. Lucia	Suriname	Turks and Caicos
	Hurricane Luis (1995)	Hurricane Frances and Jeanne (2004)	Hurricane Dean (2007)	Hurricane Keith (2000)	Hurricane Ivan (2004)	Hurricane Paloma (2008)	Hurricane Dean (2007)	Hurricane Frances & Jeanne (2004)	Hurricane Ivan (2004)	Floods (2005)	Hurricane Jeanne (2004)	Tropical Storm Fay (2008)	Hurricane Michelle (2001)	Hurricane Ivan (2004)	Hurricane Luis (1995)	Hurricane Dean (2007)	Floods (2006)	Hurricane Hanna (2008)
Direct economic damage																		
Agriculture, Forestry and Fisheries	2,274	15,910	24,916	45,425	717	58	14,940	264,906	41,136	1,871,104	5,129,863	2,580,248	38,161	195,631		6,268	18,886,847	1,746
Tourism	37,423	43,772	775	72,764	505,367	14,562	913	224,658	229,678	8,778		216,618	2,598	26,775	409,486	2,953	1,074,638	
Industry and Commerce	635			17,977	769,075	7,733	4,038			1,907,391	316,263	670,941		2,859	118,020		161,487	5,904
Manufacturing									13,387	124,400		693,945		12,058				
Total direct economic damage (US$ '000s)	40,332	59,683	25,690	136,166	1,275,159	22,354	19,891	489,564	284,201	3,911,674	5,446,126	4,161,753	40,759	237,323	527,507	9,221	20,122,972	7,650
Indirect economic losses																		
Agriculture, Forestry and Fisheries	2,177	51,316	43,005	27,494	9,322	217	20,001	77,569	34,432	163,508	7,834,025	5,003,305	3,815	295,313		8,053	470,630	1,948
Tourism	6,573	120,441	4,721	21,284	323,585	9,568	1,141	168,896	76,108	201,663		754,521		64,564	323,585	94	943,385	
Industry and Commerce	359			8,895	61,669	4,482	2,282	143,576	8,273	796,155	211,902	4,186,673		56,272	287,582		1,149,385	3,890
Manufacturing									3,234	55,169		2,350,211		114,548				
Total indirect economic losses (US$ '000S)	9,108	171,757	47,726	57,673	394,577	14,267	23,425	390,041	122,047	1,216,494	8,045,927	12,294,711	3,815	530,697	611,167	8,147	2,563,399	5,838
Total economic losses (US$'000s)	49,440	231,440	73,416	193,839	1,669,736	36,621	43,316	879,605	406,248	5,128,168	13,492,053	16,456,464	44,575	768,020	1,138,673	17,369	22,686,371	13,489

Source: ECLAC Disaster Assessment Reports – 1995-2008: www.eclac.org

Appendix Table 3: Direct and Indirect Damage to Infrastructure by type of infrastructure and by country, 1990 - 2008

	Anguilla	Bahamas	Belize	Belize	Cayman Islands	Cayman Islands	Dominica	Dominican Republic	Grenada	Guyana	Haiti	Haiti	Jamaica	Jamaica	Netherlands Antilles	St. Lucia	Suriname	Turks and Caicos
	Hurricane Luis (1995)	Hurricane Frances and Jeanne (2004)	Hurricane Dean (2007)	Hurricane Keith (2000)	Hurricane Ivan (2004)	Hurricane Paloma (2008)	Hurricane Dean (2007)	Hurricane Frances & Jeanne (2004)	Hurricane Ivan (2004)	Floods (2005)	Hurricane Jeanne (2004)	Tropical Storm Fay (2008)	Hurricane Michelle (2001)	Hurricane Ivan (2004)	Hurricane Luis (1995)	Hurricane Dean (2007)	Floods (2006)	Hurricane Hanna (2008)
Direct damage to infrastructure -																		
Water		807	88	970	8,605	72	2,876	5,415	5,264	702,906	364,877	504,548	7,445	10,933	8,756	25		448
Electricity	2,714	4,183	498	1,827	60,773	4,503		15,807	52,644	9,973		215,468	481	33,821		355	266,000	12,698
Ports and Airports	1,920				17,389	3,742	685							6,144	18,204	785		28,132
Communications	7,134	55,499	293	901	86,249	3,226	10,651		57,532	17,051			535	11,404	38,460	1,090		3,892
Roads & transportation	2,913	66,405	5,518	27,404	262,095		38,477	134,648	7,746	625,457	805,551	2,645,426	121,813	141,254	2,988	5,221	310,994	16,433
Drainage & irrigation										36,381								
Coastal zone & fire services						1,370										1,560		7,768
Government buildings		10,906			76,011	5,180								54,859				
Total direct infrastructure damages (US$ '000s)	14,742	137,800	6,397	31,102	511,123	18,092	52,689	155,870	123,187	1,391,768	1,170,428	3,365,441	130,273	258,415	68,407	9,036	576,993	69,372
Indirect losses to Infrastructure -																		
Water		4,153	44	117	1,434	27	107	2,488	752	33,617		243,456		28,038	13,311	61		58
Electricity	2,404	8,964	64	655	62,745	1,137	771	878	15,793	28,630	6,939	79,746	16	46,447		288		3,366
Ports and Airports	269				10,756	479								752	18,541			9,374
Communications	2,637		73	520	56,829	3,788	1,004		46,928	11,467		23,387		76,754	29,185	21		1,008
Roads & transport		5,064	273	19,721	87,305	351	283	264,028	902	33,617		2,392,385	520	45,701		498		
Drainage and Irrigation										208,498								
Coastal zone & fire services					6,275													
Total indirect infrastructure damage (US$ '000s)	5,309	18,181	455	21,014	225,344	5,783	2,165	267,394	64,376	315,829	6,939	2,738,974	535	197,693	31,852	868		13,807
Total infrastructure damage (US$'000s)	20,052	155,981	6,852	52,115	736,467	23,875	54,854	423,264	187,563	1,707,596	1,177,368	6,104,415	130,808	456,108	100,259	9,904	576,993	83,179

Appendix Table 4: Direct and indirect damage to social sectors by type of social sector and by country, 1990 - 2008

Impact on different sectors	Anguilla	Bahamas	Belize	Belize	Cayman Islands	Cayman Islands	Dominica	Dominican Republic	Grenada	Guyana	Haiti	Haiti	Jamaica	Jamaica	Netherlands Antilles	Netherlands	St. Lucia	Suriname	Turks and Caicos	REGIONAL TOTAL
	Hurricane Luis (1995)	Hurricane Frances and Jeanne (2004)	Hurricane Dean (2007)	Hurricane Keith (2000)	Hurricane Ivan (2004)	Hurricane Paloma (2008)	Hurricane Dean (2007)	Hurricane Frances &	Hurricane Ivan (2004)	Floods (2005)	Hurricane Jeanne (2004)	Tropical Storm Fay (2008)	Hurricane Michelle	Hurricane Ivan (2004)	Hurricane Luis (1995)	Hurricane	Hurricane Dean (2007)	Floods (2006)	Hurricane Hanna (2008)	
Direct social damage																				
Health	326	4,332		1,500	17,210	797	5,013	732	7,971	9,805	163,403	381,095	558	41,239	6,104		193	36,800	4,893	
Housing & Human Settlements	11,311	107,115	19,466	40,143	2,366,385	171,068	16,574	43,175	1,032,065	10,242,366	4,007,858	6,035,021	17,448	601,468	268,555		1,474	5,697,429	87,616	
Education & Culture	756	32,568	268	1,342	77,087	7,848	854	6,440	146,321	65,758	193,768	1,070,055	1,334	45,644	20,078		348	22,035,112	3,550	
Total direct social damage (US$ '000s)	12,392	144,015	19,734	42,985	2,460,682	179,713	22,441	50,347	1,186,357	10,317,928	4,365,029	7,486,171	19,341	688,351	294,737		2,015	27,769,341	96,058	55,157,636
Indirect social losses																				
Health	134	3,361	178	780	16,672	753	1,807	12,733		22,579	3,105	199,365	543	2,308	6,361		570	41,927	39,497	
Housing & Human Settlements		299	19	94	223,910	11,682	156	9,074	6,412	51,956		858,805	31	39,568	18,764		35		26,819	
Education & Culture	25	30	18	439	3,227	962	70	146	948	3,660	2,684	43,707	271	689	3,405		1,618	4,159	3,989	
Total indirect	160	3,690	215	1,313	243,809	13,397	2,034	21,95	7,360	78,196		1,101,8	845	42,566	28,530		2,22	46,086	70,304	1,664,55

social losses (US$ '000S)								4				77					2			8
Total social damages (US$'000s)	12,552	147,705	19,949	44,298	2,704,491	193,110	24,474	72,300	1,193,716	10,396,125	4,365,029	8,588,048	20,186	730,916	323,267	-	4,237	27,815,428	166,363	56,822,194

Appendix Table 5: Direct and indirect damage to the environment by country, 1990 – 2008

	Anguilla	Bahamas	Belize	Belize	Cayman Islands	Cayman Islands	Dominica	Dominican Republic	Grenada	Guyana	Haiti	Haiti	Jamaica	Jamaica	Netherlands Antilles	Netherlands	St. Lucia	Suriname	Turks and Caicos	REGIONAL TOTAL
	Hurricane Luis (1995)	Hurricane Frances and	Hurricane Dean (2007)	Hurricane Keith (2000)	Hurricane Ivan (2004)	Hurricane Paloma (2008)	Hurricane Dean	Hurricane Frances & Jeanne	Hurricane Ivan (2004)	Floods (2005)	Hurricane Jeanne (2004)	Tropical Storm Fay (2008)	Hurricane Michelle (2001)	Hurricane Ivan (2004)	Hurricane Luis (1995)	Hurricane	Hurricane Dean (2007)	Floods (2006)	Hurricane Hanna (2008)	
Direct environmental damage					1,076	3,052		1,317			101,293	3,256,557		147,031			28		578	
Total direct environmental damage (US$ '000s)	-	-	3,811	28,762	1,076	3,052		1,317		2,820	2,642	3,256,557		147,031			28		578	3,447,674
Indirect environmental losses					17,748	9,822		146		-	21,585						465		37,829	
Total indirect environmental losses			762	-	17,748	9,822		146		-	21,585						465		37,829	88,358

(US$ '000S)																				
Total environ mental damage (US$'000 s)	-	-	4,57 4	28,76 2	18,82 4	12,8 74	-	1,46 4	-	2,820	24,22 7	3,256, 557	-	147, 031	-	-	49 3	-	38,4 07	3,536, 031

Source: ECLAC Disaster Assessment Reports – 1995-2008: www.eclac.org

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