VULNERABILTY, RISK MANAGEMENT AND ADAPTATION: RESPONDING TO CLIMATE CHANGE CHALLENGES IN THE COMMONWEALTH CARIBBEAN

I) INTRODUCTION

The Commonwealth Caribbean is comprised of the English speaking islands of the Caribbean and the mainland territories of Belize and Guyana which collectively form the Caribbean Community and Common Market (CARICOM). Some non English speaking countries such as: Dominican Republic, Haiti, Cuba and Suriname are associate members of CARICOM. Over the past two decades the issue of climate change has become a primary concern for the small island low-lying coastal developing states of the Caribbean region. The specially convened United Nations Global Conference on Small Island Developing States (SIDS) in Barbados in 1994 identified climate change as a major environmental and economic issue facing SIDS (UN 1994). A SIDS Plan of Action was developed which recognised that sustainable development in SIDS are ultimately dependent on the sustainable utilization of coastal and marine resources (Toppin-Allahar, 2001). In addition, growing global concern about natural disasters led the world community to launch the International Decade for Natural Disaster Reduction (IDNDR 1990 – 1999), in an attempt to stimulate greater awareness of the importance of disaster reduction (Trotz 2002). This emphasis on disaster reduction highlights a theoretical shift from disaster response to a greater focus on understanding the importance of human action in reducing hazard vulnerability and the adverse effects of disasters.

In the early stages of the climate change debate, the emphasis was primarily placed on mitigation in the form of limiting greenhouse gas emissions, without sufficiently addressing other important related issues such as: land use planning, legislative and institutional strengthening, public awareness and education. Given the composition of the earth's climatic system, there is a time lag between green house gas emissions and effects. Therefore, regardless of global efforts to significantly reduce greenhouse gas emissions, projected changes in global conditions are likely to continue to the year 2100 before any possible reversal in the existing trend (Taylor et al 2007). Consequently, it is now generally accepted that for Small Island Developing States, including those in the Caribbean, the immediate priority for planners in terms of responding to global climate change ought to be adaptation, but not at the expense of mitigation. This will require a blend of short, medium and long term land use and economic strategies which take into account local conditions and externalities and which can be implemented in a cost effective and timely manner. In other words, land use decisions in the Caribbean must as a matter of necessity simultaneously address the issue climate change while creating much needed economic development.

From a spatial perspective, while entire islands within the Caribbean are vulnerable in one way or another to the effects of climate change, special attention must be given to urban centres as approximately sixty nine percent of the Caribbean's population reside in towns and cities (UNEP 1999), most of which are coastally located. Thus narrow coastal urban settlements which can be found in all Caribbean Islands are most vulnerable to the impacts of climate change. The critical task facing planners to effectively address in our cities the key causes of climate change by carefully planning settlements so that fewer people are vulnerable to natural calamities making human settlements become more liveable (Commonwealth Association of Planners 2006).

II) THREATS FROM CLIMATE CHANGE TO THE CARIBBEAN

Figure 1: Climate Change Impacts on Caribbean SIDS

CHANGE FACTOR	IMPACT
Sea level rise	▪ Sea level rose at an average rate of 1.8 MM/ yr between 1961 and 2003, but the yearly rate of increase has been rising. The rise in seal level between 1993 – 2003 averaged 3.1 MM/ yr. ▪ Extensive inundation of low-lying coastal communities ▪ Saline intrusion into groundwater
Storms & Hurricanes	▪ Increase in the intensity and frequency of hurricanes resulting in increased damage to housing, agriculture, commercial buildings, ports and infrastructure from flooding, wind and landslides. ▪ Beach erosion and damage to hotels and tourism related infrastructure
Rainfall Patterns	▪ Change in rainfall regimes ▪ Increase in both drought and heavy precipitation events resulting in more extreme drought and flood occurrences
Temperature	▪ Records show the 1990s being the warmest decade of the 20th century, with 1998 the hottest year. ▪ Stronger hurricanes forming at lower latitudes ▪ More rapid transition of hurricanes in to category 4 and 5 ▪ Increase incidences of: coral bleaching, droughts, flood events, pest infestation, beach erosion, water and vector bore diseases.

Source: *Compiled by Author with data from Leslie 2008 and Trotz 2008*

The threats posed by climate change to the islands of the Caribbean range from geo-physical hazards to health issues and impact all sectors including: tourism, water resources, energy, agriculture and land use, all of which are vital to the sustainable development of the Caribbean region. Amongst these plethora impacts, sea level rise is probably the most significant threat facing Caribbean Small Island Developing State (SIDS), Lewsey et al., 2004. Maul (1993) projected a rise in sea level of between 10 to 50 cm by 2025. Nicholls et al. (1999) conservatively estimate that in the event of a 38cm sea level rise from 1990 to 2080, the number of people likely to be flooded by storm surge in a typical year will increase five- fold, with people in low lying areas being most vulnerable. Nicholls (2002) further points out that population growth within coastal settlements are expected to exacerbate this problem. This is of significant importance to the populations of Caribbean SIDS, where over 50% of the population is already concentrated within 1.5 km of the shore.

While the small land mass and geographical location of Caribbean SIDS make them highly susceptible to hydro-meteorological hazards, their vulnerability to climate change effects are also influenced by various human related factors (Mimura et al. 2007). Among these factors which increase their vulnerability are: relatively large populations with high growth rates and densities; poorly developed infrastructure and limited human and economic resources, and subjection to external forces such as changing terms of trade, economic liberalization, migration flows, and dependence on marine resources.

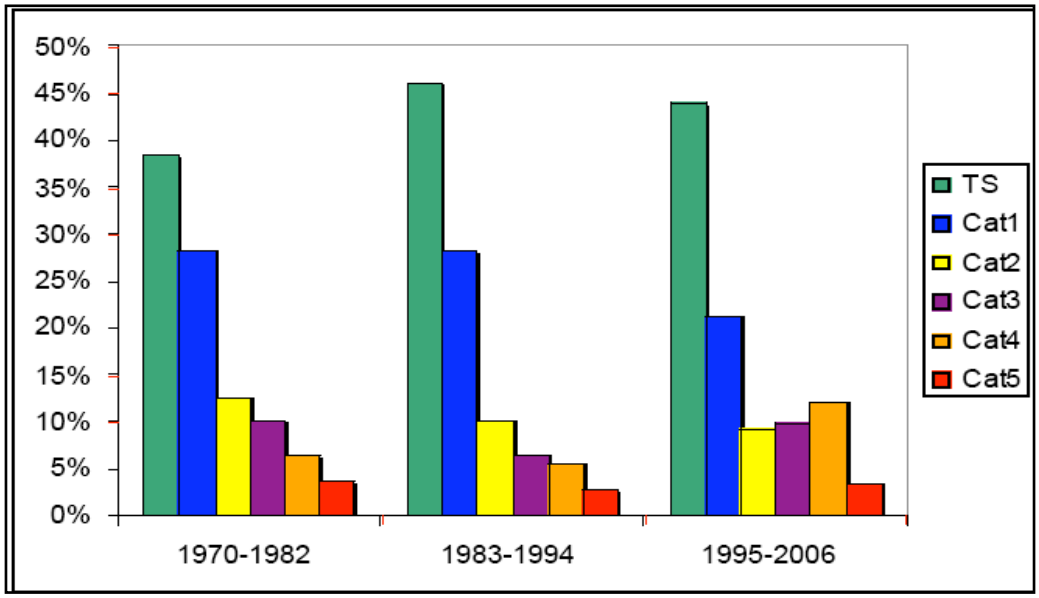
III) EFFECTS OF CLIMATE CHANGE RELATED DISASTERS ON THE CARIBBEAN

Climate variability, as manifested by changing and unpredictable weather patterns, already represents a major challenge for planners in the Caribbean (Smith 2007). Climate change related disasters such as storms, hurricanes, floods, and droughts have very devastating effects on Caribbean SIDS as entire islands are adversely affected ecologically, economically and socially, sparing no sector from their direct or indirect impact. Thus there is no safety net, i.e. unaffected area or sector which can cushion the adverse of these climate related disasters.

Another significant threat posed by climate change is the deterioration in human health due to the increase presence of vector borne tropical diseases, such as malaria and dengue and the prevalence of respiratory illnesses. These diseases will affect the well being and productivity of the work force in the Caribbean, thus compromising the region's growth and development potential. Vermieren (1993) notes that with increasing frequency countries in the Caribbean are facing situations in which scarce resources that were earmarked for development projects have had to be diverted to repair damage inflicted by disasters. With a slow recovery process, if this trend continues whereby scarce resources are continually being channelled into disaster recovery efforts, the coping capacity of Caribbean SIDS are likely to be overwhelmed. If Caribbean SIDS are to achieve sustainable development under these circumstances then they will have to take steps to become more resilient to climatic hazards and related environmental disasters.

Climatic data indicate that since 1995, there has been an increase in the intensity and distribution of more intense hurricanes in the Caribbean, as shown by the graph in **figure 3**.

Figure 2: Intensity Distribution of North Atlantic Tropical Storms 1970 - 2006



Source: *Leslie 2008* T S = Tropical Storm

The increase in the number of category 3 and 4 hurricanes has been linked to warmer air and sea temperatures in the central Atlantic and the Caribbean which makes it easier for low pressure tropical weather systems to develop into deadly hurricanes which increases the risk of damage to the islands of the Commonwealth Caribbean.

Figure three provides a summary of the number of persons in the Caribbean affected and the economic damage stemming from natural disasters such as flooding, storm surge, landslides and high winds for the period 1979 – 2004, the costs of which are undoubtedly high within the context of the existing Caribbean economy.

Figure 3: The Impact of Major Natural Disasters in the Caribbean 1979 – 2004

Year	Country	Type of Hazard	Persons Affected	Damage US $ (000's) [at the year of the event]
1979	Dominica	Hurricane David & Frederick	72, 100	$ 44,650
1980	St. Lucia	Hurricane Allen	80,000	$87,990
1988	Dominican Republic	Flood	1,191,150	
1988	Haiti	Hurricane Gilbert	870,000	$ 91,286
1988	Jamaica	Hurricane Gilbert	810,000	$ 1,000,000
1989	Montserrat	Hurricane Hugo	12,040	$ 240,000
1989	Antigua, St. Kitts/Nevis, Tortolla	Hurricane Hugo	33,790	$ 3,579,000
1991	Jamaica	Flood	551,340	$ 30,000
1992	Bahamas	Hurricane Andrew	1,700	$ 250,000
1993	Cuba	Storm	149,775	$ 1,000,000
1993	Cuba	Flood	532,000	$ 140,000
1994	Haiti	Storm	1,587,000	
1995	St Kitts & Nevis	Hurricane Luis	1,800	$ 197,000
1995	US Virgin Islands	Hurricane Marilyn	10,000	$ 1,500,000
1998	Dominican Republic	Hurricane Georges	975,595	$ 2,193,400
2000	Antigua/Barbuda, Dominica, Grenada, St. Lucia	Hurricane Lenny		$ 268,000
2001	Cuba	Hurricane Michelle	5,900,012	$ 87,000
2004	Grenada	Hurricane Ivan		$ 889,000

Source: Caribbean Development Bank (CDB) & Caribbean Community Secretariat (CARICOM) 2004

The toll from natural disasters in the Caribbean is appalling, and the rates of destruction have been increasing decade after decade, putting more strain on the already fragile ecosystems and economies of the Caribbean islands. The impact of hurricanes on Caribbean countries in the past three decades has resulted in loss and damages estimated at US $ 5.7 billion, underscoring the economic volatility of the region. Of this total, approximately 79% consisted of direct damage to infrastructure and capital assets. From a sectoral point of view damage to the social and productive sectors, including tourism consisted of 48% (UN ECLAC 2005). The Jamaica Observer dated July 10th, 2009 cited the Caribbean Development Bank (CBD)

which noted that 2008 was the most active hurricane season in more than six decades, with 15 of 18 Caribbean nations reporting damages.

With coastal oriented tourism being the bedrock of the economy of most Caribbean islands, climate change severely threatens the economic survival of the region. The Caribbean is the most tourism dependent region in the world (Tewarie, 1997) as well as the most tourism penetrated region (McElroy, 2002).More than ninety five percent of the tourism infrastructure in many CARICOM countries is located within 10 KM of the coastline, thus rendering the tourism industry highly vulnerable to the effects of exaggerated storm surge and sea level rise (Smith 2007). According to Lewsey et al. (2004) the need to act decisively in protecting coastal zones must take into consideration the demands of the tourism industry, which is likely to remain the central plank of Caribbean island economies. Thus a critical challenge to Caribbean SIDS is how to balance the immediate economic needs that the tourism industry fills while minimizing the environmental stresses that tourism has created and its resultant vulnerability to climate change.

An examination of the economic and physical impact of hurricanes on some of the major Caribbean tourism destinations in 2004 revealed the extent of the severity. Within the Caribbean losses incurred from a single hurricane event in some countries have exceeded their annual GDP. In Grenada which received the most damage, an estimated ninety percent of the hotel and housing stock was either damaged or destroyed (Smith 2007). This trend poses a major threat to the sustainable development goals of the region and is being treated with some urgency by various regional Governments.

Figure 4: Economic Impact of Hurricanes on Selected Caribbean Tourist Destinations in 2004

Country	Natural Event	Economic Impact (US $ Million)	% of GDP
Bahamas	Hurricanes Frances & T.S. Jeanne	551	10.54%
Cayman Islands	Hurricane Ivan	1620	183%
Dominican Republic	Tropical Storm Jeanne	296	
Grenada	Hurricane Ivan	889	212%
Jamaica	Hurricane Ivan	595	8%

Source: *UNECLAC 2005*

The overwhelming cost of the damage created by climate related disasters underscores the importance for Caribbean SIDS to give urgent local attention to issue of climate change. Responding reactively to the threats of climate change will only serve to further exacerbate our vulnerability to climatic hazards and environmental disasters in the Caribbean. Caribbean SIDS by themselves cannot reverse the consequences of global warming, given their negligible contribution total greenhouse gas emissions. Global initiatives to reduce carbon emissions will have a more direct effect on mitigating the threats of climate change to SIDS, including those in the Caribbean. However, for Caribbean SIDS to have a moral voice on issue of climate change within the wider global community, it's imperative that they lead by example locally in order to make a strong case to the international community. Figure 6 outlines the economic cost of global inaction on climate change to Caribbean SIDS. The figures are quite staggering and underscore the urgent need for Caribbean SIDS to lobby for greater action on climate change by the wider global community.

Figure 5: Cost of Global Inaction on Climate change to Caribbean SIDS

Cost of Inaction: % of current GDP				
Country	**Year**			
	2025	**2050**	**2075**	**2100**
Antigua & Barbuda	12.2	25.8	31.1	41.4
Bahamas	06.6	13.9	22.2	31.7
Barbados	06.9	13.9	20.8	27.7
Dominica	16.3	34.3	54.4	77.3
Grenada	21.3	46.2	75.8	111.5
Haiti	30.5	61.2	92.1	123.2
Jamaica	13.9	27.9	42.3	56.9
Saint Kitts & Nevis	16.0	35.5	59.5	89.3
Saint Lucia	12.2	24.3	36.6	49.1
Saint Vincent & the Grenadines	11.8	23.6	35.4	47.2
Trinidad & Tobago	4.0	8.0	12.0	16.0

Source: The Caribbean and Climate Change – The Costs of Inaction By: Ramon Bueno et al, Tusfts University, May 2008

IV) THE CARIBBEAN'S RESPONSE TO CLIMATE CHANGE

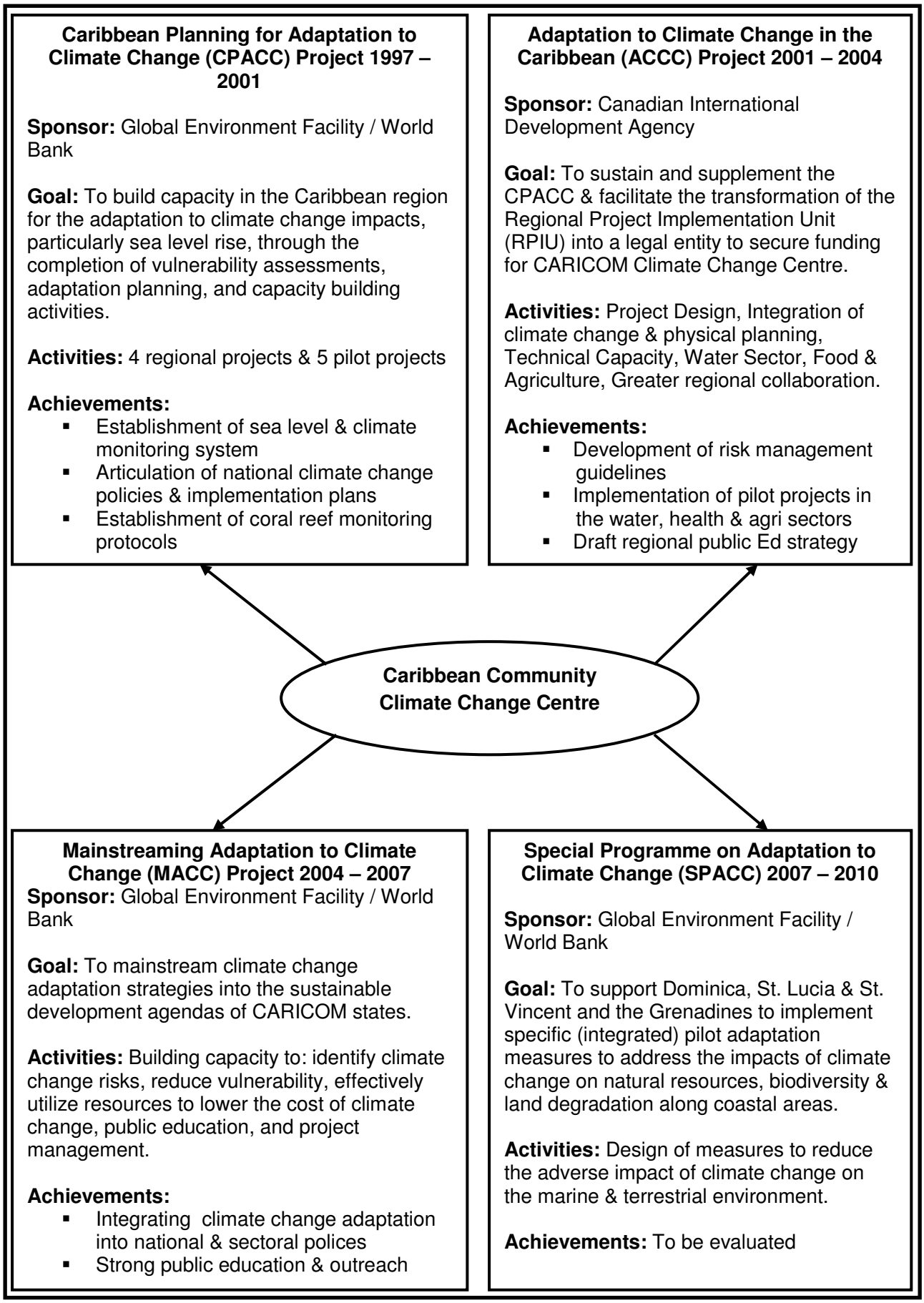
Creating Institutional, Legal and Technical Capacity for Adaptation

Regionally, CARICOM has sought to strengthen the institutional, technical and financial capacity of the Commonwealth Caribbean to better adapt to the effects of climate change through the establishment of the Caribbean Community Climate Change Centre (CCCC) in Belize. Working alongside other partners such as the Caribbean Disaster and Emergency Response Agency (CDERA), the CCCC coordinates the Caribbean's response to climate change. The CCCC is recognised by the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Environment Programme (UNEP) as the official clearing house for regional climate change data; providing climate change related policy advice and guidelines to CARICOM member states. The mission of the CCCC in part reads

> *".....support the people of the Caribbean as they address the impact of climate variability and change on all aspects of economic development through the provision of timely forecasts and analyses of potentially hazardous impacts of both natural and man-induced climatic changes on the environment, and the development of special programmes which create opportunities for sustainable development".* (CCCC 2009)

Figure 6 which was compiled using data from the CCCC (2009) provides a description of the framework in place to promote climate change adaptation, awareness and mitigation within the Caribbean.

Figure 6: The Caribbean's Response to Climate Change



A key step in creating legal, institutional and technical capacity in the Caribbean was the establishment of national climate change action plans by the individual member states of CARICOM, as part of the CPACC project outlined in figure 6. These plans outlined in detail the current state of preparedness for the adverse effects of climate change within the various sectors of each island; current initiatives being undertaken to adapt to these negative effects, as well as the additional measures needed to more effectively tackle climate change locally. In essence, the national climate change action plans of the various Caribbean islands are meant to serve as a framework for channelling development along a sustainable path in light of the immediate and future threats posed by climate change.

A review of the individual national climate change action plans for Commonwealth Caribbean countries reveal that despite facing the same basic threats from climate change, the level of adaptation and response capacity differs widely among some member states. The IPCC defines adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation and autonomous and planned adaptation (Trotz 2009).

In the Bahamas policy options to respond to climate change are limited and have been slow in developing, despite being one of the richest Caribbean territories, suggesting a lack of technical expertise. In addition, the government policy on sustainable development is yet to be defined in a single policy document, although elements of the policy do exist. In the case of Guyana, while there has been considerable progress in building its institutional capacity to respond to climate change, implementation is seriously challenged by a lack of financial resources. In an effort to address the challenge of creating much needed economic growth and development while simultaneously combating climate change, the government of Guyana in May 2010 released its third draft of Guyana's Low Carbon Development Strategy (LCDS). The document sets out Guyana's strategy to forge a new low-carbon economy over the coming decade, as opposed to the traditional high-carbon development path, and is a follow up to the 2009 Copenhagen Summit on climate change (GRG 2010).

The governments of Barbados, Belize and St. Lucia have established coastal zone management units to effectively manage their coastal resources through the creation and implementation of coastal zone management plans. As a prerequisite to the establishment of the these coastal zone management units, legislative reviews and amendments were undertaken for the various planning and environmental laws in these islands so as to eliminate redundancy and ensure the dovetailing of these laws. In 1994, Belize undertook Climate Change Vulnerability Assessments in Agriculture, the Coastal Zone and Water Resources under the US Country Studies Programme. The CPACC project assisted Belize in its efforts to compile inventories of its coastal resources, make an economic evaluation of those resources and thus quantify their vulnerability. The 1998 Coastal Zone Management Act of Barbados requires the development of a Coastal Zone Management Plan (CZMP) which presents general and specific guidelines for the following areas, among others:

1. Global and regional climate change
2. Maintenance and construction of coastal structures
3. Coastal habitat restoration
4. Zoning
5. Set Back, access and views to the sea

New legislation has been proposed in Barbados to include a Climate Change Act, an Environmental Management Act, a Disaster Management Act, and the general inclusion of

the Precautionary Principle in local legislation. The implementation of these new legislations will go a long way in addressing the issue of outdated laws, as of the thirty seven pieces of major legislation dealing with environment and land use issues in Barbados, only ten were enacted since the establishment of Agenda 21 at 1992 United Nations Conference on the Environment and Development (UNCED).

Environmental and land use planning legislation has also been reformed in Jamaica, Trinidad and the Organization of Eastern Caribbean States (OECS). The establishment of the National Environment and Planning Agency (NEPA) in Jamaica in 1993 has joined together development planning, development control, marine and land resources management under the control of a single entity, thereby enabling the development and implementation of broad based multi-sectoral environmental policies which addresses climate change within the context of local sustainable development. Similarly, the Environmental Management (EMA) of Trinidad and Tobago, established 2001, promotes climate change adaptation as part of its overall environment management policy.

A serious impediment faced by Caribbean SIDS in creating the institutional, legal, and technical capacity to adapt to climate change is a clear lack of scientific data throughout the region, as concluded from a review of the individual national climate change action / policy plans by CARICOM member states. For example, in Grenada there is a lack of bathymetry data and some countries do not have up to date topographic maps. There is also a need for basic assessment of coral reefs, particularly in the Organization of Eastern Caribbean States (OECS). Several islands of the Caribbean have highlighted the need for continual capacity building as an adaptation option. For example, the Bahamas have identified a number of projects which will require both research and effective capacities to be built. Grenada has noted a number of institutional systems which are needed for vulnerability analysis and adaptation assessments. Capacity building is critical for Caribbean SIDS to address the challenges posed by climate change, and this capacity building must be a dynamic process. This is a vital prerequisite for the development of detail technical models to aid vulnerability analysis in the Caribbean.

Policy and Programme Initiatives

The following highlights some of the current policies and programmes that are being undertaken as part of the Caribbean's response to climate change.

Sustainable Energy – The energy sector in the Caribbean is heavily dependent on fossil fuel, with petroleum products accounting for an estimated 93% of commercial energy consumption based on a 1997 baseline study (UNDP 2004). The burning of imported fossil fuels is the primary source of greenhouse gas emissions, as well as a major cause of balance of payments problems for Caribbean SIDS. At the same time, however, the expansion of electricity generation is a key aspect of the economic development of Caribbean SIDS, particularly the supply of electricity to rural communities.

Given their geography, Caribbean SIDS are, in theory, especially suited to utilise modern renewable energy sources such as solar, wind and wave energy. However, renewable energy provides less than 2% of the Caribbean commercial electricity (UNDP 2004). An irony exist in that while there are considerable opportunities for utilising Renewable Energy Technologies (RETs) in Caribbean SIDS, it's the developed countries that have access to the technology and financial resources to utilise renewable energy sources. The UNDP (2004) notes that few of the governments in the Caribbean have developed policies to promote the use of RETs, or have assessed their inventories of renewable energy resources.

To address the above concerns, the United Nations launched the Caribbean Renewable Energy Development Programme (CREDP) in January 2004. The aim of the programme is to

remove barriers to renewable energy use in the Caribbean and involves all the CARICOM member states. The programme is funded to the tune of US $ 22,337,050 spearheaded by the UN Global Environment Facility (GEF). The implementation period for the programme was 2004 – 2008, but it has been extended into 2009 (Williams 2009). RETs that are being developed in the CREDP include: wind farm, biomass cogeneration, geothermal and small hydro-electric plants, which can be connected with national electricity grids. Solar water heating is also encouraged for private use. The provision training and expertise is also part of the CREDP. Two major anticipated outcomes of the CREDP are:

a) Annual reduction of CO_2 emissions were projected to be reduced by an estimated 388, 159 tons by 2007. While progress has been made in reducing CO2 from power generation, it's uncertain whether or not this objective has been met.

b) An increase in the use of RETs from 2% of commercial electricity generation (2004) to 5% by 2015. Progress towards achieving this objective is being made, as RETs now contribute to 3% of commercial energy supply in the Caribbean (Williams 2009).

Given the lowering of oil prices since the current global economic recession, there is the risk that the drive towards the use of RETs in the Caribbean may slow down. One such example is an indefinite freeze in the divestment of Jamaican state owned sugar assets to Infiniti Bio-Energy of Brazil as part of a joint venture agreement between the Jamaican government and COIMEX of Brazil to refurbish Jamaica's ethanol plant and resume production, using locally grown sugar cane (JIS 2008). Despite these challenges, Williams (2009) warns that unless bold moves are taken, RETs will still be marginal in the Caribbean.

In the area of wind energy, the Jamaican government in 2004 developed a wind farm comprising of twenty three 900KWh turbines at Wigton in the parish of Manchester. The Wigton Windfarm initially provided 1.4% of Jamaica's energy supply but is slated to double that amount to 2.8% when expansion of the wind farm is complete with the commissioning of an additional 18 mega watt of generating capacity from nine (9) 2 mega watt Vestas V80 wind turbines in 2010. Some of the additional benefits to be derived from the fully expanded wind farm are:

- 64,693 barrels of oil will be saved
- 90.3337 tons of Carbon Dioxide will be avoided
- US$6.4693 million reduction in Jamaica's oil bill (PCJ 2009)

Under the Kyoto Protocol, the Clean Development Mechanism (CDM) allows for countries to trade emissions reductions to meet their carbon emissions targets. As a result, Wigton Windfarm Limited is able to trade the emissions reductions saved by operating the wind farm, thereby providing a secondary income stream. Thus the windfarm provides both environmental and financial benefits. On December 13, 2005, Wigton Windfarm Limited signed an agreement with the Corporacion Andina de Fomento (CAF), a multilateral development bank, for the sale of Certified Emission Reduction (CER) to the Netherlands government. The sale price was 5.5 Euros per ton of carbon dioxide saved. The agreement runs from April 2004 to December 2012 and the estimated income for the period is US$ 3.1 million. (PCJ 2010)

In Barbados, 16 megawatts wind turbine farms at good wind sites in the north of the country are being considered for development. Also a 3 megawatt ocean thermal energy conversion plant, a 10 megawatt waste combustion plant, and a 2 megawatt wave power plant are being contemplated for development (Government of Barbados 2001).

Greater use is now being made of biomass cogeneration. In Barbados, sugar factories are now engaged in cogeneration using bagasse to produce electricity which contributes to approximately 15 – 18 percent of the country's primary energy supply. Similarly, the

government of Belize recently invested US $62 million in a cogeneration plant, Belize Cogeneration Energy Limited, which will uses bagasse to generate 31.5 megawatts of electricity, most of which is sold to the national grid (Smith 2007).

Solar energy initiatives are largely private sector based and focus primarily on the provision of water heaters. Barbados is the leader in the Caribbean in the use of this technology which is supported by the following government policies:

- Taxes on raw materials for use by solar water heater manufacturers have been waived.
- Taxes on non-solar water heaters are kept high (as much as 60%).
- Householders who purchased water heaters are allowed a 100% rebate on the cost of the heaters on their income taxes. (Government of Barbados 2001)

In St. Lucia, the government with assistance from the Global Sustainable Island Initiative (GSEII) has created a national sustainable energy plan which establishes targets for renewable energy and efficiency and sets the stage for significant changes in the energy sector. Grenada and Dominica are developing similar plans (Smith 2007).

The private sector, particularly the tourism sector, is also actively involved in energy conservation initiatives. The Caribbean Alliance for Sustainable Tourism (CAST) is assisting hotels by conducting energy audits, and is a leading advocate for of incentives for the promotion of energy efficient technology (Smith 2007). Hotels in Barbados that borrow from the government run development bank are required to carry out environmental audits, which often recommend the use of solar water heaters.

Public Education and Awareness – Public education and outreach is critical to building awareness and understanding of climate change. Knowledge, Attitude and Practice (KAP) studies funded by the UNDP have been undertaken as part of the MACC project outlined in figure 6. Communities at Risk Initiatives, a pilot project which provides guidance for vulnerable coastal communities to become sustainable in the short and long term, is one such KAP study. The project was implemented in three phases, the first stage starting with six communities in Belize in 2006, followed by the second stage in 2007 which involved communities from Trinidad and Tobago and St. Vincent and the Grenadines. The final stage covers the entire Caribbean and was projected to start in 2008 (CARICOM / UNDP 2006). Another KAP study is the Jamaica Climate Change Enabling Activity (JCCEA) project which was completed in 2005 by the local Meteorological Service with funding from the United Nations. KAP surveys indicate a high level of awareness of climate change throughout the private sector within the Caribbean (> 80%), but less than 10% of the population felt that their country was prepared to address adaptation to climate change (CARICOM / UNDP 2006). KAP surveys provide a basis for measuring the success of a project in creating greater public education and awareness on climate change related issues, as well as identifying areas that are in need of improvement.

Land Use Planning – Zoning, the implementation of coastal setback distances and the establishment of modern building codes are some non-structural measures that have been used to adapt to the effects of climate change. In Jamaica, five areas along the coast have be zoned (supported by legislation) as marine protected areas in which only minimum development and human activity is allowed (GOJ 2001). This is in order to protect vital costal ecosystems such as mangroves which serve the multiple functions in protecting coastal areas. The government of Bahamas in its national climate change action plan (2001) proposed to make 20% of its shallow water areas as protected areas as part of a network of marine parks. Under the United State Agency for International Development (USAID) and the Organization of American States (OAS) Caribbean Disaster Mitigation Project (CDMP), national building codes have been developed in Antigua and Barbuda, Belize, Dominica,

Grenada and St. Lucia. A building inspector training course was also carried out within these countries as part of the CDMP. Hurricane resistant home improvement programmes were carried out in Antigua and Barbuda, Dominica, and St. Lucia.

Significant hazard mapping work has been undertaken at the local and regional levels within the Caribbean. As part of the CDMP, the Caribbean Disaster Emergency Response Agency (CDERA) has undertaken two workshops to introduce hazard mitigation planning in the Caribbean. Hazard mapping have been conducted for storm related hazards, beach erosion, landslides, drought and flood in some Caribbean territories. With the support of the CDMP, Jamaica has undertaken the development of a comprehensive national hazard mitigation policy. As part of the CPACC project (see figure 6), CDERA has developed a Coastal Resource Information System (CRIS) to capture and store data gleaned from hazard mapping and vulnerability assessments throughout the Caribbean (OAS 2001).

Structural measures that have used in the Caribbean as coastal adaptations to climate change includes: beach nourishment in order to enhance resilience of particular beaches, the construction of groynes, sea wall, revetments and breakwaters. A component of the CDMP included *Coastal Infrastructure Design, Construction and Maintenance Training* which has been completed. Coastal engineering structures will become increasingly necessary as sea level rise threatens low-lying coastal communities.

V) RECOMMENDATIONS

Caribbean SIDS are at different stages of development with respect to climate change and disaster risk management (CDERA 2006). Hence recommended programmes such as those outlined below seek to both strengthen the response capacity of the region as a whole, as well as that of individual Caribbean States.

Ongoing strengthening of the existing institutional and technical capacity to adapt to climate change - This requires a comprehensive review of the laws, policies and programmes governing land development and use of natural resources, with the aim of integrating climate change into national and local sustainable development initiatives. This is a dynamic process, as opposed to a one-off event and will require an ongoing systematic review of the legal and institutional framework in each Caribbean country to ascertain what further legal and institutional changes are needed to adapt to climate change. Technical capacity, particularly in the area of vulnerability assessment, is lacking and needs to be improved. Likewise, there is a need for greater transfer of knowledge and technology on climate change among Caribbean SIDS, as noted by the CCCC (2009). As observed in the Caribbean Planning for Adaptation to Global Climate Change Project, (April 2002) there is an over reliance on expert knowledge, as opposed to concrete scientific data, with regards to formulating conclusions regarding the impact and vulnerability of Caribbean SIDS to climate change. Thus detailed vulnerability assessment in each Caribbean country, as well as further development of regional climate change models, such as being done under the PRECIS Caribbean Climate Change Project needs to be further encouraged so that there can be locally generated scientific data to help determine the best adaptation options. While individual Caribbean islands have been developing their own Geographic Information System (GIS) and conducting hazard mapping, the development of a regional GIS would enhance information sharing and further aid in the production of hazards maps in the region.

Integration of climate change initiatives into the physical and economic planning system - Given their limited capacity and resources, the governments of the Caribbean must make adaptation to climate change a key component of their sustainable development plans. This process can be termed ‘climate proofing’ whereby national strategic development

policies and plans, land use planning regulations, building codes and standards are all cognizant and responsive to climate change. Thus both infrastructure and community projects will be developed in keeping with the locally anticipated effects of climate change. The Pacific islands of Micronesia, national strategic development plan provides an example of 'climate proofing' by requiring that infrastructure be located, designed, built and maintained to avoid unacceptable risks associated with natural hazards, including extreme variations in the local weather and climate. In addition, national climate risk assessment is also mandated in order to ensure that risks to infrastructure development projects are identified and addressed in a cost effective manner at the design stage (Kono 2007).

Promotion of local community oriented and self-sustaining climate change initiatives – Coastal communities are particularly at high risk from climate change induced hazards. Consequently, projects and programmes geared at adapting to the effects of climate change must receive the full support of such communities in order to be successful. A number of climate change related projects and programmes in the Caribbean are funded by international donor agencies, and as of such they run the risk of being terminated once the funds are exhausted. It is, therefore, important that local funding and expertise are created to provide ongoing follow up activities to internationally funded projects. The Community Vulnerability and Adaptation (CVA) programme developed by SIDS in the South Pacific provide a model which the Caribbean can adapt and modify to specifically meet the climate change adaptation needs of its coastal communities (CARICOM & UNDP 2006). The model emphasizes collaboration with NGOs and other organizations who specialise in areas such as tourism, fishing and environmental issues.

Strengthening the resilience of natural systems to climate change impacts – Natural ecosystems such as mangroves, coral reefs and forests play a vital role in reducing disasters from climate change. Greater protection of these fragile, yet vital ecosystems is needed to improve resilience to climate change in the Caribbean, as built development from urbanization and tourism continues to destroy their existence. The promotion of green spaces within Caribbean towns and cities will not only add to their aesthetic value, but will also reduce their carbon footprint by absorbing some of the CO_2 generated in these urban environments.

VI) CONCLUSION

While the Caribbean produce only a tiny fraction of ozone depleting greenhouse gas emissions, the extensive low lying coastal urban settlements and economic centres which characterize the Caribbean puts the majority of the region's population at direct risk to the effects of climate change. In addition, the fact that marine oriented tourism is the principal pillar of the Caribbean economy means that effectively addressing the issue of climate change is of crucial importance to the survival and sustainable development of Caribbean SIDS. The inextricable link between the natural environment and the prevailing economic system in the Caribbean means that the response to climate change must address the economic realities of today while pointing to the economic opportunities of the future. The critical question is, therefore, how can planners in the Caribbean create more liveable, economically and ecologically sustainable human settlements in highly climatic hazard prone areas given the existing financial constraints, coupled with the inadequate legal, institutional and technical capacity within the region? As daunting as this challenge appears, the consequences of inaction are even more dire, as pointed out in **Figure 5**. Hence the political will must be employed to garner the necessary resources needed to effectively address the issue of climate change.

The scope of response required by Caribbean SIDS to adapt to, and mitigate the effects climate change varies as each island state has its own special adaptation needs and resource constraints. To be effective, adaptation and mitigation efforts have to be vertically integrated from the regional, national to community levels, as well as horizontally integrated across the various sectors within Caribbean SIDS, supported by appropriate institutional, legal and policy mechanisms. Future adaptation and mitigation efforts on climate change must coincide with the sustainable development goals in each country, as sustainable development options must also serve as adaption options to climate change in the Caribbean. Most importantly, climate change initiatives in the Caribbean should be self sustaining and builds on the principle of people centeredness where local communities are placed at the heart of climate change adaptation and mitigation planning.

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