

# **CLIMATE CHANGE AND DEVELOPMENT IN THE CARIBBEAN SUB-REGION**

**by**

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## **INTRODUCTION**

Over the last fifteen years the climate change problematique has emerged as a major area of concern for the small island and low-lying coastal developing states of the Caribbean region. Indeed the Barbados Programme of Action (BPOA) articulated at the SIDS environmental meeting in Barbados in 1994 accorded the highest priority to addressing the emerging climate change hazard. Since then the Caribbean region has been pursuing several initiatives aimed at understanding the scope of the challenge faced by the region as a result of changing climate and developing strategies whereby the likely impacts of such change can be ameliorated.

Empirical evidence, from studies undertaken by the IPCC in their Fourth Assessment Report, suggests certain trends in the global and regional climate.

- eleven of the last twelve years (1995 -2006) rank among the 12 warmest years in the instrumental record of global surface temperature<sup>9</sup> (since 1850);
- new data since the Third Assessment Report now show that losses from the ice sheets of Greenland and Antarctica have very likely contributed to sea level rise over 1993 to 2003;
- global average sea level rose at an average rate of 1.8 [1.3 to 2.3] mm per year over 1961 to 2003. The rate was faster over 1993 to 2003, about 3.1 [2.4 to 3.8] mm per year;
- more intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics. Increased drying linked with higher temperatures and decreased precipitation have contributed to changes in drought regimes;
- the frequency of heavy precipitation events has increased over most land areas, consistent with warming and observed increases of atmospheric water vapour;
- widespread changes in extreme temperatures have been observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days, hot nights, and heat waves have become more frequent; and
- there is observational evidence for an increase of intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases of tropical sea surface temperatures.
- consistent warming trends in all small-island regions have been observed over 1901 to 2004. The percentage of days having very warm maximum or minimum temperatures has increased considerably since the 1950s, while the percentage of days with cold temperatures has decreased (Peterson et al., 2002).
- The maximum number of consecutive dry days is decreasing and the number of heavy rainfall events is increasing.
- Since 1995, all but two Atlantic hurricane seasons were above normal.
- There was a mean relative rise in sea level in the Caribbean of 1mm/year in the 20<sup>th</sup> Century

Although in its initial stages the climate change debate was mainly concerned with green house gas (GHG) mitigation, it was realised that due to the inertia in the earth's climate system, regardless of global efforts to significantly reduce GHG emissions projected changes in global climate would continue to be observed with dire consequences for SIDS and low lying coastal countries. As a result it is now generally accepted that for the Caribbean region, our immediate priority in terms of responding to global climate change (GCC) is adaptation.

## **OVERVIEW OF CLIMATE VARIABILITY AND CHANGE IN THE REGION**

Most of the islands in the Caribbean lie within the hurricane belt and are prone to frequent damage from seasonally intense weather systems. The reality of the vulnerability of the region has more recently been highlighted when Hurricane Ivan hit Grenada in September 2004. Damage assessments indicate that, in real terms, the country's socio-economic development has been set back by at least a decade – by a single event which lasted only a few hours!

So, even, without climate change, the integrity of the region's natural resources is already compromised by existing environmental stresses. Although the full impacts of climate change are unclear, it is certain that climate change will exacerbate present-day regional vulnerability to climate variability. Despite wide acceptance of this, the response from Caribbean states to climate variability and change has been inadequate. This is mainly due to lack of resources to assist where many natural systems are very degraded, and human systems are highly inflexible.

Studies in the region so far confirm that climate in the Caribbean region has changed in a manner very consistent with the observed variations at global and northern hemisphere levels. Temperature records have shown an increase in the last century, with the 1990's being the warmest decade since the beginning of the 20<sup>th</sup> century - 1998 being the warmest on record. Results from studies done by the Institute of Meteorology (INSMET) in Cuba and the University of the West Indies (UWI) indicate that the region is warming; the diurnal temperature range is decreasing; the number of warm days in the region is increasing but the number of very cold nights is decreasing; the frequency of droughts is increasing and the frequency of extreme events in the region seems to be changing. With respect to the latter, flooding events and hurricane passage through the region have increased since the mid 90's.

Using the Hadley Centre's PRECIS regional climate model (PRECIS Caribbean Climate Change Project, 2007) preliminary outputs indicate:

- an annual warming by the 2080s of between 1° and 5 ° C depending on the region and scenario employed;
- Greater warming in the northwest Caribbean territories (Jamaica, Cuba, Hispanola, Belize) than in the eastern Caribbean island chain; and
- Greater warming in the summer months than in the cooler and traditionally drier earlier months of the year.

The main projections on change in average rainfall are:

- A drier main Caribbean basin in the annual total by 2080s, except for western Cuba, South Bahamas, Costa Rica and Panama.
- A pronounced north- south gradient in rainfall change during the Caribbean dry season (January to April).
- Summer drying is more severe i.e. during the Caribbean wet season.

In essence there is enough evidence to conclude that:

- Climate in the Caribbean is changing in line with global trends;
- Average temperature has increased and will continue to do so;
- Precipitation patterns are changing leading to a drier Caribbean;
- Hurricane intensities are increasing and there is a tendency for hurricanes to form further South than normal;
- There is a shorter return period for extreme events (floods, droughts);
- Sea water temperatures have increased ( leading to episodes of bleaching of corals); and
- Sea level is rising (leading to aquifer intrusion and salinisation).

## **GREENHOUSE GAS (GHG) EMISSIONS AND MITIGATION**

The Fourth Assessment Report of the Intergovernmental Panel of Climate Change concluded that global atmospheric concentrations of carbon dioxide, methane and nitrous oxide (Green House Gases (GHGs)) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in GHG concentration are attributable to anthropogenic influences with increases in carbon dioxide concentration due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture (IPCC FAR 2007).

Based on greenhouse gas inventories for the base years 1990 or 1994 conducted in the preparation of their First National Communications, it has been observed that most Caribbean countries constitute a net source of GHG emissions. This is particularly the case in Trinidad and Tobago which is very industrialised. (This country now has an even higher per capita emission rate than the United States!) However, three exceptions were Dominica, Belize and Guyana which were net GHG sinks due to the relatively large CO<sub>2</sub> removals reported in the Land Use Change and Forestry (LUCF) sector compared to emissions from all the other sectors. When considering CO<sub>2</sub> only, Cuba, Dominica, Belize, Guyana and St. Lucia showed that removals by sinks in LUCF exceeded their total CO<sub>2</sub> emissions.

The energy sector was the largest source of GHG emissions for most Caribbean countries, except for Haiti, where the agricultural sector was the largest source and St. Lucia where it was the waste sector.

Fuel combustion in the energy sector accounted for the largest share of CO<sub>2</sub> emissions for all countries, ranging from 66 per cent in Trinidad and Tobago to 100 per cent in Antigua and Barbuda, the Bahamas, Guyana, Haiti, St. Kitts and Nevis, and St. Lucia of total CO<sub>2</sub> emissions. Total CO<sub>2</sub> emissions (excluding LUCF) increased over the period 1990 to 1994 in some Countries.

Caribbean countries have also identified possible mitigation measures in the energy sector, covering the supply and demand sides. Measures on the supply side included, among others, energy conservation and efficiency, cogeneration, increasing transformer efficiency, modernisation of thermoelectric utilities, fuel switching, electricity imports, reduction of losses in transmission and distribution, improvement of transport infrastructure, development of plans to promote rural electrification and use of renewable energy sources. On the demand side, mitigation options in the industrial, residential, commercial sectors include the enhancement of energy efficiency in lighting, cooling, cooking and air conditioning; implementation of demand-side management programmes; promotion of fuel switching; and use of renewable energy.

In the transport sector, mitigation measures identified include development of road transportation master plans; introduction of electric or compressed natural gas vehicles, encouragement of early adoption of hybrid vehicles, discouragement of the use of private vehicles, improvement of the public

transport system, introduction of vehicle emission standards, adoption of legal measures to limit the importation of used and/or reconditioned vehicles, modernisation of locomotives, improvement of road infrastructure as well as passenger and freight vehicle efficiency. However, abatement options in the energy sector are still at an early stage of assessment in most countries except for the extensive use of solar water heaters in Barbados and Antigua and Barbuda; solar techniques for drying sugar cane in Barbados; electricity generation using bagasse in Cuba; and cogeneration in Guyana and Belize. Many countries are also more recently exploring the possibility of using wind energy as a mitigation measure e.g. a 15 megawatt wind farm in Jamaica and a 10 megawatt farm in Barbados.

Caribbean countries are heavily dependent on fossil fuel combustion and, with the exception of Trinidad and Tobago, they are predominantly net energy importers. In a regional scenario of limited resources, the rising cost of energy imports is putting a severe drain on the limited financial resources of most Caribbean countries. The region's consumption of petroleum fuel has increased from slightly over 116 million barrels in 1985, costing US \$530 million, to over 160 million barrels in 2004, costing more than US \$6.5 billion. There is no doubt that increasing oil prices are having a dramatic effect on Caribbean economies and hence on their ability to find resources for adaptation to climate change. Adopting mitigative actions to deal with the energy sector must therefore be viewed as an essential component of any adaptive strategy for countries in the region.

## **CLIMATE CHANGE IMPACTS**

The Caribbean region is expected to be impacted on by rising sea level, warming sea water temperatures, changing weather patterns, more intense hurricanes, warmer temperatures and a more frequent occurrence of extreme weather events.

The main impacts from sea-level rise are erosion and setback of coastlines, increase of salinity in estuaries and wetlands with the death of mangroves, salt water intrusion into aquifers, beach degradation and losses, decrease in productivity of coastal fisheries and devastating effects on species of coral. For almost all coastal countries, including the small island developing States, climate change and its consequent sea-level rise will have a devastating effect on coastal communities and infrastructure.

The agricultural sector is adversely affected by increased climate variability and extreme events such as droughts and hurricanes, a loss of soil fertility and erosion, leaching of mineral fertilizers, heat stress on animals and the indirect effects of sea-level rise. These impacts are expected to translate into lower productivity in general, also through the reduced quality in fodder that will result in a lower productivity of livestock.

The tourism sector with its dependence on climate sensitive natural attributes of the region and its concentrated development on vulnerable coasts will experience negative impacts from climate change. The sector is already vulnerable as a result of exposure to hazards arising from climate variability, a vulnerability that is reflected in the difficulty experienced by many operators in the sector to obtain affordable insurance cover for their assets

More intense rains can result in increased runoff and the risk of flash flooding and land slippage as evidenced by recent events in Haiti. However, it is expected that climate change will cause an overall reduction in water resources and quality in the region. This is particularly disturbing for those countries that are already experiencing water shortage problems – such as Barbados and Antigua and Barbuda. Decreased river flow will also have a negative impact on the hydroelectric installations in countries like Dominica and St Vincent and the Grenadines.

The incidence of endemic diseases as a consequence of climate change, due to population growth and poorer sanitary conditions is also likely to increase. Changes in the temperature regime associated with climate change will increase the incidences of water and vector-borne diseases, as well as those related to water contamination, for example: malaria, dengue and diarrhea. Recent studies by Chen et al have confirmed the potential impact of climate variability on the incidence of dengue fever in the region. According to Professor Chen "The incubation period of the *Aedes aegypti* mosquito shortens at high temperatures and the higher the temperature, the quicker the mosquito breeds. The parasite will become more active in a shorter time. That means the transmission of the disease will become greater." Higher temperatures will also stress persons, thereby making them more prone to sicknesses. Guyana specifically reported on an increase in the incidence of skin cancer within a section of the population as a result of higher incidences of UVB radiation and higher surface temperatures.

Increased aridity will result in a decrease in land cover vegetation lower productivity of forests and rangelands. There may also be a displacement of ecosystems, changes in species composition and the proliferation of pests. Unusual climatic conditions were thought to be responsible for the infestation of thousands of hectares of pine forest in Belize by the pine beetle leading to extensive die off of previously pristine forest. This in turn led to massive forest fires, biodiversity loss and subsequent loss of top soil in an ensuing episode of unusually high rainfall.

Climate change impacts on fisheries are expected to stem from destruction of nursery areas and breeding grounds, such as mangroves and coral reefs, availability of nutrients and increased water temperatures. The availability of fish can also be affected by altering the distribution of the resources that fish depend on. Recent modeling of fish habitat in the Caribbean has shown that with a one degree centigrade rise of seawater temperatures above present average, commercial species will migrate northward out of the region to cooler water. This will have serious implications for the livelihoods of coastal communities in the region and will seriously impact on the nutritional integrity of a population that depends so heavily on the marine environment for their protein intake.

Over the last three decades, the Caribbean countries have suffered direct and indirect losses due to natural disasters estimated to be between US\$700 million and US\$3.3 billion (IADB Report, 2002). A recent estimate of the potential economic consequences of the impacts of climate change on the economies of Caribbean countries (Haïtes, 2002), in a "no-adaptation" scenario, ranges from 5% to over 30% of GDP on average (annualised values), with an even broader range for some individual countries.

## **ADAPTATION OPTIONS AND MANAGEMENT INTERVENTIONS**

Adaptation in the region thus far has been informed by the urgent need to respond to risks arising from climate variability. This approach has been adopted by the GEF-funded Caribbean Planning for Adaptation to Climate Change (CPACC) project, and the preparation of National Adaptation Plans of Action. Regional and national consultations have improved understanding of perceptions of vulnerability to climate variability, capacity to cope and effective current responses.

Under one of the components of the CPACC project countries were assisted with the formulation of a National Climate Change Adaptation Policy and Implementation Plan. These Policy documents sought to integrate the consideration of climate change adaptation issues across the entire spectrum of a country's development planning process. This Component of the CPACC project was intended to assist national governments to:

- a) strengthen national capacity for analysing climate and sea level dynamics and trends, seeking to determine the immediate and potential impacts of GCC.
- b) identify areas particularly vulnerable to the adverse effects of climate change and sea-level rise;
- c) develop an integrated management and planning framework for cost-effective response and adaptation to the impacts of GCC.
- d) Identify and assist in the development of policy options and instruments that may help initiate the implementation of a long-term programme of adaptation to GCC in vulnerable coastal areas.

The process to develop a National Climate Change Adaptation Policy commenced with the preparation of a National Issues Paper that was prepared by the country National Focal Point and climate change committee in consultation with key national stakeholders. These “Issues Papers” served to:

- (i) identify the national context within which adaptation and vulnerability issues will, where possible, be discussed during subsequent national workshops. These issues included the physical character, local climatology, important ecological attributes, a brief socio-economic profile of the country and a statement of other factors which can exacerbate vulnerability to climate change;
- (ii) identify the critical issues, factors and processes that require urgent attention if meaningful policies and strategies for adaptation to climate change are to be designed and implemented;
- (iii) prioritise identified issues of concern; and
- (iv) summarise institutional and legal structures for responding to identified issues of concern.

The Issues Papers identified the following climate change factors of concern to the region:

- sea level rise
- increased temperature (including ocean temperature rise)
- possible increase in the intensity and frequency of storms
- increased magnitude and intensity of storm surges
- changes in rainfall and temperature patterns as manifested in more extreme weather conditions

The Issues Papers also identified sectors at risk from the likely impacts of climate change that were considered as requiring priority attention.

- Coastal zone
- Hydrological characteristics and water resources
- Human settlement and infrastructure
- Human health
- Tourism
- Agriculture and fisheries (food security)
- Forestry and terrestrial biodiversity

Most of the conclusions drawn from the Issues Papers depended to a great extent on the experience and expert judgment of the stakeholders who participated in the consultative process.

Under Component 6 (*Coastal Vulnerability and Risk Assessment*) the CPACC project, Guyana, Barbados and Grenada have conducted in depth vulnerability assessments for selected pilot sites. This component involved a review of existing coastal vulnerability assessment models (IPCC and UNEP) to develop a customised methodology for the three countries. In preparation of the National

Communications for countries that are signatories to the UNFCCC, vulnerability assessments have also been conducted for various socio-economic sectors, and evaluation of impacts on specific economic activities (e.g. “*Potential Impacts of Greenhouse Gas Climate Change Scenarios on Sugarcane Yields in Trinidad*”) have been the focus of some other climate change-related studies over the past few years since the recognition of the pervasiveness of climate change. Many of these studies have generally been weak in their treatment of adaptation options, which has rarely gone beyond the preparation of lists of possible adaptation measures. However, all of these studies recognise that the region is indeed vulnerable, and conclude that climate change impacts will vary even within the region and implementing adaptation measures can reduce vulnerability significantly and even enhance any beneficial impacts, but will not prevent all damages. These studies also recognise that the region has considerable experience with climate variability and to some degree has put measures in place to address natural disasters arising therefrom. Caribbean States can therefore draw upon experience with adaptation to climate variability and extremes to develop appropriate policies and strategies for adapting to likely climate change effects.

The studies supported the conclusions derived from the exercise of articulating National Issues Papers in terms of likely climate change impacts and the sectors which would be most vulnerable to these impacts. The key vulnerability issues identified by these pilot studies were as follows:

- Intensification of water scarcity
- Negative impacts on human settlement and infrastructure
- Negative impacts on the economy especially on tourism
- Disruption of coastal zone ecosystems
- Negative impacts on fisheries and agriculture
- Impacts on public health

Another project, built on the foundations of CPACC, was the Adaptation to Climate Change in the Caribbean (ACCC) funded through the Climate Change Development Fund (CCDF) of the Canadian International Development Agency (CIDA). Under this project the region has built capacity for integrating adaptation to climate change into the physical planning process, in the private sector and governments, using a risk management approach.

Risk management has been regarded as providing an excellent framework for facilitating decision making in an environment of uncertainty. Given the uncertain nature of climate change science at this juncture it is therefore not surprising that the Risk Management approach is being adapted to facilitate the choice of appropriate policy options for dealing with climate change adaptation.

Under the ACCC project the Canadian Standards Association (CSA), “Risk Management Guidelines for Decision Makers” an approved National Standard of Canada was adapted to assess climate change risks in the Caribbean. This component was designed to:

- Identify how a risk management approach can address climate change risks in the Caribbean;
- Review appropriate sectoral approaches for integrating risk management into climate change adaptation planning and management.
- Identify mechanisms whereby risk management processes can be integrated into existing legal, institutional and policy frameworks; and
- Identify an appropriate process to initiate the integration and consideration of risk management processes between the various sectors; and
- Integrate sectoral adaptation measures into National Development Planning.

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<sup>1</sup> Singh, B. and M. El Maayar, (1998)

The Mainstreaming of Adaptation to Climate Change (MACC) project, now being implemented in 12 CARICOM states and 5 UK Overseas Territories seeks to mainstream climate change adaptation into national development planning and supports building the knowledge base for adaptation through developing regional climate change scenarios through climate modelling, vulnerability assessments, climate change impact studies, identifying and costing adaptation options and incorporating the latter into national sectoral development plans.

Throughout the national communications in the Caribbean countries have identified possible management options and interventions which could play an important role in aiding countries to adapt to climate change. Many countries in the region have identified their adaptation options by examining the sectors and using expert judgement to suggest management options which would facilitate adaptation in the sector. There are few references to scientific or other studies, or the use of quantitative methods to determine the next steps to cope with the adverse impacts of climate change. Expert judgement has been used to identify many of the adaptation options being posited.

In the water sector most countries have identified the need for water conservation and water management techniques to be applied. This is consistent within the communications although the water situation in many of the countries is very different. Desalination has also been identified as a possible adaptation option, but the need for continuous water resource assessments is an adaptation option which has also been identified

In the tourism sector many countries have noted the need for the diversification of the industry with a movement towards ecotourism and heritage tourism. Given the concentration of tourism infrastructure many countries have identified the need for coastal protection structures not only for tourism but to protect other critical infrastructure and reduce erosion rates on beaches.

Many countries have also identified the need for hazard mapping, and the application of building codes to aid in future development but also to prevent developments in areas which will be susceptible to climate change. There will also be the need for the reinforcement of many buildings in areas which are considered susceptible to climate change. The need for the controlling of building in susceptible areas is consistently mentioned, with the use of setbacks and other policies suggested. These policies are basically being used to protect human settlements and also to protect critical infrastructure. Early warning systems for natural disasters have also been identified as key adaptation tools. Many national communications have noted that very little work has been in the area of human health and identify this area for more research, as there is concern of an increase in vector borne and water borne disease, with the climatic changes. There is also the concern that there could be increases in heat related illnesses (e.g. heat stroke), but there is the continued need for research on the impacts of human health.

In terms of adaptation options for the agricultural sector diversification has been highlighted as one of the possible options. However the need for further research into drought resistance cultivars has also been identified. Research as an adaptation option for agriculture is clearly critical for many Caribbean countries given the dependence on agriculture for many Caribbean economies. Research in the forestry sector along with watershed management, and reforestation have been identified as possible options for the forestry sector.

Research and monitoring are required for fisheries, but many countries have also noted that there is a need for detailed monitoring programmes for coral reefs and fisheries to be put in place.

In many instances public awareness has been identified as an important adaptation option which can aid in changing behaviour so that practices such as constructing in susceptible areas, or planting certain crops that are unsuitable for a changing climate, will change. It is clear that public awareness

is a key adaptation activity which will have to be undertaken to accompany any future climate change programme in the Caribbean.

In many instances the adaptation options identified are sustainable development practices which can also allow for the issue of climate change to be integrated into national development planning. For example many countries will carry out the water resource management independent of the climate change issue. The opportunity therefore lies in integrating climate change concerns into many sustainable development practices. Several of the possible adaptation options identified also coincide with actions being implemented under other conventions – Desertification and Biodiversity. Caribbean countries should therefore explore options for developing synergies between these Conventions when designing appropriate response measures to meet their obligations under the respective Multilateral Environmental Agreements. Capacity building, research and monitoring are also key activities which need to be supported as there is a dearth of scientific data and other basic information in the region to support work on climate change adaptation.

Caribbean, countries will have to take effective measures to manage natural hazard<sup>2</sup> risks and become more resilient to the negative impact of natural hazards and related environmental disasters.

Additionally, countries in the region were involved in implementing the Caribbean Disaster Mitigation Project (CDMP) funded by the Offices of Foreign Disaster Assistance (OFDA) (1993 – 1999). The broad purpose of the CDMP was to establish sustainable public/private sector mechanisms which invariably lessen loss of life, reduce the potential of physical and economic damage and shorten the disaster recovery period in the project area. The project sought to make development more sustainable by strengthening the linkage between development and disaster reduction.

*To support this objective, CDMP sought to achieve three programme results:*

- Promotion of the acquisition and application of disaster mitigation skills, techniques and methodologies;
- an increased pool of professionals in the region with disaster mitigation skills;
- incorporation of mitigation activities in post disaster reconstruction and recovery programmes.

*Six project outcomes were posited:*

- Reduced vulnerability of basic infrastructure and critical public facilities
- Improved building standards and practices to reduce natural hazard vulnerability.
- Increased availability and access to natural hazard/disaster risk information for use by stakeholders
- Increased community awareness of and involvement in disaster preparedness and mitigation measures
- Improved ability of public sector and private property insurers to link premium structure to risk
- Incorporation of mitigation activities in post-disaster reconstruction/recovery.

This project facilitated the shift of the disaster management paradigm from that of *disaster response* to one of *disaster reduction* as embodied in the ISDR.

## **MAIN OBSTACLES TO CLIMATE CHANGE ADAPTATION**

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<sup>2</sup> A 'hazard' has potential to cause significant negative impacts on community elements and can be natural, human-induced or technological in nature. It is not in itself, a disaster, but the potential cause of one.  
(Comprehensive Hazard and Risk Management (CHARM): Guidelines for South Pacific Islands, 2001

Climate change adaptation has emerged recently as an imperative for developing countries in the region. Although the region has the financial resources and technical capacity to implement certain “no regrets” adaptation options immediately governments are not yet disposed to invest in these measures due to a lack of sufficient understanding of the climate change phenomena in the region to inform policy. Most measures therefore that might be determined as adaptive are not the result of a direct response to climate change impacts but to some other stressor e.g. investment in desalination plants in some countries in the region – Antigua and Barbuda, Barbados, Trinidad and Tobago, Curacao, Aruba. Other adaptive practices e.g. water harvesting, mulch agriculture, Building Codes etc. are employed in several countries in the region but these are not informed by knowledge of the extent of climate change the region is expected to experience.

Apart from the absence of awareness, the region along with other developing countries have identified the lack of resources as a major obstacle to climate change adaptation activities. Although the UNFCCC provides for the provision of these resources by the major polluting developed countries these have not been realised and remain a major bone of contention between developed and developing countries. Related to the issue of resources is the question of favourable terms for the transfer of technology for adaptation in developing countries. This too has not been forthcoming.

In summary one can conclude that the main obstacles to climate change adaptation in the sub-region are lack of awareness at the policy level, lack of capacity to develop decision support tools for policy makers, lack of resources and access to appropriate technology for adaptation on favorable terms.

## **CAPABILITIES AND GAPS**

Most SIDS suffer from a lack of capacity and limited availability of data for rigorous climate and vulnerability studies. Projecting the extent of climate change is a starting point in developing adaptation programmes. This forms the basis of quantifying climate change impacts on critical socioeconomic sectors and hence of designing appropriate adaptation options. Our experience over the last ten years implementing capacity building for climate change adaptation in the region has revealed the following gaps:

- The existing climate change models are global in nature and too aggregated to permit projections at the Caribbean countries' level. These models require downscaling (dynamic) to be tailored to meet the requirements of Caribbean SIDS. In addition capacity to carry out statistical downscaling of global climate models need to be enhanced.
- Capacity for trend analyses of climate data is an essential need to help validate modeling work in the region.
- The information database on climate and sea-level monitoring, including monitoring of coral-reefs, which feeds into the climate change projection, is limited. There is a need for upgrading infrastructure in the already created under CPACC to deepen the process of collection, analysis and mapping for a comprehensive climate and sea-level monitoring information database.
- In addition, standard mapping and interpretation approaches need to be developed to make the information easy to understand by the policy makers, the private/public sector and the civil society.
- The knowledge base to effectively perform climate change impact assessment on Caribbean ecosystems is weak. This includes an assessment of the physical and socio-economic vulnerabilities and risks associated with climate change that is insufficient to inform the process of identification of climate change risk and formulation of appropriate adaptation strategies.

- Models and capacity to assess the impact of climate change scenarios on coastal ecosystems and on the water-cycle specific to the Caribbean SIDS' situation are yet to be developed.
- In most Caribbean SIDS, there is a lack of comprehensive inventory of existing critical facilities to assess the vulnerability of key infrastructure and economic sectors to climate change.
- The focus of the limited vulnerability assessments carried out until now ignores the social vulnerabilities and does not incorporate community level information in the assessments.
- The range of available climate change impact models, vulnerability and risk assessment methodologies needs to be carefully reviewed, selected, tailored and applied to regional economies, so as to develop a more refined and reliable knowledge base covering the expected impacts of climate change on the national economies.
- Methodologies for cost benefit analyses of climate change adaptation options.
- Sectoral impact studies – water, agriculture, tourism, health.
- Impact studies on ecosystems (terrestrial & marine), human settlement, coastal infrastructure.
- Public education and outreach.
- Definition of the climate change risk in the region so as to facilitate the design and availability of appropriate and affordable insurance instruments.

## **CONCLUSION**

Immediate action is required to increase current resilience to risks arising from climate variability in order to improve capacity to respond to long-term climate change and ensure sustainable development in the region. However to better inform the process of adaptation to climate change the region needs to address the knowledge-base through climate modeling, vulnerability assessments and impact studies so as to better identify and quantify adaptation options to inform national policy decisions on adaptation. That said, there are several 'no regrets' adaptation actions that countries can and should embark on, in that they are capable of increasing the resilience of the natural, built, social, economic and human systems of the region to projected climate change impacts.

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