

# **Caribbean Regional Research Diagnostic**

Climate Change and Development  
Research Capacities and Regional  
Priorities in the Caribbean

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This document has been prepared by Acclimatise for the Climate Development Knowledge Network, on behalf of CARICOM's Caribbean Community Climate Change Centre, to provide a research diagnostic to assist in delivery of the Implementation Plan to guide the delivery of the 'Regional Framework to Achieving Development Resilient to Climate Change'.

The Climate and Development Knowledge Network (CDKN) is managed by an alliance of organisations led by PricewaterhouseCoopers LLP (PwC), and including Fundación Futuro Latinoamericano, INTRAC, LEAD International, the Overseas Development Institute, and SouthSouthNorth. CDKN's purpose is to support decision makers in developing countries to design and deliver climate compatible development. For more information visit the CDKN website: [www.cdkn.org](http://www.cdkn.org).



# List of acronyms and abbreviations

ACCC	Adaptation to Climate Change
AIACC	Assessments of Impacts and Adaptations to Climate Change
BPoA	Barbados Plan of Action
CACCE	Coastal Areas Climate Change Education Partnership
CANARI	Caribbean Natural Resources Institute
CARIWIN	Caribbean Water Initiative
CARDI	Caribbean Agricultural Research and Development Institute
CARICOM	Caribbean Community. Members of CARICOM are: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago.
CCBIC	Climate Change and Biodiversity in the Insular Caribbean
CCCCC	Caribbean Community Climate Change Centre
CC CRA	CARIBSAVE Climate Change Risk Atlas
CCMI	Caribbean Climate Modelling Initiative
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CDKN	Climate and Development Knowledge Network
CDM	Clean Development Mechanism
CDRMP	Caribbean Disaster Risk Management Program
CERMES	Centre for Resource Management and Environmental Studies
CHAMP	Caribbean Hazard Mitigation Capacity Building Programme
CIDA	Canadian International Development Agency
CIMH	Caribbean Institute of Meteorology and Hydrology
CLLJ	Caribbean Low-Level Jet
CMIS	Caribbean Modelling Initiatives
CPACC	Caribbean Planning for Adaptation to Climate Change
CREDP	Caribbean Renewable Energy Development Programme
CRIS	Coastal Resources Information System
CSGM	Climate Studies Group, Mona
DFID	UK Department for International Development
EIA	Environmental Impact Assessment
ENSO	El-Niño Southern Oscillation
EUCARINET	EU Caribbean Research and Innovation Networks
GCM	Global Climate Model
GDP	Gross Domestic Product
GECAFS	Global Environmental Change and Food Systems
GEF	Global Environmental Facility

GHG	Greenhouse Gas
GIS	Geographic Information Systems
HAB	Harmful Algal Bloom
ICT	Information and Communication Technology
IDB	Inter-American Development Bank
IDLO	International Development and Law Organization
IIED	International Institute for Environment and Development
INSMET	Instituto de Meteorología, Cuba
IP	Implementation Plan
IPCC	Intergovernmental Panel on Climate Change
LACREG	Canada-Latin America and the Caribbean Research Exchange Grants
LCDS	Low Carbon Development Strategy
MACC	Mainstreaming Adaptation to Climate Change
MDG	Millennium Development Goal
MRI	Meteorological Research Institute, Japan
MSD	Mid Summer Drought
NEA	National Enabling Activities
NGO	Non-government organisation
NOAA	US National Oceanic and Atmospheric Administration
NRM	Natural Resources Management
OAS	Organization of American States
PRECIS	Providing REgional Climates for Impacts Studies, regional climate modelling system
RCM	Regional Climate Model
RECCC	Review of the Economics of Climate Change in the Caribbean
REMO	REgional atmosphere MOdel
RISA	Regional Integrated Sciences and Assessments
RWH	Rain water harvesting
SECCI	Sustainable Energy and Climate Change Initiative
SIDS	Small Island Developing State
SRES	Special Report on Emissions Scenarios
UNDP	United Nations Development Programme
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UWI	University of the West Indies
WHO	World Health Organisation
WRF	Weather Research and Forecasting model

# Contents

<b>Executive Summary</b>	<b>1</b>
<b>1 Introduction</b>	<b>2</b>
1.1 Context of the Regional Diagnostic	2
1.2 Objectives of the Regional Diagnostic	4
1.3 Research Diagnostic Methodology	4
<b>2 Climate Change and Development Priorities</b>	<b>6</b>
<b>3 Caribbean Climate Change Research Programmes</b>	<b>9</b>
3.1 Climate Modelling, and Impact and Economic Modelling Implementation Plan (2011–2021)	9
3.2 Developing National Research and Monitoring Capacity for the Management of Belize's Marine Protected Areas and Natural Resources	111
3.3 Regional climate modelling, including PRECIS, WRF, RegCM3 and ERA15	111
3.4 Hydrological modelling	11
3.5 Climate Change and Biodiversity in the Caribbean (CCBIC) Project (2007 - 2008)	122
3.6 Regional Framework	122
3.7 Assessment of Legal Preparedness for Participation in the Carbon Market by Members of the Caribbean Community (2011)	122
<b>4 Priority Research Gaps and Key Research Questions in the Caribbean</b>	<b>13</b>
4.1 Priority research gaps	13
4.1.1 Impacts	13
4.1.2 Responding to a changing climate	20
4.1.3 Evaluating climate compatible development	23
4.1.4 Policy processes	23
<b>5 Research Networks and Partnerships</b>	<b>24</b>
5.1 Existing research networks and partnerships on climate change and development in the Caribbean	24
5.2 Potential partnerships	26
5.3 Developing the research / policy interface	26
5.4 Developing research networks	27
<b>6 Research Capacity in the Caribbean</b>	<b>28</b>
6.1 Regional Research Capacity	28
6.1.1 Systemic research capacity	28
6.1.2 Institutional research capacity	28
6.1.3 Individual research capacity	30
6.2 Capacity building requests from the Caribbean	30
6.3 Regional capacity for policy influencing	30
<b>7 Conclusion</b>	<b>32</b>
<b>8 Bibliography</b>	<b>33</b>
<b>9 Annexes</b>	<b>34</b>
Annex 1. List of consultees	34
Annex 2. List of consultation interview questions	36

# Executive summary

Caribbean Community (CARICOM) member states have much in common. Existing social, economic and environmental challenges are now increasingly compounded by the impacts of climate change, which pose a severe threat to Caribbean countries' development prospects. This report supports the delivery of the Implementation Plan for the *'Regional Framework for Achieving Development Resilient to Climate Change'* by documenting the knowledge gaps and information required and by providing an assessment of the region's research capacity. Many aspects of the Regional Framework and the Implementation Plan will require evidence-based research and research-based tools that are not already available.

Caribbean research institutions and consortia are undertaking a broad range of climate change related research, some of which has recently been completed. Many of these projects are detailed in Section 3 of this report. However, several key research gaps and priorities have been identified. These include research on: the impacts of climate change on coasts, water resources, agriculture and fisheries, energy, tourism and health, amongst others; adaptation options in sectors such as water resource management, disaster management, agriculture and food security, economic sectors, and energy sector responses; indicators and methodologies for evaluating impacts and progress; and policy and evidence-based decision-making processes. It is crucial to incorporate climate hazards into assessments of the impacts of a changing climate. Climate change science research needs to ensure that specific climatic drivers in the Caribbean are captured and understood in order to help policy-makers and practitioners understand the Caribbean's current exposure to climate variability and hazards and the actions that need to be taken to address climate change. Additionally, thorough and comprehensive cost-benefit analyses of adaptation and mitigation strategies, nationally, locally and across the region are needed. A key priority for research relating to climate change, however, is ensuring that research is undertaken in a holistic manner. Studies at the intersection of natural resources and socio-economic systems in the Caribbean context are lacking, and cross-cutting research and collaboration must be encouraged.

Successful research networks and partnerships are crucial for addressing the region's research gaps and priorities to support the Regional Framework's implementation. It seems that universities and campuses within the region are working well with one another on issues central to climate and development, even if their work is often not explicitly linked to climate change at this stage. Several universities or research institutes have also established relationships with others internationally. A number of regional programmes are further strengthening partnerships and consolidating emerging networks among researchers within the Caribbean, as well as with research institutions outside the region. These efforts need to be reinforced and developed further. Cross-institutional mechanisms to coordinate policies and programmes, to build capacity and to link national development planning, project cycle management and secure collaborative management are required across the Caribbean. It would be beneficial to develop a Caribbean interdisciplinary climate change research network, and to encourage further collaboration between researchers.

In terms of research capacity, academic expertise within Caribbean universities is widely held to be high. However, the region's formal mechanisms for building interdisciplinary research capacity and communicating research results are seen to be weak. Specific capacity building needs in the Caribbean have been identified in this report, including for undertaking climate change related research and for achieving policy influence. Poor communication between scientists (particularly between natural and social scientists), hinders the development of truly multi-disciplinary climate change research and take-up of research results into policy. Additionally, much greater engagement between researchers and the private and public sectors is needed. It is vital that research is communicated effectively and taken up in policy discussions as key ingredient for evidence-based decision-making on climate compatible development issues.

# 1. Introduction

This Regional Diagnostic on Research Capacity and Priorities for the Caribbean is designed to aid the delivery of the Implementation Plan for the '*Regional Framework for Achieving Development Resilient to Climate Change*' (the Regional Framework). Approved by the CARICOM Heads of Government in July 2007, the Framework defines CARICOM's strategic approach for coping with climate change and provides a roadmap for action by member states and regional organisations over the period 2009-2015. The Framework comprises five strategic elements designed to significantly increase the resilience of the CARICOM member states' social, economic and environmental systems.

The Implementation Plan (IP) for the Framework acknowledges that a transformational change in mindset, institutional arrangements, operating systems, collaborative approaches and integrated planning mechanisms are essential to deliver the strategic elements and goals of the Regional Framework. Additionally, the IP identifies a number of priority challenges and actions for the region, including the imperative to develop capacity by building on the knowledge, information and expertise that already exists in the region. It recognises that considerable time, research effort and resources have been invested into impact and vulnerability assessments and that, in some cases, the recommendations and guidance have not been implemented for lack of resources and coordination. The Implementation Plan also identifies the need to retain and grow technical, professional, managerial and academic research expertise and capacity in the region as a priority challenge. It is anticipated that the Implementation Plan will be released in March 2012; the draft is currently awaiting approval by the CARICOM Heads of Government.

This Research Diagnostic aims to complement the Implementation Plan by documenting knowledge gaps and information requirements identified to deliver the strategic elements and goals of the Regional Framework, along with an assessment of the region's research capacity. The Diagnostic, along with the IP and the Framework, are directly applicable to the 15 CARICOM member states, which are: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago. However, many of the messages will have a wider regional applicability.

CDKN will be launching a Caribbean Regional Research Call to support research priorities as identified in the Implementation Plan and highlighted in this Research Diagnostic. The Call will be launched in January 2012. Further details of the Call can be found on the CDKN website, at [www.cdkn.org](http://www.cdkn.org).

## 1.1 Context of the Regional Diagnostic

Caribbean Community (CARICOM) countries have considerable cause for concern as the threats posed by a changing climate to their development prospects are severe. The Caribbean region currently deals with climatic variability and extreme events, and is projected to be confronted with considerable impacts associated with a changing climate. Both mitigation and adaptation efforts will require a significant and sustained investment of resources that the Member States are unlikely to be able to provide on their own.

The Caribbean states share many of the following social, economic and environmental challenges:

- heavy dependence on natural resource base (agriculture, forestry, fishing, tourism, mining, and light manufacturing);

- high external indebtedness that in some cases is above 115% of gross domestic product (GDP);
- susceptibility to the vagaries of international trade;
- insufficient generation of scale economies;
- high transportation and communication costs;
- high energy costs that reduce the prices competitiveness of their products;
- high levels of emigration of skilled personnel;
- extreme vulnerability to natural disasters;
- scarce land resources; and
- ever-increasing pressures on coastal and marine environments.

These are compounded by the additional challenges of widespread poverty, high population density, rapid urbanisation, food and energy insecurity, a lack of infrastructural resources and inadequate data collection and management to allow for informed decision-making and robust development planning. Climate change, combined with these challenges, poses a severe threat to Caribbean countries' development prospects.

Given that the region contributes less than 0.1% of global greenhouse gases (GHG) (IPCC, 2007) the focus has been centrally on adaptation to climate change and its related events. Nonetheless, interest in following low carbon development pathways has also been growing. Building climate resilient, low carbon economies requires a sizable and sustained investment of resources, transformational change by CARICOM governments, regional organisations, NGOs, the private sector and civil society supported by an unprecedented level of financial and technical assistance from the developed world.

This concern is reflected in the Liliendaal Declaration on Climate Change and Development, which was endorsed by the CARICOM Heads of Government in July 2009 (CARICOM, 2009). The Liliendaal Declaration defines the national and international position of the CARICOM member states on climate change and development issues. Delivery of the Declaration will require transformational, capacity building measures.

At the same July 2009 meeting the Heads of Government also approved the Regional Framework. As mentioned previously, the Regional Framework is guided by five strategic elements and some twenty goals designed to significantly increase the resilience of the CARICOM member states' social, economic and environmental systems. The strategic elements are as follows:

1. Mainstreaming climate change adaptation strategies into the sustainable development agendas of CARICOM states.
2. Promoting the implementation of specific adaptation measures to address key vulnerabilities in the region.
3. Promoting actions to reduce greenhouse gas emissions through fossil fuel reduction and conservation, and switching to renewable and cleaner energy sources.
4. Encouraging action to reduce the vulnerability of natural and human systems in CARICOM countries to the impacts of a changing climate.
5. Promoting action to derive social, economic, and environmental benefits through the prudent management of standing forests in CARICOM countries.

The Regional Framework's roadmap for action over the period 2009-2015 builds on the groundwork laid by the Caribbean Community Climate Change Centre (CCCCC) and its precursor programmes

and projects in climate change adaptation. It also builds upon the extensive work undertaken by governments, regional organisations, NGOs and academic institutions in recent years (and in many cases funded by the international development community) assessing the impacts of a changing climate. To take forward and deliver the strategic elements and goals identified in the Regional Framework, the IP has been prepared by the CCCCC at the request of the Heads of Government.

The Regional Framework and IP provide the context and the overview for a research programme in the Caribbean, which CDKN will support through the Caribbean Regional Research Call in early 2012.

## 1.2 Objectives of the Regional Diagnostic

The overall objective of this report is to identify the areas in the Regional Framework and the IP which will require evidence-based research and research-based tools that are not already available. The specific objectives of the Regional Diagnostic are to:

- Identify knowledge gaps and research priorities required for the activities in the Regional Framework Implementation Plan;
- Document current priority research gaps on climate change and development with experts in the field to inform regional research strategy;
- Identify key research providers, applied academics and research-oriented policy makers in the region;
- Document existing research partnerships and structures;
- Investigate and document regional research capacities and strengths and relative weaknesses and abilities to engage on future research bids amongst research institutions in the region; and
- Provide a useful document for other potential research funders on climate change in the Caribbean.

Additionally to this standalone Research Diagnostic, this report will be included in the Implementation Plan as a technical annex.

It is intended that this Diagnostic will inform applications to the CDKN Caribbean Regional Research Call. Through this Call, CDKN will fund high-quality research with evidenced demand from Caribbean governments, which relates to research gaps and priorities outlined in this document. Proposals are expected to demonstrate their potential for policy impact, and research should foster strong partnerships involving research organisations in the Caribbean region. More details about CDKN research requirements and the Caribbean Regional Research Call can be found on the research pages of the CDKN website [here](#).

## 1.3 Research Diagnostic Methodology

This Research Diagnostic was produced following a desk review and consultation process, which included the following:

- A Regional Diagnostic Research Capacity and Priorities workshop, held in Saint Lucia on 5<sup>th</sup> May 2011. This workshop was attended by approximately 20 regional researchers, together with representatives from regional financial institutions and trade associations. A list of consultees in this process can be found in Annex 1.
- A comprehensive desk review stock-take compiling:

- key research institutions in the region and internationally working on climate change and development issues in the region,
- a summary of the various climate change related adaptation and mitigation research projects and research networks in the CARICOM member countries, as well as regionally and internationally, on climate change and development, and
- links to existing reports and consultations.

This stock-take has been compiled as database; a web-based version of the database is available on the Caribbean Community Climate Change Centre (CCCCC) [here](#) as part of a larger database that includes climate change related adaptation and mitigation strategies, policies, programmes and actions being carried out within the region.

- Further consultations (for those who were not able to attend the workshop) with Caribbean and international researchers and representatives.

The report also builds on the extensive consultation process undertaken by the CCCCC during the preparation of the IP, involving an extensive programme of in-country discussions with politicians, government officials, regional agencies, NGOs, the private sector, donors and development banks. For the most part these discussions were undertaken on a one-to-one basis or in small groups, followed by further engagement and focussed on identifying those actions stakeholders believed were required to be undertaken within the next 2 to 5 years. Meetings were held with over 140 stakeholders during the in-country discussions over a period from September 2010 to June 2011. Two major workshops were held, in Barbados in November 2010, and in Saint Lucia in May 2011, in addition to the meetings.

## 2. Climate change and development priorities

This section summarises priorities in the region as evidenced by past and existing projects relating to climate change and development.

Global climate change is the most serious threat to sustainable development facing CARICOM states. According to the IPCC (2007), the projected impacts of global climate change in the Caribbean are expected to be great. These impacts would be reinforced due to the limited adaptive capacity of CARICOM small island and low-lying coastal states. Specifically, global climate change is expected to result in more hostile regional climate change and rising sea levels. The rising sea levels with associated coastal erosion and salt water intrusion, an escalation in the frequency and intensity of tropical storms and hurricanes, and disruptions in rainfall and fresh-water supply threaten the very existence of the small island and low-lying coastal states of the Caribbean.

The seriousness of the challenge global climate change poses to the development prospects of small island and low-lying coastal states is addressed in the Barbados Plan of Action (BPoA), as the first of 14 priority areas for achieving sustainable development. Of particular note is the increasing intensity of extreme weather events, resulting in severe damage to the region's socio-economic resource base, due to the direct and indirect climate impacts on infrastructure, tourism, agriculture, fisheries and forestry. Disaster risk reduction is crucial to aid the process of building resilience to climate change impacts and needs to be integrated with all future development plans. Dangerous climate change is already occurring in all Small Islands and Low-lying Coastal Developing States (SIDS) regions, including the Caribbean, requiring urgent, ambitious and decisive action by CARICOM states and by the international community.

In response to the priority given to the issue of climate change in the BPoA, the region has systematically been addressing the issue of capacity-building to climate change since 1998. Caribbean countries have implemented a range of national enabling activities and participated in a number of major regional projects designed to build institutional, national, and human capacities. This has resulted in a better understanding of actual and potential climate impacts on the region. The most important activities to date, as outlined in the Regional Framework, include:

- National Enabling Activities (NEAs): The completion of First National Communications, Green House Gas Inventories, and Vulnerability Assessments with assistance from a Global Environmental Facility-funded initiative, supported by the United Nation Development Programme's National Communications Support Programme.
- The Caribbean Planning for Adaptation to Climate Change (CPACC) project (1998-2001): This GEF Stage I project was implemented by the World Bank and executed by the Organization of American States (OAS). It responded to mandates in the SIDS/BPoA at the national, regional and international levels. It has assisted CARICOM countries develop national programmes to address the challenges of climate change, including the design of a Regional Sea Level/Climate Monitoring Network, and regional database and information systems to help regional and national institutions acquire, analyse, store, and disseminate data. In addition, National Climate Committees were established in all CPACC participating countries.
- The Adaptation to Climate Change in the Caribbean (ACCC) project (2001-2004): This is a CIDA-funded initiative that provided an effective bridging facility between CPACC and the Mainstreaming Adaptation to Climate Change (MACC) project. It built on the foundation laid by CPACC, including addressing some of the gaps identified during implementation of the

CPACC project. This Project facilitated the establishment of the Caribbean Community Climate Change Centre (CCCCC) that was founded at Belmopan, Belize (2004).

- The Mainstreaming Adaptation to Climate Change (MACC) project (2003-2009) is being finalized by the CCCCC with GEF funding through the World Bank: This project focuses on creating an enabling environment to enhance adaptation programmes across the region by:
  1. developing national policy frameworks for adaptation;
  2. mainstreaming climate change issues into key sectoral activities;
  3. preparing national pilot adaptation projects;
  4. strengthening public awareness and participation in climate change programmes;
  5. further strengthening of the knowledge base; and
  6. facilitating the development of monitoring, analysis, and the building of regulatory planning instruments for mainstreaming climate change issues in the region.
- The Implementation of Adaptation Measures in Coastal Zones (SPACC) project (2006 – 2011): This is a GEF activity which is funded through the World Bank to implement specific (integrated) pilot adaptation measures that primarily address the impacts of climate change on the natural resource base of Dominica, St. Lucia and St. Vincent and the Grenadines. Project activities include the design and implementation of adaptation measures to reduce the vulnerability of buildings to hurricanes, enhance water capture and use; pilot renewable energy options, support land use planning and management, and reduce anthropogenic stress on national parks and key natural habitats, while at the same time enhancing ecosystem resilience.

As evidenced above, there are a number of external organisations which are very active in supporting climate compatible development in the Caribbean. These include the World Bank, working largely through their Global Environmental Facility (GEF), the Organization of American States (OAS) and Canadian International Development Agency (CIDA), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), UK Department for International Development (DFID), Inter-American Development Bank (IDB) and United Nations Economic Commission for Latin America and the Caribbean (UNECLAC). These organisations provide funding and support to the following projects, which highlight the areas which they view as a priority:

#### **Water resources:**

- National Integrated Water Resources Management Policy (including climate change) for Belize (World Bank, UNDP)
- Climate Change-induced drought adaptation strategy for the Caribbean region and beyond (UNDP)
- Water and Sanitation Programme, South East and Central Haiti (UNDP)
- Rainwater Harvesting (RWH) Project (UNEP)
- Case Study on the Impact of Climate Change on Water and Sanitation in Jamaica (UNDP)
- Adapting to climate change in water resources and water services in Caribbean and Pacific small island countries (GEF, UNDP, UNEP)

#### **Disaster management:**

- Needs Assessment for Capacity Building in Risk Management and Vulnerability Reduction in the Caribbean Islands of Antigua and Barbuda, Barbados, Cuba, Dominica, and Grenada (UNDP)

- Enhancing Disaster Preparedness in the Caribbean (UNDP)
- Comprehensive Approach for Disaster Management in the Caribbean (CDM) (UNDP)
- Caribbean Disaster Risk Management Program (CDRMP) (GEF, UNDP)
- Comprehensive Disaster Management Harmonized Implementation Programme (CDM-HIP) (Phase 1) (DFID, CIDA)
- Caribbean Hazard Mitigation Capacity Building Programme (CHAMP) (CIDA)
- Updating Building Codes of the Greater Caribbean for Winds and Earthquakes - Phase I (IDB)
- Caribbean Catastrophe Risk Insurance Facility (CCRIF) (UNECLAC)
- Enhancing Gender Visibility in Disaster Risk Management and Climate Change in the Caribbean (UNDP)
- CARIBSAVE Climate Change Risk Atlas (CCCRA) (DFID)

#### **Agriculture and food security:**

- Global Environmental Change and Food Systems Caribbean project (GECAFS Caribbean) (UNEP)
- Case Study on the Impact of Climate Change on Agriculture on an Indigenous Community in Guyana (UNDP)
- Case Study on the Impact of Climate Change on Agriculture and Housing on Indigenous Communities in Suriname (UNDP)

#### **Economic sectors:**

- Review of the Economics of Climate Change (RECC) in the Caribbean project (DFID, UNECLAC)
- Economics of Climate Adaptation (ECA) Initiative (UNECLAC)
- Assessments of Impacts and Adaptations to Climate Change (AIACC) (UNEP)
- CARIBSAVE Modelling Impacts of Climate change and Sea Level Rise (UNDP)
- CARIBSAVE Seed Funding Project (Caribbean Climate Change, Tourism and Livelihoods: A sectoral approach to vulnerability and resilience) (DFID, UNEP)
- Climate Change and Tourism: Responding to the Global Challenges (UNEP)
- Disaster Risk Management for Coastal Tourism Destinations Responding to Climate Change (UNEP)
- Regional Disaster Risk Management for Sustainable Tourism in the Caribbean Project (IDB)
- Analytical Support for Climate Change Action in Cities in Latin America and the Caribbean (IDB)

#### **Energy:**

- The Caribbean Renewable Energy Development Programme (CREDP) (UNDP, GEF)
- Sustainable Energy and Climate Change Initiative (SECCI) (IDB)
- Sustainable Energy Framework for Barbados (IDB)

Full details of these programmes are available in the web-based database on the CCCCC [website](#).

# 3. Caribbean climate change research programmes

This section summarises relevant current or recent research taking place at Caribbean research institutions and consortia. This information is based on documents that were submitted in advance of the workshop in May 2011, with the purpose of providing a basis for discussion. Hence this section does not provide a complete picture of all the research being undertaken in the region.

## 3.1 Climate Modelling, and Impact and Economic Modelling Implementation Plan (2011 – 2021)

There are several activities that make up the Caribbean Modelling Initiatives (CMIS), which will provide outputs that can assist decision makers in the public and private sector understand the predicted changes in climate, their impacts and socio-economic effects in the Caribbean region. The modelling initiatives are divided into three types:

1. Caribbean Climate Modelling Initiative (CCMI),
2. Impact Studies Modelling, and
3. Economic Modelling.

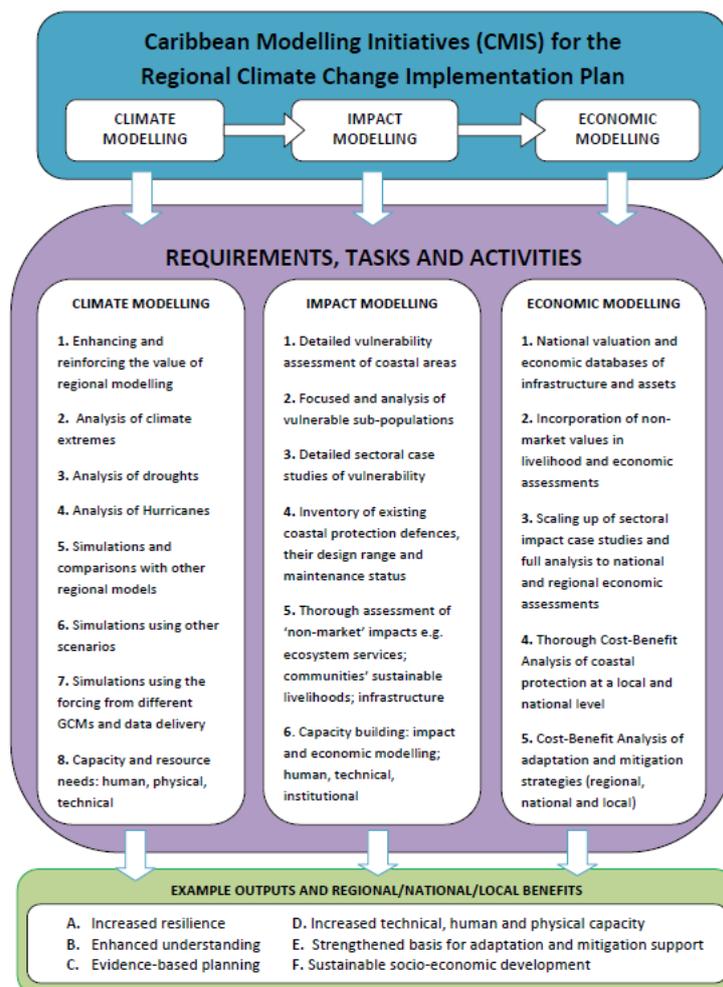


Figure 1: Caribbean Modelling Initiatives.

The research institutions which form the consortium for undertaking this work are mostly based in the Caribbean. These are as follows:

- Climate Studies Group, Mona (Climate Studies Group, Mona-CSGM) – Jamaica
- University of the West Indies, Cave Hill – Barbados
- Caribbean Institute of Meteorology and Hydrology (CIMH) – Barbados
- Instituto de Meteorología (INSMET) – Cuba
- Anton de Kom University of Suriname – Suriname
- Caribbean Community Climate Change Centre (CCCCC) – Belize
- The CARIBSAVE Partnership (CARIBSAVE) – Barbados
- The Hadley Centre – United Kingdom
- The University of Oxford – United Kingdom

The Caribbean Modelling Initiatives will yield specific outputs and deliverables. The chief outputs are listed below:

- A coordinated framework for pursuing climate science in the Caribbean and for the delivery of timely results.
- Multi-model analysis (under different scenarios) of climate change at the scale of the Caribbean basin.
- Expanded database of regional model output for the Caribbean, including maps and graphs differentiating the results by sub-regions.
- Validated methodology for detecting and projecting changes in tropical cyclone frequency and intensity in the Caribbean under climate change.
- A comprehensive study of meteorological and agro-meteorological drought in the Caribbean under climate change.
- A completed down-scaled analysis of climate extremes.
- A framework for conducting new impact and sectoral studies.
- Training of new regional experts, and institutional, human and technical capacity building in climate change modelling and its' applications (climate, impact and economic) and the launching of a climate model interface for the Caribbean.
- An accurate valuation database of the assets (physical and livelihood/non-market) and costs associated with building protective structures along the coasts of the Caribbean islands, especially near major urban centres and popular tourism developments.
- Comprehensive data on the vulnerabilities to climate change impacts for key sectors including: water, coastal and marine ecosystems, tourism, human health and energy.
- Improved methodology for the costing of impacts, including a database of asset values across countries and an analysis of gender differential and vulnerable sub-groups.
- Thorough and comprehensive cost-benefit analyses of adaptation and mitigation strategies, nationally, locally and across the region
- Inventory of non-market values and coastal protection defences (inc. design and maintenance)

## 3.2 Developing National Research and Monitoring Capacity for the Management of Belize's Marine Protected Areas and Natural Resources

In September 2010, the University of Belize Environmental Research Institute (ERI) was awarded a five year grant by the Oak Foundation, submitted on behalf of the University for a project entitled: Developing National Research and Monitoring Capacity for the Management of Belize's Marine Protected Areas and Natural Resources. Implementation of the project began on November 1st, 2010. The ultimate goal of this project is to develop a research and capacity building mechanism within the national University that will enable a sustained programme of scientific research and monitoring in Belize. Details of the project can be found here: <http://www.eriub.org/projects/national-research-monitoring.html>.

## 3.3 Regional climate modelling

At the University of the West Indies (UWI) Mona campus, the regional climate modelling system PRECIS has been used to undertake present-day and climate projection (with the SRES A2 scenario) studies, using the HadAM3P and ECHAM4 boundary conditions data. In particular, their focus has been the studies of Caribbean Low-Level Jet (CLLJ) and the mid-summer drought (MSD). The performance of PRECIS over the Caribbean domain has been evaluated and published. To supplement studies using PRECIS, there are plans to use the high-resolution (20km) climate model data from the Meteorological Research Institute (MRI), Japan and the REMO model from Max Plank Institute, Hamburg.

At the UWI Cave Hill campus, the modelling efforts are focused on 25km simulations using PRECIS over the small islands in the Eastern Caribbean. The completed simulations include present-day, SRES A2 and SRES B2 simulations using the HadAM3P and ECHAM4 forcing data. There are also efforts to use the method of "direct-area downscaling" of GCM's to produce high-resolution outputs for small areas without running computationally expensive RCMs and in light of the absence of historical data.

At the Cuban Institute of Meteorology (INSMET), PRECIS has also been used to carry out present-day and scenario simulations using ERA15, HadAM3P and ECHAM4 data. INSMET have performed simulations to study the effect of resolution and domain size on the model's ability to reproduce climate features of the Caribbean. The preliminary results highlight the need of using high resolution climate models to generate climate change information for the island nations in the Caribbean. Regional Climate Model RegCM3 is also used for present-day simulations, driven with ERA15, and its results are comparable with observations as well as with results from PRECIS. The PRECIS experiments using the CORDEX domain are carried out at INSMET for the ERA Interim data and are presently being evaluated. INSMET is planning more PRECIS experiments using the perturbed physics boundary conditions from the Hadley Centre. These experiments will be carried out in collaboration with UWI Mona.

## 3.4 Hydrological modelling

At the Caribbean Institute of Meteorology & Hydrology (CIMH), modelling activities mainly focus on surface and ground water modelling using FLO-2D, HydroGeosphere, and MIKSHE. There are also plans to carry out climate model simulations using WRF and REMO, together with a Flood Forecasting Project, Barbados Groundwater Study and CARIWIN project.

### 3.5 Climate Change and Biodiversity in the Caribbean (CCBIC) Project (2007 - 2008)

This project focused on increasing understanding and consensus about the predicted climate change trends and their impact on biodiversity in Caribbean Small Island Developing States. The project was funded by the John D. and Catherine T. MacArthur Foundation and undertaken by the Caribbean Natural Resource Institute (CANARI). The goal was to develop a regional research agenda and capacity needs assessment to address identified gaps and to consider how protected area management, biodiversity protection, and conservation policy might address climate change in the region. Three working groups focused on the development of climate change scenarios and models; coastal and marine biodiversity; and terrestrial biodiversity. More information about this project can be found at [www.canari.org/macarthurclimatechange.html](http://www.canari.org/macarthurclimatechange.html).

### 3.6 Regional Framework

Within the Caribbean Agricultural Research and Development Institute (CARDI) Medium Term Plan (MTP) 2008 – 2010, climate change has a prominent position under Strategic Action 1. Strategic Axis 1 comprises two Focal Areas, 'Science, Technology and Innovation' and 'Natural Resource Management' (NRM).

The NRM Focal Area addresses environmental limitations, constraints and opportunities that influence the attainment of sustained and efficient production and productivity. The Priority Areas identified in this focal area are:

- Invasive species
- Climate change
- Biotechnology

The Programmes include support to invasive species initiatives Coordination of Climate Change and Disaster Management, and Biotechnology development. Further details about this project are available at [www.cardi.org/commodities-themes/natural-resource-management/](http://www.cardi.org/commodities-themes/natural-resource-management/).

### 3.7 Assessment of Legal Preparedness for Participation in the Carbon Market by Members of the Caribbean Community (ongoing)

In partnership with the CCCCC, the International Development and Law Organization (IDLO) will conduct an assessment of the national and regional legal environment that fosters participation in the carbon market. The proposed project will be the first phase of implementation in a more comprehensive program of Legal Preparedness for Climate Change, to be implemented subject to the availability of funding.

Project outputs will include:

- Legal Preparedness Assessment Report identifying legal and institutional barriers to participation in the carbon market.
- Stakeholder consensus building events convened to develop Legal Action Plans in select Caribbean countries.

Further information can be found at [www.idlo.int/english/WhatWeDo/Programs/ClimateChange/Pages/LPCCI.aspx](http://www.idlo.int/english/WhatWeDo/Programs/ClimateChange/Pages/LPCCI.aspx).

## 4. Priority research gaps and key research questions in the Caribbean

This section of the report presents and analyses the results of the consultations with regional research specialists. The individuals consulted were predominantly active researchers based largely in the Caribbean, with additional consultees from North America, the UK, and representatives from regional financial institutions and trade associations. The full list of consultees can be found in Annex 1.

### 4.1 Priority research gaps

The research priorities for climate change and development in the Caribbean region are outlined below, arranged under four priority areas:

- **Impacts** (e.g. modelling bio-physical changes, assessing the socio-economic implications, identifying vulnerability hotspots)
- **Responding to a changing climate** (or the building blocks of climate compatible development e.g. adaptation or mitigation options)
- **Evaluating climate compatible development** (e.g. cost-benefit analysis, identifying trade-offs, decision-making tools)
- **Policy processes** (e.g. politics and power, the role of institutions)

#### 4.1.1 Impacts

In order to assess and model the impacts of a changing climate, it is crucial that **climate hazards** are sufficiently understood. There is a need to focus climate change science research to ensure that the specific climatic drivers in the Caribbean are captured and understood. This will help policy-makers and practitioners understand the Caribbean's current exposure to climate variability and the actions that need to be taken. In order to do this, the following are required:

- Accurate and geographically dispersed baseline data, for example, the expansion of sea-level monitoring.
- Improve understanding of changes in oceanographic systems, physical oceanographic process and coastal geomorphology.
- Climate projections need to be country-specific, which could be addressed through the use of higher resolution climate models or statistical downscaling.
- Detailed analysis of tropical cyclones, particularly the effect of warming on tropical storms and how the frequency, geographic distribution, duration and intensity will change over time.
- Further research to gain a better understanding of the influences of the Equatorial Trough, the El-Niño Southern Oscillation (ENSO) and other regional influences on the area.
- Development of multi-hazards, multi-zone geographic information systems (GIS), to provide a detailed understanding of the overlays between climate hazards and receptors.
- Identifying and understanding the drivers for current climatic variability in the Caribbean.

Considering the assessment of the **impacts** of a changing climate, it is important to highlight the need for a holistic approach. Numerous interviewees stressed that the interconnections between natural resources (and in particular water) and other systems (e.g. social or economic systems) are not well

studied or understood in the Caribbean. It was emphasised that cross-cutting research and collaboration needs to take place; for example one consultee stated that many people do not understand the relationship between agriculture, forestry and health, together with water and health. Research gaps appear when people within these disciplines work in isolation.

Having understood climate hazards, the next key challenge is to develop a risk ethic and undertake research within a risk assessment framework. This has been identified as a priority challenge in the Implementation Plan and underpins the Research Framework. A risk assessment approach will provide research that is more readily usable by decision-makers. It also has a major advantage in that it encourages exploring a wider research context, inter-relationships between hazards and impacts, and a multi-disciplinary approach.

Sectoral research gaps, with respect to climate change impacts, are explored in more detail below.

### **Coastal Zone: Coastal and marine infrastructure**

Some work is underway in this sector, for instance the UNDP-funded work undertaken by the CARIBSAVE partnership to assess the economic impacts of coastal inundation under different sea-level rise scenarios (Simpson et al., 2010). This report provides a detailed and vigorous assessment of the losses and damages associated with sea-level rise impacts on the population, ecosystems and key economic sectors in CARICOM. However, it is stressed that there is a further need to undertake detailed and localised climate risk assessments of the vulnerability of infrastructure to inundation and erosion. This should include infrastructure that supports economic sectors, either directly (e.g. tourism – ports, coastal highways, hotels, water supply, and beaches) or indirectly (e.g. health facilities, security and military installations, playgrounds and community centres/facilities, schools). Coordinated approaches to coastal zone management and robust data collection are necessary in order to comprehensively analyse the vulnerability of marine and coastal infrastructure to a changing climate, and to take account of these more formally in decision-making processes for efficient technology adoption and disaster preparedness.

### **Coastal Zone: Coastal and marine ecosystems**

Historically, there has been a wealth of research undertaken and available on the impacts of climate change on coral reefs. The World Bank-funded project '*Caribbean Planning for Adaptation to Climate Change (CPACC)*', running between 1997 and 2001, contained a component that sought to increase the existing knowledge about the extent and sources of coral reef degradation in three countries (The Bahamas, Belize, Jamaica). CPACC was executed by the Organization of American States (OAS), overseen by a Project Advisory Committee chaired by CARICOM, and implemented by a Regional Project Implementation Unit established by the University of the West Indies (UWI). The CPACC project developed a number of informational tools, such as the Coastal Resources Information System (CRIS). This project was followed by the '*Mainstreaming Adaptation to Climate Change (MACC)*' project, between 2003 and 2009, that strengthened the climate and coral reef monitoring network, through upgrade and expansion of the sea level, coral reef, and climate monitoring network installed by CPACC.

However, there are a number of other gaps with respect to the coastal and marine ecosystem, with less information available on:

- Other coastal and marine ecosystems, such as mangroves, sea-grass and continental shelf fish communities,
- Coral diseases and invasive species in the region, and how they are influenced by climatic factors,
- Spatial extent of coastal and marine ecosystems,
- Inventories of flora and fauna,

- Basic biology and responses of species including seabirds, waterfowl, and key cetacean species,
- Climate change impacts on plankton distribution and algal blooms, which are key components of the marine food-chain and also potentially harmful to humans,
- Linkages among species and systems within the overall marine ecosystem which comprises the Caribbean Sea and adjacent water bodies,
- Linkages between coastal-marine areas and terrestrial ecosystems, both within the Caribbean region, at a catchment-scale, and externally (for example across regional watersheds such as the Amazon and Caribbean Sea),
- Physical oceanographic process and coastal geomorphology, and their changes as a result of climate change (e.g. ocean currents and circulation, sediment erosion, transportation and deposition, changes in salinity, water temperature, water chemistry and concentration of carbon dioxide in the oceans) within the region (at the regional and local levels),
- Man-made inputs into the marine environment, including sedimentation, pollution discharges and transportation, as well as the way that climate change may affect these inputs,
- Monitoring of ecosystem changes,
- Climate change impacts for marine flora and fauna, and hence fisheries (production, distribution, species composition etc) and the social and economic impacts (implication for employment and food security).

There is a need to map and assign a value to all coastal ecosystems, abundance, diversity and habitats; this would involve documenting their location, state of health and respective contribution to economic development. This would naturally build on the CARIBSAVE *Climate Change Risk Atlas (CCCRA)* project, which identifies the impacts of climate change in 15 countries across the Caribbean, on key sectors as they relate to tourism and livelihoods (see <http://caribsave.org/index.php?id=5>). The CCCRA project is using climate models, examining sectoral vulnerabilities, assessing adaptive capacity and developing practical response strategies with the countries across the region. There is also the need to construct different scenarios, i.e., different levels of sea level rise and what these would mean for the coastal assets. In this case, the use of aquacams to determine diversity, health, abundance, etc of various marine species may also be useful. The currently large variation in the availability of ecosystem data makes it difficult to go beyond site-specific statements.

### Water resources

Water resource assessments of both ground and surface water are a priority, as highlighted in the IP. There are also a number of specific research gaps regarding the supply, demand and management of water resources, as outlined below:

#### *Supply:*

- Impact of saline intrusions on freshwater resources, as a result of sea level rise;
- Assessment, quantification and mapping of groundwater resources;
- Understanding how different catchments will react under different climate and land management scenarios;
- Determining the environmental requirements in catchments and river systems.

#### *Demand:*

- Estimating future total water demand under various climate change scenarios and future water demand across different sectors (domestic and commercial users, farming, energy, tourism and ecosystems).

#### *Management:*

- Understanding how the natural storage capacity of the watershed will be impacted by climate change;
- Storage and rationing of water, including use of appropriate infrastructure and design. This may involve the potential redesign of the urban environment;
- Management of water during periods of excess water, in both rural and urban environments. There is a need to assess urban drainage issues and management of flood water from the marine, fluvial and pluvial sources.
- There is also the fundamental problem of water leakage and water wastage, with a need to assess the feasibility of a system that allows for better and more efficient water pricing, along with the incentive regime to encourage innovation, wastewater treatment, etc.

Water must be considered as an integral element of all climate change impact research, rather than in isolation.

### **Agriculture and fisheries**

With respect to agriculture, priority issues identified to reduce the risks to the region's food security associated with a changing climate include:

- Identifying drought-resistant crop varieties that yield more mass per unit of water consumed;
- Promoting better soil management, fertilization and pest and weed control;
- Improving irrigation management through better timing of the provision of water supplies to help reduce stress at critical crop growth periods;
- Using more deficit, supplemental and precision irrigation systems;
- Encouraging improved farming practices that reduce land degradation;
- Developing a hazard risk reduction strategy for the agricultural sector to address impacts over the short, medium and long term;
- Research in projected land use changes associated with climate change, which has implications for agriculture, food security, migration and other social impacts;
- Utilising traditional knowledge and its relevance for adaptation;
- Developing agricultural projects which increase Carbon sequestration and can gain support of the Clean Development Mechanism (CDM).

There is a need to undertake country-specific vulnerability studies for food security, which look at agricultural production and challenges including climate change. A series of pilot projects (sweet potato) are currently being undertaken in Jamaica by UWI (Mona Campus, Climate Studies Group) which utilise climate and crop yield models in order to develop a tool for non-scientists. It was suggested that this could be extended across the Caribbean region to give wider coverage of staple and added value crops, in a greater number of countries.

Furthermore, given that most of the agriculture crops are cultivated on the coast of the Caribbean countries, the issue of saltwater intrusion, associated with a rising sea level and exacerbated by dry El

Nino type episodes, are all important to study and to gain a better appreciation of their occurrences. This is also vital for the impacts on coastal aquifers.

With respect to fisheries, there is a research need to better understand fisheries systems. At the national level some fisheries data does exist, but there is a need to gain an understanding of the level of detail and completeness, together with knowledge of the areas where data needs strengthening. Research needs include:

- The collection of basic data and research to better understand the biology, ecology and population dynamics of commercially important fish species,
- Determination of catch and size limits for key fish species, including snappers, groupers, hogfish, barracuda, sharks, queen triggerfish and mackerel, and to monitor trends in production and biomass.

It was suggested that a tool could be developed to model the climate change impacts on fish stocks for commercially important fish species, and associated consequences for food security and employment. There is a need to develop and adapt ecosystem-based approaches to ensure optimum sustainable use, management and conservation of fisheries and other living marine resources. This will help inform the development and appraisal of appropriate adaptation strategies.

## Energy

Energy is a key sector for the Caribbean region, particularly for manufacturing, tourism, transportation and agro-processing, and a comprehensive assessment of the energy sector's vulnerability to climate change impacts is crucial. There is an overriding imperative to improve the resilience of the economies of the Caribbean by reducing the dependency on imported high-cost fossil fuels, by improving energy efficiency and through the development of low carbon energy generation. This would transform economies, lower unit costs of production and enable countries to increase the resources devoted to resilience building. For those nations utilising or considering a shift to renewable energy resources, which is highlighted as a priority action in the CARICOM Implementation Plan (2011), it was highlighted that there is a need to undertake feasibility studies in order to gain an understanding of the impacts climate change may have on renewable technologies and initiatives (e.g. generating capacity of hydropower schemes), and effects on forest stocks. For the smaller islands, climate impacts on small hydro productivity are an important issue for their energy sector. There are a number of research and development areas of interest for the use of renewable energy technologies, including the feasibility of biofuel production from different feedstock (e.g. Jatropha, Cohune, Arundo), the production of photovoltaic cells from Guyana's silica deposits and utilising energy resources from Trinidad and Tobago.

It was also highlighted that there is a need to improve baseline data and systems of monitoring energy consumption, through energy audits and balances. This would help predict climate change-driven shifts in future energy demand.

## Tourism

Tourism is a major part of the economies of Caribbean nations, but the impacts of sea level rise on tourism and national economies has, until recently, largely been overlooked. A recent UNDP-funded study by Simpson et al. (2010) found that major resort properties were at significant risk to 1m sea-level rise in various countries, notably, Belize (73%), St. Kitts and Nevis (64%), Haiti (46%), Bahamas (36%) and Trinidad & Tobago (33%). Such impacts would transform coastal tourism in the region, with implications for property values, insurance costs, destination competitiveness and marketing, with wider issues of local employment and economic well-being for thousands of employees (Simpson et al., 2010). Further research on climate change impacts on tourism in the Caribbean would be welcomed.

Additionally, there are a number of uncertainties and critical questions relating to tourism around the impacts of climate change on consumer behaviour, as outlined below:

- What will be the potential climate change impacts on pristine environments, as tourism is heavily dependent on these ecosystems?
- Can the Caribbean still maintain a quality product if less emphasis is placed on the sun, sea and sand product?
- Would tourists be willing to come if the hotel is more than X metres of the beach (as a flood risk management measure)? Is there a minimum threshold?
- How might customer behaviour change due to policy recognition about the environmental vulnerability of an area?
- How does demand change based on climate change impacts (e.g. higher temperature, precipitation)?
- Consumers are becoming more aware about energy and biodiversity challenges. Do we understand what might trigger changes in consumer behaviour?
- Research about international tourism trends and how that affects the Caribbean (e.g. airline industry taxes). Some of this information already exists through organisations such as the Caribbean Tourism Organisation (CTO) and there is a need to collate and then review this.
- What are the wider tourism impacts on natural resources (direct and indirect)? Is there a role for natural resource accounting?

## Biodiversity

Island ecosystems are especially vulnerable to climate change because island species populations tend to be small, localized, and highly specialized, and thus can easily be driven to extinction. Biodiversity research is important to identify key species (both flora and fauna) that are particularly susceptible to climate change. A number of challenges and constraints within the field of biodiversity are highlighted below (as identified by CANARI in their Working Group III report, as part of the framework of the project '*Climate Change and Biodiversity in the Insular Caribbean (CCBIC)*' (2008)):

- The marked fragmentation of the information on the regional biodiversity,
- Lack of a comprehensive ecosystem assessment and species inventories and continued monitoring of key species,
- There are some biological-related parameters for which there are no available climate change projections,
- Information on invasive and introduced species, diseases and pest species is dispersed and in some cases incomplete,
- Lack of a data portal through which data and information on the impact of climate change on the regional biodiversity can be accessed. It was stressed that the facility should be developed with at least bilingual capability.
- Documented information on the traditional knowledge of the biodiversity of significance to local and indigenous peoples is limited, dispersed and at risk of being lost. There is an urgent need to record the oral traditional knowledge.
- There is an absence of information on the effectiveness of protected areas under future climate change scenarios,
- Existing management plans for protected areas do not take climate change into account.

Addressing these issues would then allow independent verification of the impacts of environmental change and help inform decision-making on habitat protection under climate change. Projections must be modelled and generated to support adaptation planning for biodiversity conservation and for strategically important economic sectors. There is a need to understand how seasonal changes would affect biodiversity (e.g. fruiting, reproduction, closed and open seasons for hunting) and what type of policy changes may be necessary.

It is worth noting that Guyana is developing plans to establish a Centre for Biological Diversity in support of its Low Carbon Development Strategy (LCDS).

## Forests

The importance of forestry for all 15 CARICOM nations was stressed at the Regional Workshop, through its role in watershed management and for those countries that have large standing forests (Belize, Guyana and Suriname). There is a need to understand the impacts of climate change on forest ecosystems and indicator species, together with adaptability and extinction rates, at a country-specific level. This information would help to inform how forests should be managed to build resilience to climate change. An economic valuation of forest resources (timber and non-timber products and services, and ecosystem services) is also needed, together with an assessment of how these resources (and the values provided) may change in the short and long-term as a consequence of climate change.

## Health

Climate change, including climate variability, has multiple influences on human health. Both direct and indirect impacts can be expected including alterations in the geographic range and intensity of transmission of vectors, such as ticks and mosquitoes. Climate change can also result in changing patterns of rodent borne diseases and food- and waterborne diseases, and changes in the prevalence of diseases associated with air pollutants and aeroallergens. However, as identified in the Regional Framework, there is a significant information gap and lack of knowledge regarding appropriate responses to the negative health impacts of the climate change threat. It was stressed in the Regional Framework that this issue must feature as a high priority, as the poorest segments of the Caribbean populations stand to suffer the most.

A study published by the Lancet-UCL Commission (Costello et al., 2008), recommended some key areas for research which provide useful guidelines for studies on climate change and public health in the Caribbean. These include:

- Improving global health and health equity;
- Risk assessment of population displacement;
- Understanding degradation of water supplies;
- Assessing the effects of multiple environmental hazards on vulnerable populations;
- Taking action against climate sensitive risks and appropriate interventions to reduce current and future health burdens

Of note is a recently begun project from the Global Environmental Facility (GEF), which will investigate water scarcity and the impact that it will have on health and the adaptation measures required. The project was initiated in July 2011, titled '*Piloting Climate Change Adaptation to Protect Human Health*'. It focuses on 7 countries distributed around the world, including Barbados.

At the Regional Workshop, the potential climate change impacts on health were largely discussed in the context of water resources (fresh and marine water). For example, the links between water quality, health and extreme events or the impacts of Harmful Algal Blooms (HABs) and their

relationship to public health. It was highlighted that there is a need to understand the impacts that climate change may have on sanitation systems (municipal, community and individual), together with the potential impacts of disinfection by-products in water supply systems, particularly of water that originates in highly organic areas (surface water).

More generally, there is a need to establish the use of key indicators for early warning systems for the onset of diseases such as dengue, typhoid and malaria, and respiratory diseases. Furthermore, there is the need to conduct analyses of the full socio-economic impacts of climate change on health.

## Social impacts

There is a broad gap around the social dimensions of climate vulnerability, which unfortunately has not been fully addressed in this report due to a lack of engagement with social scientists during the regional workshop and consultation process. Excellent work is currently being undertaken on Caribbean social challenges, but this is not tied up with climate change. This reflects the global divide between natural sciences research and social science research. This divide is slowly closing, but there is a time lag in the Caribbean.

Despite high levels of urbanisation in the region, a concerted policy effort to deal with urban issues in general (independent of climate change) is lacking. Because climate change research in the Caribbean is concentrated in natural science studies programmes, urban climate issues have tended not to be seen as a priority. This represents a significant additional gap, and urban elements of vulnerability and adaptation, as well as impacts related to urban infrastructure, should be seen as a priority.

There is a need to understand how climate change will affect local community livelihoods, including gender perspectives. However, it is important that this research does not lose sight of the links between climate change and poverty/livelihoods. The establishment of a monitoring system to assess the impact of climate change on local communities would be beneficial; this would build on CANARI's work on assessing livelihoods. The key livelihoods highlighted for the Caribbean context were forestry, tourism and fisheries. With respect to forest users, it is crucial to understand how their livelihood may be affected by climate change as forest resources are impacted.

### 4.1.2 Responding to a changing climate

Fundamentally, there is a crucial need to understand what are the enabling factors and constraints for mainstreaming climate compatible development. It is important to understand potential uptake for transformative change and technology transfer in the Caribbean context. For example,

- Is the Caribbean making use of the best available technology?
- Can local and indigenous practices and innovation be incorporated in the Caribbean responses to a changing climate
- What actions are farmers already taking to adapt?
- What are the best mechanisms to facilitate uptake of technology / practices that are already available and understood (but not at local level, e.g. individual farms)?

A thorough and comprehensive cost-benefit analysis of adaptation and mitigation strategies, nationally, locally and across the region is needed. The UN-ECLAC has undertaken several sectoral studies assessing the economic costs of climate change, through the project '*Review of the Economics of Climate Change in the Caribbean (RECCC)*' (see

<http://www.eclac.org/id.asp?id=41807>). One key question in need of cost-benefit analyses is the costs and benefits associated with changing infrastructure within the tourism sector.

## Adaptation actions

There are a number of important considerations to highlight:

- Adaptation measures need to be robust to uncertainty and therefore adaptable from event to event, without reliance on precise projections of future conditions (as many scenarios have limited utility at the island scale);
- Adaptation is a process and it should follow the established path of understanding the vulnerabilities, risks and impacts, developing the capacity and pursuing actual actions. This is where fact-based research and validation become extremely useful.
- There is a need to be able to measure adaptation (e.g. indicators).

With respect to protection of the coastal zone, there is a need for an accurate valuation database of the assets (physical and livelihood/non-market) and costs associated with building protective structures along the coasts of the Caribbean islands, especially near major urban centres and popular tourism developments. Equally, there needs to be an assessment of the social and economic benefits of ecosystem / biodiversity buffers (such as Marine Protected Areas, National Parks, and Active Management Areas) and the economic value of conservation and disaster mitigation. The financing of protected areas in the Caribbean is highly complex.

Coastal and fishing communities are particularly vulnerable to the effects of climate change and any associated adaptation actions. Research is needed to understand what the adaptation options for these communities are. For example, it might be appropriate to develop aquaculture techniques and methodologies for making indigenous species more resilient. Equally, it might be appropriate to explore alternative livelihood options, in order to reduce pressure and dependence on marine species that are likely to be impacted by changes in climate. Similarly for forest-based livelihoods and the assessment of potential adaptation actions, it is important to understand what the potential changes may be and the rate of change, together with any actions users are currently taking. There is a need to undertake feasibility studies into potential alternative livelihoods, including low-carbon uses and economic feasibility. Furthermore, an assessment involving the private sector of the establishment of micro-finance mechanisms for small communities (growers, fisheries, tourism service economies) would be beneficial.

With respect to agriculture and food security, research is needed on sustainable practices, such as low till agriculture, organic farming, water harvesting, drip irrigation, greenhouse cultivation and mulching, agroforestry, permaculture, and soil conservation in the Caribbean context. Equally, research is needed into the methods of processing agricultural products, to add value and variety to output for food and other uses. This research will help inform national food security adaptation strategies, which include agriculture adaptation strategies, and facilitate the design of insurance schemes for small farmers.

A number of further, more specific agricultural research needs are highlighted below:

- Develop and identify drought/flood resistant and salt and temperature-tolerant varieties of staple and commercial crops, drawing upon local and indigenous knowledge. These would need to be placed in multiple sites around the Caribbean region. (This would expand on UWI Mona research currently being undertaken).
- Research and potentially introduce indigenous and other breeds of cattle, pigs, goats and poultry that are heat tolerant and more feed efficient for commercial meat, milk and egg production by 2020.

- Take stock of indigenous germplasm for key crops (food and feed) and livestock.

## Energy and carbon management actions

The focus of mitigation research needs and actions is naturally the energy sector. Important questions to address include:

- What is a low carbon community in the Caribbean context?
- What is needed for transition to a low carbon community?
- What are the regulatory/legislative/fiscal incentive/policy barriers to the adoption of low carbon energy generation? How can these barriers be overcome?
- What are the available alternative energy sources (including some not being widely considered e.g. geothermal, solar thermal, hybrids)?
- What is the feasibility of the renewable energy mix at national, regional and local (e.g. rural community) level?
- What is the appropriateness of alternative energy sources considering efficiency and environmental and social impacts?

An assessment of mitigation actions within the energy sector needs to take place at the country-level, recognising that there are specific challenges due to the diversity of the energy sector within the Caribbean. For example, Trinidad and Tobago has significant oil and gas resources, whereas smaller Caribbean islands are dependent on oil and gas imports. There is a need to look at the issues in common and those that are divergent within the region.

In order to assess the potential for a low carbon community in the Caribbean, the first research priority is to map out the overall pattern of needs, which as explained above are very different between countries. In all Caribbean countries, renewable energy projects are viable, if finance can be mobilised and the technical and regulatory challenges removed. There is also a need to map out the financing of energy alternatives across the Caribbean, which is a complicated calculation (e.g. due to different transport distances). Following on from the mapping exercise, there is a need to provide different cost estimates for alternative energy sources and the level of subsidy needed (which will be spatially variable), in other words, the economy of adjustment policies. Policy-makers are largely not aware that the private sector can become involved in the financing. Finally, the region needs to think strategically and holistically for the best sites for production of alternative energy.

Other mitigation actions and research needs mentioned include:

- Research into sustainable buildings and sustainable communities (urban centres), including retrofitting. Whilst pilot demonstration projects on new build are vital, the primary challenge is to retrofit existing buildings with new technology to reduce energy demand.
- Assessments of vegetation cover and other resources, using remote sensing among other technologies and methodologies to facilitate participation in mitigation initiatives, potentially establishing permanent sample plots.
- Analysis of the impacts of climate change on forest/timber growth/sequestration.
- Understanding of the feasibility of Payment for Ecosystem Services (PES) schemes, including a valuation of services provided, the enabling environment and the impacts for forest communities' livelihoods.
- Carbon sequestration potential of mixed tropical forests
- Studies to improve technology, competitiveness and economic efficiency in fishing operations recognising that they currently use significant volumes of fossil fuels.

### 4.1.3 Evaluating climate compatible development

The research gaps identified by the consultations include:

- There is a need to research the sensitivity of economic indicators to the impacts of climate change. There is a need to present the “hard” economic facts and hence collation of economic data is necessary.
- There needs to be an improved methodology for the costing of impacts, including a database of asset impact costs across countries.
- An analysis of the impacts on gender and vulnerable sub-groups to inform policy decisions is required.
- Understanding the context of climate change impacts and the wider sustainable development and growth objectives in developing countries.
- Developing a risk management ethic within the research community to deliver data sets and tools to meet the needs of decision-makers.
- Working with business, financial and legal researchers in collaboration with financial institutions to develop alternative financial instruments in the Caribbean.

### 4.1.4 Policy processes

The lack of clarity and understanding regarding governance and decision-making is a key research priority. There is very little information on government structures to facilitate decision-making. This is crucial in order to respond adequately to changes in climate. There needs to be an assessment of the policy, legal, regulatory and institutional frameworks and governance arrangements, together with compliance incentives, across a number of sectors, including tourism, fisheries and coastal and marine ecosystems. The assessment of policies, laws, regulations, codes and standards should also include cost-benefit analysis. For example, it might be appropriate to research the cost effectiveness of new building codes that incorporate climate change considerations.

There is also a need for adoption of the principle of evidence-based decision-making as part of governance system. A culture of using climate change science as an aid to decision-making is needed. Greater public awareness will increase accountability on the part of policy makers and politicians to demonstrate that decisions are evidence-based. However, the capacity of government to use information from researchers is not yet developed. To help address knowledge gaps, case studies (including costings) on knowledge based decision-making within the Caribbean are required. For example, an analysis of economic incentives and alternatives to water provision solutions (households and businesses including the tourism, and government sectors) may be appropriate.

There is a need to develop cross-agency institutional mechanisms to coordinate policies and programs, to build capacity for linking national development planning, project cycle management, collaborative management, and conflict resolution. These cross-agency networks need to develop and show the benefits of multi-way information exchanges that facilitate shared awareness and coordinated action.

With respect to Environmental Impact Assessment (EIA) legislation, this should be extended to include social impacts and the effect of climate change on a project during its lifetime. Monitoring of projects post-construction must also be enforced and publicly reported.

## 5. Research networks and partnerships

### 5.1 Existing research networks and partnerships on climate change and development in the Caribbean

Several regional programmes are strengthening partnerships and consolidating emerging networks among researchers within the Caribbean, as well as with research institutions outside the region. On issues central to the impact of climate on development it seems that, within the region, individual campuses and universities are working well with one another. Additionally, The University of the West Indies (UWI) has a longstanding relationship with the US National Oceanic and Atmospheric Administration (NOAA) and the Caribbean Community Climate Change Centre (CCCCC) implementing early monitoring systems for coral reefs, climate and sea level monitoring. The Climate Studies Group (CSG) of the UWI Mona Campus has also collaborated with the CCCCC, the UK Hadley Centre, and the Institute of Meteorology for Cuba (INSMET) on climate scenario development and downscaling activities.

#### Existing research networks and partnerships include:

**CCCCC:** the official archive and clearing house for regional climate change data in the CARICOM Caribbean. The Climate Change Centre coordinates the CARICOM countries' response to climate change, working on effective solutions and projects to combat the environmental impacts of climate change and global warming. The Centre also provides climate change-related policy advice and guidelines to the CARICOM Member States through the CARICOM Secretariat. The CCCCC has been very successful in developing and encouraging partnerships across regional and international research institutions. Most of the CCCCC 15-20 staff members are funded on a project-by-project basis (fewer than 5 scientific professional staff are employed full time by the Centre independent of projects), though the organisation is trying to move towards longer-term funding for employees. The Centre employs a mix of social and physical scientists.

The Agreement establishing the CCCCC includes a number of functions directly relevant to research:

- Collecting, analysing, storing, retrieving and disseminating meteorological and sea-level data relevant to the observation of climate change and facilitating, in collaboration with specialized Caribbean agencies, the collection of information about the impact of climate change on the economic sectors in the Caribbean.
- In collaboration with Members and relevant agencies, develop special programmes to address implications in the Region for coastal zone management, disaster management, and potentially vulnerable sectors such as tourism, health, agriculture and insurance.
- Promoting the sharing of resources, technical co-operation and information exchange with other global climate change initiatives, in particular in Small Island Developing States and Latin America.
- Coordinating (and initiating) the development of regional research programmes, including adaptation of global climate and impact modelling efforts and specialized training focused on effective adaptation to global climate change.

[www.caribbeanclimate.bz](http://www.caribbeanclimate.bz)

**Caribbean Natural Resources Institute (CANARI):** a non-profit organisation whose mission is to promote equitable participation and effective collaboration in managing the natural resources critical

to development. It conducts applied research, analysis, monitoring and evaluation of innovative policies, institutions and approaches to participation and governance. The organisation also engages in capacity building and fostering partnerships, particularly those that build on regional assets and talents and contribute to closer regional cooperation. CANARI's main areas of expertise include biodiversity, ecology and fisheries sectors.

[www.canari.org](http://www.canari.org)

**Coastal Areas Climate Change Education Partnership (CACCE):** A network of institutions, scientists, and educators seeking to help people in coastal areas learn about and address the impacts of climate change. The network is supported by the US National Science Foundation's Climate Change Education Partnership (CCEP) Program. Regional focus: Florida and the Caribbean, emphasizing coastline issues.

[www.cacce.net](http://www.cacce.net)

**CARIBSAVE partnership:** a not-for-profit organisation based in the Caribbean, headquartered in Barbados and formed in 2008. CARIBSAVE works with stakeholders to address the impacts and challenges surrounding climate change, the environment, economic development, tourism and community livelihoods across the Caribbean Basin, using an integrated and holistic approach.

[www.caribsave.org](http://www.caribsave.org)

**The Latin American and Caribbean Research Network:** created by the Inter-American Development Bank in 1991. Though not focused on climate change, this network finances applied research and contributes to development policy agendas in the region by providing grant funding for studies on economic and social issues. The network comprises nearly 350 regional research institutes. Its objectives are to improve the quality of research performed in the region, and to contribute to the development policy agenda in Latin America and the Caribbean.

<http://www.iadb.org/en/research-and-data/the-latin-american-and-caribbean-research-network,3316.html>

**Caribbean Research and Innovation Networks (EUCARINET):** a 4 year project whose main goal is to strengthen bi-regional sustainable policy dialogue on science and technology between EU Member States and the Caribbean. The project, which has already begun to look at renewable energy priority setting in the region, will work at policy, programme and institutional (research entities) levels. The consortium includes 12 partners, 6 from the EU and 6 from the Caribbean, representing stakeholders from research, industry, government and civil society.

<http://www.eucarinet.eu/>

**Canada-Latin America and the Caribbean Research Exchange Grants (LACREG):** a program designed to strengthen international partnerships and consolidate emerging networks among researchers from Canada, Latin America and the Caribbean. Managed by the Association of Universities and Colleges of Canada, and supported financially by the International Development Research Centre (IDRC), LACREG offers Latin American, Caribbean and Canadian researchers small grants to support joint activities that contribute to creating, disseminating and applying knowledge for international development.

[http://www.aucc.ca/publications/auccpubs/brochures/lacreg\\_e.html](http://www.aucc.ca/publications/auccpubs/brochures/lacreg_e.html)

## 5.2 Potential partnerships

### Working with donors and IFIs

The role of the international development community is set out in the Implementation Plan. Several of the key elements of that role are particularly relevant to a Caribbean research programme including:

- Providing financial and technical resources.
- Facilitating technology transfers.
- Supporting the development of international research partnerships.
- Financing scholarships, graduate and teaching exchange programmes.
- Using Caribbean based institutions to undertake donor and IFI research.
- Providing financial and technical assistance to universities and research institutions to support long-term development plans.
- Ensuring that all baseline data collected as part of any funded project should be considered as open access, including data collected in projects undertaken to inform donor and IFI policy.

This research diagnostic can be used by the CCCCC and research institutions to develop a co-ordinated research programme for discussion with potential funding partners.

## 5.3 Developing the research / policy interface

A number of challenges were identified during the consultations regarding the importance of greater engagement between researchers, decision-makers and the wider society. In particular, the following issues are a priority:

- Identifying the process by which research could be integrated within and/or disseminated to existing regional networks of policy makers, academics, and/or civil society networks.
- A greater level of co-ordination amongst the regional research community, which would enable cross-sectoral themes and a more holistic view to develop. This would assist in providing applied research for decision-making.
- An assessment of the barriers to and opportunities for improving information sharing and communication on climate and climate impacts across the region.
- Ownership and access to data held by governments and regional agencies, which for a variety of reasons is not readily available to the research community. Addressing this barrier has been identified as a priority action in the Implementation Plan. Mechanisms for access must be practical and sufficient to support widespread dissemination and use.

Specifically, a number of questions were raised during the consultations and at the Saint Lucia workshop:

- Do researchers understand what information and tools users need to make more effective decisions?
- How can governments and the private sector be encouraged to make evidence-based decisions using the best available information?
- What are the most effective communication strategies to influence policy-makers or other key audiences in the Caribbean (e.g. farmers and the private sector)?

- Can technologies (such as mobile ICT) be used as an effective tool for communication? There has been a trial by UWI (Mona) to engage farmers by utilising mobile phones to provide information. There is a need to embrace ICT and recognise the potential multiplier effect it can have in leveraging scarce resources (particularly trained researchers) and in disseminating information.
- Additionally, extra funding is critically needed for engagement, communication and capacity-building. There needs to be a widespread recognition that science should be accessible to the people.

## 5.4 Developing research networks

It would be beneficial to develop a Caribbean interdisciplinary climate change research network. The focus of this research network should be on:

- Appropriate formality and structure of a Caribbean interdisciplinary climate change research network.
- Creating greater collaboration between researchers and institutions.
- Identifying joint-funding opportunities.
- Developing joint research institutions.
- Developing multi and inter-disciplinary research programmes to move away from single focus projects.
- Building on the body of research and knowledge about climate change that already exists in the region.
- Sharing baseline data and promoting open-source and open-access cultures.
- Acting as a research 'clearing-house' matching user needs with researcher skills and expertise.
- Developing international research programmes.

Consultees offered a number of clear and concrete recommendations for the development of future research networks more generally, mainly in the area of support for cross-sector or cross-agency working. For example, support for collaborative research among individual faculties and campuses across the region's universities (particularly for joint working between physical and social scientists) could be much improved and would offer beneficial multi-disciplinary results.

As few formal mechanisms currently exist to encourage collaboration between academics and regional 'implementing organisations' (e.g. health services, water resource managers, town and country planning agencies, etc.), there is a critical need for agreed structures to facilitate and encourage research that is relevant to end-users and implementing organisations, and which is practically focused. Some partnerships of this type are beginning to emerge through individual projects, but they do not have long-term financial sustainability. Additionally, because government funds tend to be focused on national needs rather than regional needs (there are few opportunities, for example, for coastal geomorphologists in one country to work with town planners and coastal flood risk managers in another country) there is a basic need for mechanisms that enable joint working between researchers from different nations.

# 6. Research Capacity in the Caribbean

## 6.1 Regional Research Capacity

This section of the report explores what capacity exists or is lacking within research institutes and universities in the region at the systematic, institutional and individual levels, with respect to climate change and development. The approach follows the UNDP's 'National Capacity Self-Assessment' methodology that has been used across the Caribbean.

Capacity refers to the ability of entities (institutions, organizations, and communities) and individuals operating within a system to define specific objectives and work effectively and efficiently to attain those objectives.

### 6.1.1 Systemic research capacity

Systemic capacity is enhanced through:

- Inter-agency coordination arrangements,
- Political commitment,
- Public service incentives and accountability, and
- Legal and regulatory frameworks.

Currently, the region's formal mechanisms for building interdisciplinary research capacity and communicating research results are weak. Poor communication among scientists, especially between natural and social scientists, impairs dissemination of truly multi-disciplinary climate change research and prevents take-up of research results into policy. The timing of research is also an important issue for building capacity; researchers should actively seek out windows of opportunity to insert research results into national policy-making processes as they become available.

Establishing climatic and socio-economic baselines are critical in order to conduct research that contributes toward progress on climate-compatible development. National assistance in collecting, maintaining and providing access to datasets is a crucial requirement for building research capacity. The Caribbean Development Bank is providing financial resources to "rescue" climate related data across the region and develop protocols for data management – this should be expanded to other areas. The CCCCC currently facilitates information sharing through its Clearinghouse, but success in this initiative is dependent on national support to develop, maintain, and disseminate Clearinghouse contents regionally.

### 6.1.2 Institutional research capacity

Institutional capacity is strengthened by incorporating:

- Clear mandates and strategies,
- Management systems, structures and processes,
- Information management within and among organizations,
- Human and financial resources, infrastructure, and
- Public accountability and client orientation.

The academic expertise within regional universities is widely held to be very high. Within UWI, the Mona campus (Jamaica) houses the well-regarded Climate Studies Group, while Barbados' Natural Resources Group includes the Centre for Resource Management and Environmental Studies

(CERMES). The Trinidad campus also contains a nascent climate studies group. The University of Belize is very involved in coastal and marine resources research and issues surrounding coral reefs. The University of Suriname is very engaged in mangrove and biodiversity research, and a Centre for the Study of Biological Diversity is to be established at the University of Guyana. Each of these universities has recognised expertise in climate change related research, and several representatives from these institutions participated in the Research Capacity workshop.

The basic academic resources at these institutions are of a high standard, and researchers are well integrated with international networks (Caribbean researchers are represented within the IPCC process, for example). UWI's capacity to lead research is felt to be very high. Importantly, work done by UWI has a particular legitimacy for Caribbean policy makers because it has high regional relevance. Resources to take on more research and access to funding are often limited within the region, however, and this lowers capacity.

Very good research is currently being conducted in the natural sciences (e.g. ecology, biodiversity, coral reefs, and forestry), though this is not necessarily linked to climate change at present. This is beginning to change, however. Regional academics possess excellent research skills in the areas of agricultural science, sociology of agriculture and food security, some of which is beginning to be linked up with climate change research. Excellent work is also being done in the Faculty of Social Sciences at UWI Mona on the multi-dimensional aspects of poverty and Caribbean vulnerability, though this hasn't yet looked in detail at climate change impacts. The disconnect between physical and social science work with climate change impacts should be highlighted as a gap.

Interestingly, this artificial 'divide' between climate impacts assessment and natural/social science research was ascribed by consultees to two potential factors:

1. Different timescales - the focus on longer term planning in the adaptation community versus the emphasis on short-term and present-day impacts for agriculture, health, disaster management, etc. mean that these haven't been integrated as they should have. A possible solution is to look for co-benefits in both areas. Consultees also cautioned that attention needs to be paid to the overlap in implementation planning and practice to avoid doing the same thing twice.
2. Different funding mechanisms – much climate change funding has been tied to mitigation and emissions reductions issues, with vulnerability and adaptation research as an 'add-on'. Adaptation has generally been treated as a different funding 'pot' from other sectoral research funding. This is a critical issue which should be addressed in future research planning.

The capacity of research institutions that are not university-based is more mixed. For example, the Caribbean Natural Resources Institute (CANARI) is very strong, and has good convening power with the region, though other organisations are considered to be less successful.

There are also several international institutions which work very well with Caribbean research organisations. International institutions have capacity to take on various work packages as a support to regional research leads, for example, and many such institutes have employees who have worked and developed networks in the region, and have gained an appreciation for regional strengths and challenges.

### **6.1.3 Individual research capacity**

Individual capacity is indicated through:

- Job descriptions, responsibilities and motivation,
- Technical skills, and

- Personal workspace facilities.

Suggestions for initiatives to help researchers improve their individual research capacity include building skills in modern data collection, analysis and interpretation, and enhancing researchers' ability to use modelling tools (e.g. catchment modelling, agent based modelling). Acquisition of cost-benefit analysis skills would also make a significant contribution to research capacity of individuals. Finally, workshop participants felt that use of innovative technology (e.g. mobile phones and video recorders) would aid in data collection from local communities, which would in turn facilitate identification of climate change impacts.

## 6.2 Capacity building needs in the Caribbean

At the Regional Diagnostic Research Capacity and Priorities workshop, participants made several specific capacity building requests. These included:

- Training for non-academics to undertake baseline data research and monitoring on climate trends and impacts;
- Continual professional training, and seminars/short courses on climate impacts and adaptation for practitioners;
- Scenarios for both climate and development pathways – these were seen as a useful cross-cutting tool in many areas;
- Support for data collection, data protocols, and data management;
- Use of CCCCCs clearinghouse to facilitate sharing of information on what research is being done;
- Better access for regional agencies to decision-makers;
- Training in the use of modern data collection, analysis and interpretation tools;
- Training in the use of modelling tools (i.e. catchments, agent based modelling);
- Training in the use of cost benefit analysis (water economists);
- Improved identification and recording of climate change impacts;
- Collection of data from local communities using innovative technology tools e.g. mobile phones, video.

## 6.3 Regional capacity for policy influencing

Current methods of engagement between researchers and policy makers in the Caribbean include one-on-one personal relationships, ad-hoc workshops and presentations. It is widely felt that these mechanisms are not adequate, and far more engagement between researchers and the private and public sectors is needed.

Consultees noted that there are very few formal entry points (e.g. white or green papers) within the parliamentary system in the region, where researchers' views and recommendations can be taken into account. A second difficulty arises when policy makers attempt to manage negotiation and compromise between a fairly strong activist community on the one hand and equally strong financial/business stakeholders on the other. The research community is often seen as closer to environmental activism and distant from 'real world' policy decisions. Given the perceived need for regional development, policy-makers may have tended to see all input on 'environmental issues' (including research) as anti-development, and this might explain some reluctance for formal policy engagement with researchers. Helping policy makers to see climate change as an economic and social issue, as well as an environmental one, is critical to overcoming this reluctance.

There was a suggestion from consultees that sub-regional hubs, or ‘boundary organisations’ (at universities or other research institutions) could be set up to ensure that research becomes embedded in policy and planning. These boundary organisations would work between researchers and practitioners, producing information from research that is relevant and useful for end users. Boundary organisations would also sustain the dialogue between researchers and practitioners, so that research is not simply taken up in a crisis-oriented fashion. This role falls within the remit of the CCCCC and of other regional organisations to develop in conjunction with users and decision-makers. A good model for boundary organisations is the Regional Integrated Sciences and Assessments (RISA, [http://www.climate.noaa.gov/cpo/cpo\\_pa/risa/](http://www.climate.noaa.gov/cpo/cpo_pa/risa/)) Program in the US.

## 7. Conclusion

CARICOM states share many social, economic and environmental challenges. These are compounded by the additional problems of poverty, high population density, rapid urbanisation, food and energy insecurity, a lack of infrastructural resources and inadequate data collection and management to allow for informed decision-making and robust development planning. In combination with these challenges, climate change poses a severe threat to Caribbean countries' development prospects. Responding to climate change will require a large and sustained investment of resources. This report has attempted to support the areas in the Regional Framework and the Implementation Plan which will require evidence-based research and research-based tools that are not already available.

A broad range of climate change research is currently underway (or has recently been completed) at Caribbean research institutions and consortia, and it is vital that the results of this work are communicated effectively and taken up in policy discussions. Despite this broad range of research, several research gaps were identified.

In order to assess and model the impacts of a changing climate, it is crucial that climate hazards are assessed. There is a need to focus climate change science research to ensure that the specific climatic drivers in the Caribbean are captured and understood. This will help policy-makers and practitioners understand the Caribbean's current exposure to climate variability and the actions that need to be taken. A holistic approach is essential when considering the impacts of a changing climate. The interconnections between natural resources and other socio-economic systems are generally not well studied or understood in the Caribbean, and cross-cutting research and collaboration should be encouraged.

Another key challenge is the development of a risk assessment framework for research. There is a crucial need to understand which enabling factors and constraints facilitate or hinder the mainstreaming of climate compatible development. Furthermore a thorough and comprehensive cost-benefit analyses of adaptation and mitigation strategies, nationally, locally and across the region is needed.

There is a need to develop cross-agency institutional mechanisms to coordinate policies and programs, to build capacity for linking national development planning, project cycle management, collaborative management, and conflict resolution. Several regional programmes are strengthening partnerships and consolidating emerging networks among researchers within the Caribbean, as well as with research institutions outside the region, though this needs to be reinforced and more broadly developed.

At the 'Regional Diagnostic on Research Capacity and Priorities' workshop held in Saint Lucia in May 2001, it was agreed by the workshop participants that it would be beneficial to develop a Caribbean interdisciplinary climate change research network. This would support the critical need for agreed structures to facilitate and encourage research that is relevant to end-users and implementing organisations. Several criteria and elements that foster and support successful research networks were defined at this workshop and through consultation. Collaboration was regarded as the key ingredient to successful and enduring regional research partnerships.

In terms of research capacity, the academic expertise within regional universities is widely held to be high. However, the region's formal mechanisms for building interdisciplinary research capacity and communicating research results are seen to be weak. Poor communication between scientists (particularly between natural and social scientists), hinders the development of truly multi-disciplinary climate change research and prevents take-up of research results into policy. Overall, far more engagement between researchers and the private and public sectors is needed.

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## 9. Annexes

### Annex 1. List of consultees

The following people participated in the Regional Diagnostic Research Workshop, held on 5<sup>th</sup> May 2011. The workshop discussions have been incorporated into this report.

Name	Organization/Institution
Dr. Michelle Kooy	Climate and Development Knowledge Network
Dr. Paulette Bynoe	School of Earth and Environmental Sciences, University of Guyana
Ms. Gabrielle Gellineau	Caribbean Association of Industry and Commerce (CAIC)
Dr. Elma Kay	Environmental Research Institute, University of Belize
Dr. Adrian Trotman	Caribbean Institute of Meteorology and Hydrology
Dr. Riad Nurmohamed	Faculty of Technology, Department Infrastructure, University of Suriname
Ms. Gail Henry	Caribbean Tourism Organization
Ms. Saudia Rahat	Caribbean Disaster and Emergency Management Agency
Ms. Cheryl Dixon	Caribbean Development Bank
Dr. Michael Taylor	Climate Studies Group, University of the West Indies, Mona
Mr. Keith Porter	Forestry Department, Jamaica
Dr. Adrian Cashman	Centre for Resource Management and Environmental Studies (CERMES)
Mr. Milton Haughton	Caribbean Regional Fisheries Mechanism
Dr. Leslie Simpson	Caribbean Agriculture Research and Development Institute
Dr. Christopher Cox	Caribbean Environmental Health Institute
Dr. Kenrick Leslie	Caribbean Community Climate Change Centre
Dr. Ulric Trotz	Caribbean Community Climate Change Centre
Dr. Mark Bynoe	Caribbean Community Climate Change Centre
John Firth	Acclimatise
Mrs. Nicole Leotaud	Caribbean Natural Resource Institute
Mr. Carlos Fuller	Caribbean Community Climate Change Centre
Patricia Leon	Climate and Development Knowledge Network
Sarah Horsfield	Climate and Development Knowledge Network
Alison Cambray	Climate and Development Knowledge Network

The following people were consulted after the workshop through telephone interviews. A list of interview questions is provided in Annex 4.

- Arnaldo Bezanilla, Instituto de Meteorología de la República de Cuba (INSMET)
- Dr. Dave Chadee, Department of Life Sciences, University of the West Indies St Augustine
- Dr. David Dodman, International Institute for Environment and Development
- Emily Morris, Centre for Latin American Research and Consultancy, London Metropolitan University

- Dr. Michelle Mycoo, Department of Surveying and Land Information, University of the West Indies St Augustine
- Dr. Roger Pulwarty, US National Oceanographic and Atmospheric Administration

## Annex 2. List of consultation interview questions

**Question 1: Research Capacities:** What are the strengths and capacities of research institutions [your institution if applicable]?

**Question 2: Research Gaps and Priorities:** What are the research gaps related to climate change and development? What are the priorities for policy makers?

**Question 3: Research Partnerships:** What are the successful research partnerships in-country and why?

**Question 3a:** Do you feel that CDKN should devise an open call to research institutes outside the Caribbean, or keep it restricted to regional organisations?

**Question 4:** Do stakeholders have a **vision** of how they would like research on climate change and development to be in the future? What does this look like?

**Question 5:** Current **methods of engagement** of research with policy makers, covering: degree of consultations by policy makers; perceived role of research and function of research; perceived role of research in informing policy; role of civil society and other stakeholders involved (e.g. private sector).

**Question 5a:** What are the existing platforms for getting research to policy-makers? Should funding be made available for dissemination and communication?

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