

Coral Reef Monitoring for Climate Change Impact Assessment and Climate Change Adaptation Policy Development

Leslie John Walling and Marcia M. Creary-Chevannes

Abstract

Small Island and Low Lying Developing States of the Caribbean produce less than 1 per cent of the total global greenhouse gas emissions, but bear an overwhelmingly disproportionate level of risk associated with the impacts of climate change.

Coral reefs represent a coastal ecosystem of great economic and social importance to the countries of the Caribbean. As elsewhere, the coral reefs of the area are expected to have a low to moderate vulnerability to climate change, but are likely to experience extreme stresses from local land-based human activities, especially when these activities are combined with the pressures caused by climate change. As little can be done to mitigate the phenomenon of climate change in the short-term, adaptation measures represent the only realistic way of reducing the vulnerability of coral reefs to climate change. Adaptation policies provide policy frameworks within which meaningful strategies for sustainable coral reef management may be developed and implemented.

This paper looks at the implementation of the Global Environment Fund/World Bank sponsored Caribbean Planning for Adaptation to Global Climate Change (CPACC) project, under which 12 Caribbean countries are preparing to cope with the adverse aspects of climate change. It focuses on components of the project dedicated to coral reef monitoring and policy formulation.

The establishment of monitoring programs and the progress toward the preparation and adoption of national adaptation policies are documented. It is noted that the limited availability of human capacity for monitoring constitutes a widespread problem, requiring the development of innovative strategies to collect accurate environmental data on which to base policies. Extensive use of digital video technology is expected to help overcome the problem of data collection.

The fact that many of the adaptation measures also constitute sound coastal resource management practice means that the allocation of scarce resources to adaptation initiatives can be justified in terms of short-term planning and resource management benefits while also addressing the need to prepare for the more distant potential impacts of climate change and sea level rise.

Introduction

Like other small island developing states (SIDS),¹ the small and low-lying states of the Caribbean share a number of socioeconomic challenges.

Among these challenges are heavy dependence upon narrow resource bases, susceptibility to the vagaries of international trade, lack of economies of scale, high transportation and communication costs, grave vulnerability to natural disasters,

¹ The United Nations Department of Economic and Social Affairs, which monitors the progress made in the implementation of the Barbados Programme of Action for the Sustainable Development of SIDS, currently lists 41 SIDS: Africa (Cape Verde, Comoros, Mauritius, Sao Tome and Principe, Seychelles); West Asia (Bahrain); Asia and the Pacific (Cook Islands, Fiji, Kiribati, Maldives, Marshall Islands, Micronesia, Nauru, Niue, Palau, Papua New Guinea, Samoa, Singapore, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu); Europe (Cyprus, Malta); Latin America and the Caribbean (Antigua and Barbuda, Aruba, the Bahamas, Barbados, Cuba, Dominica, the Dominican Republic, Grenada, Haiti, Jamaica, the Netherlands Antilles, Saint Lucia, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Trinidad and Tobago, and the United States Virgin Islands).

scarce land resources, and ever-increasing pressures on coastal and marine environments and resources. These challenges are compounded by the limited availability of human capacity and of the means to manage and use natural resources on a sustainable basis.

The features that small island states have in common also serve to increase their vulnerability to the projected impacts of climate change. These features include, but are not limited to, small size; the fact that they are surrounded by large expanses of water and hence are relatively isolated; limited natural resources; extreme openness of economies that are highly sensitive to external shocks; large populations with high growth rates and densities; and limited funds, human resources, and skills (Nurse and Sem 2001).

SIDS in the Caribbean produce less than 1 per cent of the total global greenhouse gas emissions, but bear an overwhelmingly disproportionate level of risk of damage from the impacts of associated climate change due to their inherent vulnerability to natural disasters. The most recent assessment of the consequences of, and adaptation responses to, climate change identifies small island states as among the locations most vulnerable to the potential adverse effects of climate change and sea-level rise (IPCC 2001). The report describes model-projected scenarios for the Caribbean Sea based on a 1 per cent per year growth in greenhouse gas (GHG) concentrations after 1990, with the resulting GHG-induced positive radiative forcing and negative radiative forcing of sulphate aerosols. The projected scenarios for the Caribbean include:

- Sea-level rise of between 0.09 to 0.88 m between 1990 and 2100;
- Marginal decrease in diurnal temperatures as a result of the relatively more pronounced increase in minimum daily temperature than in maximum temperature over the regions where small island states are located;
- Projected area-average annual mean warming over the Atlantic Ocean and Caribbean Sea of approximately 2°C by the 2050s and 3°C by the 2080s;
- Fewer rainy days per year and an increase in the daily intensity of precipitation, resulting in a greater probability of more frequent drought and flood events;

- No significant change in hurricane frequency, but a possible increase of 10 to 20 per cent in hurricane intensity (Nurse and Sem 2001);
- Mean rainfall intensity up by 20 to 30 per cent;
- Temperature-induced bleaching that poses a distinct threat to the productivity and survival of coral reefs.

“Coral reefs are subject to a range of interacting influences and processes originating from marine, terrestrial and atmospheric sources operating over a wide range of spatial and temporal scales” (Boesch et al. 2000). The openness of coral reef communities makes them susceptible to activities that take place in different environments or at some distance, provided the reefs are linked in some way to that activity by physical and/or biological processes. Caribbean coral reefs are already under threat from a wide range of land-based development activities (Wilkinson 2000). The stresses from land-based human activity are a manifestation of the poor or misdirected planning and management of those activities. The over-exploitation of the reef resources, excessive domestic and agricultural pollution, increased sediment runoff from unregulated landuse practices, and habitat destruction are some of the anthropogenic factors contributing to the decline of coastal ecosystems. The implications of these planning and policy failures are compounded by the characteristic challenges facing SIDS (see above).

It is anticipated that development activities in the coastal zones of SIDS and low-lying coastal states will:

- Lead to a decrease in the ability of coastal systems to cope with natural variability;
- Adversely affect the natural capability of these systems to adapt to changes in the climate;
- Lead to increased risk of hazards that affect coastal populations, infrastructure, and investment (Bijlsma 1997).

Coral reefs are expected to have a low to moderate vulnerability to climate change, but are expected to experience extreme stresses from local land-based human activities (Maul 1993). Vulnerability to climate change is a function of both exposure to changes in the climate and ability to adapt to the impacts associated with that exposure. Since the climate change

phenomenon will not respond in the short term to mitigation efforts (Nurse and Sem 2001), adaptation measures represent the only realistic way of reducing the vulnerability of coral reefs to the impacts of climate change.

Adaptation planning encompasses the concepts of “damage reduction” and “increased resilience” (IPCC 2001) and “vulnerability reduction” through changes in behavior and economic structure. The resilience of coral reef communities is being compromised by anthropogenic activities. This reduction in, or loss of, resilience represents a corresponding loss or reduction in adaptive capacity. Managing those factors that stress coral reefs and reduce their resilience therefore represents an adaptation strategy. Since measures to manage land-based impacts on coral reefs are desirable and beneficial, even in the absence of global climate change (GCC), the development of adaptation policies and strategies to reduce anthropogenic impacts on the Caribbean coral reefs represents a no-regrets, win-win strategy.

Strategies for the effective conservation and sustainable management of coral reefs cannot be successfully implemented in isolation from strategies to address other coastal resource management issues. There must, therefore, be an integrated approach to coastal resource management within which the need for sustainable coral reef management can be nested. This approach has been labeled Integrated Coastal and Ocean Management. The Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) have identified it as the most important vehicle for adapting to GCC (Bijlsma 1997). Integrated Coastal and Ocean Management will address short-term, present-day needs (climate variability, uncoordinated coastal development, the need for sustainable coastal resource use, etc.) while providing a predictive tool with the capability to plan for and respond to medium- and long-term issues such as sea-level rise and climate change.

Many of the strategies that small island states might employ to adapt to climate change would be those that constitute sound environmental management and appropriate responses to current climate variability (Nurse and Sem 2001). Given this commonality and the gaps in existing policies for addressing climate variability and coastal resource management issues, it is

likely that there will be adaptation strategies suited to addressing, immediately and with no regrets, both climate variability and climate change.

The Caribbean Planning for Adaptation to Global Climate Change (CPACC) project

In order to address the issue of climate change, a number of Caribbean Community (CARICOM) member countries and the Organization of American States (OAS) formulated the Caribbean Planning for Adaptation to Global Climate Change (CPACC) project. The project was initiated during the United Nations Global Conference on SIDS, held in 1994 in Barbados. Twelve CARICOM member states now participate in the implementation of the project, which is Global Environment Facility (GEF) supported by the World Bank as the GEF implementing agency and the OAS and the University of the West Indies Centre for Environment and Development (UWICED) as the executing agencies. The project was completed in December 2001. The successor project, Mainstreaming Adaptation to Climate Change (MACC) in the Caribbean, was initiated in April 2003 to build on the successes of the CPACC Project. The project’s overall objective is to support Caribbean countries preparing to cope with the adverse effects of GCC, particularly sea-level rise, through vulnerability assessment, vulnerability reduction planning, and capacity building.

More specifically the CPACC aims to:

- Strengthen the regional capability for monitoring and analyzing climate and sea-level dynamics and trends, seeking to determine the immediate and potential impacts of GCC;
- Identify areas particularly vulnerable to the adverse effects of climate change and sea-level rise;
- Develop an integrated management and planning framework for cost-effective responses and adaptation to the impacts of GCC on coastal and marine areas;
- Enhance regional and national capabilities for preparing for GCC through institutional strengthening and human resource development; and
- Identify and assess policy options and instruments that may help the implementation of a long-term program of

adaptation to GCC in vulnerable coastal areas.

The project follows a regional approach to strengthen regional cooperation and regional institutions and to provide cost-effective means for planning, data collection and storage, and skills. The project activities focus on planning for minimizing risk from GCC in vulnerable areas, and include data collection and management of regional sea/climate data impact and vulnerability studies, and the assessment of policy options through a series of regional activities and pilot studies. These activities are being complemented by selective capacity-building activities aimed at creating or strengthening the local capacity required to prepare a long-term program to minimize the impacts of GCC.

Specific achievements of the project are discussed below:

1. Establishment of a sea-level and climate monitoring system that contributes to global and regional assessment of the issues

Monitoring stations and related information networks installed in 12 countries have improved regional climate change monitoring and evaluation capacity. The data are primarily used to document sea-level rise and changes in sea surface temperature (SST), thus assisting in the global monitoring of the impacts of climate change. The contribution and placement of this Caribbean monitoring activity within the global monitoring efforts have been assessed. Additional applications in areas such as shipping, tourism and monitoring of extreme events are being promoted. The system will be upgraded and expanded under the successor project, Mainstreaming Adaptation to Climate Change (MACC) in the Caribbean.

2. Improved access to and availability of data

The project has developed an extensive database for coastal zone management and climate change monitoring, accessible to a

wide range of environment and development agencies in each country.

3. Increased appreciation of climate change issues at the policy-making level

CPACC has made policy-makers, decision-makers, technical personnel and the wider public fully aware of climate change, and they have increased appreciation of the complexity of climate change issues. The project has enabled a more unified and better documented positioning of the region in relevant fora.

4. Expanded vulnerability assessment

Pilot vulnerability studies have increased understanding of vulnerability assessment tools and methods and helped raise awareness of the most physically vulnerable sectors in the Caribbean sub-region.

5. Establishment of coral reef monitoring protocols

Coral reefs have proven to be key indicators of climate change. CPACC data are used to help document the pace of coral bleaching and impacts on coral reefs caused by changes in SST. As with SST and sea-level change, CPACC coral reef monitoring activities are being linked to global networks.

6. Creation of a network for regional harmonization

Through collaboration with a number of agencies,² CPACC is introducing climate change to these agencies' agendas, and is establishing linkages between climate change and other programs.

At the national level, National Implementation Coordinating Units (NICUs) have been established. These NICUs include representatives from several government agencies and, in some cases, representatives from the private sector and non-governmental organizations. In many respects, the CPACC

² For example, the Caribbean Tourism Organization (CTO), the Caribbean Alliance for Sustainable Tourism (CAST), the Centre for Resource Management and Environmental Studies (CERMES) of the University of the West Indies, the Caribbean Energy Information System (CEIS), the Caribbean Development Bank (CDB), the Caribbean Conservation Association (CCA), the Caribbean Environmental Health Institute (CEHI), the Caribbean Disaster and Emergency Response Agency (CDERA), and private sector interests such as Petrotrin of Trinidad and Tobago as well as the insurance and banking sector.

project is responding to the prescriptions for regional action on climate change and sea-level rise contained in the Barbados Programme of Action.³

A Regional Project Implementation Unit (RPIU), established under the aegis of UWICED, was responsible for the implementation of the project as a regional coordinating and implementing mechanism.

Component 5: Coral reef monitoring for climate change impacts (C5)

The overall objective of C5 is to assist CPACC countries establish long-term coral reef monitoring programs which will, over time, show the impacts of climate change factors such as temperature stress, sea-level rise and hurricanes. These monitoring programs will continue beyond the life of the CPACC project through support from the MACC project. The countries that have been selected for this pilot activity are the Bahamas, Belize and Jamaica. The lessons learned, skills, methods and protocols will be shared with the eight non-C5 countries through activities conducted under CPACC's successor, the Mainstreaming of Adaptation to Global Climate Change project.

The specific objectives of Component 5 are to:

- I. Determine the most appropriate method for recognizing impacts of climate change on coral reefs, having regard to the need for long-term measurements;
- II. Establish and maintain monitoring sites in the Bahamas, Belize and Jamaica to determine the potential impacts of climate change on coral reefs, including biological and physical indicators;
- III. Establish mechanisms to ensure that coral reef monitoring continues beyond the life of the CPACC project;

- IV. Strengthen existing institutions' (public, private, and NGO) activities in coral reef monitoring;
- V. Increase awareness of the importance of coral reefs and the potential impacts of climate change;
- VI. Ensure that the benefits and lessons learned are transferred to the other CPACC countries.

Method

The C5 site selection protocol (Woodley 1999) stipulates that at least three operational areas should be monitored in each of the pilot countries and these should be representative of least impacted, mildly impacted and severely impacted conditions. For the purpose of the study, "impact" was defined as land-based, anthropogenic impacts, transported to reefs by fluvial inputs, or actual physical impacts on reefs caused by activities within the marine environment. The monitoring sites selected for each country are outlined in Table 1.

Table 1. Sites selected for CAPCC monitoring in the pilot countries

Status of monitoring area	Pilot country		
	Bahamas	Belize	Jamaica
Least impacted	Exuma Cays Land and Sea Park	Glovers Reef Marine Reserve	Monkey Island, Portland
Mildly impacted	Manjack Cay, Great Abaco	South Water Cay Marine Reserve	"Gorgo City," Discovery Bay
Severely impacted	The Ridge, New Providence	Hol Chan Marine Reserve	Southeast Cay, Port Royal

Transects were located using the procedure outlined in the site selection protocol (Woodley 1999). A total of 20 transects, each 20 m in length, were monitored at all three monitoring sites established in every monitoring area.

Underwater digital video cameras were used to record the benthic cover of the coral reefs in each transect (Miller 2000). A software-assisted manual process was used to "capture" adjacent,

³ The aims of this programme are to:

- Create and/or strengthen programmes and projects to monitor and improve predictive capacity for climate change, climate variability and sea-level rise, and to assess the impacts of climate change on marine resources, freshwater and agricultural production, including pests.
- Develop and/or strengthen mechanisms to facilitate the exchange of information and experiences among small island developing states, and to promote technology transfer and training in those states in response to climate change, including preparedness responses.
- Provide technical assistance for ratification or accession to the United Nations Framework Convention on Climate Change and assist those Parties that have ratified the Framework Convention in assuming their major responsibilities under it.
- Support national efforts aimed at developing strategies and measures on adaptation to climate change as well as the development of technical guidelines and methodologies to facilitate adequate adaptation to climate change.

non-overlapping images from the video footage of each transect.⁴

In 1999, temperature data loggers were deployed at monitoring sites in the Bahamas and Belize. The data loggers deployed at the Belize sites were lost in Hurricane Keith in 2000. Temperature data for the period December 1999 to June 2000 were reviewed for incorporation into the Bahamas 2000 coral reef monitoring report.

Institutional arrangements

A lead government agency in each pilot country was responsible for planning, coordinating and executing the country's annual monitoring and data analysis program. The CPACC RPIU provided technical assistance and training to each lead agency.

During the March 1998 technical workshop for the implementation of C5, the representatives of each pilot country met to identify prospective operating areas for monitoring. The operating areas were selected to reflect a gradient of impacts resulting from anthropogenic activities. Selection criteria included the existence of institutional capacity to undertake monitoring activities in the operational areas. Consideration was also given to past and current coral reef research or

monitoring in these areas, and the monitoring of complimentary parameters, such as water quality. The institutions identified were considered to be capable of undertaking coral reef monitoring and/or data analysis at the national or local levels (Table 2).

Between June and November 1998, the CPACC RPIU undertook institutional assessment missions to the Bahamas, Belize, and Jamaica. The missions assessed the interest and institutional capacity of the prospective institutions to undertake the tasks associated with monitoring, data processing and analysis. The findings, combined with assessments of logistic requirements and capacity factors undertaken by pilot country lead agencies, led to a revision of the lists of the operational areas for each pilot country (Table 3).

The national focal point in each pilot country, supported by the NICU, provided a general overview of the implementation of C5 activities and institutional support to the C5 lead agency(ies) when necessary. The C5 lead agency in each pilot country was responsible for identifying the human and material resources required to monitor the coral reefs, and process and analyze the resulting data.

Table 2. Proposed operating area sites and institutional support arrangements

Bahamas		Belize		Jamaica	
Operating area	Institution	Operating area	Institution	Operating area	Institution
New Providence – Rose Island	Fisheries Dept/ Dive Operators	Hol Chan	Fisheries Department	Negril	Negril Coral Reef Preservation Society
New Providence – Sea Viking	Fisheries Dept/ Dive Operators	Glovers Reef	Fisheries Department/ Environmental Non-Governmental Organization	Montego Bay	Montego Bay Marine Park
Lee Stacking Island	Fisheries Dept/ Dive Operators	Dangriga	Fisheries Department/ Coastal Zone Management Authority/Institute	Discovery Bay	UWI Discovery Bay Marine Laboratory
				Pedro Cays	Natural Resources Conservation Authority/ Jamaican Fisheries Department Coast Guard
				Port Antonio	Portland Environmental Protection Association

⁴ An automated process, managed by the WinBatch for Windows batch-processing program, generated random dots in Microsoft Excel and superimposed them on the images. The benthic component under each random data point was identified and then information entered into Microsoft Excel spread sheets, which automatically tabulated and grouped the substrate categories and calculated the percentage cover and standard deviation. Provision was also made in the spreadsheet for recording the occurrence of bleached and diseased corals. Quality Assurance-Quality Control checks were carried out on the video tapes, processed images and resulting data (Creary 2001) to refine the monitoring and data analysis processes.

Table 3. Final selection of operational sites and institutional support arrangements

Pilot country	Lead agency	Supporting institutions	Operating areas
Bahamas	Fisheries Department	National focal point – Bahamas Environmental Societies Trust Commission OAS Country Office	Sea Viking, New Providence Walker's Cay, Abbaco
Belize	Coastal Zone Management Institute/Authority/ Fisheries Department	National focal point - Meteorological Service National Coral Reef Committee National Climate Change Committee OAS Country Office	Glovers Reef Hol Chan South Water Cay
Jamaica	Natural Resource Conservation Authority/Centre for Marine Sciences	National focal point – Ministry of Economic Development National Climate Change Committee UWI Discovery Bay Marine Laboratory, OAS Country Office	Discovery Bay Port Royal Cays Monkey Island, Portland

The Caribbean Coastal Data Centre (CCDC) of the Center for Marine Sciences (CMS) at UWI served as the technical support node and archiving center for the pilot countries. The C5 Coordinator at the CCDC provided technical support to the pilot country teams. The coordinator also liaised with consulting experts to develop and refine the protocols and provide training. The arrangements by which the CMS provided technical support to C5 were documented in a memorandum of understanding (MOU). The CMS CCDC also provides support for the Caribbean Coastal Marine Productivity (CARICOMP) Network Project and serves as the regional node for the Global Coral Reef Monitoring Network (UNESCO 1998).

Coral reef monitoring and the policy process

Three critically important questions should be asked when considering the role that coral reef monitoring data could play in national policy and planning processes. The questions are: (a) Do the monitoring data lend themselves to the generation of policy relevant information? (b) Are the data and/or information in a format that can support the decision-making process? (c) Is this information accessible?

To provide strategic input into the policy cycle, coral reef monitoring programs should:

- Establish the baseline against which the effectiveness of adaptation policy interventions can be measured;
- Provide the scientific basis that will be used in the identification of policy issues and the evaluation of appropriate policy options;

- Provide accurate and easily understood information to assist in public consultation programs and in the presentation of policy options to decision-makers (de Romilly 2001).

Coral reef data and the resulting information can provide support in the development, implementation and evaluation of sectoral adaptation policies for fisheries, marine protected areas, coastal resource management, tourism, and economic development. However, even where policy processes are established, capacity constraints may prevent the monitoring of coral reefs necessary to generate the information to support the policy process.

In the member countries of the Organization of Eastern Caribbean States (OECS), Fisheries Departments are responsible for coral reef monitoring. The Fisheries Departments focus, primarily and understandably, on fisheries related issues, but also on tourism and conservation issues (Murray 2001). CANARI (2000) attributed their limited involvement in reef monitoring to a narrowing of the focus of fisheries administrations to issues of production and processing. Some obstacles to their involvement in coral reef monitoring include a shortage of personnel and financial constraints. A lack of personnel was cited as a constraint by every OECS fisheries administration (CANARI 2000). A less obvious obstacle to the sustained involvement of Fisheries Departments in coral reef monitoring is the perception that coral reef monitoring is a highly technical activity requiring extensive skills, equipment and other resources (CANARI 2000).

In 1999, the status of coastal resource data holdings in the 12 countries participating in the CPACC project was assessed. It was found that, in

the 10 countries that responded,⁵ coral reef data are used by national governments in the planning process. Seven of the 10 respondents indicated that a shortage of personnel was a problem encountered in the collection of coral reef data.

The survey also showed that the main uses to which the data were put were research, teaching, environmental planning and the monitoring of trends. Further research is required to determine exactly which government agencies collect and use coral reef data and the purposes for which these data are used.

CPACC Component 4: Formulation of a policy framework for integrated adaptation planning and management (C4)

CPACC C4 was designed to assist the 12 participating Caribbean states with the formulation of:

- (a) A national climate change adaptation policy and an implementation plan; and
- (b) A regional climate change adaptation policy and an implementation plan.

It was anticipated that the implementation of a national plan in each of the 12 CARICOM countries would establish mechanisms to guide national processes for addressing the short-term, medium-term and long-term effects of GCC. The adaptation policies would reflect the unique circumstances of each country, providing integrated approaches to adaptation planning and management at the national and regional levels, and would not be limited to dealing with the impacts of sea-level rise on coastal environments.

A seven-stage process of consultation, document preparation, and review was developed to guide participating countries in writing their respective adaptation policies (Table 4).

CPACC RPIU facilitated the drafting and consultation process in the 12 participating countries. In-country coordination was undertaken by the national focal points of the national climate change committees.

All 12 countries completed the first five stages of the process. St. Lucia has completed the entire process having obtained Cabinet approval for its

national climate change adaptation policy and implementation plan. Belize has submitted its adaptation policy to its Cabinet and is awaiting final approval. Draft adaptation policies have been developed in Dominica, Guyana, Barbados, Antigua and Barbuda, Trinidad and Tobago, and, in some instances, have already been reviewed by local Cabinet sub-committees. Once approved by Cabinet, it is expected that these adaptation policies will initiate a series of five-year national programs and strategies aimed at reducing vulnerability to existing climate extremes, and thereby help to manage anticipated impacts from climate change.

It is intended that, by the end of December 2001, all CPACC participating countries will have submitted policy documents to their respective Cabinets for final approval. The CPACC project ends in December 2001, and a follow-up project has been designed to implement Stage 2 adaptation activities, as defined by guidance from the Conference of Parties on Adaptation.

Saint Lucia's policy paper is a comprehensive document, the goals of which speak to the avoidance of, reduction of, or adaptation to negative climate change impacts on a range of sectoral interests and natural resources. It clearly defines the level and nature of the Government's commitment to its obligations under international conventions, and to the recently enacted climate change adaptation policy.

Policy directives regarding coastal and marine resources address the issues of monitoring, resource assessment, coastal land protection, the enhancement of ecosystem resilience, ecosystem restoration, the development of a national land use and management plan, the promotion of different fishery and resource use activities, and the fostering of increased public awareness of climate change impacts.

The National Climate Change Strategy is a direct derivative of the Climate Change Policy, each sub-component of the strategy corresponding to a subject area under the policy directives provided in the policy (Table 4).

Discussion

The CPACC project has succeeded in establishing a process that has led to the approval by Cabinet of a national adaptation policy in St. Lucia, and the submission of a policy to Cabinet for approval

⁵ The coastal characteristics of Guyana do not permit the growth of coral reefs. No response to the survey was received from Saint Kitts and Nevis.

Table 4. Component 4: Implementation Process⁶

Stage/Activity	Output	Responsibility
First (inception) mission	<ul style="list-style-type: none"> • Outline activities to be undertaken to develop the National Climate Change Policy • Identify resources required from CPACC RPIU to implement C4 	<ul style="list-style-type: none"> • CPACC RPIU (Technical support and resources) • National Focal Point (Coordination) • National Climate Change Committee (technical support)
Issues paper development	<ul style="list-style-type: none"> • Identify national context for evaluation of vulnerability issues and formulation of policy options • Identify critical issues to be addressed through adaptation policies and strategies • Prioritize identified issues • Document institutional and legal structures for responding to issues of concern 	<ul style="list-style-type: none"> • National Focal Point, National Climate Change Committee, Project Coordinating Committee • CPACC technical assistance to review policy, legal and institutional structures
National consultative review of issues paper	<ul style="list-style-type: none"> • Refine issues paper to reflect consensus of public and private sector stakeholders 	National Focal Points, National Climate Change Committee, private and public sector stakeholders
Second mission: National workshop	<ul style="list-style-type: none"> • Stakeholder participation in the <ul style="list-style-type: none"> ➢ identification and evaluation of appropriate policy options ➢ critical review of comments arising from national consultative review of issues paper • General agreement on appropriate <ul style="list-style-type: none"> ➢ strategies and management mechanisms for GCC adaptation planning and management ➢ Intervention options to address issues 	National Focal Points, National Climate Change Committee, private and public sector stakeholders
First drafting of National Climate Change Policy	<ul style="list-style-type: none"> • Identify anticipated changes to local/regional climate • Outline anticipated impacts • Identify vulnerable activities and sectors • Outline appropriate adaptation planning and management policy options • Define implementation plan • Identify regional level activities to support and complement national policy development • Identify legal, institutional and financial mechanisms (effect and coordination) • Outline policy review process (5-10 years) 	<ul style="list-style-type: none"> • National focal point, National Climate Change Committee • CPACC RPIU provided Information Note to the Cabinet, and Guide to the preparation of Country Policy Papers on Climate Change Adaptation Planning and Management
Development of action plan/strategy for implementing Climate Change Adaptation Policy	<ul style="list-style-type: none"> • Details of activities, finances, resources and agency responsibilities for a 5-year program to implement policy directives contained in the <i>National Climate Change Adaptation Policy</i> 	National Focal Point, National Climate Change Committee, private and public sector stakeholders
Review draft <i>National Climate Change Policy</i>	<ul style="list-style-type: none"> • Peer review process • Five countries have completed first drafts 	National focal point, National Climate Change Committee, Private and public sector, CPACC stakeholders
Submission of final <i>National Climate Change Policy</i> to Cabinet for approval	<ul style="list-style-type: none"> • Preparation of the final text • Preparation of support documents to facilitate submission to the Cabinet 	National Focal Point, National Climate Change Committee

⁶ Based on CPACC, 2000.

in Saint Lucia. Draft policies have been developed in Dominica, Guyana, and Barbados, and documents are pending Cabinet approval in the Bahamas, Antigua and Barbuda, Belize, and Trinidad and Tobago. In some instances, Cabinet sub-committees have already reviewed these documents.

Coral reefs represent a coastal ecosystem of great economic and social importance to the countries of the Caribbean. Their conservation will have implications for economic development at the national and regional levels. Climate change

adaptation policies will provide a policy framework within which meaningful strategies for sustainable coral reef management may be developed and implemented. The policy papers speak to the need for enhancing and conserving the resilience of coastal systems and set the groundwork for action through accompanying strategies. The conservation and enhancement of ecosystem resilience will require the integrated planning and management of land-based activities that currently threaten the region's coral reefs. As economic development is an adaptation strategy in its own right, the importance of

sustainable management of the region's coral reefs to the region is that much more important. Programs of sustained coral reef monitoring will contribute to the development of baseline data underlying stress-identification and mitigation assessments (Risk 1999) for both adaptation planning and climate change impact assessment. Much of the scientific research on coral reefs does not reach the decision-making process, and that which does is often not applicable to the decisions being made (McManus 2001). In many Caribbean countries, only limited coral reef data collection is currently undertaken by government agencies. Most of it is on a case-by-case basis for environmental impact assessments in support of monitoring. The major constraints that limit coral reef data collection are staff shortages (as opposed to shortages of technically competent staff to undertake coral reef monitoring (CANARI 2000)), financial constraints, and a narrow institutional focus (CANARI 2000; Murray 2001).

The CPACC project has attempted to address the widespread problem of limited human capacity by employing digital video technology to record benthic features. This technique was chosen as the preferred data collection method because it:

- Reduces the time spent collecting data in the field and hence the time that government officers are absent from the office;
- Reduces the need for taxonomic expertise in the field, thereby reducing the requirement of in-house technical expertise;
- Facilitates the transmission of data for processing and analysis at a centralized technical support facility;
- Generates permanent photographic records of the coral reef, allowing changes over time to be easily demonstrated to decision-makers.

Further support in addressing this issue has been provided through a collaborative arrangement among the CPACC project, the CMS, and the Caribbean Coastal Data Centre at the University of the West Indies (UWI) in Barbados. The CMS provides the pilot countries with technical data processing, analysis and archiving support. This arrangement reduces the workload of government agencies until they are able to develop the institutional capacity to undertake all aspects of the data processing and analysis.

Plans are being developed to duplicate the technical support system provided by this collaborative arrangement in anticipation of the

expansion of the coral reef monitoring program to the eight CPACC countries in the eastern Caribbean. It is envisaged that a collaborative arrangement will be established between the CPACC project (and its successor project), the Coastal Zone Management Unit of the Government of Barbados, and the Natural Resources Management Programme of the UWI in Barbados. The technical support group will provide the data processing, analytical and management support that are currently provided by the CMS to the pilot countries in the northern Caribbean. It will also provide a roving support team that can assist, as necessary, the various Fisheries Departments in monitoring activities.

Small island states are among the locations most vulnerable to the potential adverse effects of climate change and sea-level rise (IPCC 2001). Adaptation measures must be put in place to minimize the social and economic impacts of both phenomena. Information on the potential site-specific climate change and the sea-level rise impacts must begin to inform planning and development decision-making processes immediately. Action must be initiated before complete knowledge of the nature and severity of local and regional impacts is available, and before the potential impacts are evident. The fact that many of the adaptation measures constitute sound coastal resource management practice means that the allocation of scarce resources to adaptation initiatives can be justified in terms of short-term planning and resource management benefits. At the same time, they address the more distant potential impacts of climate change and sea-level rise.

To ensure the development and ongoing refinement of local and regional climate, vulnerability, and risk assessment models, adaptation action must be based on the ongoing availability of accurate environmental data. It is this information that will be used to inform and refine national and regional adaptation policies and development plans.

Island states have small populations and limited human capacity to devote to coastal ecosystem monitoring and assessment. Despite this, the need for quality data to inform the climate change adaptation process means that innovative strategies must be developed to ensure that the necessary policy-relevant data and information are generated, accessible, and in the appropriate format.

Annex 1. CPACC Component 5 (C5) implementation history

Date	Activity	Results	Outcome
March 1998	Monitoring methods workshop	Consensus on parameters to be monitored, methodological approaches and options for institutional participation at the pilot country level	Selection of appropriate monitoring methods Identification of potential national lead institutions
June to Oct 1998	Institutional assessment missions to the Bahamas, Belize and Jamaica	Follow-up on suggestions for institutional participation made at March methods workshop Identification of lead agencies or a consortium for each of the three pilot countries that would be responsible for monitoring, data processing, analysis and reporting The identification of technical and logistic needs, and institutional and inter-organizational linkages	Finalization of institutional arrangements for implementing coral reef monitoring activities under C5
Dec 1998 to March 1999	Delivery of monitoring equipment (Sony DCR VX100 digital video camera, L & M Stingray underwater video camera housing, temperature data loggers and computers and software for data analysis)	Lead agencies received the equipment and software necessary for coral reef monitoring, data processing and analysis	Pilot country lead agencies had tools to monitor, process and analyze data Press coverage of handover in Belize
March 1999	Training workshop to ensure pilot countries select and monitor coral reef sites and analyze data in the same way, and to train pilot country team leaders in the monitoring, data processing and analysis protocols Established CC-Reefs e-group	Trained national monitoring teams in monitoring, data processing and analysis Creation of a global forum for the exchange of information on coral reef monitoring and climate change issues	Monitoring successfully conducted in 2000 Media coverage in the Bahamas
June 1999	Public awareness documentary on C5 produced in 3-minute and 10-minute versions	Convenient promotional tools were prepared that provided: a brief introduction to GCC and its implications; the role of the CPACC Project; an overview of C5; the training workshop aims and objectives; feedback on GCC and coral reef monitoring by the Environmental Minister and workshop participants	A documentary was made available to all Caribbean television stations on 3 June for showing on World Environment Day, 5 June 1999. Stations that acknowledged showing it were: Channel 5, Belize; ATV, Surinam; CBC, Barbados; St. Maarten Cable, St. Maarten; ZIZ TV, St. Kitts; GTV, Guyana; Little Rock TV, Guyana; SVG TV, St. Vincent
Nov 1999	Draft site selection protocol developed	Adoption of standardized methodological approach for activities	Recognition of a standardized approach to spatial arrangements for monitoring the region's coral reefs

June 2000	The data analyst conducted an assessment mission to the Bahamas and Belize to meet with representatives of the C5 lead agencies	Progress of the coral reef monitoring program reviewed Monitoring data reviewed and compliance with the video monitoring protocol determined Institutional capacity to monitor, process and analyze data assessed Plans for year 2000 monitoring reviewed Orientation dives on the Sea Viking site, New Providence, Bahamas undertaken	
2000	Pilot countries conduct coral reef monitoring	Baseline coral reef data collected by pilot countries	Training successfully applied in unsupervised monitoring Confirmation of capacity for pilot countries to undertake monitoring
March 2001	C5 brainstorming meeting	Monitoring methods and protocols reviewed and assessed	Refinement and endorsement of monitoring method Data requirements for assessing GCC impacts on reefs acquired
April 2001	Quality control/quality assurance assessment of data from 2000 monitoring campaign completed	Quality Control/Quality Assurance Manual Developed	Monitoring teams have access to information necessary to assure quality
May 2001	Planning	Links between C5 and the CRIS (C3) and the policy and mainstreaming process (C4) defined 2000 monitoring data reported and reviewed Monitoring methods reviewed and revised Technical and institutional aspects of C5 expansion discussed	Media coverage in Jamaica
July 2001	Applied statistical methodologies report	Report on statistical methods as applied to CPACC pilot country coral reef monitoring data released	Guidance on statistical approaches for reporting coral reef monitoring data for practitioners unfamiliar with statistical methods
August 2001	UNEP CPACC meeting	Commitment by UNEP to support Phase II reef monitoring and training	Increased sustainability and institutionalization of monitoring activities
2001	Data processing, analysis and reporting Monitoring for 2001	Country monitoring reports for 2000 Second year of coral reef data collection	Training successfully applied to data processing and analysis with assistance from UWI, CMS, and CCDC Documented site-specific baseline data on reef condition for pilot countries Institutionalization of coral reef monitoring
Dec 2001	Produce promotional CD-ROM	Increased awareness of C5 activities in the region	Decision-makers and heads of department supportive of C5

References

- Bijlsma, L. 1997. Climate change and the management of coastal resources. *Climate Resources* 9:47-56.
- Boesch, D. F., J. C. Field and D. Scavia (eds). 2000. The potential consequences of climate variability and change on coastal areas and marine resources. NOAA's Coastal Ocean Program. Decision Analysis Series No. 21.
- CANARI. 2000. An assessment of capacity for reef monitoring in the Eastern Caribbean: towards the creation of an Eastern Caribbean global coral reef monitoring network (GCRMN) node in collaboration with the United Nations Environmental Programme. CANARI Technical Report No. 266.
- CPACC. 2000. Policy framework for integrated adaptation planning and management (Component 4). Inception Mission Report.
- Creary, M. M. 2001. Component 5: Coral reef monitoring for climate change. Paper presented to the Caribbean Planning for Adaptation to Global Climate Change Planning and Technical Review Workshop, 21-25 May 2001, Kingston, Jamaica.
- IPCC. 2001. Climate change. 2001: Impacts, adaptation, and vulnerability. Part of the Working Group II Contribution to the Third Assessment Report of the Intergovernmental Panel on Climate Change. UNFCC.
- Maul, G. A. (ed.). 1993. Climate change in the Intra-Americas Sea. Edward Arnold, London, U.K., 389 p.
- Miller, J. 2000. Using videotape to sample coral reefs. US Geological Survey. Biological Resources Division. Virgin Islands Field Station. St. John, USVI. (www.cpacc.org).
- Murray, P. 2001. Institutional capacity and national priorities for coral reef monitoring in the OECS states. Proceedings of the CPACC Component 5: Coral Reef Monitoring for Climate Change Impacts, Planning and Technical Review Workshop, 21-25 May 2001, Kingston, Jamaica.
- Nurse A. L. and G. Sem. 2001. Chapter 17 Small Island States. *In* Climate change 2001: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change. Cambridge University Press.
- Risk, M. J. 1999. Paradise lost: how marine science failed the world's coral reefs. *Mar. Freshwater Res.* 50:831-7.
- Romilly, G. de B. 2001. Coral reef monitoring in the context of climate change adaptation policy. *In* Proceedings of the CPACC Component 5: Coral Reef Monitoring for Climate Change Impacts, Planning and Technical Review Workshop, 21-25 May 2001, Kingston, Jamaica.
- UNESCO. 1998. CARICOMP – Caribbean coral reefs, seagrass and mangrove sites. Coastal region and small island paper 3, UNESCO, Paris, France, 347 p.
- Wilkinson, C. 2000. State of coral reefs of the world: 2000. Australian Institute of Marine Science, Townsville, Australia.
- Woodley, J.D. 1999. CPACC Component 5: Coral reef monitoring. (Draft) Site Selection Protocol. Prepared for the CPACC Project.