Vulnerability and Capacity Assessment Methodology

A guidance manual for the conduct and mainstreaming of climate change vulnerability and capacity assessments in the Caribbean

CARIBBEAN COMMUNITY CLIMATE CHANGE CENTRE (CCCCC)

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A guidance manual for the conduct and mainstreaming of climate change vulnerability and capacity assessments in the Caribbean Region

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Abbreviations

ACCC	Adapting to Climate Change in the Caribbean
AOGCM	Atmosphere-Ocean Global Climate Model
CARICOM	Caribbean Community
CCCCC	Caribbean Community Climate Change Centre
CVAT	Community Vulnerability Assessment Tool
ENSO	El Nino – Southern Oscillation
EVI	Environmental Vulnerability Index
GDP	Gross Domestic Product
GCM	Global Climate Model
GEF	Global Environment Facility
GIS	Geographical Information System
ICZM	Integrated Coastal Zone Management
IPCC	Intergovernmental Panel on Climate Change
IWCAM	Integrated Water and Coastal Areas Management
IWM	Integrated Watershed Management
MACC	Mainstreaming Adaptation to Climate Change
NGO	Non Governmental Organization
NOAA	National Oceanographic and Atmospheric Administration
PML	Probable Maximum Losses
RACUE	Resources, Access, Capacity, Use and Environment
RCM	Regional Climate Model
SIDS	Small Island Developing State
SPI	Standard Precipitation Index
SRES	Special Report on Emissions Scenarios
TPI	Tourism Penetration Index
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
VCA	Vulnerability and Capacity Assessment
WPI	Water Poverty Index

Executive Summary

The first of the Mainstreaming Adaptation to Climate Change project's technical components is the development of assessments of vulnerability and capacity (VCA) to adapt to climate change. This project seeks to build regional capacity to collect and analyse data, and expand the overall knowledge base on climate change impacts and associated physical, social, environmental and economic vulnerabilities. The VCA methodology described below was developed to provide useable decision support information and tools to assist civic and business leaders in making critical decisions to mitigate climate hazards in regions and sectors of high consequence. The framework is intended to be seamlessly embedded into existing or planned Integrated Coastal Zone Management Plans and Integrated Watershed Management Plans.

The aim of the manual is not to present a 'recipe' of steps, but rather to present the process, i.e. the types of information that should be gathered, how to manage relevant stakeholder processes and to provide some of the tools that can be used to analyse the information gathered to develop usable products for decision making. It is understood that given the various limitations of data availability and limited finance amongst other things, that not every component of the methodology may be undertaken or completed to the same degree. To this end the rapid assessment methodology presented in Section 3 provides an outline of the steps that should be taken in any event and also provides an example of a conceptual model that can guide the process. As with the full VCA, the role of the stakeholders and the identification of data gaps and knowledge gaps are highlighted as important components of the process.

The remaining sections of the manual provide guidance for completing a full VCA. From the beginning an advisory council is formed representing the stakeholders and they work with the VCA team to determine the scope of the assessment. This council is central to increasing the likelihood of mainstreaming the VCA processes and implementing the adaptation strategies after the initial VCA is complete. Local technical teams are formed from the stakeholders when necessary to assist with the identification of data sources, assessing indicators etc.

As the data is gathered it is organised into a graphical map-based format (preferably GIS) to assist with identifying hotspots and priorities for adaptation strategies. Any gaps or biases in the data should be identified and reported as part of the process of incorporating uncertainty into the assessment. Acknowledging the data gaps reduces the probability of 'surprises' and can give impetus to new areas of research. Where data is limited the issues identified can be ranked based on input from the stakeholder advisory council and other technical experts. Coping with the uncertainties associated with estimates of future climate variability and change and the impacts on economic and environmental resources means adopting management measures that are robust enough to apply to a range of potential scenarios, some as yet undefined.

The most important component of the VCA is the social aspect and how people cope with events at present. Included in this is an assessment of their awareness and perception of risk; if they do not perceive themselves to be vulnerable then they are unlikely to implement adaptation options. A combination of surveys, interviews and workshops are recommended to elicit this information. The data collected feeds into the assessment of a community's strengths and weaknesses, for example they may have adequate resources, but insufficient access to solutions. Climate variability and change will affect all sectors and the relationships between the sectors, producing multiple stresses on each location. The relationships between the different stakeholders and the cross-sectoral responsibilities are therefore mapped to ensure that each agency incorporates climate change in their planning processes. Vulnerability is not only driven by conditions at a local scale, but the international and regional context also plays a significant role and must be considered as part of the VCA. For example, trade agreements, conflict, decline of an international markets in particular sector etc.

The existing trends and observations of past climate are use to develop projections for future climate and the potential impacts that future events and changes will have. Large-scale and regional models can be used where appropriate, but it should be noted that these models tend to smooth out extremes, which can lead to unforeseen surprises and are important for effective adaptation. The economic costs of a particular event in the past, in conjunction with socio-economic trends such as population growth, can be used to determine what the likely costs will be of a future event and to assess the typical recovery times from events of certain strength or nature. Future scenarios of socio-economic conditions are developed based on current trends and observations of changes in the society of interest. These scenarios are not projections, but storylines that describe alternative futures and they are useful for structuring discussion amongst stakeholders, especially when determining how different policies can help stakeholders achieve development targets. The economic calculations can be used to determine the benefits of increasing expenditure on vulnerability reduction measures to reduce the cost of recovery.

All of the information gathered should be stored in the GIS database and then used in the development of integrated vulnerability indicators. The indicators help to identify the trends that impact either positively or negatively on vulnerability and also the conditioning factors on those trends. For example, increased demand as a result of population growth might impact negatively on adaptive capacity in a situation where natural resources are already over-stretched. The indicators lead to the development of risk profiles, vulnerability checklists and sensitivity matrices. The latter are used by the advisory council to determine priority areas and communities for adaptation measures. The chosen measures should aim to reduce the risks in both the short and long term as well as offer immediate development benefits.

The existing decision making process is assessed to ensure that the findings of the VCA can be effectively mainstreamed and implemented. Potential entry points for the information gathered during the VCA are identified by asking amongst other things 'at what stage (or stages) does climate information influence the outcome of the planning process?' Similarly, barriers to effective decision making are identified to ensure that the system works to turn capacity on paper to implementation. The final sets of scenarios are then discussed with stakeholders to ensure that they are relevant and that the tools can be utilised. Gaming exercises may be carried out with the different advisory groups asking 'what if' questions to determine how people might respond to an event individually, institutionally and in a coordinated way. These discussions should lead to a preliminary set of adaptations, but the process is iterative and should be repeated as new data and knowledge become available or in response to policy changes that hadn't been previously considered. Where there are major uncertainties, natural buffers, such as coral reefs and mangroves, provide flexibility in the system and can be enhanced and protected to help mitigate the impacts of 'surprises'.

The final report of the VCA presents the methodology, data sources, results and the future directions identified through interpretation and application of the results to the existing decision-making process. The advisory council can continue to provide leadership after the final report to ensure that informed adaptation continues as climate evolves and development decisions are taken. The scenarios can be adapted to provide continuous, updated information to guide decision makers at all levels.

1 BACKGROUND

The Mainstreaming Adaptation to Climate Change (MACC) Project under the Caribbean Community Climate Change Centre (CCCCC) is a regional effort funded through the Global Environment Facility (GEF). The project objective is to facilitate the creation of an enabling environment for climate change adaptation in CARICOM states. The participating countries are: Antigua and Barbuda; Bahamas; Barbados; Belize; Dominica; Grenada; Cooperative Republic of Guyana; Jamaica; St. Kitts and Nevis; Saint Lucia; St. Vincent and the Grenadines; and Trinidad and Tobago.

Under the first of its technical components the Project seeks to build regional capacity to collect and analyse data, and expand the overall knowledge base on climate change impacts and associated physical, social, environmental and economic vulnerabilities. The component includes the development of a harmonized approach for assessing climate change vulnerability and risk, and developing capacity for adaptation planning and decision making. These activities are intended to assist the region in preparing vulnerability and risk assessment studies in the key economic sectors (water resources, tourism, and agriculture) and coastal areas, and to have the results mainstreamed into practice. Mainstreaming, in this context, refers to the seamless embedding of climate information into existing risk assessment, management and development planning portfolios.

The IPCC defines vulnerability as “The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity”. This definition corresponds very well with the long history of risk assessment and management in the hazards and disasters literature (see Downing and Patwardhan 2004). Traditional approaches to assessing vulnerability to climatic risks developed elsewhere have been found to be limited in transferability and applicability within the Caribbean context of small economies and low-lying regions. A cooperative agreement with the US National Oceanographic and Atmospheric Agency (NOAA) led to the development of a framework (hereafter the NOAA-CCCCC methodology) for conducting vulnerability and capacity assessment pilot studies across the region.

The goal of the NOAA-CCCCC methodology is to develop usable decision support information, tools and capacity to assist civic and business leaders in making critical decisions to mitigate climate hazards in regions of high consequence. Thus, one aim of the methodology is to develop a synthesis of successful approaches for assessing climatic risks in the key sectors identified above and to integrate these under a common framework or protocol. Cross-sectoral teams would then conduct assessments in the Caribbean region, with mainstreaming as an objective, under MACC guidance. A specific objective is to adapt and advance vulnerability assessment methods that explicitly incorporate uncertainty and risk into system performance, technology assessment and investment strategies. Coping with the uncertainties associated with estimates of future climate variability and change and the impacts on economic and environmental resources means adopting management measures that are robust enough to apply to a range of potential scenarios, some as yet undefined. Empirical research has shown that there are rarely simple cause-effect relationships between climate change risks and the capacity to adapt. Adaptive capacity can vary over time and is affected by multiple processes of environmental and societal change as societies adjust from event (drought, flood, abrupt change) to event. The framework is intended to be seamlessly embedded i.e. mainstreamed, into the goals and objectives of existing or planned Integrated Coastal Zone Management (ICZM) and Integrated Watershed Management (IWM) programs in the context of climate variability and change.

The methodology forms part of the Master of Science curriculum, taught since 2003 by the lead author of this document, in Natural Resources Management (Climate Change focus) at the Cave Hill campus of the University of the West Indies. The methodology has to date been used as core material in two regional training workshops to introduce a wide range of technicians in the region (potential users) to the concepts and their application. It is intended that the personnel conducting the assessments, themselves become part of the regional capacity i.e. the approach is not just an academic exercise, but one that develops place-based capacity for local analyses and facilitates the development of future practitioners. Components of the methodology have been utilized in selected countries to conduct pilot vulnerability and capacity assessment studies and the information produced can now be used to assist in the preparation of sector-wide assessments and adaptation strategies. Appendix 1 contains a list of the pilot VCA projects carried out under the MACC project.

2 INTRODUCTION

The NOAA-CCCCC methodology has been elaborated and is presented here in a user-friendly guidance manual to be used across the region for conducting integrated vulnerability and capacity assessments (VCA) to support adaptation to climate change. Additional technical and supporting materials are referred to throughout and will be distributed on a supplementary CD developed by the authors and available from the CCCCC.

The aim of the manual is not to present a 'recipe' of steps, but rather to present the process, i.e. the types of information that should be gathered, how to manage relevant stakeholder processes and to provide some of the tools that can be used to analyse the information gathered to develop usable products for decision making. It is accepted that given the various limitations of data availability and limited finance amongst other things, that not every component of the methodology may be undertaken or completed to the same degree. To this end a rapid assessment is presented in the next section that can help to presage a fuller VCA. Thus the steps described below should be carried out across sectors to the greatest extent possible for a VCA. It is anticipated that once the pilot projects have been completed and assessed that a series of cases will be developed in each of the key sectors to further assist practitioners in expanding their VCA methodologies to the sector-wide and country-wide level and to identify and overcome potential pitfalls in implementation.

2.1 Climate and vulnerability in the Caribbean

Climate and climatic impacts cross multiple temporal (from extremes, seasonal, decadal, and longer term trends) and spatial (community, watershed, urban, national, regional, global) scales. For example there have been increases in the number of tropical storms in the Atlantic between 1995-2006 and during decades in the earlier century. Large scale features of the climate system, such as ENSO, the Atlantic Multi-decadal Oscillation, the North Atlantic Oscillation, the Thermohaline Circulation, and variability within the Caribbean Basin itself, significantly influences the regional climate. Producing usable assessments of climate risks at the local level is therefore an iterative and evolving process in a changing environment.

Given their small size the islands of the Caribbean typically have limited natural resources, including water and are relatively isolated. As small developing countries there are limited financial, technological and human resources available to either implement adaptation measures or to respond and recover from climate related events. Similarly the small, open economies with limited diversity (such as dependence on tourism or agriculture alone) are highly sensitive to external shocks (Nurse *et al*, 2001).

The poor are most vulnerable to extreme climate and weather events. Picture above shows damage to shelter and fishing boats in a poor fishing community in Jamaica from Hurricane Dean in 2007. (Photo: Jamaica Observer)

Climate change is projected to affect the region through (WGII TAR Chapter 17, FAR Chapter 16):

- increases in evaporation losses,
- decreased precipitation (continuation of a trend of rainfall decline observed in some parts of the region),
- reduced length of the rainy season – down 7–8% by 2050,
- increased length of the dry season – up 6–8% by 2050,
- increased frequency of heavy rains – up 20% by 2050,
- increased erosion and contamination of coastal areas.

A recent study (Bueno et al, 2008) showed that for climate change scenarios (without variability), the costs of inaction on climate change mitigation and adaptation (in terms of 2004 GDP for the Caribbean region) could run from a low impact (i.e. rapid stabilization) of 1.8% to a high impact (business as usual) of 6.8% by 2025 and 4.5% or 26% respectively by 2100. Clearly the short–term, low impacts (rapid stabilization) are highly optimistic given non-linearities in the full climate system.

Given the high levels of vulnerability to the impacts of climate change in the Caribbean it is essential that countries begin the process of adaptation (Pulwarty et al, 2008). The primary drivers of regional-scale climate and vulnerability are described in Nurse et al (2007), and Pulwarty et al (2008), but major uncertainties persist. There are several reasons why uncertainties are large and difficult to characterize in this context (Walker et al 2002 and others):

- Key drivers, such as climate and technological change, are unpredictable in specific localized situations. Many change non-linearly.
- Human action in response to projections is reflexive. People will react to new interventions and events in ways that will change the future.
- The system may change faster during periods of transition than models can be recalibrated, so forecasts are most unreliable in precisely the situations where they are most wanted for present and near-term adaptations.
- Adaptation results from crises, learning and redesign.

Assessing these physical drivers in the context of local and national resources and capacities will be elaborated further below.

2.2 The nature and role of vulnerability and capacity assessments

In order to ensure that investments in adaptation measures achieve desired outcomes it is first necessary to determine the degree to which a community, an island or the region is vulnerable and the extent of their capacity to adapt and/or cope with climate related events. It is further necessary to conduct usable vulnerability and capacity assessments to guide the decision making process in prioritizing appropriate steps that should be taken to adapt to climate change. Essentially, it is not possible to adapt to climate change impacts if the country/community is already highly vulnerable and does not have the financial, technical or human resource capacity to implement and sustain adaptation practices.

The risk assessment framing identifies the exposure or elements at risk and the nature of that risk. Risk here is taken to be a function of the characteristics of a physical event or hazard (e.g. severity, duration, frequency, and trend) and the societal and environmental vulnerability. Figure 1 shows examples of the variables involved in a risk assessment and management framework. The productive resources in each Caribbean nation consist of human-made capital (buildings, transportation networks, agricultural production systems), human capital (skills, knowledge), and natural capital (soil, forests, swamps, coral reefs). The measurement of direct economic impacts centres on several types of effects, including (1) damage to human capitals; (2) interruptions of production processes (fisheries, government services, industry); (3) identification of economic activities to be monitored over time; (4) damages to cultural and historic assets; (5) damages to human capital (disease, morbidity); and possibly the least appreciated but highly significant (6) damage to natural capital (see Howe and Cochrane, 1993; Pulwarty et al, 2008).

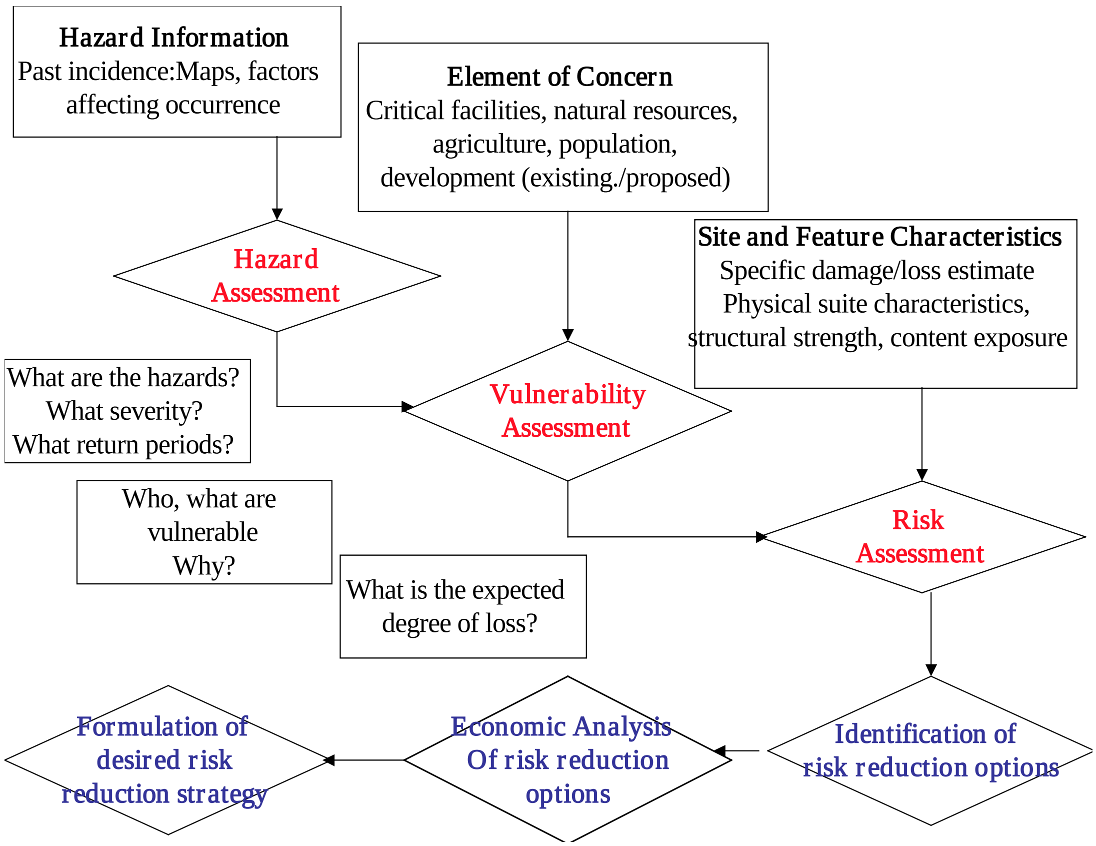


Figure 1: Risk as a function of hazard and vulnerability

Source: OAS, 2003; Steve Bender and Jan Vermeiren pers.comm.

It is important to distinguish between the theoretical and practical range of choices. The physical environment at a given stage of technology sets the theoretical range of choice open to any resource manager. The practical range of choice is set by culture and institutions, which permit, prohibit, or discourage a given choice. An avenue for integration between these two frames lies in collaborative explorations of information, communication of that information and its use. At the same time consideration must be given to examining the capacity of audiences to critically assess claims made by others for their reliability and relevance to those communities. This is dealt with in more detail in Sections 4 and 10.

Key adaptation uncertainties arise from a limited understanding of:

Physical/material vulnerability and capacity: The most visible area of vulnerability is physical/material poverty. It includes land, climate, environment, health, skills and labour, infrastructure, water supply, housing, finance and technologies.

Social/organisational vulnerability and capacity: This aspect includes formal political structures and the informal systems through which a nation and its communities achieve planned goals.

Motivational/attitudinal vulnerability and capacity: How individuals and communities in society view their ability to affect their environment, manage their risks and take charge of their future direction. Experience shows that groups that share strong ideologies or belief systems, or have experience of successful co-operation are usually the most resilient.

These uncertainties and the experience of the disaster management community point to the need for multi-sector and multi-agency coordination. This approach is emphasized for the following reasons (Collymore, 2003):

- In major incidents the resources of a single sector, agency or community will not be adequate.
- The range of risks and their complex impacts demand information and skills from diverse sources.
- No single person or agency can be expected to anticipate all scenarios.
- Sharing of resources will enhance response and recovery during windows of opportunity.
- Team building and networking will facilitate access to the community's full resources and build local coping capacity.
-

Any VCA should begin with a stakeholder-driven description of the system and the issues, leading to a limited set of scenarios that capture the major uncertainties in the system's present and future dynamics. A variety of simple models and other means of describing the dynamics of the system are then used to collaboratively work through the scenarios to identify the components of the system's capacity and, therefore, how capacity may be lost or enhanced.

In addition to providing policy makers in the relevant country offices with adaptation guidance, a complete VCA also provides a baseline analysis of structural vulnerability and constructs historical socio-economic data sets from basic infrastructure and logistical data for risk preparedness and response. An analytical review of historical data also provides indicators of the interaction or co-evolution of past climate events with development pathways, and responses after or between particularly significant events. The VCA undertakes analysis of the sensitivity to climate variation and change across different timescales, the different components of each sector and the cross-sectoral or integrated response. All of this information may be then co-ordinated in an Information System Database (e.g. GIS) for mapping and comparing the available data sets for incorporation into a final composite vulnerability analysis.

The tourism sector is a key element in the economic development of the island nations of the Caribbean. Coastal-based infrastructure, as in the case of Barbados, is at high risk to tide surges and other elements from more intense and frequent tropical cyclones (hurricanes). (Photo: Ministry of Environment, Barbados)

Many of the traditional approaches to assessing vulnerability to climatic risks have focused at the two ends of climate variation spectrum, i.e. extremes (and associated return periods) and climate change predictions from models. Adaptation will inevitably be implemented at the local level, whether that is at a community, watershed or island scale. In the context of island and low-lying regions, compounding factors (e.g. island characteristics) render the isolation of climate effects from other factors problematic. The team-based approach for VCA presented here allows for multi-sector and multi-agency coordination, through sharing of resources and networking, to facilitate access to the communities in question to inform the assessment of local coping capacity. This document focuses on critical sectoral and cross-sectoral problems and methodologies for assessment at different scales of analysis (community, parish/county, watershed, national, regional).

Major foci for mainstreaming adaptation planning are to identify entry points for climate information use and outline actions required to reduce the loss and damage expected from impending changes and events caused by the combination of variability and change. As such, a critical need is to assemble information from existing cross-sector adaptive governance programs such as disaster mitigation plans, Integrated Coastal Zone Management (ICZM) plans, Integrated Watershed Management (IWM) plans, Marine Protected Areas, and early warning systems.

The Rapid Assessment protocol described below provides a generalized outline of the procedural steps of the full VCA Methodology. The initial assessment is to understand the climate risks and exposure of a particular community, and the planning goals of the community, the private sector and the government for the unit being analysed: what values (e.g. participation, equity, environmental quality, resource extraction, economic growth) are being maximized? In order to identify the types of information that are useful for decision makers at all levels (policy to household) and at different points in time it is first necessary to understand the existing decision making process. The following sections present the tasks that should be completed for an initial rapid assessment (Section 3) or a more detailed VCA (Sections 4-12).

3 RAPID ASSESSMENTS

Since it is evident that a comprehensive VCA may not be possible in all locations, a screening assessment of critical problems and existing data must be conducted. A screening assessment is not a substitute for a full VCA Methodology. The framing at the rapid assessment level is similar to that of an early warning system in that it includes: (1) monitoring and projections (including past events, gaps, projections and uncertainties); (2) risk profiles i.e. risk assessment, perception, and existing risk management (including in sectoral and cross-sectoral decision making such as IWRM, ICZM etc.); and (3) communication and engagement of the preparedness communities and decision makers.

The following procedure is proposed for carrying out a rapid assessment:

Stage 1: Develop advisory group at the national level.

Stage 2: Define spatial scale of assessment using biophysical and socio-economic boundaries (watershed, bay, city, fishing community). Assimilate static risk maps (Section 4.2) of the built and natural environments.

Stage 3: Conduct stakeholder workshops to define critical issues, existing knowledge and practices, and data gaps.

Elicit key stakeholder problem framing and needs (for seasonal and longer climate-sensitive information). Outline decision processes involved using the decision calendar.

Develop a risk assessment and management conceptual model (example in Figure 1) showing the typology of physical, social, economic and environmental pressures on a community of economy, environment, and society from global, regional, and local scales.

Stage 4: Define temporal scale that incorporates current and potential environmental change.

Stage 5: Collect data and information, including existing maps, on the relevant biophysical characteristics of the study area.

Stage 6: Collect data and information on the socio-economic and management characteristics and trends of the study area. Data availability and knowledge gaps should be inventoried and reported during the rapid assessment.

Stage 7: Conduct situation assessments: characterize participants, activities including livelihoods, practices, infrastructure location, land use, needs, resources etc.

Stage 8: Map decision processes and information entry points.

Stage 9: Refine conceptual model. Provide a summarised overview.

As noted in Stage 3, a conceptual model (see Figure 1) is constructed to identify the nature of climatic risks, critical elements at risk and risk management practices. This model may be refined as the assessment is conducted. It also forms an information basis for the detailed VCA to follow.

The following Sections build on the rapid assessment framework and are tasks that should be completed concurrently to achieve a full VCA.

4 DEFINE AND SCOPE THE VCA

The stakeholders should be involved in determining the specific geographic scope etc, but at the same time the geographic scope must be defined in order to determine who the key stakeholders are. An advisory council (hereafter referred to as the Council or Advisory Panel) comprising of representatives from relevant government ministries/departments, private sectors, NGOs, and trade associations should be established by the VCA team leadership. This group will help to direct problem definition and develop the VCA team membership. Most importantly this council will be central in increasing the likelihood of mainstreaming the results of such assessments into practice and will be capable of supporting the adaptation process and prioritizing subsequent adaptation needs after the initial VCA lifetime. Important considerations in establishing the vulnerability checklists and sensitivity matrices are:

- National system outputs: ecosystem (e.g. protected area per country size), forests, social, and infrastructure
- Sectoral, economic, political and administrative context (including international influences)
- Community: Livelihood and livelihood activities, local and site specific, individuals and small groups

The in-country team leader(s) should begin this process by engaging the climate change Focal Point (if he/she is not the team leader) and individuals from the Advisory Council to identify relevant stakeholders and groups already engaged in deliberative processes in the area of concern (Box 1). Where these processes are non-existent, individual relevant stakeholders should be identified and contacted ensuring that the categories into which they fall are represented. For instance in the water resources sector, these categories may include:

- Community water users
- Residential, Industrial, Agricultural water users
- Government regulators (local, urban, state, national)
- Scientists, engineers and academia
- Providers of products and services
- Non-governmental organisations (NGOs), especially representing biodiversity interests.
-

The identification of both national (the Advisory Council) and local stakeholders and involving them meaningfully is essential to any VCA methodology and is often quite challenging given the competing pressures on time and institutional inertia regarding climate change. One of the keys to getting full participation is to identify already existing problems within the community or sector, how these are being framed (characterized and described) within the community, and how they overlap with the issues being assessed by the VCA process (Box 1).

From these stakeholders a local stakeholder technical team (based on the unit of analysis, watershed, urban, coastal community) may be formed to actively participate in the research with the VCA team by suggesting sources of data and information, identifying least-served constituencies and hotspots, and assessing the utility of particular indicators and scenarios. Key personnel may include representatives from the ICZM and IWM programs, where they exist. This bottom-up approach, identifying operationally useful information with the people who will be using the information has proven to be successful in developing receptivity to implementation and to sustain activities. The role of this advisory panel is further explained in Box 1 with reference to later components of the VCA methodology. Additional technical panels can be assembled as needed throughout the assessment depending on the critical issue being dealt with at the time.

Box 1 Role of the Advisory Council

Partners (government, community, private, academic) must be consulted to assist in identifying potential priority vulnerabilities and potential stakeholder partnerships. These advisory panels are key to maintaining partnerships among the stakeholders long after the VCAs are completed, ensuring some degree of continuation and implementation. The supporting functions carried out by the panel includes assisting the VCA team in answering the following questions:

- What are the relevant indicators of vulnerability (or adaptive capacity) (Sections 7 and 8) nationally, and locally? Many of the indicators will be specific to the livelihood and the hazard. For instance, crop-drought indicators (such as yield) are of different importance for subsistence agriculture than for commercial farms. Are there indicators that are relevant across a range of livelihoods and hazards? Household income is one; transport links and access to markets might be others.
- Where are the initial hotspots (at or near critical conditions) and sensitive areas?
- Which stakeholders and institutions[1] are best placed to implement adaptation options for each livelihood? It should be possible to look back at the list of stakeholders and map their relevance to the critical vulnerabilities identified (Section 9).
- What is the initial risk assessment and management conceptual model? (This will be refined as the study progresses).
- What are the criteria for implementing the adaptation options?
- How are these criteria selected and prioritized for evaluating the adaptation options?
- What is the practical range of adaptation options: within and across sectors? When and how should they be updated as climate changes? (Section 11).
- Are the adaptation options specific to livelihoods and hazards or more generic?

4.1 Select the exposure unit and time horizon

With the input from the stakeholder advisory council the study area is defined and could be the whole island, a particular community, a watershed or certain sectors within a geographically defined area. The time horizon over which the assessment will take place is decided by taking into consideration the timescales of the climate events of interest, i.e. decadal, ENSO cycles or longer-term change. Care must be

[1] Institutions are made up of the organizations, rules, behaviours and values by which society functions. They can be as simple as a village with a village council or as complex as a national government

taken to avoid working to purely politically motivated, short timescales, such as fitting in with a short-term 2 year plan.

The base year for the scenarios must be chosen so that comparison's can be made relative to a known time. This is not to assume that the base year has optimal conditions for resilience but simply to act as a reference point from which changes are assessed .The choice of base year or base period should consider that concurrent inter-annual, decadal and other variations may make the year of choice unrepresentative if background climatic conditions (e.g. chosen during a major ENSO event, or multi-year drought etc.) are unusual. Baselines will continue to change with time as the population, demand and/or supply patterns and legislation change.

4.2 Assemble or construct static risk maps: physical infrastructure and administrative units

This step assesses and organizes the physical and organizational components of risk into a graphical map based format to help identify priorities. These may already exist in the relevant ministries or from past consultants reports and access may be enabled through the advisory council. As needed, preliminary maps (preferably GIS-based) should be developed for the area being assessed. The maps are referred to here as static risk maps since they portray the situation as it exists (e.g. fixed structures) rather than making any projections of development into the future or analysing the past drivers that result in existing vulnerable conditions. Information to be contained in such maps includes the location of the following:

- Infrastructure and the built environment including transportation networks (roads, rail, ports).
- Hydro-geomorphology of watersheds (flooding patterns, strengths and limitations of present mitigation etc.).
- Ecological and woodland status of the area.
- Impervious (paved) vs. pervious (unpaved) % area in watersheds.
- Agricultural, mangrove, and saltwater production systems.
- Existing industrialization and commercial land-use.
- Basin infrastructure and housing, territorial organization of the zone.
-

The key action of mapping decision-making processes and evolving information requirements are discussed below.

4.3 Review available data and data quality: initiate datasets development

Brief descriptions of present vulnerabilities from the rapid assessment are prepared using existing reviews and reports of projects under development. Any limitations and gaps in the existing reports whether data, framing concerns[2] etc. should be identified at this stage with a view to addressing these weaknesses as part of the VCA. An important potential constraint on the quality of the VCA is the existing level of climate data availability and its adequacy. This should be assessed early in the project and the VCA team should be clear about the period of record, the completeness of the dataset, its reliability and the spatial extent relative to elevation at the area of concern etc. Once the existing available data has been assessed the time horizons can be finalized with stakeholder input, including the timescale for the completion of the VCA and the implementation of the VCA recommendations.

Based on the information gathered during previous studies (from international or national agencies and consultants) in the chosen location an initial list of the critical issues/problems within the unit of analysis (city, watershed etc) is created. The maps produced will assist the stakeholders in identifying an initial list of critical issues/hotspots (e.g. in accordance with the CEHI Integrated Watershed and Coastal Areas Management, IWCAM, definitions below). Where data is limited or unavailable, ranking by expert judgement can be used instead based on input from the stakeholder advisory panel and other technical experts. A simple ranking system for each issue might be 0 – non-existent to 5 – severe.

The IWCAM defines: “Environmental hot-spots” and “threatened sensitive areas” as follows:

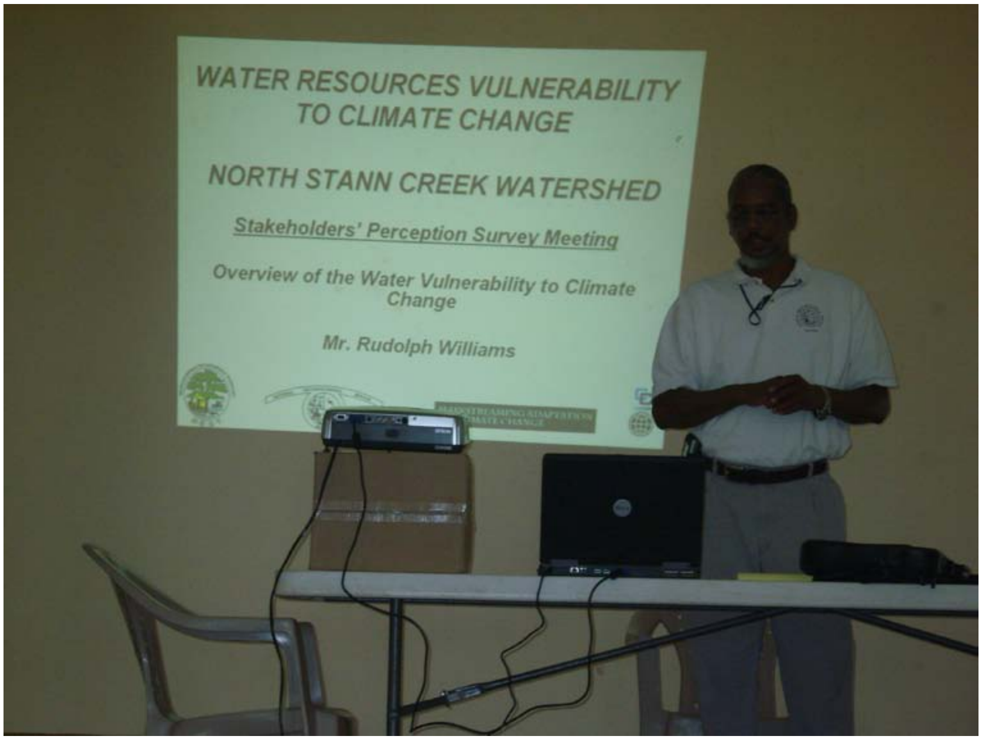
> <u>Environmental hot-spots</u> are geographically defined watershed, coastal areas and other areas of the sea, of national, regional and/or global significance, where the conditions are such as to adversely affect human health, threaten ecosystem functioning, reduce biodiversity and/or compromise resources and amenities of economic importance in a manner that would appear to warrant priority management attention. A degraded area is said to display significant and measurable environmental degradation.
>
> <u>Threatened sensitive areas</u> are geographically defined areas, of national regional and/or global significance which, although not degraded at present, are threatened with future degradation, either because of sensitivity of the receptor or the magnitude of the anthropogenic activity posing the threat.

4.4 Social vulnerability, perception and decision making surveys

At this stage a survey/interview protocol is developed and tested with the advisory group before conducting surveys. The actual conduct of the surveys and the selection of interview candidates are done in collaboration with the on-site advisory council. The preliminary goal of this analysis is to uncover the mental model of stakeholders that elicits what individuals already know and believe about existing

[2] Framing refers to the ways in which different communities or individuals in a unit of analysis (watershed, urban) view and describe a problem and its relevance to them.

climate-related risks i.e. not just climate change but what are significant events in their memory? How have communities (and individuals) experienced and coped with recent events (hurricanes, floods, drought, etc.)? A second goal is uncovering present coping strategies i.e. eliciting the present perception of relative climatic risk among different sub-communities: what are their most important issues? What do people already know or believe about their interactions with climate (drawn from the climate risk inventory of recent events, focusing events and climate change)? Are they aware of the risks to existing activities and livelihoods? How are response and adaptation decisions made at present? This information then feeds into future focus group meetings and/or semi-structured, follow-up one on one interview with key individuals. This latter detailed focus would be on assessing the particular physical, social and environmental capitals (see Resources, Access, Capacity, Use and Environment discussed in Section 8) within the sector or community. Thus the initial survey seeks to obtain information that sets the context for the VCA team. By assessing what has happened in the past and how the nation, communities, and individuals responded and coped one starts to identify how present risks are understood and what risks are considered acceptable. For example, the pilot VCA completed in Speightstown, Barbados identified that tourism businesses have suffered from flooding in the past, but rather than undertake adaptation measures businesses are willing to simply clean up and get back into business. Useful approaches for guiding this aspect of the VCA include the Mental Models (Morgan et al, 2002) and the AKAP (Awareness, Knowledge Attitudes Practices) approaches. Focus groups, one-on-one interviews with key partners and workshops are vehicles for eliciting more nuanced and insightful responses. These fora carry greater legitimacy with participants when co-developed with the advisory council and a local stakeholder technical team.



VCA Consultative Workshop in Belize – presentation of the Stakeholders Perception Survey Report. (Photo: Joe McGann)

Care must be taken to avoid the limitations of large-sample survey approaches. Fixed survey instruments, unless designed and compared with other sources of data such as reports, can at times lead to an individual giving answers one assumes the analyst wants to hear. The results should therefore be triangulated with other data gathering techniques (e.g. analysis of official reports, in depth interviews) to validate the results. For example, in a focus group setting individuals might be more likely to be clear since they know that other people in the group might challenge them, on the other hand they may find the anonymity of an interview appealing to their being forthcoming about present situations.

4.5 Mapping decision making processes I: cross-cutting issues and responsibilities

As is well-documented the sustainability of adaptations that reduce vulnerability requires an understanding of human agency i.e. the choices and outcomes of individuals and institutions that shape human-environment interactions including policy over time (Downing and Patwardhan, 2004). This step focuses on mapping the decision processes for adaptation in terms of mitigation, preparedness, response and recovery. The key components are identification of: the critical actors at each jurisdictional level; the assumptions of each actor regarding risk; the different types of information each actor requires for informed policy making; and the design of an information infrastructure that will support such broad, multi-way exchange of information, resources, incentives, and action. The ultimate aim of the VCA is to develop information and tools that can be seamlessly mainstreamed into existing decision-making and planning processes. Only by making the complexities of environmental risk management explicit is it possible to transform the learning process for responsible management of the environment.

In each case, the issues to be considered when working with the information developed above include:

- Time for implementation (bureaucracy);
- Reliability of the information;
- Credibility of the informants;
- Stakeholders who will eventually implement options;
- Winners and losers of the options;
- Acceptability of the outcomes to those most affected.
-

The assessment of the existing plans will therefore help identify potential entry points for the information derived from the VCA. Additional information to be collected includes:

- Legislative and organizational frameworks for promotion of development in the exposure unit.
- Organizational and planning structures for early warning (preparedness, risk communication etc.) and emergency management systems.
- Role of partners/stakeholders through existing interventions, and their different attitudes regarding development risk reduction and climate.

Climate variability and change will affect all sectors and the relationships between the sectors, producing multiple stresses on each location. For example, tourism is heavily reliant on healthy watersheds, stable beachfronts and healthy coral reefs. Reduced water supply and/or extensive beach erosion will also heavily impact tourism. Responsibility for the different resources and services is often spread across different agencies (Table 1). In any country there will typically be a water supplier, an agency responsible for ensuring that environmental legislation or zoning is adhered to and the industry and local communities whose activities could impact on the quality of the water supply (cross-sectoral and cross-agency responsibility).

These relationships must be determined and mapped, again with input from the stakeholder advisory panel.

Data sharing is a critical problem in the Caribbean. One of the main roles of the advisory council is to facilitate access to the data by the VCA team. Similarly climate change issues are rarely the responsibility of one agency and therefore it is necessary to get each of the relevant agencies to incorporate climate change considerations into their planning processes. Table 1 is an example of a tool that can be used for assessing the responsibilities across multiple sectors, using water as an example (World Bank, 2004).

Table 1: Cross-sectoral matrix of responsibilities and jurisdiction over water resources

Potential matrix of responsibilities within agencies, private and community partners

	Public and Private Agencies and Organizations					
Tasks	Water & Sewerage	Met. Services	Agriculture Agribusiness	Health	Nat. Res.	Others
Water Supply						
Sanitation						
Irrigation						
Flood Contol						
Recreation						
Watershed Management						
Ports						
Quality (Pollution)						
Groundwater management						
Instream management						
OtherÉ						

Source: World Bank 2004

5 ASSESS PAST, CURRENT AND PROJECTED CLIMATE CONDITIONS

An inventory of past climate events (hereafter referred to as the climate inventory, developed below) will identify the frequency of occurrence values, or return periods, and trends in climate, such as the changes in the frequency of hurricanes observed since 1995. This information can be used to characterise future climate-related risks and potential impacts from a purely climate-based perspective. For example, the observed trend in sea level rise can be carried forward to estimate the level of erosion that can be expected over 5, 10, 20, 50 years or any other period of time. Assessing impacts at scales that matter for planning is complicated by the involvement of human interaction, such as through building shoreline protection structures, local changes in topography etc. GIS approaches are invaluable in this context.

5.1 Develop a climate risk inventory of past, recent (and projected) events

The climate risk inventory aims to characterise the current state of relevant knowledge of climate variability on relevant time-scales for social and environmental impacts. Most importantly, these should highlight the characteristics of recent focusing events for use in stakeholder surveys and interviews. Focusing events are those significant events that result in widespread public attention and engage national and local leadership. This data, linked to the economic and social impacts of particular events that have occurred in the past from the climate inventory, can be used to construct statistics and indices such as:

- Standardized Precipitation Index (SPI is a drought index based on precipitation probability over different climatic timescales),
- Recurrence and exceedance statistics (i.e. likelihood of exceeding a particular threshold number give the past record),
- Variability of extremes for past periods (over the last 5, 10, 15 years and longer),
- Seasonal, inter-annual, decadal and long-term changes.
-

Table 2 shows the dimensions of a matrix that could be used to develop a climate risk inventory.

Table 2: Example matrix for developing a climate inventory for a particular location

Climatic catalysts at different timescales
(Seasonal, Interannual, Decadal, Trends, Change) (S, I, D, T, C)

	Magnitude	Duration	Spatial extent	Econ Impact	Return period	other
Drought						
Heavy precip (seasonal)						
Hurricanes						
SLP						
Temperature						
Humidity						
Evaporation						
Other extremes						

Additional events (i.e. Other extremes in Table 2) would include characteristics of high ocean and sea surface temperatures that lead to coral bleaching events, such as occurred in 2005 (Oxenford et al, 2008).

The inventory forms a basis for the ensuing components of the VCA. For instance a basic water budget for a small watershed can be expressed as:

$$P + \quad = ET + \quad +$$

where; P = precipitation,
= water flow into the watershed,
ET = evapotranspiration (the sum of evaporation from soils, surface-water bodies, and plants),
Δ*S* = change in water storage, and
= water flow out of the watershed (see Healy et al, 2007).

The return period or recurrence interval (**T**) is the number of years in the record (**N**) divided by the number of events (**n**). When there is a magnitude associated with the data (such as size of a flood discharge) the recurrence interval (**T**) is **T = (n+1)/m** where **n** is the number of years of the record and **m** is the magnitude ranking.

Using the above information, the long-term risk in the built environment for an event such as a flood may be stated as:

$$R = 1 - [1 - P\ (X \geq \ \ )]^{n}$$

Where: $P(X \geq \ )$ = the annual probability that X (the maximum stage or flow) exceeds a specified target or the capacity, *;*

R = the probability that an event $X \geq$ will occur at least once in n years.

These may be input to simple stocks and flows models for Section 6.2 (Preliminary data analysis), such as sensitivity of water budget calculations to different climatic events for a watershed or for agricultural requirements.

It is very critical to note that past recurrence intervals are not reliable under conditions of climate change (Milly et al 2008). Additions to this inventory using future projections of change are discussed below.

5.2 Characterize future climate projections

Questions concerning the impacts of future climate change in this region would require the use of high resolution information. However, there are not yet any Regional Climate Model (RCM) experiments that clearly demonstrate the difference that high resolution makes to the results of impacts studies here. A foremost requirement for the use of RCMs in climate change applications is that they adequately reproduce the regional characteristics of present day climate, and that model errors in describing the climate of a region be identified and possibly minimized.

In developing climate scenarios, the common procedure has been to combine changes in climate (perturbed climate versus control climate) with observed climate data, because the errors in the climate models, especially for precipitation, are too large to allow for direct use of the control runs in impacts models. This is still generally true in the case of RCM results. However, as the resolution of the climate runs increases, it becomes more difficult to obtain observed data at the desired resolution. Comparisons of both direct RCM output and observations found that using the control run output directly produced hydrologic impacts quite different from those obtained when using observed climate data. Essentially observed data should still be used when possible. If the desired resolution is not available, then careful evaluation of the error introduced by using direct output should be made, and this error considered in any inferences made from the study results (see Section 8.2).

Mearns et al (2003) summarize guidance material for developing regional climate projection scenarios:

1. Carefully consider the purpose of the study and evaluate what the role of higher resolution, but still highly uncertain information, would be in that context. The key issue may often be the need to represent uncertainty at a spatial scale amongst a range of other uncertainties which may also need to be allowed for in the study.

2. If regional/time slice/variable resolution modelling is to be used, work with experienced climate/regional modellers.

3. Emphasis of analysis should be on the scale dependence of the scenarios and impacts when this makes sense, i.e., compare impacts using driving global climate model (GCM) scenarios with high resolution RCM scenarios, except where there really isn't any sensible corresponding coarse scenario. This is particularly true for research-oriented studies.

4. Keep the uncertainty associated with spatial scale in perspective given other uncertainties affecting climate projections. These particularly include the uncertainty on the regional scale of different GCMs and atmosphere-ocean GCMs (AOGCMs). Also remember that different regional models can respond differently and there is uncertainty in the responses of regional models.

5. Take advantage of existing RCM output. Many experiments (at least with) have been performed over many regions. Many of them can be used for certain types of impact investigations, such as sensitivity analyses exploring the effect of altering spatial scale.

There are both statistical and dynamical tools available to assist in downscaling data from the currently large scale climate change models. It should be noted that, at present, most models smooth out extreme events and it is the extreme events, rather than the gradual changes that are likely to have the greatest impacts. Thus the impacts of climate change superimposed on variability i.e. actual climate change can lead to surprises. For the Caribbean islands the validity of such projections are particularly unreliable for rainfall. However, most models agree that a drying signal is projected for the region.

6 ASSESS SOCIO-ECONOMIC TRENDS AND CONDITIONING FACTORS

6.1 Assess key development trends

With the future climate-related risks described above the equivalent socio-economic development scenarios are formulated by assessing trends and changes in the development of the country or region of interest. Scenarios are not a prediction or projection; they are storylines that describe alternative futures. Scenarios are a tool for structuring discussion amongst stakeholders and raise awareness of the future connections between different environmental problems and illustrate how different policy directions can achieve their targets. Thus scenarios provide mechanisms for collaborative or co-produced insights between the VCA team and stakeholders to initiate discussion on commonly formulated questions such as “Given these trends; what outcomes and pathways are plausible? Where would we as a community like to be?”

The types of trends to be considered include: past and present supply and demand management practices (e.g. controls on access to fresh water, increased levies on certain goods); national and local development trends (include population growth, urbanisation, rural migration, dependency on imported goods, percentage paved areas in a watershed); and potential climate change impacts (e.g. loss of coastal infrastructure through beach erosion). Box 2 shows how the current population trend can be used to determine how many people might be affected by a future event of the same severity as one experienced in the past. The calculation assumes that no adaptations have been taken to reduce vulnerability.

Box 2. Projection of population to future events

Projected population:

$$P_d = P_0 e^{rt}$$

Where = population on the day of the disaster
= most recent official estimate of population
r = annual exponential growth
t = length of time in years between the disaster and the baseline year 0.

Generic data to be collected on the socio-economics of the area chosen and used in the creation of scenarios include:

- Demographic changes including affluence
- Trends in resource use and economic development including property at risk on coasts
- Land use (incl. % crop types, % paved or impervious area, forests) and ownership
- Infrastructural and other economic assets
- Cultural assets and institutional arrangements such as community and religious groups
-

This type of data can often be found from departments such as the census bureau and the statistical office or other local and national authorities. International organisations such as the World Bank, UNDP and UNEP may also have national scale information for these types of indicator. The scenarios may be aggregated for the type of event (drought, hurricane) and the timescale, (inter-annual variations, ENSO and non-ENSO, decadal-scale and climate change scenarios) or to uncover the degree to which a particular event has affected the unit of analysis and what response mechanisms have been put into place to reduce risk between events.

6.2 Refine database development and conduct preliminary data analysis

The data required to formulate the scenarios (climate and socio-economic aspects) are assimilated into a database of the key input and output variables for the chosen indicators from the previous sections. The data should cover present scenarios for population growth, industrialization, and change (e.g. irrigation, desalinisation).

A preliminary assessment of the relationship (through simple models such water budgets or CROPWAT for agriculture) between climate and key variables such as economic outputs, water supply, agricultural yield, coral bleaching etc. is also carried out giving due consideration to the different national or community scale inputs and outputs over time. Where possible, regression calculations between the events and the indicators should be carried out to examine any lead or lag time in the system. There is often a gap in time between the climate event and the impact. For example, impacts on sugar cane yield in the Southern Caribbean typically occur one year after an El Nino event. In Trinidad rainfall during the start of the rainy season (May-June-July) shows the strongest correlations with ENSO warm or cold events 3-6 months earlier because of the mediating impacts on Caribbean Sea surface temperatures. There are also direct atmospheric teleconnections at the time of an ENSO event and the concurrent rainy season.

7 ASSESS SOCIAL CAPITALS AND VULNERABILITY

As discussed above, vulnerability is assessed by considering the physical, economic, social and ecological trends and conditioning factors in selected sectors to climate on the seasonal to centennial and longer timescales. For example, how do transformations such as demographic changes (population, livelihoods, and land use) influence vulnerability to climate risks including abrupt changes?

7.1 Assessing the social construction of risk

Political ecology is the study of how political, economic, and social factors affect environmental and social vulnerability. The majority of such studies analyse the influence that society, state, corporate, and transnational corporations and policies have on environmental services and their influence on environmental policy. The conceptual model shown in Figure 2 describes an integrated view of the political ecology perspective for assessing how and in what contexts vulnerability arises. An example would be to assess where people are located (e.g. hillsides prone to landslides) and why they are there (e.g. displacement from lower lands through privatisation and development, decline in agriculture or fisheries). Understanding the conditioning factors (i.e. why are trends and particular data points observed?) and establishing the context (or contexts) of the situation will determine how feasible recommended adaptation options are given present capacity.

Poverty combined with urban pressure on land in Kingston, Jamaica force high risk squatting on river/gully sides. Squatters become increasingly vulnerable to hazardous events such as hurricanes and floods. (Photo: Jamaica Observer)

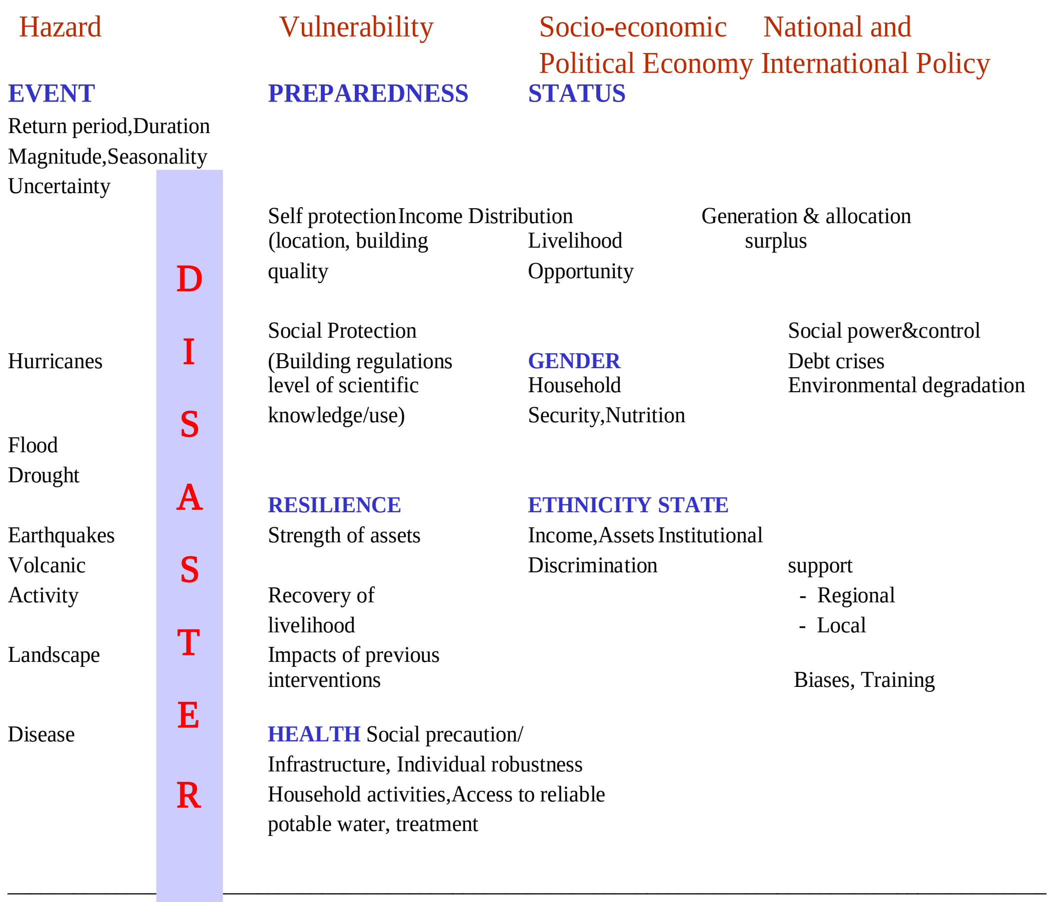


Figure 2: Political ecology conceptual model

Source: Wisner et al, 2005; Pulwarty and Riebsame, 1997

When assessing the socio-economic trends it is important to place these in the context of proximate causes (e.g. the link between individual behaviour and perception of the environment) and the political ecology of the system being assessed. International and regional situations or conditions can have important influences on vulnerability in any sector or community, especially in SIDS with small, open economies. Trade agreements, world market forces, wars etc. can all have a major impact on the developmental choices that are made within a country as well as influence the markets within a country. Within the social capitals context, some indicators to test climate sensitivity from a social vulnerability perspective can be constructed from the categories given in Table 3.

Table 3: Political ecology variables

Components of Vulnerability	Variables involved	Socio-economic and Technical Determinants of variables
Initial well-being	Nutrition; physical & mental health; morale/faith; capacity for self-reliance	Class position; gender; ethnicity; age; State and Civil Society
Livelihood and resilience	Income and exchange opportunities; livelihood type; qualifications; assets and savings	The above plus: shifts in power relations and effects on livelihood after hazard impact
Self-protection	Building quality; hazard protection; location of home and livelihood (safe site);	Socio-Economic: as above plus: technical ability & knowledge of and availability of protective measures; Hazard-specific: Type of protection, its cost and feasibility; return period; duration; intensity; magnitude
Societal protection	As above, plus: Building regulations; technical interventions by higher levels; mitigation measures; shelters; preparedness.	As above, plus: Level of scientific knowledge; characteristics of technical practices (elitist?); quality and robustness of insurance systems; type of science and engineering used by state and dominant groups
Social capital (social and political networks and institutions)	Social cohesion; rivalries; number & strength of potentially conflicting groups;	As above, plus: Type of state power; capacity for civil society to develop and enable positive networks and interactions

Adapted from Cannon (2000)

7.2 Economic loss estimates: impacts and sensitivity

Disasters can result in significant economic damage through the immediate loss of assets as well as the longer term impacts on the prices of goods and services. Immediately after a disaster countries might receive additional aid to offset some of the costs, but recovery may take several years and during that time production will drop and imports will increase to replace the goods and services that were lost. Both economic and insured losses globally show an increasing trend since the 1970s as a result of population growth and increased levels of property at risk. The Advisory Committee should be employed to assist the analyst in choosing weights to be placed on the policy alternatives, including monetary and non-monetary impacts, such as to the natural environment. What are the benefits (values gained) and costs of various adaptation programs over time, and who gains or loses from these?

One way to assess recovery times (between events) from an economic perspective is to composite the grouped economic quantity of interest for a particular event across all such events and compare that to the equivalent values for the years preceding the event. Changes attributable to an event can be dynamic and continue over time and must be cumulatively measured by monitoring over time. For example, Figure 3 shows the annual growth in long stay tourist arrivals before, during and after all hurricanes of a particular magnitude in the period 1970 to 1997. The graph shows that there is a drop in arrivals during the year of the events, followed by steady growth in the following 3 years. However, the growth rate remains below that experienced in the 3 years before the events (Avg-123).

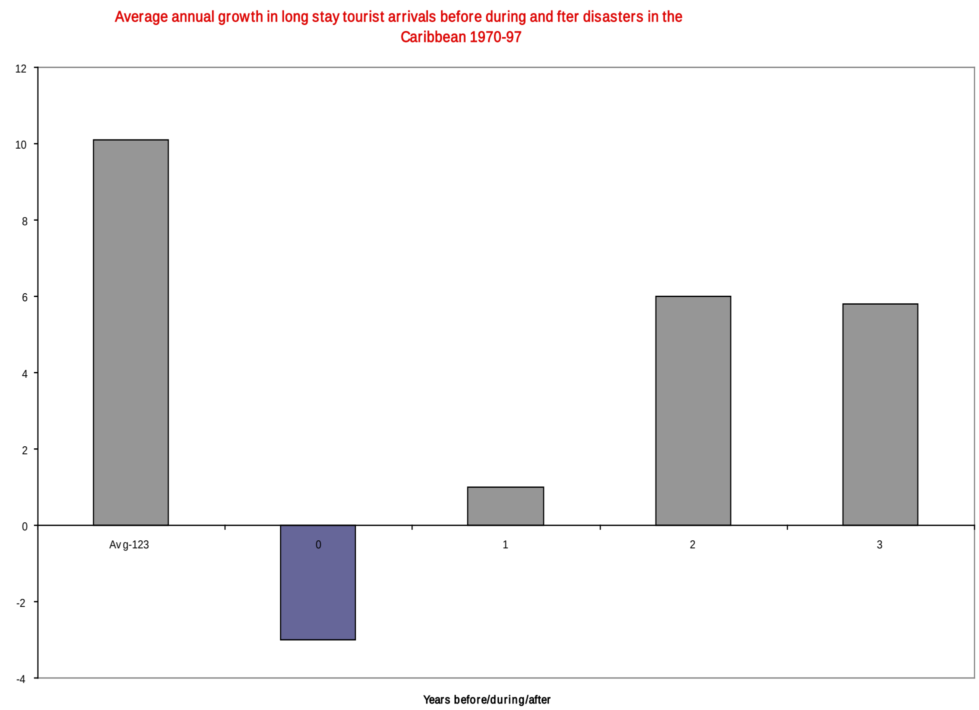


Figure 3: Example graph of composite economic quantity: Average annual growth in long stay tourist arrivals before during and after disasters.

Source: Crowards, 2000

Losses, when strictly infrastructure-related, can be calculated from input of the following four modules (Pollner et al 2001). The stochastic module consists of climatic events and their statistical distributions based on historical data, scientific analyses and expert opinions. The hazard module includes characteristics of the event intensity and distributions. The damage function module includes calculation of potential crucial damage for different intensities and experiences. Much of the data should now be in the database assembled earlier. These drive the financial or loss quantification module to determine the cost of catastrophic risks. Box 3 (Pielke, R. et al, 1999) gives further details on one approach to calculating the loss estimates and is based on models used in the insurance industry.

Box 3. Calculation of normalized national loss estimates

Source: Pielke et al, 1999

To calculate the losses from a storm, normalized to year x ( ):

$$NL_x = \sum L_{y,c} I_{y,c} W_{y,c} P_{y,c}$$

Where x = year in which losses are to be estimated
y = year of storms impact
c = country of storms impact
$_{,c}$ = storms actual losses in country c (in current year dollars)
$_{,c}$ = inflation factor (implicit price deflator for country c in year x to that of year y)
$_{,c}$ = wealth factor for country c (inflation adjusted per capita GDP) in year x to that of year y
$_{,c}$ = population factor for country c as a ratio of population in year x to that of year y (see Box 2)

A simple indicator that can be used to benchmark more complex proxies for which comprehensive data might not exist is the Economic Loss Potential (ELP) under present and future conditions of population and property. This may be derived when the detailed data required above are unavailable. For instance, Hurricane Donna impacted the Dominican Republic in 1960 and the ELP of such a hurricane hitting the Dominican Republic in 1980 is calculated as follows:

ELP = Change in wealth per capita x Inflation factor x Population change

E.g. Dom. Rep. ELP for 1980 since 1960 = 1.82 x 2.59 x 1.8 = 8.52

That is, the damage may be expected to be 8.5 times that in 1960. Note that this simple number does not account for adaptations or changes in social vulnerability over the intervening period and as such should be used only for benchmarking more detailed local level economic calculations.

If data is limited or accurate and precise predictions for a location are unavailable then sensitivity analyses for different hazard severity should be conducted. One method by Pollner (2001) gives very useful guidelines for such an approach. The cost of financing catastrophic risk can be defined as a function of the damage ratio D, where D=H*V; H = hazard intensity factor (e.g. wind speed) and V= structural vulnerability factor of exposed property (i.e. amount of damage for a particular storm strength). V is determined from the damage record of previous storms, (Pollner et al, 2001).

From an adaptation standpoint these studies show that spending 1% of the value of a building on retrofit/vulnerability reduction measures could significantly reduce the

Probable Maximum Losses (PML) arising from a category 3 hurricane with wind speed of 120 mph. If no risk reduction measures are implemented, the PML for a structure could be 10% of the value of the building while, if risk reduction measures are implemented the PML falls to 5% of the value of the structure.

Examples of tools for calculating economic loss estimates are available from numerous sources (see IPCC WGII, 2007 Chapter 2) It should be noted that risk transfer mechanisms, such as insurance, do not necessarily reduce overall vulnerability. These should be implemented in support of, rather than as a replacement for, broad hazard risk reduction initiatives, such as strengthened building practices, land use planning and increased environmental protection.

8 DEVELOPMENT OF INTEGRATED VULNERABILITY INDICATORS

Many Caribbean countries and international agencies have produced inventories, such as poverty maps, human development indices, and environmental sustainability indices in an effort to assess vulnerability and risk. From these inventories a comprehensive set of spatial and temporal indicators of physical, social, economic and environmental vulnerability should be identified and complemented with the locally specific data developed in Section 6. Integrated indicators in this context are not to be aggregated into one composite number but are intended to develop a profile and relative weighting of risks in a particular location. Some suggestions for the type of information that might be required were discussed in Sections 5.1 and 6.1. It should be noted that indicators are in fact proxies and therefore it is important to ensure that the relationship between the indicator and the issue of concern is robust. For example, GDP is often used as an indicator of poverty, but can be grossly misleading. GDP as an index can be used for inter-comparison with other countries, but it becomes an inappropriate indicator when it is used to represent something else (such as poverty).

8.1 Integrated indicators: examples

Integrated indicators can provide an improved understanding of the relationship between the physical availability of a resource, its accessibility, and the level of welfare (Sullivan et al 2003). They can also provide inputs for prioritising resource needs and act as a tool for monitoring progress in the particular sector. Examples of integrated vulnerability indicators include the following:

- Water poverty index (WPI)
- Tourism penetration index (TPI)
- Agricultural-climate relationships and crop production indices
- Environmental vulnerability indices (EVI)
-

The data required to calculate the chosen indices should be added to the database described in Section 6.2. Each indicator must be viewed in the context of analysis of social and environmental vulnerability (see below). Further details on the development and use of the indicators are provided in sector-specific appendices available from CCCCC. Developing many of these indicators, such as EVI, is data intensive.

Based on the indicators and for the critical issues only, trends that impact vulnerability whether positively or negatively and from both a climate and non-climate perspective should be identified. Similarly any conditioning factors on those trends, both climate and non-climate, should also be identified. For example, increasing demands based on population growth might impact negatively on adaptive capacity given a situation where natural resources are already over-stretched. Alternatively, population growth may reduce vulnerability in a community with ample natural resources but limited skills.

Some of the socio-economic considerations from the analysis of political ecology and proximate drivers (behavioural) that would be included in a scenario for climate change in the different sectors are shown in Table 4.

Table 4.Examples of socio-economic data required for scenarios

	General	Water resources	Coastal zones	Agriculture
Economic growth	✓			
Population growth	✓			
Land use		✓ (for run-off)	✓	✓
Water use		✓		✓
Population density			✓	
Economic activity and investments			✓	
Food demand				✓
Atmospheric composition and deposition				✓
Agricultural policies				✓
Adaptation capacity		✓	✓	✓

One example of an integrated index into which political ecology variables are embedded is the Water Poverty Index (WPI) developed by Sullivan et al (2003). The WPI builds on the understanding that vulnerability is a function of the complex relationships between people as well as the social security infrastructure that may or may not exist. It focuses on capacities and resources that exist, i.e., not just what is lacking; but what already is extant within communities. Its dimensions are resources, access, capacity, use and environment. The integrated WPI frames livelihood strategies as the ways in which people gain access to these available assets, combine them in particular ways, and transform them into resilient livelihood outcomes. Table 5 gives an example of social indicators in the water resources sector.

Table 5: Example Resources, Access, Capacity, Use and Environment indicators for the water resources sector: Water Poverty Index

Component	Indicators
Resources	Assessment of surface water and groundwater availability using hydrological principles and hydrogeology. Quantitative and qualitative assessments of water quality.
Access	Access to clean water as a percentage of households having piped water supply. Reports of conflict over water use. %of water gathered/carried by women. Time spent on water collection, including waiting. Access to irrigation coverage adjusted by climate characteristics.
Capacity	Membership in coops or water users associations/village councils etc. Percent households reporting illness due to water supplies. Percent households receiving a pension/remittance or wage. Access to water authorities.
Use	Domestic water consumption rate. Agricultural water use expressed as the proportion of irrigated land to total cultivated land. Livestock water use, based on livestock holdings and standard water needs. Industrial water use (purposes other than domestic and agricultural).
Environment	Impacts and resilience (e.g. role of reefs in hurricane protection, water quality decline).

Source: Sullivan et al. (2003).

As noted in the political ecology framing, critical issues in the water resources sector include gender distribution and role in society (e.g. who carries water, is responsible for nutrition and sanitation? etc.), type of livelihood, ethnicity, access to potable water, training opportunities etc. For example, during the January 2005 floods in Guyana some of those affected were women who were heads of the household and who made their living at home by making clothes. Many lost their sewing machines in the floods and therefore lost their supporting source of income.

One form of visualization of a complex index is given in Figure 4. The analyses conducted in the sections above may be ranked within the blue pentagram. The vertices represent the maximum availability, 100%, of components (for instance 90% access means that equity issues are minimal). The various issues may be “ranked” (shown in black) through a combination of the data analyses described previously and expert judgement. The ranking process should be a collaboration between the VCA team and the advisory council to provide a sense of relative weighting of each component. In the example shown in Figure 4, access and capacity are both low <50%, relative to actual resources, ~96%.

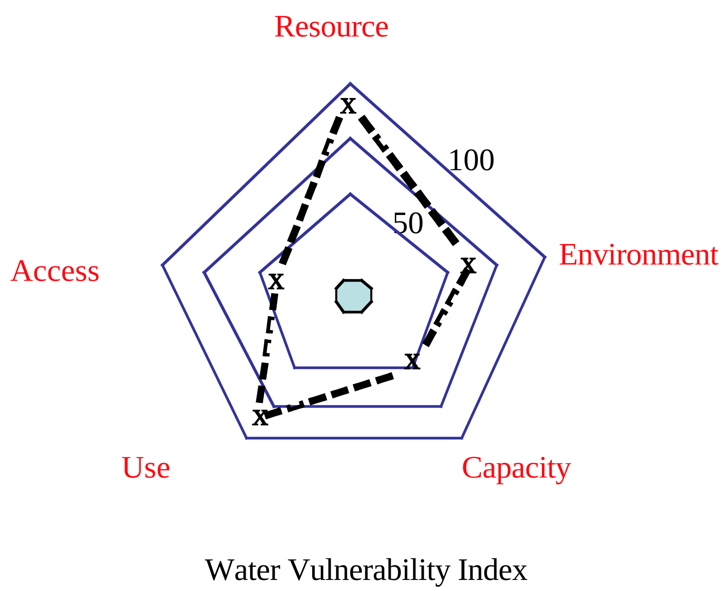


Figure 4: Visualization of the Water Poverty (RACUE) Index

8.2 Uncertainty characterization

The indicators used and reported in the VCA must include some measure or characterisation of the associated uncertainty. In many previous studies the role of uncertainty, beyond the technical uncertainty of model projections, is almost never explicitly given as an overriding factor. Given the gaps in technical knowledge and the inability to provide accurate projections of environmental changes or technological development with certainty into the future, uncertainty is a key component in the development of scenarios of alternative futures. Acknowledging the data gaps will reduce the probability of 'surprises' since some of the possible events can be gamed into "what if this (event, magnitude, rate of change etc.) occurs? What would be the appropriate response?" exercises. Identifying data gaps can also give impetus to new research. Scenarios and sensitivity studies give a range of suggestions as to what might happen, but these are still only a subset of all possible outcomes.

There is a wide range of statistical tests that can be used to determine the uncertainty in a forecast or trends in an indicator (Wigley, 2006). It is recommended that uncertainty is assessed in the individual components rather than attempting to assess uncertainty for the combined data. Figure 5 shows a recommended typology for categorizing the degree of uncertainty for climate projections. It may also be applied in the narrative, describing outputs of the vulnerability and capacity analyses (based on a combination of data, modelling, theory and informed judgement) undertaken by the VCA team in collaboration with the advisory council and local participants.

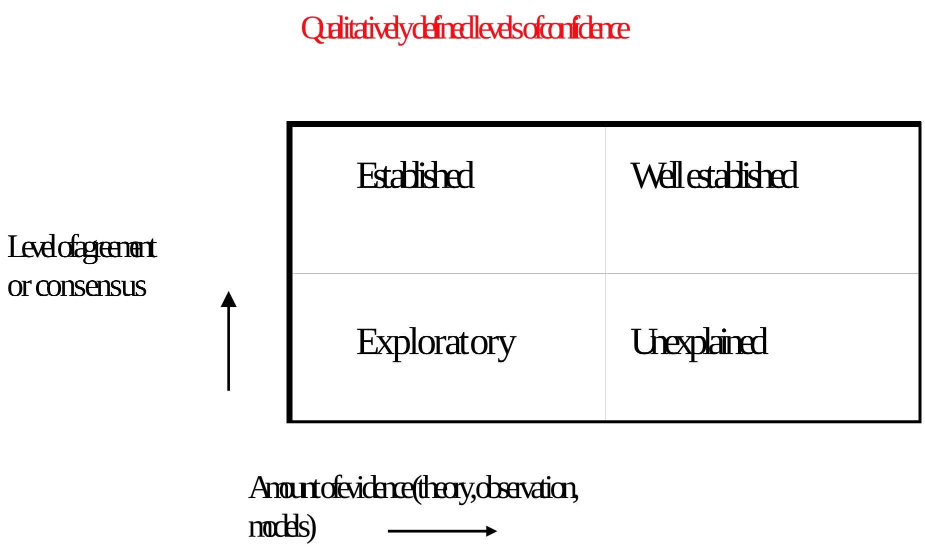


Figure 5: IPCC typology of uncertainty

Source: IPCC TAR, 2001

Consideration must be given to how the uncertainties are communicated for public awareness and for decision making. This is a widespread problem in the field of climate change especially in the compounding links between variability and change and the limited reliability of downscaled results for planning. The combined vulnerability and capacity approach reframes the question to be one of uncovering the drivers of national and local resilience in the context of risk management for adaptation without relying on the explicit precision of a particular model or projection.

9 DEVELOP NATIONAL AND COMMUNITY-LEVEL RISK PROFILES

A profile should answer the initial questions of who is at risk, from what, when, where and how (including capacity needed to cope)? The sensitivity and vulnerability assessments carried out in the Sections above lead to the development of a vulnerability and capacities profile using the indicators developed and assessed previously. The profile should have at a minimum the key vulnerabilities, community or national goals, socio-economic and climatic trends, conditioning factors, uncertainties, projections and alternatives for any unit of analysis and the communities affected therein. The information gathered is used to construct the following items:

- Maps, charts of variations and trends in indicators, and
- National, watershed, and community radar diagram for the different capitals (RACUE),

The decision/climate calendar described in Section 10 and the trend information developed should allow for the identification of key entry points for climate information in the decision making process and the construction of the vulnerability checklists and relevant sensitivity matrices.

The vulnerability checklist is constructed for each type of event and identifies the potential impacts of that event on all sectors. The checklist can help systematise what is already known about the event from past experience and how this and additional information can assist planners to anticipate problems that might arise in future events. The checklist should therefore be used for events of different severity to get an idea of the range of impacts that could occur.

The vulnerability checklist is then used to prepare sensitivity matrices and indicators (Table 6). The sensitivity matrices are developed to determine the level of impacts that would occur under events of different severity. For example, if there were a 10% increase in rainfall, what would be the level of impact on small farms compared to a 10% or 20% decrease in rainfall? The sensitivity matrices should be cross-impact for each sector: water, agriculture and tourism.

The sensitivity matrices are reviewed and revised with stakeholder input. The stakeholders ensure that the critical variables are included, provide credibility through their review and ensure usability for decision–making including timing, i.e. whether the indicators are useful for predicting impacts or whether they simply describe an event that is already happening.

Table 6: Sensitivity matrix

Vulnerable sector/ activity/ group	**Magnitude**	**Rates of change**	**Persistence and reversibility**	**Likelihood and confidence**	**Distribution**	**Potential for adaptation**
Economic sectors (Water, Ag, Tourism etc.); communities at risk; bounded ecosystems such as coastal, mountain that are already stressed.	State/situation of existing levels of vulnerability for different magnitudes of change, especially thresholds, relative to temperature, precipitation or the other critical parameters that create the vulnerability.	State any critical rates of change that affect vulnerability.	Provide information on the likelihood that the vulnerable sector will be affected by an irreversible impact and whether it is likely to persist.	Overall confidence and likelihood, but state confidence with any specific figures or points.	Provide information on the distribution of impacts – both physically and socially within countries (not in a simple developed/ developing dichotomy).	State capacity for adaptation. Is adaptive capacity sufficient to delay or prevent adverse impacts and at what cost?

Each of these dimensions would be conditioned with a statement based on the data and team judgments of the associated level of confidence (L= low confidence; M= medium confidence, H = high confidence).

The advisory council together with the VCA team should be able, at this stage, to identify priority areas and communities for adaptation measures. The types of places that should be prioritised are those that have high vulnerability to climatic hazards and where adverse climate-related outcomes are frequent. The types of adaptation measures that should be prioritised are those that reduce the risks in the short as well as the long term and offer immediate development benefits.

10 MAPPING DECISION MAKING PROCESSES II: ENTRY POINTS FOR MAINSTREAMING

The development of narratives or particularly illustrative stories from both technical and non-technical stakeholders for different options (as opposed to just those based on model scenarios), and gaming and “what if” exercises, are used to elicit decisions that would be made in light of trends, i.e. what types of outcomes would result? The construction of decision trees and simple rules based models of how those affected might respond to different scenarios and options can be used to develop criteria for ongoing effectiveness of adaptation and improvements in adaptive capacity.

A key activity within mainstreaming is to foster co-production of decision calendars with advisory groups from impacted communities. The decision calendar is used to identify information needs and the entry-points for climate information into current risk assessment and decision processes. The decision calendar can then be linked to the climate calendar for different sector activities. The question asked is ‘at what stage (or stages) does climate information influence the outcome of the planning process?’ What are the entry points for particular climate information inputs during decision making and panning? In Section 4 the existing disaster mitigation plans, ICZM plans, IWM plans and any early warning systems were assessed. The aim in developing the decision/climate calendar for each sector is to ensure that the information is mainstreamed into the planning for each sector and into these existing plans, at seasonally critical entry points. An example of a decision calendar is shown in Figure 6 for the management of reservoirs and/or groundwater. Similar calendars can be developed for agriculture, tourism etc. Box 4 provides further detail on how to prepare a decision/climate calendar. These have been constructed for various crops (sugar, rice) in different parts of the Caribbean.

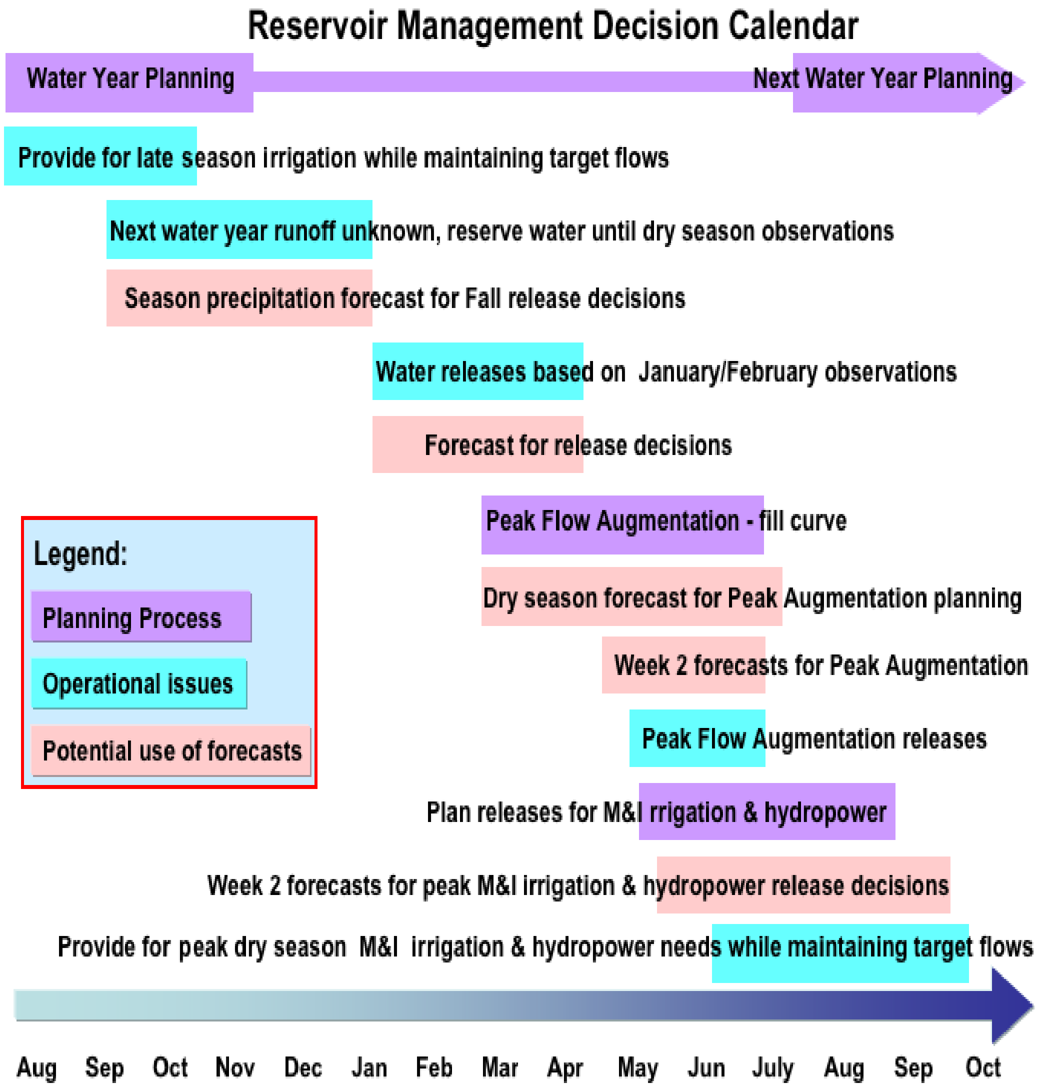


Figure 6: The decision calendar: Linking the decision-making and climate calendars.

Box 4. Construction of decision/climate calendar

Construct the calendar/annual cycle of decisions for different processes (planning, information gathering, forecasting, decision making, implementation, evaluation etc.) to identify entry points for relevant climatic information and competing pressures at different stages. Ask what activities, information, mechanisms are used during different seasons to reduce vulnerability (e.g. off tourist season employment in the fisheries sector, application of fertilizer at specific times for crops etc.)? What and where is existing climate/weather information obtained and used? Where are the risks? For example, will flooding affect timely shipping of the crop? Scale up the information (e.g. small holders, cash cropping, local and national markets) (Pulwarty et al, 2004).

Clearly document single historical events of significance and evaluate the context within which decision-making occurred, including lessons learned and incorporated. Adjustments and lessons accumulated over time (e.g. before, during and after major hurricanes or droughts and resulting mitigation put into place) provide insights into actions recommended by managers, forecasters and private sector investments for enhanced economic productivity.

Evaluate the decisions made within the context of longer-term climate variations such as decadal-scale wetter and drier periods. This includes evaluating the cumulative impacts of shorter multi-year variations. Key emphasis should be on analysis of the role of these antecedent decisions on constraining or enabling alternatives recommended during rapidly developing events and for longer-term strategic horizons (5, 10, 20 years).

As part of the assessment of the barriers to effective decision making it is important to clarify the fundamental features and the gaps in existing knowledge of climate relationships and whether present adaptive mechanisms functioning (e.g. marine reserves and parks, IWM, ICZM, coral reef management) are relevant to the problem at hand. These will include:

- The extent of institutional interactions, i.e. who works with/talks to whom as an authoritative source, where and how? (using the matrix of responsibilities and jurisdiction in Section 4.5);
- Characteristics of decisions and decision processes;
- Impediments to flows of knowledge between nodes in the decision process;
- Opportunities for and constraints to interactive learning and innovation; and
- The assessment of policies and practices that can give rise to failures of the component parts working as a system to turn capacity on paper to implementation.

11 EVALUATE SCENARIOS IN THE CONTEXT OF MAINSTREAMING

The various components (physical, social, economic, environmental) of the scenarios developed in previous Sections should be drawn together at this stage and evaluated by eliciting input from the stakeholder advisory council. The data gathered thus far essentially forms the baseline, or the situation that will exist in the future taking into account population growth etc, but assuming no policy interventions to reduce vulnerability. The baseline therefore provides a reference for assessing the future under new interventions. The panel can determine what policies could be implemented and use the scenarios to assess what impact those policies may have. Alternatively the Council could determine where they want to end up and work backwards to see what policies are needed to get there. The economic impacts of the different paths should be considered as well as the uncertainties of future environmental conditions and societal driving forces. One aspect of development that can not be predicted is the invention of new technologies that may address certain issues and significantly affect the suggested outcome. The panel should assess the various scenarios for plausibility, likely development of the scenarios and management of the scenario information (archiving and opportunities for updating as physical, environmental and social situations change into the future). Based on this discussion final scenarios are selected for wider stakeholder dialogue. The narrative used for the scenarios should take the form of critical issues, community or national goals, trends, physical, social and institutional factors that condition or are responsible for the observed trends, projections and alternatives.

The existing knowledge, identified uncertainties and knowledge gaps must be developed into a framework for incorporation into existing or planned IWRM, ICZM and IWCAM programs. By working with the stakeholders one is defining the pathways for implementation that will work in the given situation. Appendices available from the CCCCC provide an example of how watershed management can be used as a tool to integrate vulnerability assessments with the management of water and coastal resources through a framework that incorporates multi-sectoral planning and management.

For the final selected scenarios, policy or gaming exercises may be carried out among key stakeholders using key entry points in their decision calendars and criteria for information relevance. These exercises take the form of “what if?” experiments and questions being posed to the advisory groups based on the vulnerability analyses conducted earlier: What if X happens? How might we respond individually, institutionally, and in an integrated way? etc.

The development of scenarios is an iterative process and in an integrated assessment should involve relevant stakeholders at key stages. The stakeholder discussions should lead to a preliminary range of adaptations that are then considered further to identify the potential barriers to adaptation and opportunities for effective decision-making. It is possible to identify small adaptation steps that carry the VCA towards a long-term goal, but which allow for new knowledge to be incorporated as it becomes available (or for mistakes to be reversed). Where there are major uncertainties, natural buffers such as reserves and protected areas, provide flexibility in the system. For example coral reefs and mangroves can be enhanced and protected to help mitigate against any ‘surprises’.

12 DEVELOP FINAL REPORT

The final step is to prepare the report on the VCA process for each unit of analysis (sector, community, watershed etc) and include all the findings. The suggested contents are:

- Objectives of the joint vulnerability and capacity analysis;
- Data sources and variables;
- Partners and stakeholders: characteristics and problem framing;
- Conceptual model;
- Methodology (selection of indicators, including rationale, data preparation, clustering, and analyses);
- Results (baseline and current vulnerability, system thresholds, buffers, analysis of risk and coping, risk perception, capacity, area profiles, preparedness and decision making);
- Interpretation and application of results and discussion of linkages to programming and targeting; barriers and opportunities to mainstreaming adaptation (indicators, sensitivity matrices, plausible responses);
- Future directions;
- Tables and maps (at end or embedded in text).
-

The VCA should, drawing on the disasters and adaptive management experience, identify several initiatives that would contribute to the long-term goal of reducing the impacts of climate change (Comfort et al, 1999). These contribute to and inform:

- *A coordinated effort to improve the assessment of risk in a geographic place-based approach to vulnerable regions.* Among other advantages such systems make it possible to secure accurate, timely measures of environmental degradation or renewal that are connected with social, economic, political or technical changes in monitored regions.

- *Multi-way information exchange systems*. These increase the capacity of communities to engage in coordinated actions by making available and sharing timely, accurate information about risk. Such systems lead toward 'self organization' of disaster management.

- *Informed action at the local level*. Local initiatives to reduce vulnerability and increase community participation may be facilitated by training, capacity building and resource transfers. These kinds of efforts may require outside support and can be sustained through a network of organizations engaged in economic, social, political and scientific action and inter-organisational learning at regional and national levels.

- *Maps of the decision processes for disaster mitigation, preparedness, response and recovery,* co-produced with assessors and stakeholders.

- *Empowerment of affected populations*. People who face hazards should be assisted to manage their own environments more responsibly and equitably over the long term by joining in a global structure that supports informed, responsible, systematic actions to improve local conditions in vulnerable regions. The hurricane experience validates the notion of socially constructed disasters.

Risk reduction and hazard mitigation strategies must address the underlying practices that contribute to vulnerability. If they do not, our current response and reconstruction policies are likely to perpetuate the very disasters that we seek to avoid.

Embedded within all of these are scale considerations: international, regional, national, local. Who are the actors at the different scales? What are their perspectives and needs? What are the entry points for decision-making?

An important component of any type of assessment is ensuring that the assessments are ongoing in a changing social and environmental climate (i.e. that it continues after the final report has been prepared). By outlining the future directions and establishing that the VCA assessors themselves become a decision support resource (part of the national and local capacity), the council can continue to provide the leadership needed to ensure that learning and informed adaptation continues in the co-evolution of climate and development decisions. However, monitoring progress and evaluating the response to the assessment is highly beneficial in identifying where the assessment needs refining. As mentioned before, an adaptive process such as this must incorporate new information as it becomes available and therefore the database and the risk maps prepared early in the project should continually be updated. The scenarios can then be adjusted to provide continuous, updated information to guide decision makers at all levels.

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14 APPENDIX: LIST OF MACC VCA PILOT PROJECTS

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