Updated Sourcebook on the Integration of Natural Hazards into the Environmental Impact Assessment Process

Caribbean Development Bank

Incorporating Disaster and Climate Risk Reduction into the Project Cycle
2015

Cover picture credits

Clockwise from top left:

Strewn: Rocky debris surrounds this settlement in Dominica after Erika vented its fury on Thursda Daily Mail 2015. Florida declares state of emergency over Tropical Storm Erika as death toll in Caribbean hits 20, Published 28 August 2015 by Associated Newspapers Ltd, Part of the Daily Mail, The Mail on Sunday & Metro Media Group. Downloaded from more: http://www.dailymail.co.uk/news/article-3214175/Tropical-Storm-Erika-lashes-Caribbean-islands-heads-Florida.html

Masters, J., 2010. Deadly late-season Atlantic hurricanes growing more frequent, posted November 17, 2010 on The Weather Channel, LLC. Downloaded from http://www.wunderground.com/blog/JeffMasters/deadly-lateseason-atlantic-hurricanes-growing-more-frequent

MichaelJay, 2010. St. Lucia Hurricane Tomas Relief, posted November 3, 2010 on DeepDish, Philosophical gossip. Food for thought. Downloaded from http://philosophicalgossip.blogspot.com/2010/11/st-lucia-hurricane-tomas-relief.html on November 12, 2015.

Daily Mail, 2015. "Dominica's Douglas-Charles airport is pictured above covered in debris. It is too badly damaged for planes use. The island's other airport is also closed" in Florida declares state of emergency over Tropical Storm Erika as death toll in Caribbean hits 20. Published 28 August 2015 by Associated Newspapers Ltd, Part of the Daily Mail, The Mail on Sunday & Metro Media Group. Downloaded from more: http://www.dailymail.co.uk/news/article-3214175/Tropical-Storm-Erika-lashes-Caribbean-islands-heads-Florida.html

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Preface

This document is an update of the *Sourcebook on the Integration of Natural Hazards into the Environmental Impact Assessment Process,* hereinafter referred to as the Sourcebook (2004). The Sourcebook (2004) was developed as a collaborative effort between the Caribbean Development Bank (CDB) through its Disaster Mitigation Facility for the Caribbean (DMFC) and the Caribbean Community (CARICOM) Adapting to Climate Change in the Caribbean (ACCC) Project and published in 2004 by the Caribbean Development Bank. The expected outcome of the update, according to the contract terms of reference, is improved capacity within BMCs to assess and manage risks associated with natural hazards and climate variability and change in their project appraisal and supervision processes. The updated Sourcebook is required to reflect the many changes that have taken place since its original publication, to ensure its continued relevance for use by the Region's development practitioners, presented in an interactive electronic format to facilitate wider dissemination.

The overall goal of the CDB, according to the CDB Disaster Management Strategy and Operational Guidelines (2009), is to contribute to sustainable development and poverty reduction in the BMCs by reducing the burdens caused by disasters due to natural hazards and climate change through effective DRM. CDB's Climate Resilience Strategy (2012) seeks to contribute to the sustainable development and poverty reduction efforts of BMCs through the implementation of a transformative climate resilient policy and investment financing strategy for BMCs. Updating the Sourcebook is particularly consonant with the CDB strategic theme to support BMC efforts to reduce risks related to natural disasters and climate change.

The original Sourcebook (2004) provided details of the EIA process in each of CDB's BMCs. This information is not repeated in this edition, as the process is similar in all the countries, and EIA requirements in the countries have not changed since the original publication. It is assumed that updated Sourcebook users are familiar with the EIA requirements in their countries.

This updated Sourcebook provides new information, particularly in relation to climate change impacts. The Sourcebook (2015) recognizes that information relating to disasters and climate impacts is continually changing at the international, regional and national levels, and an effort is made to provide users with guidance to support their continued access to current information over time. It is further recognized that project design lives typically exceed 20 years, and notwithstanding the uncertainties that still surround the quantification of climate change impacts today, it is important to plan for incorporation of appropriate climate change adaptation measures in new development design and implementation.

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Glossary

Acceptable risk The level of potential losses that a society or community considers acceptable given existing social, economic, political, cultural, technical and environmental conditions (UNISDR, 2009).

Adaptation The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (UNISDR, 2009). In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2014).

Building code A set of ordinances or regulations and associated standards intended to control aspects of the design, construction, materials, alteration and occupancy of structures that are necessary to ensure human safety and welfare, including resistance to collapse and damage (UNISDR, 2009).

Capacity The combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals (UNISDR, 2009).

Climate change Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes (IPCC, 2014).

Climate Extreme (extreme weather or climate event) The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes.' The full definition is provided in Section 3.1.2 of the SREX report (Development Knowledge Network, 2012).

Climate Variability Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (IPCC, 2007).

Coping capacity The ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters (UNISDR, 2009).

Critical facilities The primary physical structures, technical facilities and systems which are socially, economically or operationally essential to the functioning of a society or community, both in routine circumstances and in the extreme circumstances of an emergency (UNISDR, 2009).

Disaster A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources (UNISDR, 2009).

Disaster risk The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period (UNISDR, 2009).

Disaster risk management The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster (UNISDR, 2009).

Disaster risk reduction The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to 11 hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events (UNISDR, 2009).

Drought The naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems (United Nations Convention to Combat Desertification in CDB, 2009)

Earthquake The sudden release of slowly accumulated energy along tectonic plates that make up the earth's crust. They represent a particularly severe threat due to the irregular intervals between events, the lack of adequate predictive models, and the associated hazards which include: ground shaking; vertical or horizontal fault movements; landslides, and liquefaction (amplification of ground shaking in areas of unconsolidated materials and high water tables in CDB, 2009).

Exposure The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected (Development Knowledge Network, 2012).

Flood A rise, usually brief, in the water level in a stream to a peak from which the water level recedes at a slower rate (International Glossary of Hydrology in CDB, 2009).

Flooding Overflowing by water of the normal confines of a stream or other body of water, or accumulation of water by drainage over areas which are not normally submerged (International Glossary of Hydrology in CDB, 2009).

Global Warming Increase in the average temperature of the Earth's near-surface air and the oceans since the mid-twentieth century and its projected continuation (CDB, 2009).

Hurricane A rotating, intense low pressure system, which forms over tropical oceans with maximum surface wind speeds that exceed 74 mph (119 km/h) (CDB, 2009).

Environmental degradation The reduction of the capacity of the environment to meet social and ecological objectives and needs (UNISDR, 2009).

Environmental impact assessment Process by which the environmental consequences of a proposed project or programme are evaluated, undertaken as an integral part of planning and decision making processes with a view to limiting or reducing the adverse impacts of the project or programme (UNISDR, 2009).

Exposure The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2014).

Geological hazard Geological process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR, 2009).

Greenhouse gases Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds (UNISDR, 2009).

Hazard A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR, 2009).

Hydrometeorological hazard Process or phenomenon of atmospheric, hydrological or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR, 2009).

Impacts Effects on natural and human systems. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as *consequences* and *outcomes*. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts (IPCC, 2014).

Land-use planning The process undertaken by public authorities to identify, evaluate and decide on different options for the use of land, including consideration of long term economic, social and environmental objectives and the implications for different communities and interest groups, and the subsequent formulation and promulgation of plans that describe the permitted or acceptable uses (UNISDR, 2009).

Landslide A general term covering a wide variety of landforms and processes involving the movement of earth, rock and debris down slope under the influence of gravity (CDB, 2009).

Mainstreaming The process of analyzing how a particular process impacts on all sectors, now and in the future, both internally and externally, to determine how each sector should respond based on its comparative advantage (CDB, 2009).

Mitigation The lessening or limitation of the adverse impacts of hazards and related disasters.

Comment: The adverse impacts of hazards often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures encompass engineering techniques and hazard-resistant construction as well as improved environmental policies and public awareness. It should be noted that in climate change policy, "mitigation" is defined differently, being the term used for the reduction of greenhouse gas emissions that are the source of climate change (UNISDR, 2009). In this Sourcebook, mitigation refers to environmental impact or hazard mitigation, unless it expressly refers to climate change mitigation (UNISDR, 2009).

Natural hazard Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR, 2009).

Natural Hazard Impact Assessment A study undertaken to identify, predict and evaluate natural hazard impacts (from existing hazards as well as those which may result from the project) associated with a new development or the extension of an existing facility. This is achieved through an assessment of the natural hazards that are likely to affect or result from the project and an assessment of the project's vulnerability and risk of loss from hazards. An NHIA is an integral component of and extension to the environmental review process and environmental impact assessment in that it encourages explicit consideration and mitigation of natural hazard risk (CDB, 2004).

Prevention The outright avoidance of adverse impacts of hazards and related disasters (UNISDR, 2009).

Residual risk The risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained (UNISDR, 2009).

Resilience (1)The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation (IPCC, 2014).

Resilience (2) The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions (UNISDR, 2009).

Retrofitting Reinforcement or upgrading of existing structures to become more resistant and resilient to the damaging effects of hazards (UNISDR, 2009).

Risk (1) The combination of the probability of an event and its negative consequences (UNISDR, 2009).

Risk (2) The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard (IPCC, 2014).

Risk assessment A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend (UNISDR, 2009).

Risk management The systematic approach and practice of managing uncertainty to minimize potential harm and loss (UNISDR, 2009).

Risk transfer The process of formally or informally shifting the financial consequences of particular risks from one party to another whereby a household, community, enterprise or state authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party (UNISDR, 2009).

Storm Surge An above normal rise in water level on the open coast due to atmospheric pressure reduction as well as wind stress (CDB, 2009).

Structural and non-structural measures

> **Structural measures:** Any physical construction to reduce or avoid possible impacts of hazards, or application of engineering techniques to achieve hazard resistance and resilience in structures or systems;
>
> **Non-structural measures:** Any measure not involving physical construction that uses knowledge, practice or agreement to reduce risks and impacts, in particular through policies and laws, public awareness raising, training and education (UNISDR, 2009).

Sustainable development Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (UNISDR, 2009).

Transformation The altering of fundamental attributes of a system (including value systems; regulatory, legislative, or bureaucratic regimes; financial institutions; and technological or biological systems) (Development Knowledge Network, 2012).

Tropical Depression An organised low pressure system forming in tropical latitudes with sustained wind speeds of between 23-37 mph (37-60 km/h) (CDB, 2009).

Tropical Storm An organised low pressure system forming in tropical latitudes with sustained wind speeds of between 38-73 mph (38-73 km/h) (CDB, 2009).

Tsunami An ocean wave or series of waves caused by an abrupt disturbance of the ocean floor that displaces a large volume of water. They can be caused by earthquakes, volcanic activity, or undersea landslides. Volcanic eruption refers to openings in the earth's crust through which molten rock and gases escape to the surface (CDB, 2009).

Volcanic hazards These stem from two classes of eruptions: explosive eruptions in which the rapid dissolution and expansion of gases from the molten rock takes place as it nears the surface; and, effusive eruptions where lava flows are the major hazard (CDB, 2009).

Vulnerability (1) The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014).

Vulnerability (2) The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (UNISDR, 2009).

Acronyms

ACCC	Adapting to Climate Change in the Caribbean Project
BVI	British Virgin Islands
CANARI	Caribbean Natural Resources Institute
CARDI	Caribbean Agricultural Research & Development Institute
CARPHA	Caribbean Public Health Agency
CBD	Convention on Biological Diversity
CCCCC	Caribbean Community Climate Change Centre
CDB	Caribbean Development Bank
CDEMA	Caribbean Disaster Emergency Management Agency
CDKN	Climate and Development Knowledge Network
CDM	Comprehensive Disaster Management
CEA	Cumulative Effects Assessment
CEHI	Caribbean Environmental Health Institute (now Caribbean Public Health Agency, CARPHA)
CERMES	Centre for Resource Management and Environmental Studies, Cavehill
CGCED	Caribbean Group for Cooperation in Economic Development
CIMH	Caribbean Institute for Meteorology and Hydrology
CSGM	Climate Studies Group, Mona
DDM	Dept of Disaster Management (BVI)
DMFC	Disaster Mitigation Facility for the Caribbean
DRM	Disaster Risk Management
EA	Environmental Assessment
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
ENSO	El Nino/La Nina Southern Oscillation
GCM	General Circulation Model
GFDRR	Global Facility for disaster reduction and Recovery
HFA	Hyogo Framework for Action
IDNDR	International Decade for Natural Disaster Reduction
IICA	Inter-American Institute for Cooperation on Agriculture
INSMET	Institute of Meteorology (Cuba)
IPCC	Inter-Governmental Panel on Climate Change
NHIA	Natural Hazard Impact Assessment
OAS	Organisation of American States
OECD	Organisation for Economic Cooperation and Development
RCM	Regional Climate Model
SLR	Sea Level Rise
SRC	Seismic Research Centre, St. Augustine
SRES	Special Report on Emission Scenarios
UNEP	United Nations Environment Programme
UNISDR	United Nations Secretariat of the International Strategy for Disaster Reduction
UNFCCC	United Nations Framework Convention on Climate Change
UWI	University of the West Indies
V&A	Vulnerability and Adaptation
VEC	Valued Ecosystem Component
WDR	World Development Report

Section 1 Introduction

1.0 Background

The Caribbean region is subject to a broad range of potentially hazardous natural phenomena such as hurricanes and tropical storms, earthquakes, volcanic eruptions, landslides, flooding, tsunamis, drought and bush fires. These have formed and continue to shape the region, impacting livelihoods and social, economic and physical infrastructure, resulting in physical damage, economic loss, dislocation and/or loss of life. Over the period 1990-2008, the Caribbean experienced 165 natural disasters. The total impact (damage and losses) for this period was estimated to be US$ 136 billion, with the economic impact being the highest at US$ 63 billion (46%) (Association of Caribbean States, 2012).

As economies and populations grow across the region, new developments can either exacerbate existing hazardous conditions and vulnerability, or they can contribute to the reduction of overall hazard risk. The purpose of this updated Sourcebook is to improve the incorporation of hazard impacts (including climate variability and climate change) into the Environmental Impact Assessment[1] (EIA) process, resulting in developments designed to limit or reduce vulnerability to natural hazards. Application of the guidance contained in this updated Sourcebook will support identification of natural hazards and climate change phenomena that are likely to affect a project, and an assessment of the project's vulnerability to and risk of loss from, natural hazards and climate change. It encourages explicit consideration and mitigation of natural hazard risks, to minimise the hazard risks associated with development projects.

1.1 Sourcebook Target Audience

It is expected that the updated sourcebook will be used primarily by EIA practitioners responsible for undertaking EIA and EIA appraisers who are required to screen, scope and review the EIAs, resulting in completion of EIAs with recommendations for impact (including of hazards) mitigation and climate change adaptation that better inform design and implementation of programmes and projects.

A wide variety of development impacts are possible across a variety of sectors and environments, depending on the type of development proposed and the characteristics of the development site(s). Conduct of EIA is therefore an inherently multi- disciplinary process, requiring a team with a broad range of knowledge and experience, potentially including expertise in disciplines such as air and water quality, terrestrial and marine ecologies, coastal management and waste management. Full incorporation of natural hazard and climate risk considerations into the EIA process will often require the addition of natural hazard and climate change expertise to the NHIA-EIA team.

1.1.1 Structure of the sourcebook

It is assumed that users of the Sourcebook are already familiar with the EIA process in their countries and/or the region. The Sourcebook therefore identifies the stages in the EIA process at which NHIA is to be integrated, and provides guidance as to how this should be done.

This Sourcebook presents a generic approach to the integration of NHIA into EIA, which can be adapted to existing EIA processes applied in the region. An effort is made to clearly identify, for each step of the NHIA-EIA process, the responsibilities of those who prepare and review EIAs.

The Sourcebook is intended to be a compilation of current and appropriate mechanisms for assessing, within EIA, the potential interaction between a proposed project and natural hazards. The main body of the Sourcebook is divided into three sections:

- Section 1 provides the rationale for, and an overview of the NHIA-EIA process, and brief descriptions of the prevalent natural hazards in the Caribbean.
- Section 2 presents a generic EIA process and identifies how natural hazard risk considerations should be

[1] EIA and EA are used interchangeably in the literature. Except where information excerpted from a reference uses different terminology, EIA will be used in this Sourcebook as this is the terminology used by CDB.

addressed at each stage of the generic process.

- Section 3 discusses cumulative impacts from multiple natural hazards or from inter-hazard exacerbations.

1.2 Rationale for incorporating natural hazards into the EIA process

The EIA process is accepted and applied across the Caribbean. The United Nations Environment Programme (UNEP, date unknown)) defines environmental impact assessment (EIA) as “a tool used to identify the environmental, social and economic impacts of a project prior to decision making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers. By using EIA both environmental and economic benefits can be achieved, such as reduced cost and time of project implementation and design, avoided treatment/clean-up costs and impacts of laws and regulations”. The CDB requires environmental and social impact assessment to evaluate a project’s potential environmental and social risks and impacts in its area of influence and identify ways of improving project design and implementation by preventing, minimising, mitigating and compensating for adverse environmental impacts and enhancing positive impacts (CDB, 2008).

Natural hazards are environmental phenomena that potentially damage and disrupt projects, and can jeopardise their success. In a hazard-prone region such as the Caribbean, it is essential that environmental assessments cover natural hazards and related risks, and that the interactions between the proposed project and natural hazards are explicitly investigated. In a number of Caribbean countries, this is still not routinely done although full incorporation of natural hazards assessment into the EIA process requires only relatively minor adjustments to existing EIA procedures.

The EIA phase of a project appraisal process is the appropriate place to collate data on the types, magnitudes and probability of occurrence of natural hazards in the project area, to inform other required appraisals and engineering design. The potential disaster–related consequences of proposed projects must be examined and taken into account in project design. A project may increase risk exposure to certain hazards, or it may result in potential risk reduction benefits that support improved environmental management. All of these possibilities should be considered in the EIA process.

CDB defines Natural Hazard Impact Assessment (NHIA) as “a study undertaken to identify, predict and evaluate natural hazard impacts associated with a new development or the extension of an existing facility (from existing hazards as well as those which may result from the project). This is achieved through an assessment of the natural hazards that are likely to affect or result from the project and an assessment of the project’s vulnerability and risk of loss from hazards. An NHIA is an integral component of and extension to the environmental review process and environmental impact assessment in that it encourages explicit consideration and mitigation of natural hazard risk” (cited in Sourcebook, 2004).

The state of the environment is a major factor that determines vulnerability to natural hazards. Environmental degradation (often a result of inadequate planning, unsustainable land use practices and weak institutional frameworks), is well-recognized as both a cause and an outcome of natural disasters (CDB, 2009). For example, drought and flood impacts are exacerbated in watersheds degraded by deforestation and other human activity that have resulted in increased riverbed sedimentation. Degradation of mangroves, reefs and sea grass beds increases coastal exposure to storm surge. Climate change is expected to increase the frequency and/or intensity of climatological hazards (Provention Consortium in collaboration with CDB, 2007), posing a growing threat to the development strategies of Caribbean countries by destroying infrastructure and productive capacity, interrupting social and economic activity, and creating irreversible changes in the natural resource base (CDB, 2009).

1.3 Overview of prevalent natural hazards in the Caribbean

The Caribbean is vulnerable to a wide range of natural hazards. These include:

Atmospheric and hydro-meteorological hazards

- Flooding
- Tropical storms and hurricanes
- Tsunamis
- Drought

Geological hazards

- Earthquakes
- Volcanoes
- Landslides

Other hazards

- Bushfires

The following sections describe these hazards in some detail[2]. All of the atmospheric and hydro-meteorological hazards (with the exception of tsunamis) and bushfires are exacerbated by climate change. More climate change information is provided in Section 1.5. Box 1.1 is excerpted from World Bank News (2012), and examines some of the natural disaster impacts in the region.

Box 1.1. Typical Impact of Natural Disaster in the Caribbean

"When Hurricane Ivan swept through Grenada in September 2004, devastation was widespread: damages were equivalent to 200% of the country's GDP, 9 out of 10 buildings were affected, and 39 people were killed. More recently, in October 2010, 1,200 persons were displaced after Hurricane Tomas lashed Saint Vincent and the Grenadines………. In the Eastern Caribbean, disasters account, on average, for almost 20% of the variation of real GDP growth every year. And, as demonstrated by Hurricane Ivan, when one country is devastated by an event such as a hurricane or drought, it directly affects the regional economy….... "One of the greatest challenges for the region is to finance the many investments needed to correct decades of maladaptation and better prepare for future changes in the climate," says Niels Holm-Nielsen, Disaster Risk Management Regional Coordinator for Latin America and the Caribbean at the World Bank" (World Bank News, 2012).

1.3.1 Atmospheric and hydro-meteorological hazards

1.3.1.1 Flooding

Two types of flooding can be distinguished:

1. land-borne floods, or river flooding, caused by excessive run-off brought on by heavy rains, and
2. sea-borne floods, or coastal flooding, caused by storm surges, often exacerbated by storm run-off from the upper watershed. Tsunamis are a special type of sea-borne flood.

Coastal flooding

Storm surges are an abnormal rise in sea water level associated with hurricanes and other storms at sea. Surges result from strong on-shore winds and/or intense low pressure cells and ocean storms. Water level is controlled by wind, atmospheric pressure, existing astronomical tide, waves and swell, local coastal topography and bathymetry,and the storm's proximity to the coast.

Most often, destruction by storm surge is attributable to:

[2] The content of Sections 1.3.1 and 1.3.2 are excerpted from the Organisation of American States' Primer on Natural Hazard Management in Integrated Regional Development Planning (1991), except for the section on drought.

1. Wave impact and the physical shock on objects associated with the passing of the wave front.
2. Hydrostatic/dynamic forces and the effects of water lifting and carrying objects.

The most significant damage often results from the direct impact of waves on fixed structures. Indirect impacts include flooding and undermining of major infrastructure such as highways and railroads.

Flooding of deltas and other low-lying coastal areas is exacerbated by the influence of tidal action, storm waves, and frequent channel shifts.

Photos 1.1 through 1.4 show some examples of storm surge and its impacts in the Caribbean. Much of the Caribbean's development is on its coastlines, making it highly vulnerable to this hazard.

Photo 1.1. Tidal surge during the passage of Hurricane Omar in Aruba in 2008
(Source: Pedro Famous Diaz/Associated Press in CDB News World http://www.cbc.ca/news/world/omar-weakens-into-a-tropical-storm-1.719029)

Photo 1.2. Impact of storm surge during Hurricane Ivan in Grenada in 2004
(Source: mff.livejournal.com)

Photo 1.3. Sea swells in Saint Lucia during Hurricane Omar in 2008
(Source: https://sites.google.com/site/jenniferleshnower/october%7C%2708)

Photo 1.4. Hurricane Omar in Bonaire in 2008
(Source: daisyatsea.blogspot.com)

River flooding

Land-borne floods occur when the capacity of stream channels to conduct water is exceeded and water overflows banks. Floods are natural phenomena, and may be expected to occur at irregular intervals on all stream and rivers. Settlement of floodplain areas, a very common occurrence in the Caribbean, is a major cause of flood damage. See some examples of flood impacts in Photos 1.5 through 1.10.

1.3.1.2 Tropical storms and hurricanes

Hurricanes are tropical depressions which develop into severe storms characterized by winds directed inward in a spiraling pattern toward the center. They are generated over warm ocean water at low latitudes and are particularly dangerous due to their destructive potential, large zone of influence, spontaneous generation, and erratic movement. Phenomena which are associated with hurricanes are:

Photo 1.5. Impact of flooding during Hurricane Tomas, Saint Lucia, 2010
(Source: Operation Blessing International
http://www.ob.org/bringing-relief-to-hurricane-ravaged-st-lucia/)

Photo 1.6. Massive quantities of sediment transported by flood waters in Saint Lucia, Hurricane Tomas, 2010
(Source: Olga Morales, http://www1.american.edu/ted/ice/saint-lucia.htm)

Photo 1.7. Highway breached by ravine after culvert failed, Saint Lucia, Hurricane Tomas, 2014
(Source:
http://www.wunderground.com/blog/JeffMasters/archive.html?year=2011&month=03)

Photo 1.8. Banana crop damage, Saint Lucia, Hurricane Tomas, 2014
(Source: Eurofruit
http://www.fruitnet.com/eurofruit/article/8778/st-lucia-sees-banana-industry-wiped-out)

Photo 1.9. Coastal bridge abutments washed away, Dominica, Tropical Storm Erika, 2015
(Source: www.caribbean360.com http://www.caribbean360.com/news/help-on-the-way-for-dominica-after-tropical-storm-erika-leaves-four-dead-others-missing-and-island-devastated)

Photo 1.10. Bridge blocked by debris, Dominica, Tropical Storm Erika, 2015
(Source: Orlando Sentinel
http://www.orlandosentinel.com/weather/hurricane/os-raw-tropical-storm-erika-pummels-dominica-20150828-embeddedvideo.html)

- Winds exceeding 64 knots (74 mi/hr or 119 km/hr), the definition of hurricane force. Damage results from the wind's direct impact on fixed structures and from wind-borne objects.
- Heavy rainfall which commonly precedes and follows hurricanes for up to several days. The quantity of

rainfall is dependent on the amount of moisture in the air, the speed of the hurricane's movement, and its size. On land, heavy rainfall can saturate soils and cause flooding because of excess runoff (land-borne flooding); it can cause landslides because of added weight and lubrication of surface material; and/or it can damage crops by weakening support for the roots.

- Storm surge (explained in the previous section), which, especially when combined with high tides, can easily flood low-lying areas that are not protected.

1.3.1.3 Tsunamis

Tsunamis are long-period waves generated by disturbances such as earthquakes, volcanic activity, and under-sea landslides. The crests of these waves can exceed heights of 25 meters on reaching shallow water. The unique characteristics of tsunamis (wave lengths commonly exceeding 100 km, deep-ocean velocities of up to 700 km/hour, and small crest heights in deep water) make their detection and monitoring difficult. Characteristics of coastal flooding caused by tsunamis are the same as those of storm surges.

The most likely events to trigger tsunamis in the region are an earthquake along the Puerto Rico Trench (see Box 1.3) or an eruption of the Kick'em Jenny volcano (see Box 1.3).

Box 1.2. New study warns of significant tsunami risk in Caribbean[3]

BRIDGETOWN, Barbados (CMC) — The global catastrophe risk management firm, RMS, has released a global tsunami risk study that identifies more than 20 subduction zones worldwide, including some in the Caribbean, capable of generating a giant earthquake and tsunami. According to the study, a number of coastal populations, industrial clusters, ports and vacation resorts are at risk from this underestimated tsunami threat. To conduct the study, RMS said it examined all subduction zones worldwide capable of producing magnitude 9.0 earthquakes, including those considered dormant or inactive.

"While the Cyprus Arc subduction zone and Puerto Rico Trench, among others, are dormant, RMS analysis reveals they are capable of generating tsunami waves similar in scale to those produced along the Japan Trench in 2011, and with it unprecedented devastation," said Dr Robert Muir-Wood, chief research officer at RMS.

"Future mega-tsunamis should no longer be considered black swan events, as we now know where these events can occur," he added. "While these events have very low occurrence rates, communities and businesses on the coastlines at frontline risk of these events should assess the risk accordingly."

The study shows a tsunami generated on the Puerto Rico Trench could inundate popular tourist resorts in the Dominican Republic and in the British and US Virgin Islands with waves up to nine metres. The same tsunami could also flood coastlines along western and northern Puerto Rico, including areas of San Juan. "Many people are completely unaware they live in direct range of a potentially catastrophic tsunami," said Muir-Wood. "As we saw four years ago with the Tohoku event (in Japan), mega-tsunami events can devastate local communities and have far-reaching impacts on global supply chains."

Box 1.3. Kick'em Jenny volcano July 2015 eruption alert and updates and implications for tsunami generation[4]

BRIDGETOWN, Barbados, July 23, 2015 (AMG) — The Seismic Research Centre (SRC) of the University of the West Indies (UWI) has issued an orange alert for the underwater volcano Kick'em Jenny, after strong and sustained signals were recorded in the early hours of this morning, suggesting than an eruption could occur with less than 24-hours' notice. Instruments monitoring the volcano, located 8 km north of Grenada, recorded strong, continuous activity between 1:25 a.m. and 3.a.m this morning. In a media statement issued today, the SRC said that signs of elevated seismic activity began on July 11, and have continued since then. "For the period since July 11, a total of more than 200 micro and small earthquakes, of varying magnitudes, have been recorded, with the largest, prior to the strong signal, less than magnitude 3.0," the SRC reported. "This activity is being closely monitored by the UWI-SRC and further updates will be issued as more information becomes available," the statement continued.
Also speaking to the media today, Director of the Coastal Zone Management Unit in Barbados, Dr. Lorna Innis, reassured residents of the island that the probability of a tsunami following the possible eruption of Kick'em Jenny was low – but not non-existent. Said Dr. Innis, the chances of a tsunami generation from an underwater volcano increased the closer the volcano's dome was to the surface of the water, unlike Kick'em Jenny, which is believed to be located at a depth of 268 m under water.
"An eruption [of Kick 'em Jenny] can cause a tsunami, but we are dealing with possibilities. The dome of the volcano is in

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[3] Jamaica Observer, 2015. News Mar 13, 2015: New study warns of significant tsunami risk in Caribbean. Downloaded from http://www.jamaicaobserver.com/news/New-study-warns-of-significant-tsunami-risk-in-Caribbean_18558412 on November 28, 2015.

[4] Antillean Media Group, 2015. Experts warn of possible imminent eruption of Kick'em Jenny volcano. In: Environment and sustainability. Downloaded from http://www.antillean.org/kick-em-jenny-eruption-246/ on November 28, 2015.

extremely deep water at this stage. As the dome grows… and it grows extremely slowly over decades and centuries… it moves closer to the surface of the water, and the greater the probability that when it erupts you will have a tsunami. At this point in time it is rather low as it is in extremely deep water and therefore the possibility of a tsunami is low," she stated.

At the orange alert level, the SRC recommends that the governments of Grenada, St. Vincent, Barbados and Trinidad & Tobago should advise residents of evacuation routes, and put transportation on standby to facilitate evacuation in the event of a tsunami. Shipping vessels should stay 1.5 km from the summit of Kick'em Jenny, and non-essential shipping, such as pleasure craft, should not enter within 5 km of the volcano's summit. An eruption, or increased activity around Kick'em Jenny, is particularly dangerous for marine vessels, since the gases released from the volcano can lower water density and can cause ships to sink. Kick'em Jenny last erupted on December 4, 2001 – the time of the last orange alert issue – and it has erupted twelve times since 1939.

Authorities in Barbados have reiterated that no tsunami watches or warnings have been issued, and they continue to urge calm in light of today's announcement. Similarly, in Grenada and Trinidad & Tobago, authorities there have been advised that there was no need to move residents from coastal areas.

Update (July 24, 2015 @ 2302 hrs): The orange alert status remains in effect for Kick'em Jenny, and seismic activity around the volcano has continued, with the SRC confirming that there was a second, small eruption of the volcano just after midnight on July 24. UWI SRC has however reiterated that the chance of a tsunami being generated by an eruption of the volcano was low, and that the more-immediate concern was the impact of the volcanic activity on shipping. SRC therefore continues to urge marine vessels to observe the exclusion zones. "From time to time, Kick 'em Jenny has periods of increased seismicity. Eruptions are most often confined below the surface of the ocean and have not affected surrounding areas but it is always possible that magnitude could increase and eruptions could break the surface", said Dr. Richard Robinson, Director of the SRC. "Activity at Kick 'em Jenny is following similar patterns to what has occurred in the past where you've had increased seismicity followed by some sort of eruptive activity. The most common thing it does is that it goes back quiet again until the next time it happens. Since 1935, Kick 'em Jenny has had on average one episode like this every 10 years and the last time it happened was 2001, so we were expecting in a sense that something would happen within the next couple years. In fact, it's a bit overdue so this is not unusual in that sense," he added.

Despite reassurances, the Queen Elizabeth Hospital in Barbados has taken the precautionary measure to relocate its Accident & Emergency Department – a move which management said was aimed at ensuring that its services were not compromised in the event of a disaster. Fibre optic cables supporting internet and mobile data for residents in Grenada and Trinidad & Tobago were also affected by the increased seismic activity, leading to slower-than-usual data speeds.

Update – July 26, 2015: The UWI Seismic Research Centre has downgraded the level of alert for Kick'em Jenny to yellow, following significant reduction in seismic activity at the volcano.

Figure 1.1 provides information on human exposure to earthquake-induced tsunamis in the Caribbean region (Lynch, 2015).

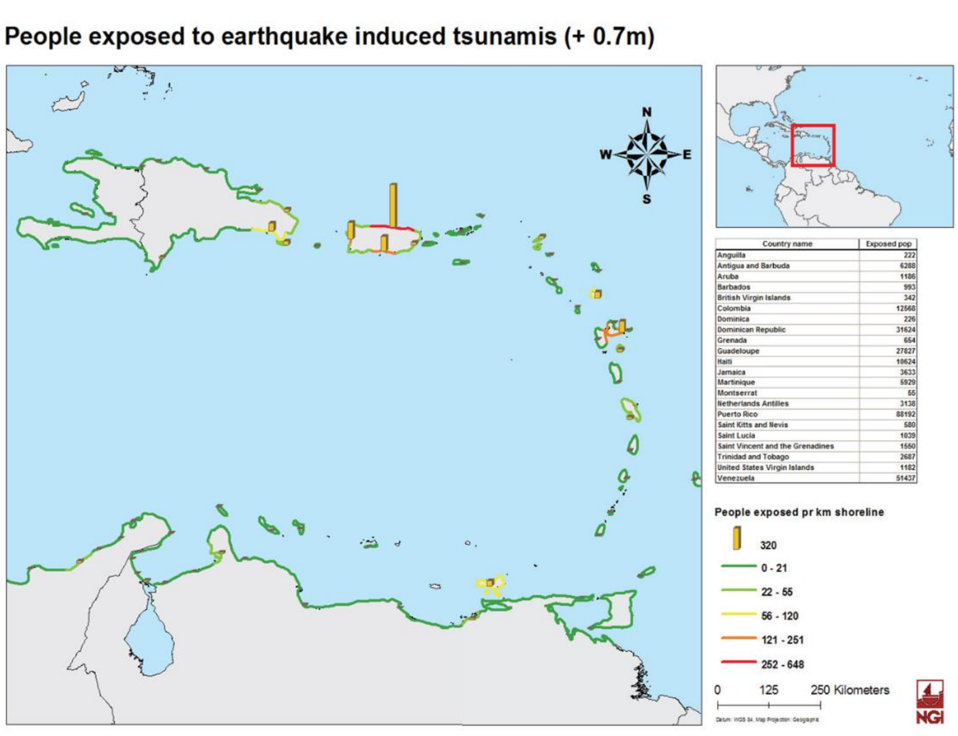

Figure 1.1. Human exposure to earthquake induced tsunamis in the Caribbean (Lynch, 2015)

1.3.1.4 Drought[5]

Drought is a natural part of climate which occurs in virtually all climatic zones. Its characteristics vary significantly from one region to another. Drought is a temporary aberration; it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate. Drought is categorized as a hydro-meteorological hazard. A broad definition of drought is a deficiency of precipitation over an extended period of time, usually a season or more, which results in a water shortage for some activity, group, or environmental sectors. However, in terms of typologies, droughts are classified as meteorological, agricultural, hydrological, and socio-economic (see Figure 1.2).

Meteorological drought is a natural event that results from climatic causes. Meteorological drought is usually defined by a precipitation deficiency over a pre-determined period of time. The thresholds chosen, such as 50 percent of normal precipitation over a six-month time period, will vary by location according to user needs or applications.

Agricultural, hydrological, and socio-economic drought, however, place greater emphasis on the human or social aspects of drought. They highlight the interaction between the natural characteristics of meteorological drought and human activities that depend on precipitation to provide adequate water supplies to meet societal and environmental demands.

Agricultural drought is defined more commonly by the lack of availability of soil water to support crop and forage growth than by the departure of normal precipitation over some specified period of time. The relationship between precipitation and infiltration of precipitation into the soil is often not direct. Infiltration rates vary depending on antecedent moisture conditions, slope, soil type, and the intensity of the precipitation event. Soil characteristics also differ. For example, some soils have a higher water-holding capacity, which makes them less vulnerable to drought (see Photos 1.11 and 1.12 for some Caribbean examples of the effect of drought).

Photo 1.11. Cattle seek refuge during drought Union Island, St. Vincent and the Grenadines
(Source: Kenton X. Chance/IPS
http://www.ipsnews.net/2015/06/prolonged-drought-leaves-caribbean-farmers-broke-and-worried/)

Photo 1.12. Drought in Haiti, 2014
(Source: http://haitiactualites.com/english_media_roundup/4097-haiti-drought-causes-extreme-emergency.html)

Hydrological drought is normally defined by deficiencies in surface and subsurface water supplies relative to average conditions at various points in time through the seasons. Like agricultural drought, there is no direct relationship between precipitation amounts and the status of surface and subsurface water supplies in lakes, reservoirs, aquifers, and streams because these hydrological system components are used for multiple and competing purposes, such as irrigation, recreation, tourism, flood control, transportation, hydroelectric power production, domestic water supply, protection of endangered species, and environmental and ecosystem management and preservation. There is also a considerable time lag between departures of precipitation and the point at which these deficiencies become evident in surface and subsurface components of the hydrologic system.

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[5] This section is excerpted from Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action. United Nations secretariat of the International Strategy for Disaster Reduction (UNISDR), Geneva, Switzerland, 213 pp. (UNISDR, 2009)

Socio-economic drought differs markedly from the other types of drought because it reflects the relationship between the supply and demand for some commodity or economic good (such as water, livestock forage, or hydroelectric power) that is dependent on precipitation. Supply varies annually as a function of precipitation or water availability. Demand also fluctuates and is often associated with a positive trend as a result of increasing population, development and other factors.

Box 1.4. The 2015 drought in the Caribbean[6]

The worst drought in five years is creeping across the Caribbean. From Puerto Rico to Cuba to St Lucia, crops are withering, reservoirs are drying up and cattle are dying while forecasters worry that the situation could only grow worse in the coming months. Thanks to El Niño, a warming of the tropical Pacific that affects global weather, forecasters expect the hurricane season that began in June to be quieter than normal, with a shorter period of rains. That means less water to help refill Puerto Rico's thirsty Carraizo and La Plata reservoirs as well as the La Plata river in the central island community of Naranjito. A tropical disturbance that hit the US territory on Monday did not fill up those reservoirs as officials had anticipated.

Puerto Rico is among the Caribbean islands worst hit by the water shortage, with more than 1.5 million people affected by the drought so far, according to the US National Drought Mitigation Center. Tens of thousands of people receive water only every third day under strict rationing recently imposed by the island government. Puerto Rico last week also activated national guard troops to help distribute water and approved a resolution to impose fines on people and businesses for improper water use.

The Caribbean's last severe drought was in 2010. The current one could grow worse if the hurricane season ending in November produces scant rainfall and the region enters the dry season with parched reservoirs, said Cedric Van Meerbeeck, a climatologist with the Caribbean Institute for Meteorology and Hydrology. "We might have serious water shortages … for irrigation of crops, firefighting, domestic consumption or consumption by the hotel sector," he said.

The Caribbean isn't the only area in the western hemisphere dealing with extreme water shortages. Brazil has been struggling with its own severe drought that has drained reservoirs serving the metropolis of São Paulo. In the Caribbean, the farm sector has lost more than $1m in crops as well as tens of thousands of dollars in livestock, said Norman Gibson, scientific officer at the Trinidad-based Caribbean Agricultural Research and Development Institute. On St Lucia, which has been especially hard hit, farmers say crops including coconuts, cashews and oranges are withering. "The outlook is very, very bad," said Anthony Herman, who oversees a local farm cooperative. "The trees are dying, the plants are dying … It's stripping the very life of rivers."

Officials in Cuba say 75% of the island is enduring a drought that has killed cattle and destroyed thousands of hectares (acres) of crops including plantains, citrus, rice and beans. Recent heavy rains in some areas have alleviated the problem some, but all 200 government-run reservoirs are far below capacity. In the nearby Dominican Republic, water shortages have been reported in hundreds of communities, said Martin Melendez, a civil engineer and hydrology expert who has worked as a government consultant. "We were 30 days away from the entire water system collapsing," he said

The tourism sector has also been affected. Most large hotels in Puerto Rico have big water tanks and some recycle wastewater to irrigate green areas, but many have curtailed water use, said Frank Comito, CEO of the Florida-based Caribbean Hotel & Tourism Association. Other hotels have cut back on sprinkler time by up to 50%, said Carlos Martínez of Puerto Rico's Association of Hotels. "Everybody here is worried," he said. "They are selling water tanks like hot cakes … and begging God for rain." Guests at Puerto Rico's El Canario by the Lagoon hotel get a note with their room keys asking them to keep their showers short amid the water shortage. "We need your cooperation to avoid waste," says the message distributed at the front desk of the hotel in the popular Condado district. At the Casa del Vega guesthouse in St Lucia, tourists sometimes find the water in their rooms turned off for the day, preventing them from taking a shower. "Even though we have a drought guests are not sympathetic to that," hotel manager Merlyn Compton said.

The relationship between these types of drought is illustrated in Figure 1.2. Agricultural, hydrological and socio-economic drought, occur less frequently than meteorological drought because impacts in these sectors are related to the availability of surface and subsurface water supplies. It usually takes several weeks before precipitation deficiencies begin to produce soil moisture deficiencies leading to stress on crops, pastures, and rangeland. Continued dry conditions for several months at a time bring about a decline in streamflow and reduced reservoir and lake levels and, potentially, a lowering of the groundwater table. When drought conditions persist for a period of time, agricultural, hydrological and socio-economic drought occur, producing associated impacts. During drought, not only are inflows to recharge surface and subsurface supplies reduced, but demand for these resources increases dramatically as well. As illustrated in Figure 1.2, the direct linkage between the main types of drought and

[6] Guardian News and Media Limited or its affiliated companies, 2015. Caribbean swelters under worst drought in five years, published June 24, 2015. Downloaded from http://www.theguardian.com/environment/2015/jun/24/caribbean-swelters-drought-in-five-years on November 28, 2015

precipitation deficiencies is reduced over time because water availability in surface and subsurface systems is affected by how these systems are managed. Changes in the management of these water supplies can either reduce or aggravate the effects of drought. For example, the adoption of appropriate tillage practices and planting more drought-resistant crop varieties can diminish the effect of drought significantly by conserving soil water and reducing transpiration. Therefore, the effects of drought are a product of both the physical nature of the hazard and our ability to manage risk (UNISDR, 2009).

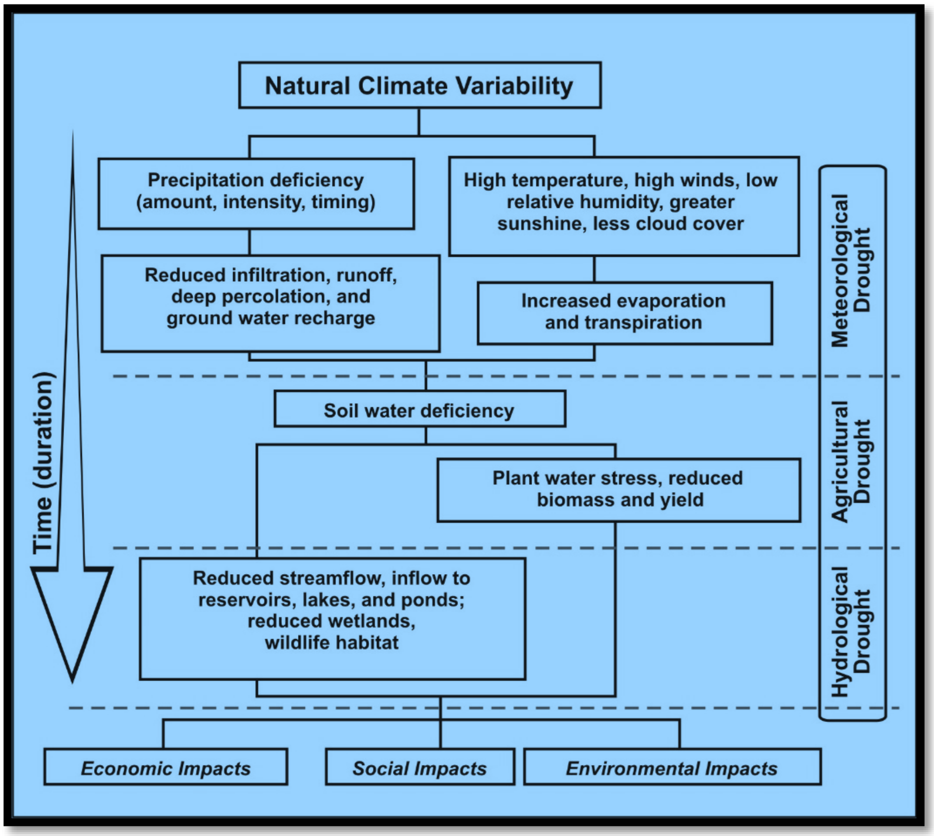

Figure 1.2. Sequence of drought occurrence and impacts for commonly accepted drought types. All droughts originate from a deficiency of precipitation or meteorological drought but other types of drought and impacts cascade from this deficiency.[7]

1.3.2 Geologic hazards

1.3.2.1 Earthquakes

Earthquakes are caused by the sudden release of slowly accumulated strain energy along a fault in the earth's crust. Earthquakes and volcanoes occur most commonly at the collision zone between tectonic plates.

Earthquakes represent a particularly severe threat due to the irregular time intervals between events, lack of adequate forecasting, and the hazards associated with these:

- Ground shaking is a direct hazard to any structure located near the earthquake's center. Structural failure takes many human lives in densely populated areas.
- Faulting, or breaches of the surface material, occurs as the separation of bedrock along lines of weakness.
- Landslides occur because of ground shaking in areas having relatively steep topography and poor slope stability.
- Liquefaction of gently sloping unconsolidated material can be triggered by ground shaking. Flows and lateral

[7] Source: National Drought Mitigation Center, University of Nebraska-Lincoln, U.S.A., downloaded from http://drought.unl.edu/DroughtBasics/TypesofDrought.aspx, downloaded November 21, 2015.

spreads (liquefaction phenomena) are among the most destructive geologic hazards.

- Subsidence or surface depressions result from the settling of loose or unconsolidated sediment. Subsidence occurs in waterlogged soils, fill, alluvium, and other materials that are prone to settle.
- Tsunamis or seismic sea waves, usually generated by seismic activity under the ocean floor, cause flooding in coastal areas and can affect areas thousands of kilometers from the earthquake center.
- Other secondary hazards are possible, such as foundation settlement, lurching, seiche and fire (Lynch, 2015).

See Photos 1.13 and 1.14 for some of the effects of the earthquake in Haiti in 2010. Some earthquake FAQs are found in Box 1.5.

Photo 1.13. Earthquake in Haiti, 2010
http://greenfieldgeography.wikispaces.com/Measuring+Disasters

Photo 1.14. Earthquake in Haiti, 2010
http://imgkid.com/really-bad-earthquakes.shtml

Box 1.5. Earthquake FAQs[8]

What is a foreshock/aftershock? The terms foreshock and aftershock have no strict scientific definition. They are used to describe the events within an earthquake sequence to distinguish those events that preceded the mainshock from those that followed it.

Can an aftershock have a larger magnitude than the main earthquake? The term mainshock refers to the largest event in a sequence. However, as energy release within a seismogenic system proceeds, it may be found that an event that was *thought* to be the largest was not the mainshock and a larger event occurs. The category into which events within a sequence would fall can only be *definitely set after* the high level activity of the sequence is complete. Research is ongoing to try to distinguish between large magnitude precursory events and mainshocks as the events are occurring (i.e. in real time).

Can buildings collapse during aftershocks? Yes, if a building has been sufficiently weakened during the main earthquake it could collapse during an aftershock.

Can climate change or hot weather cause earthquakes? No, climate change or hot weather does not cause earthquakes. Earthquakes are caused by processes deep within the Earth while hot weather and climate change are related to the atmosphere.

Can earthquakes be predicted? Scientists are unable to predict the location, time and date of when an earthquake will occur, however, forecasts can be made based on past patterns of activity in a region. The Eastern Caribbean is a seismically active area, which has generated very large earthquakes in the past. Therefore, we will continue to have earthquakes of varying magnitudes.

Can an earthquake trigger a volcanic eruption? Yes. Research suggests that large earthquakes can both trigger a volcano to begin erupting or shut down a volcano that is already erupting.

Why is it that earthquakes in some parts of the world like India, China, or Turkey seem to be more devastating than earthquakes in the Caribbean? The rate at which faults accumulate strain energy and release it in earthquakes is directly proportional to how fast plates move. The convergence rate of the plates in the Eastern Caribbean is about 2 cm/year, while the

[8] Extracted from The University of the West Indies Seismic Research Centre. Earthquakes, Frequently Asked Questions. Downloaded from http://www.uwiseismic.com/General.aspx?id=85 on November 29, 2015.

rate in Asia is much higher. As a result, their largest earthquakes occur more often than those in the Eastern Caribbean. This means that one day an earthquake as large as those seen in Asia will occur in the Eastern Caribbean.

Do we get a lot of earthquakes in the Eastern Caribbean? Each year, over 1200 earthquakes are recorded in the Eastern Caribbean. Not all of these events are felt but they serve as a reminder that the region is seismically active.

Which islands in the Eastern Caribbean are most susceptible to earthquakes? The answer to this question depends on what is meant by "susceptible". Every island in the Eastern Caribbean is within 200 km of the largest events to have occurred in the past and as such experienced damage during those earthquakes. In this context all of the islands in the Eastern Caribbean are susceptible to earthquakes. If "susceptible" means feels earthquakes most often, then those areas are near Trinidad and near Martinique.

What was the largest earthquake in the Caribbean? The largest recorded earthquake to have occurred in the Caribbean is believed to have been the El Cibao earthquake in the Dominican Republic in 1946 with aftershocks extending into 1947-48. The earthquake was of magnitude 8.1 and generated a tsunami which caused 75 deaths and rendered 20,000 homeless.

The largest earthquake to have occurred in the *Eastern Caribbean* (St. Kitts-Nevis to Trinidad & Tobago region) since continuous instrumental monitoring began in the region was the earthquake near Antigua on 8th October, 1974. The earthquake was of magnitude 7.5.

On 8th Feb 1843, the biggest earthquake known to have affected the Eastern Caribbean occurred. Damaging intensities were experienced from St. Maarten to Dominica. In Antigua, the English Harbour sank and in Point-a-Pitre, Guadeloupe, all masonry was destroyed in the earthquake, with an associated fire consuming wooden structures. One third of the population, estimated at 4,000-6,000 persons, perished. The event was felt as far south as Caracas and British Guiana and was even felt 2,000 km away in Washington, Vermont and Charlestown, U.S.A. This earthquake was not instrumentally recorded. The magnitude is estimated to have been in the range 8.0-8.5.

In relation to the Haiti January 12, 2010 earthquake:

Since the Haiti Earthquake there seems to be increased earthquake activity in the Caribbean area - Venezuela, Cayman Islands etc. Why is this happening? Is it normal or has the Haiti Earthquake triggered these other earthquakes? The Caribbean, although small, is a plate in its own right and earthquakes, small and large, will occur around its boundaries as a normal part of its motion. The northern and eastern islands in the region lie close to those boundaries with the western and southern boundaries passing close to Central America and through northern South America. The occurrence of an earthquake indicates that a fault, which had been accumulating strain, reached its limit and released that energy. Big faults can accommodate larger amounts of energy before slipping than smaller faults. It is therefore unsurprising that when a big fault slips and generates a large magnitude earthquake - such as the Haiti Earthquake - that other smaller faults, which were also accumulating strain energy within the same system, reach their limit and generate earthquakes around the same time e.g. the earthquake in Cayman Islands region on January 19th. While earthquakes in general can advance or delay the timing of other earthquakes in an area, the cause of most earthquakes remains the motion of plates.

Is it normal to have an earthquake of this size in the Caribbean? Yes, it is normal to have an earthquake of this size and larger in the Caribbean. In the last three years at least three earthquakes greater than 7.0 magnitude have occurred in the Caribbean.

What does this earthquake mean for neighbouring countries like Jamaica or Puerto Rico? Countries in the near vicinity may have felt the earthquake. For example, the quake was reportedly felt along the Eastern corridor, particularly the North East and South East coasts of Jamaica. Assessments are being conducted to determine if there has been any structural damage to buildings and infrastructure. As strain adjusts in the area following the occurrence of an earthquake of this size, seismic activity in the area is expected to be somewhat elevated for some time to come.

If the earthquake occurred near Haiti how come it was felt in Caracas, Venezuela and not in any other islands in the Eastern Caribbean? When an earthquake occurs, the energy is released in waves of different frequencies. The effect of the high frequency waves is reduced rapidly as they travel through the crust. The shaking generated by such waves mostly affects buildings with few stories. Therefore those closer to the earthquake in low-rise buildings would be affected by these waves. Low frequency waves, on the other hand, can travel for greater distances and tall buildings respond to such waves. The report from Caracas came from someone on the 14th floor of a building. It may also be that features exist on the eastern side of the Caribbean plate that serve to lessen the energy of the waves coming from that direction reducing their effect as they pass through the region.

Are the Eastern Caribbean islands in any danger as a result of the Haiti Earthquake? Large earthquakes can, in some cases, advance or delay the occurrence of some future earthquakes. That said the Eastern Caribbean is known to have a history of major earthquakes and the reality is that, with or without the occurrence of the Haiti earthquake, big damaging earthquakes can and will occur in the Eastern Caribbean.

Table 1.1. Distribution of Damaging Geologic Events by Country (Lesser Antilles; 1690-2010) (Source: Lynch, 2015)

Trinidad/Tobago:	10 earthquakes,	2 fatal events,		1 tsunami
Grenada:	4 earthquakes,			2 tsunamis
St. Vincent:	4 earthquakes,	2 fatal events,	*5 eruptions*	
Barbados:	3 earthquakes,			2 tsunamis
St. Lucia:	7 earthquakes,	1 fatal event		
Martinique:	9 earthquakes,	4 fatal events*,*	*2 eruptions*	3 tsunamis
Dominica:	5 earthquakes,		*1 eruption,*	3 tsunamis
Guadeloupe:	9 earthquakes,	3 fatal events,	*2 eruptions*,	2 tsunamis
Montserrat:	9 earthquakes,	3 fatal events,	*1 eruption*,	1 tsunami
Antigua/Barbuda:	3 earthquakes,	2 fatal events,		2 tsunamis
St. Kitts & Nevis:	7 earthquakes,	1 fatal event,		1 tsunami
Netherlands Antilles:	3 earthquakes,	1 fatal events,		1 tsunamis
British Virgin Is:	2 earthquakes,	1 fatal event,		1 tsunami

Table 1.2. Distribution of Damaging Geologic Events by Country (Greater Antilles; 1550 – 2010) (Source: Lynch, 2015)

Puerto Rico & Virgin Island:	13 earthquakes,	2 fatal events	3 tsunamis
Dominican Republic:	16 earthquakes,	4 fatal events	3 tsunamis
Haiti:	13 earthquakes,	6 fatal events	8 tsunamis
Cuba:	27 earthquakes,	4 fatal events	2 tsunamis
Jamaica:	15 earthquakes,	6 fatal events	4 tsunamis
Cayman Islands:	1 earthquake		

1.3.2.2 Volcanoes

Volcanoes are perforations in the earth's crust through which molten rock and gases escape to the surface. Volcanic hazards stem from two classes of eruptions:

Photo 1.15. Soufriere Hills volcano erupting, Montserrat, 1995
(Source: http://www.pacificviews.org/weblog/archives/015928.php)

- Explosive eruptions which originate in the rapid dissolution and expansion of gas from the molten rock as it nears the earth's surface. Explosions pose a risk by scattering rock blocks, fragments, and lava at varying distances from the source.

Photo 1.16. Soufriere Hills volcano erupting, Montserrat, 1995
(Source: https://en.wikipedia.org/wiki/Soufri%C3%A8re_Hills)

- Effusive eruptions where material flow rather than explosions is the major hazard. Flows vary in nature (mud, ash, lava) and quantity and may originate from multiple sources. Flows are governed by gravity, surrounding topography, and material viscosity.

Hazards associated with volcanic eruptions include lava flows, falling ash and projectiles, mudflows, and toxic gases. See Photos 1.15 and 1.16 for images of the 1995 Montserrat Soufriere Hills volcano erupting. Volcanic activity may also trigger other natural hazardous events including local tsunamis, deformation of the landscape, floods when lakes are breached or when streams and rivers are dammed, and tremor-provoked landslides.

1.3.2.3 Landslides

The term landslide includes slides, falls, and flows of unconsolidated materials. Landslides can be triggered by earthquakes, volcanic eruptions, soil saturated by heavy rains or groundwater rise, and river undercutting. Earthquake shaking of saturated soils creates particularly dangerous conditions. Although landslides are highly localized, they can be particularly hazardous due to their frequency of occurrence. Classes of landslide include:

- Rockfalls, which are characterized by free-falling rocks from overlying cliffs. These often collect at the cliff base in the form of talus slopes which may pose an additional risk.
- Slides and avalanches, a displacement of overburden due to shear failure along a structural feature. If the displacement occurs in surface material without total deformation it is called a slump.
- Flows and lateral spreads, which occur in recent unconsolidated material associated with a shallow water table. Although associated with gentle topography, these liquefaction phenomena can travel significant distances from their origin.

Photo 1.17. Landslide in Saint Lucia, Hurricane Tomas, 2010
(Source: http://cabot-institute.blogspot.com/2014/07/pearls-of-wisdom-importance-of.html)

The impact of these events depends on the specific nature of the landslide. Rockfalls are obvious dangers to life and property but, in general, they pose only a localized threat due to their limited areal influence. In contrast, slides, avalanches, flows, and lateral spreads, often having great areal extent, can result in massive loss of lives and property. Mudflows, associated with volcanic eruptions, can travel at great speed from their point of origin and are one of the most destructive volcanic hazards. See photos 1.17 to 1.20 for a few examples of landslide impacts in the region.

Photo 1.18. Landslide below popular resort, Saint Lucia, Hurricane Tomas, 2010
(Source: http://www.nationnews.com/nationnews/news/33013/worst-disaster-st-lucia)

Photo 1.19. Landslide undermines house, Saint Lucia, Hurricane Tomas, 2015 (Source: https://aphroditeares.wordpress.com/2011/03/03/poetry-music-art-a-celebration-to-benefit-st-lucia/)

1.3.3 Other natural hazards

1.3.3.1 Bush fires[9]

Fire is an important recurrent phenomenon in all forested and non-forested regions of the globe. In some ecosystems fire plays an ecologically significant role in biogeochemical cycles and disturbance dynamics. In other ecosystems fire may lead to the destruction of forests or to long-term site degradation. As a consequence of demographic and land use changes and the cumulative effects of anthropogenic disturbances many forest types adapted to fire, are becoming more vulnerable to high-intensity wildfire. Ironically, this is often due to the absence of periodic low-intensity fire. In other forest types, however, as well as many non-forest ecosystems e.g. in savannas and grasslands, fire plays an important role in maintaining their dynamic equilibrium productivity and carrying capacity.

In most areas of the world wildfires burning under extreme weather conditions will have detrimental impacts on economies, human health and safety, with consequences that are comparable to the severity of other natural hazards. In all ecosystem fire needs to be managed to balance the benefits derived from burning with the potential losses from uncontrolled fires.

Photo 1.20. Bushfire in Jamaica
(Source: http://www.jamaicaobserver.com/news/More-bush-fire-in-St-Andrew-hills)

Photo 1.21. Bushfire in Jamaica, 2011
(Source: http://jamaica-gleaner.com/gleaner/20110121/news/news9.html)

[9] This section on wildfires is excerpted from "International Decade for Natural Disaster Reduction, IDNDR Early Warning Programme. Report on Early Warning for Fire and Other Environmental Hazards" Convener of International Working Group, and first Author: Dr. Johann G. Goldammer Max Planck Institute for Chemistry, Biogeochemistry Department Fire Ecology Research Group, Freiburg University http://www.unisdr.org/2006/ppew/whats-ew/pdf/report-on-ew-for-fire-and-other-environmental-hazards.pdf downloaded November 12, 2015.

Fires in forests and other vegetation produce gaseous and particle emissions that have impacts on the composition and functioning of the global atmosphere. These emissions interact with those from fossil-fuel burning and other technological sources which are the major cause for anthropogenic climate forcing. Smoke emissions from wildland fires also cause visibility problems which may result in accidents and economic losses. Smoke generated by wildland fires also affect human health and in some cases contribute to the loss of human lives. Fire risk modelling in expected climate change scenarios indicate that within a relatively short period of the next three to four decades, the destructiveness of human-caused and natural wildfires will increase. Fire management strategies which include preparedness and early warning cannot be generalized due to the multi-dimensional effects of fire in the different vegetation zones and ecosystems and the manifold cultural, social, and economic factors involved. However, unlike the majority of the geological and hydro-meteorological hazards included in the International Decade for Natural Disaster Reduction (IDNDR) Early Warning Programme, wildland fires represent a natural hazard which can be predicted, controlled and, in many cases, prevented (Goldamer, J.G., 2006).

1.4 Natural Hazard Risk Management

The approach to disaster risk management has evolved from the traditional response which focused on immediate preparedness and response to a specific event, to include a broad range of longer-term activities designed to reduce the overall vulnerability to hazards. Today, hazard risk management anticipates problems and ensures that development addresses the likelihood of hazards and their interaction with environmental and other systems. Hazard exposure is now viewed as an ongoing process, and the Comprehensive Disaster Management (CDM) approach aims to reduce hazard vulnerability across all sectors. To succeed, the philosophy needs to be integrated at all levels of development planning, from economic planning and policy making all the way down to the planning of individual buildings.

Caribbean regional agencies have embraced this approach as part of their mandate for reducing social and environmental risk. The Caribbean Disaster Emergency Management Agency (CDEMA), recognizing the critical link between disaster management and sustainable development, spearheaded the adoption of a strategic CDM framework in 2001 in collaboration with stakeholders. The strategic objective of the CDM framework is the integration of disaster management considerations into the development planning and decision making process of CDEMA’s Participating States (PS). In 2007, the CDEMA Coordinating Unit (CU), with the support of and in collaboration with its partners, completed an Enhanced Regional Strategy and Programming Framework to guide CDM programming in the Caribbean for the period 2007-2012 in the first instance. This Strategy was established within the context of the 2005-2015 CARICOM Regional Framework and developed in line with Results-Based Management (RBM) principles and approaches. The Enhanced CDM Strategy was used as the basis for developing the draft 2014-2024 CDM Strategy, with the goal to realize “safer, more resilient and sustainable CDEMA Participating States through Comprehensive Disaster Management” (CDEMA, 2014).

CDB and CCCCC, through the original Sourcebook 2004 on the Integration of Natural Hazards into the EIA process sought to mainstream disaster risk management within CDB’s operations, and within the development planning processes in Borrowing Member Countries. CDB has also facilitated information sharing (conferences and workshops), training courses, manuals and tools, the development of building codes and a model mitigation policy.

Box 1.6 is an example of a hazard risk management strategy (from a physical planning perspective) at a national level.

The three main, interrelated, categories of risk management actions, i) risk identification, ii) risk reduction and iii) risk transfer, are described in Box 1.7.

Risk identification entails hazard assessment and mapping, vulnerability assessment and risk assessment. Risk reduction can be achieved through physical, socio-economic or environmental measures, as well as through measures implemented post-disaster. Risk transfer relates to budget self-insurance, market insurance and re-insurance, public asset coverage, risk pooling and diversification, and risk financing.

Box 1.6. National Spatial Development Strategy for Trinidad and Tobago. POLICY 20: MANAGING HAZARD RISK (Source: SRC, 2015)

Vulnerable uses and forms of development should be prohibited in areas of High hazard risk.

Decisions should be informed by up-to-date Hazard Risk Assessments, which should consider both the probability of hazards occurring and the likely impact of such occurrences.

A risk-based sequential approach should be applied to the location of development to avoid hazard risk to people and property where possible and to manage any residual risk. Areas of higher hazard risk should normally be avoided and areas of low hazard risk should be preferred.

Development should only be allowed in an area of High or Significant hazard risk if it can be demonstrated that there is no alternative site available in an area of Low hazard risk and the risk can be mitigated satisfactorily and without increasing risk elsewhere.

Developments likely to increase the probability of hazards or exacerbate their impacts (on the site involved or elsewhere) should not be permitted unless satisfactory measures to mitigate those effects and impacts are to be undertaken in association with the development.

Appropriate and proportionate limitations and restrictions (which may include design and construction specifications) should be imposed whenever development is allowed in areas of high or significant hazard risk.

Whenever mitigation measures are required, their implementation in full should be required as a condition of permission being granted or, if appropriate, by enforceable legal agreement.

Box 1.7. Categories of natural hazard risk management actions[10]

Risk Identification. Steps taken to understand existing vulnerabilities including their location and severity. A broad range of activities contributes to the identification and understanding of natural hazard risk: hazard data collection and mapping, vulnerability assessment, risk assessment and post-disaster assessment (see recommendations for good practices in Table 1 of this reference).

Risk Reduction. Risk reduction activities are designed to mitigate damage from hazard events. These activities address existing vulnerability through such measures as retrofit strengthening and relocation. Actions taken to reduce future vulnerability such as the implementation and enforcement of building standards, environmental protection measures, land use planning that recognises hazard zones and resource management practices will provide significant benefits over the long term (see recommendations for good practices in Table 2 of this reference).

Risk Transfer. In cases where it is not possible to eliminate risk it is important to strengthen fiscal resilience and to reduce financial risk through mechanisms that ensure funds are readily available to rectify the damage or replace the facility should a loss occur. Utilizing the insurance mechanisms is appropriate for risks that cannot be mitigated through structural or ex-ante damage reduction measures and against events that have the potential to cause large economic losses (see recommendations for good practices in Table 3 of this reference).

The Caribbean Development Bank (CDB) developed a Disaster Management Operational Strategy and Guidelines for its DRM engagement with BMCs in 2009 and also established the Community Disaster Risk Reduction Trust Fund with grant financing from the Department of Foreign Affairs, Trade and Development, Canada and the Department for International Development, United Kingdom, to finance community-based disaster risk reduction (DRR) and climate change adaptation (CCA) initiatives at the local

[10] Extracted from Natural Hazard Risk Management in the Caribbean: Revisiting the Challenge (World Bank, 2002), document available at http://www.oas.org/cdmp/riskmatrix/rm_annex.doc

level across eligible borrowing member countries of the CDB.

1.5 Climate variability and change

1.5.1 Climate trends

Taylor et al (2007) reported that the climate in the Caribbean region has changed in a manner very consistent with the observed variations at global and northern hemisphere levels. Temperature records have shown an increase in the last century, with the 1990s being the warmest decade since the beginning of the 20th century, and 1998 the warmest year on record.

Taylor et al (2007) went on to note that the observed regional temperature increase is confirmed by other studies done by national institutions within the region, which also provide insight into other ways in which the regional climate might be changing. For example, results from studies done by the Institute of Meteorology (INSMET) in Cuba and the University of the West Indies (UWI) indicate that:

- The mean temperatures of individual Caribbean territories similarly trend upward for periods of three decades or more to the present.
- At the end of the 1970s a significant warming in the lower part of the atmosphere was detected in the region, and supports the idea that changes are occurring in background climate conditions.
- The upward trend in the mean temperatures seems to be largely driven by changes in the minimum temperatures. For example, the mean annual temperature in Cuba (1960s to 2007) has increased by approximately 0.5°C. For the same period, there is a statistically significant increase of 1.4°C in minimum temperatures, but no significant trend in maximum temperatures.
- The diurnal temperature range is decreasing, consistent with global trends. For the region, a two degree change has been detected (1950s to 2007).
- The number of very warm days in the region is increasing, but, the number of very cold nights is decreasing (1950s to 2007).
- The frequency of droughts has increased significantly since 1960. In the last few years Cuba has been affected by one of the more intense and longer droughts in the record.
- The frequency of occurrence of other extreme events in the region seems to be changing. Flooding events and hurricane passage through the region have increased since the mid-90s. Tornadoes, hail and heavy rains have become more frequent in Cuba since 1977.

Box 1.8 contains information extracted from the State of the Climate Report 2014 (2015). This current information further substantiates the observed and predicted global and Caribbean climate trends.

Figure 1.3 presents annual projected temperature and precipitation change relative to 1986–2005 for three small islands regions (using regions defined in WGI AR5 Annex 1: Atlas of Global and Regional Climate Projections) (Nurse et al, 2014).

Figures 1.4 to 1.6 summarise the latest documented IPCC climate impacts and projections for SIDS. For more detail, refer to Nurse *et al* (2014).

Box 1.8. State of the Climate 2014[11]

Most of the essential climate variables monitored annually in the State of the Climate report continued to follow their long-term trends in 2014, with several setting new records. Carbon dioxide, methane, and nitrous oxide—the major greenhouse gases released into Earth's atmosphere—all reached record high average atmospheric concentrations for the year. Accompanying the record-high greenhouse gas concentrations was nominally the highest annual global surface temperature in at least 135 years of record taking. The warmth was distributed widely around the globe's land areas. Eastern North America was the only major region to observe a below-average annual temperature. But it was the oceans that drove the record global surface temperature in 2014. Although 2014 was largely ENSO-neutral, the globally averaged sea surface temperature (SST) was the highest on record. Globally, upper ocean heat content was record high for the year, reflecting the continued increase of thermal energy in the oceans, which absorb over 90% of Earth's excess heat from greenhouse gas forcing. Owing to both ocean warming and land ice melt contributions, global mean sea level in 2014 was also record high and 67 mm greater than the 1993 annual mean, when satellite altimetry measurements began.

Sea surface salinity trends over the past decade indicate that salty regions grew saltier while fresh regions became fresher, suggestive of an increased hydrological cycle over the ocean expected with global warming. Precipitation was quite variable across the globe. On balance, precipitation over the world's oceans was above average, while below average across land surfaces. Across the major tropical cyclone basins, 91 named storms were observed during 2014, above the 1981–2010 global average of 82. The Eastern/Central Pacific and South Indian Ocean basins experienced significantly above-normal activity in 2014; all other basins were either at or below normal. Similar to 2013, the North Atlantic season was quieter than most years of the last two decades with respect to the number of storms, despite the absence of El Niño conditions during both years. In higher latitudes and at higher elevations, increased warming continued to be visible in the decline of glacier mass balance, increasing permafrost temperatures, and a deeper thawing layer in seasonally frozen soil. In the Arctic, the 2014 temperature over land areas was the fourth highest in the 115-year period of record and snow melt occurred 20–30 days earlier than the 1998–2010 average.

In September, Arctic minimum sea ice extent was the sixth lowest since satellite records began in 1979. The eight lowest sea ice extents during this period have occurred in the last eight years. Conversely, in the Antarctic, sea ice extent countered its declining trend and set several new records in 2014, including record high monthly mean sea ice extent each month from April to November. The 2014 Antarctic stratospheric ozone hole was 20.9 million km2 when averaged from 7 September to 13 October, the sixth smallest on record and continuing a decrease, albeit statistically insignificant, in area since 1998 (Blunden, J. and D. S. Arndt, 2015).

The Azores high pressure and above-average North Atlantic sea surface temperatures dominated conditions over the Caribbean. This resulted in normal to below-normal annual rainfall and normal to above-normal annual temperatures over most of the region. The base period for comparisons is 1981–2010 (Stephenson et al, 2015).

[11]Excerpted from:

i. Stephenson, T. S., Taylor, M. A., Trotman, A. R., Marcellin-Honore', V., Porter, A. O., Hernández, M., Gonzalez, I. T., Boudet, D., Spence, J. M., McLean, N., Campbell, J. D., Shaw, A., Aaron-Morrison, A. P., Kerr, K., Tamar, G., Blenman, R. C., Destin, D., Joyette, S., Jeffers, B., and Stephenson, K., 2015. The Caribbean [in "State of the Climate in 2014"]. Bull. Amer. Meteor. Soc., 96 (7), S176-178

ii. Blunden, J. and D. S. Arndt, Eds., 2015: State of the Climate in 2014. Bull. Amer. Meteor. Soc., 96 (7), Sxvi.

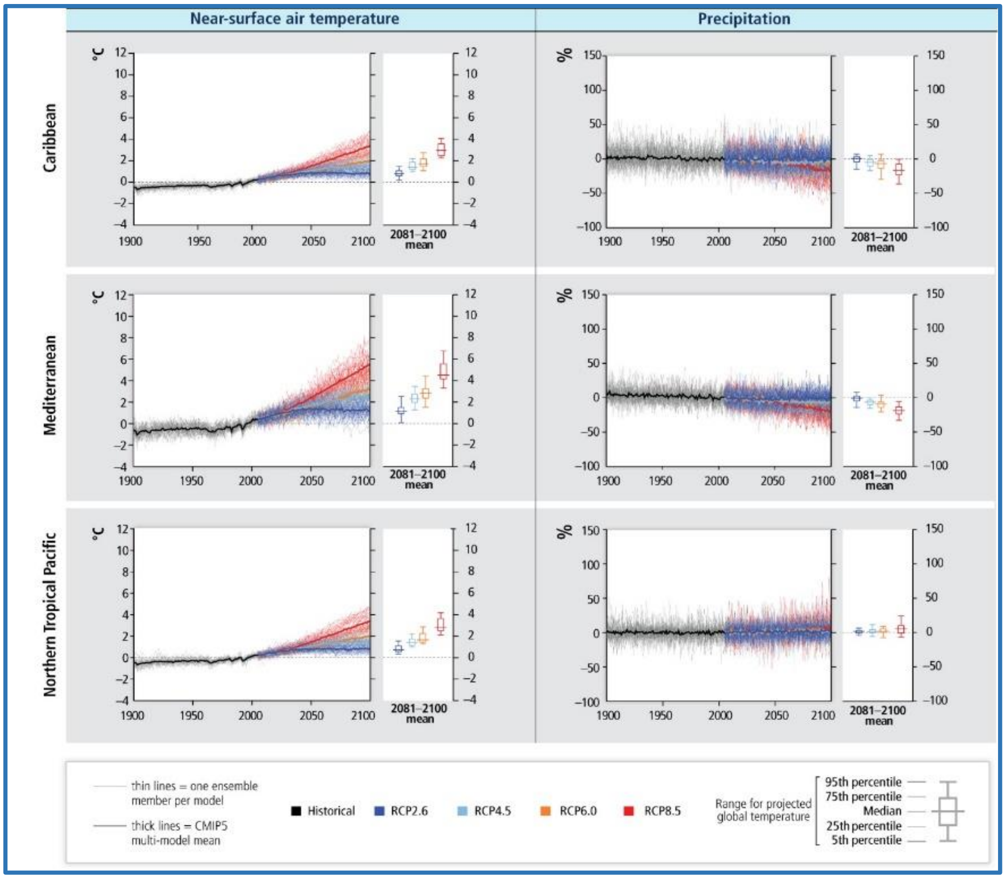

Figure 1.3. Time series of Representative Concentration Pathway (RCP) scenarios annual projected temperature and precipitation change relative to 1986–2005 for three small islands regions (using regions defined in WGI AR5 Annex 1: Atlas of Global and Regional Climate Projections). Extracted from Nurse et al, 2014, Figure 29-3. Thin lines denote one ensemble member per model, and thick lines the Coupled Model Intercomparison Project Phase 5 (CMIP5) multi-model mean. On the right hand side, the 5th, 25th, 50th (median), 75th, and 95th percentiles of the distribution of 20-year mean changes are given for 2081–2100 in the four RCP scenarios. Note that the model ensemble averages in the figure are for grid points over wide areas and encompass many different climate change signals.

- Current and future climate-related drivers of risk for small islands during the 21st century include sea level rise (SLR), tropical and extratropical cyclones, increasing air and sea surface temperatures, and changing rainfall patterns (***high confidence; robust evidence, high agreement***).
- SLR poses one of the most widely recognized climate change threats to low-lying coastal areas on islands and atolls (high confidence; robust evidence, high agreement). It is virtually certain that global mean SLR rates are accelerating. Projected increases to the year 2100 (RCP4.5: 0.35 m to 0.70 m) superimposed on extreme sea level events (e.g., swell waves, storm surges, El Niño-Southern Oscillation) present severe sea flood and erosion risks for low-lying coastal areas and atoll islands (***high confidence***).
- Transboundary processes such as air-borne dust from the Sahara and Asia, distant-source ocean swells from mid to high latitudes, invasive plant and animal species, and the spread of aquatic pathogens already have a negative impact on small islands (***high confidence; robust evidence, medium agreement***).
- Given the inherent physical characteristics of small islands, small islands are highly vulnerable to multiple stressors, both climate and non-climate (***high confidence; robust evidence, high agreement***).
- Wave over-wash of seawater will degrade fresh groundwater resources and that sea surface temperature rise will result in increased coral bleaching and reef degradation(***High confidence***)

Source: Nurse *et al* (2014), IPCC AR5, SIDS Chapter

Figure 1.4. Summary of Climate Change Impacts for SIDS[12]

[12] Nurse, L.A., R.F. McLean, J. Agard, L.P. Briguglio, V. Duvat-Magnan, N. Pelesikoti, E. Tompkins, and A. Webb,

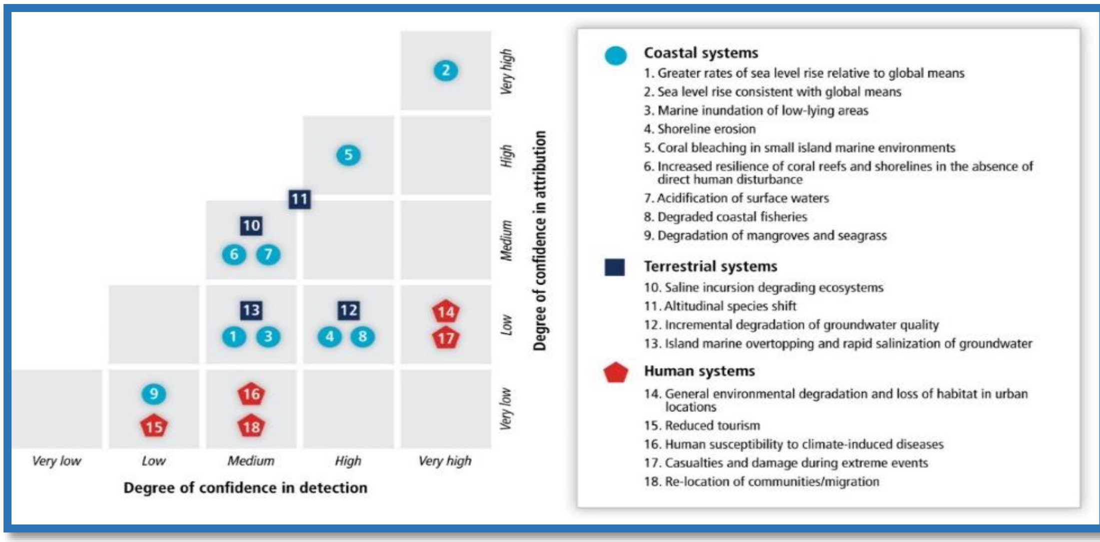

Figure 1.5. A comparison of the degree of confidence in the detection of observed impacts of climate change on tropical small islands with the degree of confidence in attribution to climate change drivers at this time. Extracted from Nurse et al, 2014 (Figure 29-2). For example, the blue symbol No. 2 (Coastal Systems) indicates there is very high confidence in both the detection of "sea level rise consistent with global means" and its attribution to climate change drivers; whereas the red symbol No. 17 (Human Systems) indicates that although confidence in detection of "casualties and damage during extreme events" is very high, there is at present low confidence in the attribution to climate change. It is important to note that low confidence in attribution frequently arises owing to the limited research available on small island environments.

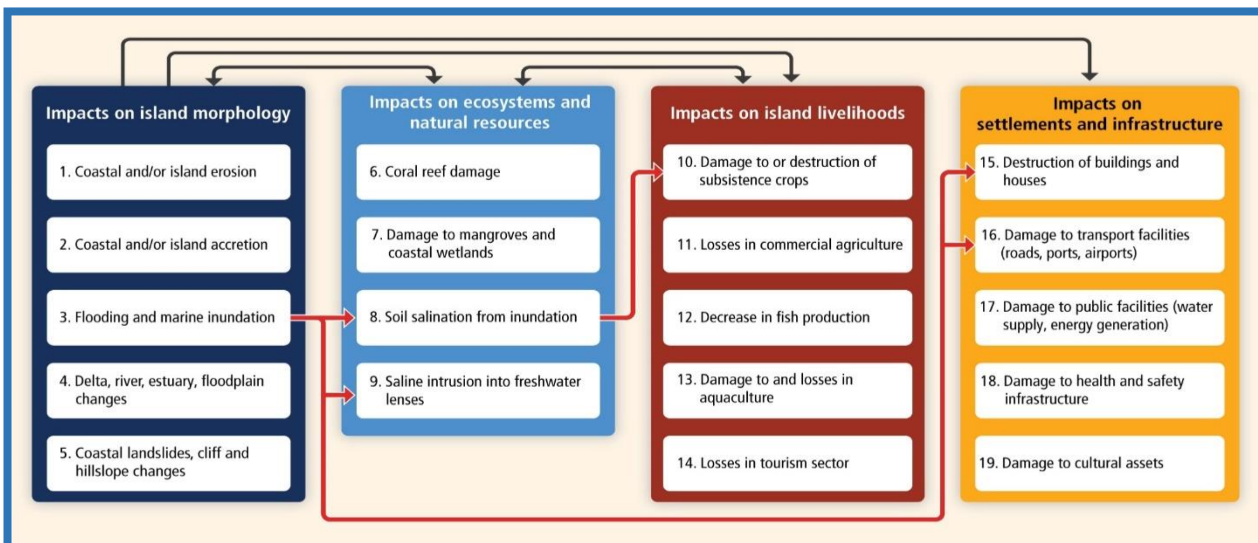

Figure 1.6. Tropical and extratropical cyclone (ETC) impacts on the coasts of small islands. Extracted from Nurse et al, 2014 (Figure 29-4) Four types of impacts are distinguished here, with black arrows showing the connections between them, based on the existing literature. An example of the chain of impacts associated with two ETCs centered to the east of Japan is illustrated by the red arrows. Swell waves generated by these events in December 2008 reached islands in the southwest Pacific and caused extensive flooding (3) that impacted soil quality (8) and freshwater resources (9), and damaged crops (10), buildings (15), and transport facilities (16) in the region (example based on Hoeke et al., 2013).

2014: Small islands. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1613-1654.

1.5.2 The CARICOM response to climate change

CARICOM countries have concluded that they will be unable, on their own, to provide the significant and sustained investment of resources necessary for the implementation of requisite climate change mitigation and adaptation measures to respond to the severe threats posed by a changing climate to the development prospects of Member States. The Liliendaal Declaration (2009) defines the position of CARICOM Member States and makes a number of declarations which can only be delivered by transformational change, that include:

1. Long-term stabilization of atmospheric greenhouse gas (GHG) concentrations at levels which will ensure that global average surface temperature increases will be limited to below 1.5 °C of preindustrial levels; that global GHG emissions should peak by 2015; and ultimately reducing GHG emissions by more than 95% of 1990 CO_2 levels by 2050.

2. Adaptation and capacity-building must be prioritized and a formal and well-financed framework established within and outside the UNFCCC to address the immediate and urgent, as well as long-term, adaptation needs of vulnerable countries, particularly the Small Islands and Low lying Coastal Developing States (SIDS) and the Least Developed Countries (LDCs).

3. The need for financial support to SIDS to enhance their capacities to respond to the challenges brought on by climate change and to access the technologies that will be required to undertake needed climate change mitigation actions and to adapt to the adverse impacts of climate change.

The Declaration emphasized that dangerous climate change is already occurring in all Caribbean SIDS, and that urgent ambitious and decisive action by CARICOM States and the international community is necessary. It expressed the grave concern of the Heads of Government that the devastating effects of climate change and sea level rise pose a severe threat to the region's efforts to promote sustainable development and achieve the Millennium Development Goals (MDGs). In particular, the increasing intensity of extreme weather events is resulting in severe damage to the region's socio-economic resource base.

The 'Regional Framework for Achieving Development Resilient to Climate Change' (the Regional Framework) (Caribbean Community Climate Change and Centre and the Climate and Development Knowledge Network, 2012) defined CARICOM's strategic approach for coping with climate change and is guided by five strategic elements designed to significantly increase the resilience of the CARICOM Member States' social, economic and environmental systems:

a. Mainstreaming climate change adaptation strategies into the sustainable development agendas of CARICOM states.

b. Promoting the implementation of specific adaptation measures to address key vulnerabilities in the region.

c. Promoting actions to reduce greenhouse gas emissions through fossil fuel reduction and conservation, and switching to renewable and cleaner energy sources.

d. Encouraging action to reduce the vulnerability of natural and human systems in CARICOM countries to the impacts of a changing climate.

e. Promoting action to derive social, economic, and environmental benefits through the prudent management of standing forests in CARICOM countries.

Box 1.9 notes the economic cost of doing nothing in response to climate change.

Box 1.9. Economic Costs of Climate Inaction[13]

An economic analysis of the costs of a changing climate in just three categories -increased hurricane damages, loss of tourism revenue, and infrastructure damages- projected that the Caribbean's annual cost of inaction could total $10.7 billion annually by 2025, $22 billion by 2050 and 46 billion by 2100. These costs represent 5%, 10% and 22% respectively, of the current Caribbean economy (2004 GDP). The net effect of costs on this scale is equivalent to causing a perpetual economic recession in each of the CARICOM Member States

1.5.3 Caribbean climate change predictions

Predictions for future climate are based on greenhouse gas emission scenarios that climate scientists have developed. Each scenario is premised on a 'storyline' of how the world might develop in terms of possible changes in population, energy use, economics and technology. Details of the greenhouse gas scenarios can be found in detail in the IPCC Special Report on Emission Scenarios (SRES). The SRES greenhouse gas emission scenarios are used to generate future climate scenarios. Although there are many methods to create climate scenarios, the most common involve the use of *General Circulation Models* (GCMs) to simulate the climate from the present into the future under each SRES scenario. GCMs are the best scientific tools currently available to simulate the global climate system response to a change in atmospheric composition.

The IPCC Working Group II (WG II) assesses the vulnerability of socio-economic and natural systems to climate change, negative and positive consequences of climate change, and options for adapting to it. It also takes into consideration the inter-relationship between vulnerability, adaptation and sustainable development. The assessed information is considered by sectors (water resources; ecosystems; food & forests; coastal systems; industry; human health) and regions (Africa; Asia; Australia & New Zealand; Europe; Latin America; North America; Polar Regions; Small Islands). All Working Group II reports for 2014 can be found on http://www.ipcc.ch/report/ar5/wg2/ .

GCM information is provided at a resolution of a few hundred kilometers. On this scale, the information is not very useful for small island territories (Taylor et al, 2007).

As a result a number of regional agencies have been involved in regionalization or downscaling techniques. These include: 1) regional climate modelling; and 2) statistical downscaling. There are relative advantages and disadvantages to each technique. However some of the advantages of using a regional climate model (RCM) make them an attractive option for regions like the Caribbean. These include the fact that RCMs:

(i) simulate current climate more realistically especially over regions where the terrain is not flat

(ii) predict climate change with more detail

(iii) represent smaller islands that are absent in GCMs

(iv) are much better at predicting changes in extreme weather

(v) can simulate cyclones and hurricanes

(vi) can be used to drive other models

[13] Caribbean Community Climate Change and Centre and the Climate and Development Knowledge Network, 2012. Delivering Transformational Change 2011-21. Implementing the CARICOM 'Regional Framework for Achieving Development Resilient to Climate Change' Full Report. Technical Report 5C/CCCCC-12-03-01. Caribbean Community Climate Change Centre.

(vii) produce large amounts of information which can enhance analysis of the future climate (Taylor et al, 2007).

Taylor et al (2007), in *Glimpses of the future – The PRECIS Caribbean Project* focus on how climate change could affect the countries within the Caribbean region, using a version of the Hadley Centre RCM, PRECIS, that has been deployed within the Caribbean Climate Change Modelling Centres at resolutions of 25 km and 50 km respectively. This scale can resolve the climate processes in most of the islands. Emissions uncertainty has been partially addressed by generating multiple scenarios appropriate to the IPCC definitions of A2[14] and B2[15] future emissions scenarios. Their findings were that:

- The Caribbean is expected to warm by 1°C to 5°C by the 2080s under Medium–High Emissions scenario. The greatest change is expected in the summer.
- The Caribbean is expected to be up to 25% drier by the 2080s under Medium–High Emissions scenario. The southern Caribbean will be drier than the north.

Although these scenarios are a clear step forward, many uncertainties are attached to them. For decisions involving large investment, Taylor et al (2007) recommended that these uncertainties should be explored in more detail.

The CARIBSAVE Partnership has developed the CARIBSAVE Climate Risk Atlas (CCCRA) that provides Climate Change Risk Profiles and "Snapshots" for a number of Caribbean States. These can be accessed at http://www.intasave.org/documents/Publications/Climate-Change-Science,-Policy-and-Practice/The-CARIBSAVE-Climate-Change-Risk-Atlas-(CCCRA). Climate Risk and Adaptation Country Profiles can also be accessed on the Climate Change Knowledge Portal http://sdwebx.worldbank.org/climateportalb/home.cfm?page=country_profile. These profiles provide relevant country data and information for disaster risk reduction and adaptation to climate change, providing a quick reference source for development practitioners to better integrate climate resilience in development planning and operations. Users are able to evaluate climate-related vulnerability and risks by interpreting climate and climate-related data at multiple levels of detail. Sources on climate and climate related information are linked through the country profiles' on-line platform, which is periodically updated to reflect the most recent publicly available climate analysis.

1.5.4 Challenges for the EIA Process

Many projects for which EIAs are required have relatively long life spans, that is, in excess of twenty years. These include physical infrastructure such as buildings, roads, airports and port and harbour facilities. It is therefore important to project how changing climate variables may influence the project and nearby resources, society and environment.

One of the most compelling reasons for considering climate change in EIAs is that every project is designed with some assumption about the climate in which it will function. The conventional approach to assume that the climate of the past is a reliable guide to the future is no longer a good assumption. Design criteria

[14] The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines.

[15] The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

must now be based on probable future climate, or the estimated climate change over the life of the project. Accordingly, EIAs of projects and activities should consider not only the effects of emissions, but also the impacts of impending climate-related changes on the project or activity. In addition to the traditional evaluation of the impacts of the project on the environment, the EIA process must also consider the impacts of the changing environment on the project. To properly assess the likely climate impact on a project, a Capacity and Vulnerability Assessment (CVA) is required, to systematically examine building elements, facilities, population groups or components of the economy to identify features that are susceptible to damage from the effects of natural hazards and climate change. Vulnerability is a function of the prevalent hazards and the characteristics and quantity of resources or population exposed (or "at risk") to their effects. Vulnerability can be estimated for individual structures, for specific sectors or for selected geographic areas.

As earlier noted, estimates of ranges of climate change impacts already exist. A description of the results of downscaling global models was provided in the previous section. Work continues in the region to develop climate scenarios that are specific to the Caribbean region. All these existing climate change scenarios, however, still contain some measure of uncertainty.

Section 2 Integrating natural hazards into the EIA process

2.0 Background

According to the World Bank, "EA is a process whose breadth, depth, and type of analysis depend on the nature, scale, and potential environmental impact of the proposed project. EA evaluates a project's potential environmental risks and impacts in its area of influence; examines project alternatives; identifies ways of improving project selection, siting, planning, design, and implementation by preventing, minimizing, mitigating, or compensating for adverse environmental impacts and enhancing positive impacts; and includes the process of mitigating and managing adverse environmental impacts throughout project implementation. EA takes into account the natural environment (air, water, and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples, and physical cultural resources); and transboundary and global environmental aspects. EA considers natural and social aspects in an integrated way. It also takes into account the variations in project and country conditions; the findings of country environmental studies; national environmental action plans; the country's overall policy framework, national legislation, and institutional capabilities related to the environment and social aspects; and obligations of the country, pertaining to project activities, under relevant international environmental treaties and agreements. EA is initiated as early as possible in project processing and is integrated closely with the economic, financial, institutional, social, and technical analyses of a proposed project" (World Bank, 2013).

Natural hazards are significant features of the environment in the Caribbean. Consideration of risk forms part of project evaluation through the project cycle, and hazard vulnerability analysis is an essential component of risk analysis for project viability and sustainability. Improved project selection, siting, planning, design, and implementation in vulnerable areas will be achieved through the application of the NHIA process, as the integration of appropriate hazard mitigation and climate adaptation planning and management mechanisms must be considered.

The EIA process provides a formal mechanism for inter-agency coordination and for addressing public concerns. A key factor affecting public acceptability of and support for any proposed development is the level and nature of public consultation that has been undertaken and the amount of public input obtained in the project design. To be effective, the EIA process should ensure transparency in all decision-making; provide timely, adequate and accurate information to the public; and facilitate public access to all relevant documents that are not confidential[16].

Although legislation and practice vary around the region and world, the fundamental components of an EIA would necessarily involve the following stages:

- Screening to determine which projects or developments require a full or partial impact assessment study;
- Scoping to identify which potential impacts are relevant to assess (based on legislative requirements, international conventions, expert knowledge and public involvement), to identify alternative solutions that avoid, mitigate or compensate adverse impacts (including the option of not proceeding with the development, finding alternative designs or sites which avoid the impacts, incorporating safeguards in the design of the project, or providing compensation for adverse impacts), and finally to derive terms of reference for the impact assessment;

[16] Confidentiality may be a concern in some instances, e.g. to protect a legitimate economic interest, the location of valuable cultural property, intellectual property rights, issues affecting international relations and national defense.

- Assessment and evaluation of impacts and development of alternatives, to predict and identify the likely environmental impacts of a proposed project or development, including the detailed elaboration of alternatives;
- Reporting the Environmental Impact Statement (EIS) or EIA report, including an environmental management plan (EMP), and a non-technical summary for the general audience.
- Review of the Environmental Impact Statement (EIS), based on the terms of reference (scoping) and public (including authority) participation.
- Decision-making on whether to approve the project or not, and under what conditions; and
- Monitoring, compliance, enforcement and environmental auditing. Monitor whether the predicted impacts and proposed impact (including hazard) mitigation measures occur as defined in the EMP. Verify the compliance of proponent with the EMP, to ensure that unpredicted impacts or failed impact (including hazard) mitigation measures are identified and addressed in a timely fashion (UNEP, date unknown).

Consideration of natural hazards creates few additional requirements when undertaking any EIA, and does not require any structural change to the overall EIA process. The key steps in the EIA process are presented in Figure 2.1, with natural hazard considerations are fully integrated. The following sections provide a step-by-step description of the generic EIA-NHIA process. The objective, process, information needs and responsibilities for implementation are presented for each step identified, including a discussion of the natural hazard considerations to be addressed in that step.

2.1 Step 1. Define project and alternatives

In most Caribbean countries, the planning legislation prescribes types of development for which EIA is required. The legislation also typically gives the planning agency the latitude to require an EIA for any development application, if deemed necessary by that agency. Such a decision would be based on the information submitted by the development applicant on the prescribed development application form. The format of the development application form varies across countries, but should require the following basic information to be provided:

- Location including a map
- Ownership
- Land use (existing and proposed)
- Development areas (plot size, proposed plot coverage)
- Land use and ownership of adjoining properties
- Physical setting (topography, geology, water bodies, coastline or protected areas within the area of influence)
- Biological resources (flora, fauna, protected species)
- Project/activity description including information on wastes, emissions, utility consumption, for all phases (construction, operational and de-commissioning)
- Project scope (time frame for construction, use and abandonment)
- Site preparation required
- Vulnerability to natural hazards and climate change (hazard history of the site)

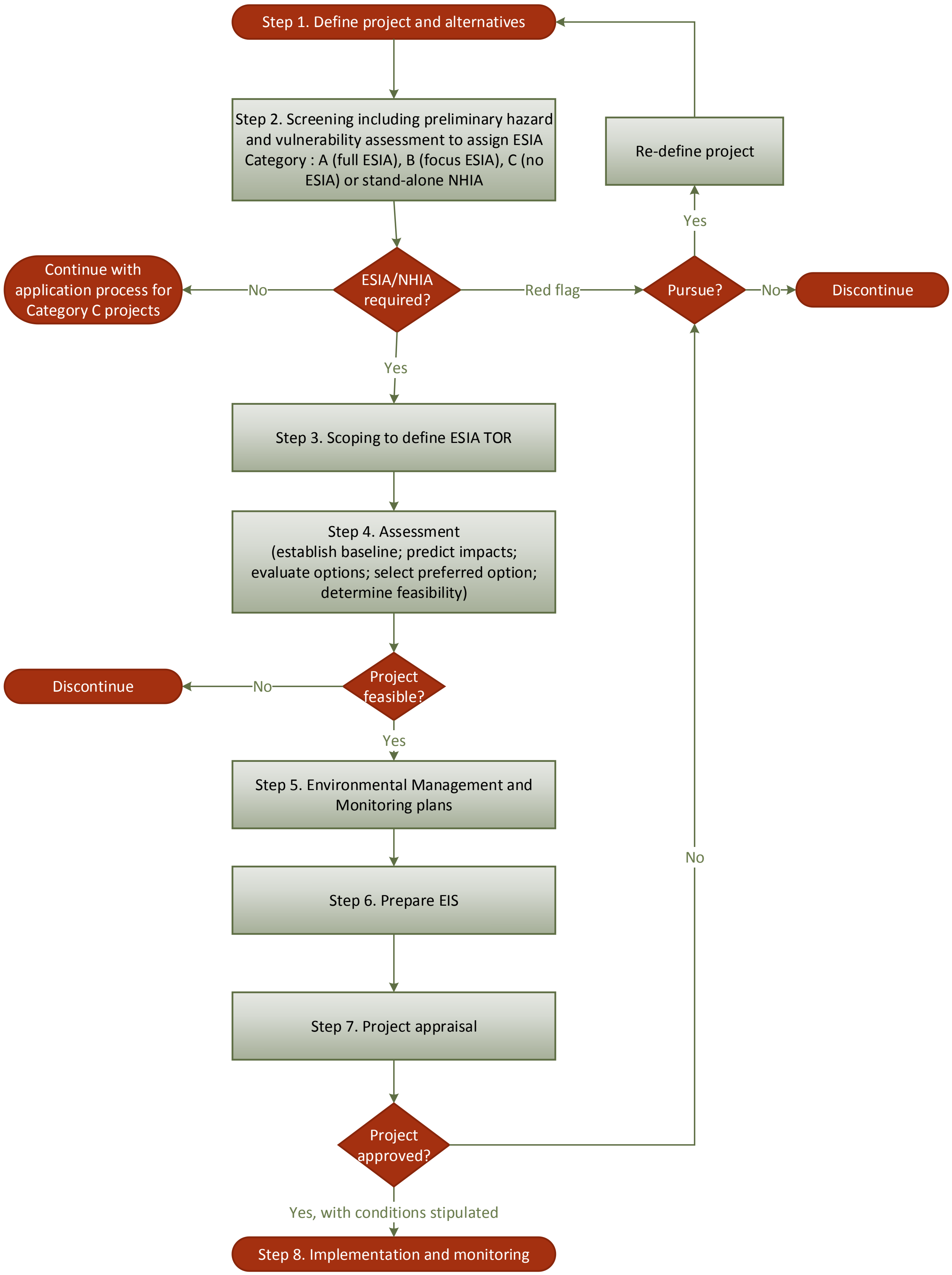

Figure 2.1. The generic EIA-NHIA process

The initial project information form is intended to provide the EIA reviewing agency with sufficient information to understand the range and complexity of environmental issues raised by the project and the project site. This will facilitate framing of the EIA so that time and resources are concentrated in areas where potential impacts are most significant. Typically, the first use of the information provided on a project information form is to determine if an EIA is required. While descriptions of the project and the project site are central components of all such forms, not all currently address NHIA requirements adequately, and additional details may be required to review the potential natural hazard impacts or vulnerabilities. If this is the case, existing forms should be amended to incorporate these NHIA considerations.

Table 2.1. EIA/NHIA Components of Step 1 (Project Definition)

	EIA	NHIA
Objective	Clearly describe proposed project, and identify alternatives to project and approaches to implementation.	Undertake preliminary identification of significant hazards and hazard impacts likely to affect this site.
Information needs	• Site information: location, environment, hazards, development and social setting • Characteristics of the proposed project—the site, structures and processes. • Project scope: spatial and temporal boundaries	• Prevalent hazards in project's zone of influence. • Climate scenarios. • Factors influencing hazard occurrence. • Disaster history. • Understanding of vulnerability to hazard impacts.
Process	Prepare project description and information on the site(s), as per requirements of review agency.	Using existing information and expert knowledge, estimate frequency or probability of hazard events (initial hazard identification). Estimate severity of impacts on project components and zone of influence (initial assessment of vulnerability).
Responsibility	Proponent.	Proponent.

2.2 Step 2. Screening to assign EIA category to development application

Screening is required to determine which projects or developments require a full or partial impact EIA. The EIA Administrator assigns the proposed project to an EIA category, reflecting the potential environmental and natural hazard risks associated with the project. This classification step determines whether an EIA is required and, if so, the level of impact assessment that must be undertaken.

The specific EIA categories and criteria for assignment of projects to these categories are defined in the EIA rules/regulations for each implementing jurisdiction. The following categories and criteria are applied by the CDB:

- Category A (Full EIA) for significant impacts: A proposed project is classified as Category A if it is highly likely to have significant adverse environmental impacts that are sensitive, diverse, or unprecedented.

  Natural hazard consideration:

  - Projects should also be assigned to Category A if the anticipated short- to mid-term impacts from natural hazards are highly likely to result in significant adverse social, economic, structural or environmental impacts. These impacts may affect an area broader than the site(s) or facility(s) subject to physical works.

- Category B (Focus EIA) for limited impacts: A proposed project is classified as Category B if its potential adverse environmental impacts on human populations or environmentally important areas are present, but less adverse than those of Category A projects.

  Natural hazard consideration:

  - Projects should also be assigned to Category B if the anticipated short- to mid-term impacts from natural hazards are likely to result in social, economic, structural or environmental impacts less adverse than those of Category A projects. These impacts are site-specific; few if any of them are irreversible; and natural hazard mitigation and climate change adaptation measures can be designed more readily than for Category A projects.

- Category C for minimal or no impacts: A proposed project is classified as Category C if it is likely to have minimal or no adverse environmental impacts, or minimal anticipated short, medium or long-term impacts from natural hazards. In such circumstances a detailed EIA report is seldom required.

There may be some cases where a traditional Category A or even Category B environmental assessment which explores the impact of a project on its surrounding environment is not required, but where a fuller hazards and vulnerability assessment which explores the impact of the environment on the project, is necessary because natural hazard events could have potentially significant adverse social, economic, structural or environmental impacts on the project. For instance, the construction of schools may have little impact on the environment but hazard-related safety concerns are paramount in building schools in hazard-prone areas (Provention Consortium in collaboration with CDB, 2007).

Note that, at this stage, these assessments are conducted using existing information from generally available sources and expert knowledge. This can be historical data, including regional and country-specific scientific studies and research papers, records of extra-regional countries and areas, and insurance company records. Such data should indicate how often particular risk scenarios have occurred in the past, and can be used to form a judgement as to the likelihood of their occurrence in the future, assuming a stable unchanging world. Table 2.2. summarises Screening components.

Table 2.2. EIA/NHIA Components of Step 2 (Screening)

	EIA	NHIA
Objective	Determine, based on information provided, whether the project is likely to have a significant effect on the environment, and therefore requires further study.	Determine, based on information provided, whether natural hazards are likely to have significant effects on the project (or vice versa), and therefore requires further study.
Information needs	Initial project description.	Output of initial hazard and vulnerability assessment.
Process	Using information from project description, assign appropriate EIA category based on frequency, probability and severity of impacts.	Using information from initial hazard and vulnerability assessment, assign appropriate NHIA category.
Responsibility	Reviewing agency.	Reviewing agency.

2.2.1 Initial hazard identification (qualitative analysis)

During initial screening of the project, the project team should undertake a preliminary hazard vulnerability assessment to identify and evaluate impacts of potential natural hazards on the project's area of influence. This preliminary assessment will typically be qualitative in nature. The purpose of this step is to gather sufficient information to inform the scoping step that follows. The following questions should be considered during any preliminary hazard vulnerability assessment, to be answered more fully during project preparation.

- What are the relevant natural hazard impacts that may affect the project?
- What, if any, project elements are likely to be affected significantly by natural hazards?

Hazards that have the potential to impact the project vicinity within the timeframe for project construction, use and abandonment must be identified (see Figure 2.2 below). Only those identified as significant will be investigated further in the EIA.

Hazard	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur
Hazards from risk scenario (deal with each separately)	Not likely to occur during the planning period	May occur sometime but not often during the planning period	Likely to occur at least once during the planning period	Likely to occur several times during the planning period	Happens often and will happen again during the planning period

Figure 2.2. Estimating Frequency or Probability of an Event[17]

The primary natural hazards in the Caribbean are described in Section 1.3. Each of these hazards should be considered during the initial hazard identification for potential impact on the project and its vicinity. Hazard maps are increasingly available throughout the region. Typical sources of hazard and hazard map information are provided in Annex 1[18].

For most areas, site-specific hazard maps do not exist. For the initial screening, available sources can be used to determine which hazards require further investigation. When collecting information, it is important to determine—whether qualitatively or quantitatively—both the potential magnitude and the frequency of occurrence of the hazard within the vicinity of the project site. Both aspects are important, as a frequently occurring hazard with moderate impacts can over time be more damaging than a less frequent hazard with higher impact.

In addition to the review of existing hazards, the initial hazard identification should consider possible hazard exacerbation as a result of the project. For instance, improper development in a floodplain or inappropriate cutting of a slope could introduce or exacerbate flooding or landslide hazards, respectively.

The longer lifespan of most projects also requires an assessment of project–climate relationships. For the purpose of undertaking the initial assessment of vulnerability to climate change, it is recommended that climate change projections by the IPCC be used, in conjunction with projections for the Caribbean region (see Section 1.5.2). The EIA analyst should research current developments in this area, as the IPCC will continue to publish current information, and regional downscaling will continue.

[17] Adapted from the Caribbean Risk Management Techniques for climate Change (ACCA, 2003).

[18] The original Sourcebook (2004) provided an inventory up to 2004 of existing hazard maps, vulnerability assessments and data, in its Annexes 2 and 5. These have not been reproduced here.

2.2.2 Initial Assessment of Vulnerability (qualitative analysis)

Once the hazards of potential concern to the project have been identified, the vulnerability of the project and project components to the impacts of these hazards must be reviewed. This evaluation will identify project and ecosystem components that are at high risk to impacts from natural hazards. This determination involves the identification of key project elements and projected impacts from natural hazards in and around the project area of influence. Vulnerability of project components must be reviewed against all hazards identified in the previous step as having potentially significant impacts.

A matrix similar to that provided in Figure 2.3 for estimating severity of the impacts can be used to identify project and ecosystem components that are at high risk to impacts from natural hazards that would warrant further quantification in the EIA. The information requirements for completing this matrix will determine the level of information to be collected in the initial hazard identification.

Degree of Severity	Impact				Economic Factors			Environmental Factors			
	Displacement	Health	Loss of Livelihood	Cultural Aspects	Property Loss	Financial Loss	GDP Impact	Air	Water	Land	Eco-systems
Very low											
Low											
Moderate											
Major											
Extreme											

Figure 2.3: Typical impact severity rating matrix[19] Note: Estimating severity usually focuses on determining the potential health, property damage, environmental or financial impacts of risk scenarios. The EIA team can choose to include any criteria that best expresses the potential impacts specific to the project under consideration in measurable terms. The impact severity rating scale developed should be appropriate to the risk criteria selected. The team needs to be cognizant that vulnerability varies substantially by sector and region within countries and also by socio-economic group. This risk evaluation will help identify high risk/impact projects that require detailed study. To evaluate and review the impacts of natural hazards and climate change on any project as part of the screening process, the EIA team should have access to persons knowledgeable about natural hazards and climate change.

Specific project components to be screened for impact will be determined by the project type, location and expected type(s) of impacts, whether social, physical and/or economic. Due to the variety of elements and impacts to review in vulnerability assessment, it is not possible to develop one standard vulnerability assessment methodology.

To evaluate the impacts of natural hazards on any project as part of the screening process, a risk management approach as described below should then be applied[20]. Once the frequency/probability of a hazard (Figure 2.2) and severity of likely impacts (Figure 2.3) have been estimated, a risk assessment matrix such as the one shown in Figure 2.4 below can be used to determine the significance of the potential hazard impacts for a project. An acceptability level is assigned to each based on the scale used by your risk management team.

The following activities may be conducted to inform the risk assessment:

- Estimate the costs of the impacts and any benefits that may be apparent. For example, if reduced water availability may make it too costly to irrigate a golf course, there will be costs in lost tourist patronage of the golf course. If the golf course closes, there may be benefits to the community if the land reverts to residential housing.
- Consider and analyse perceptions of key stakeholders, including the general public.

[19] Adapted from the Caribbean Risk Management Techniques for climate Change (ACCA, 2003).
[20] Extracted from Caribbean Risk Management Techniques for Climate Change (ACCC 2003).

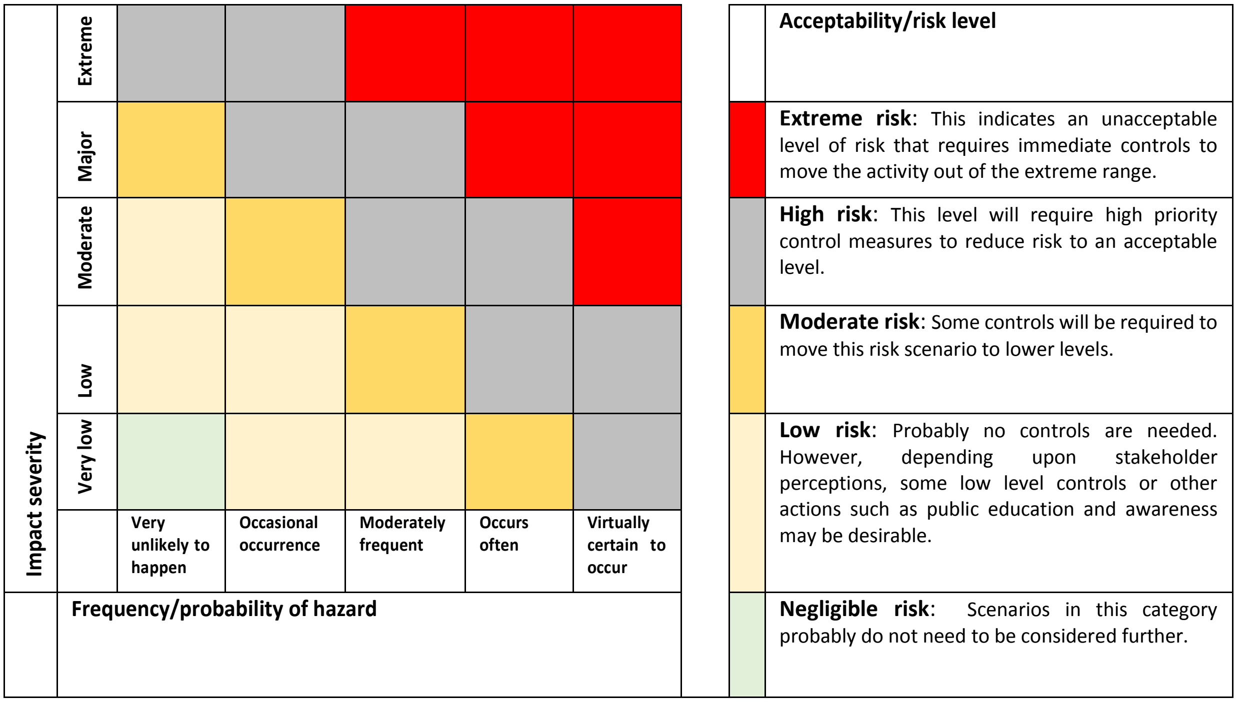

Figure 2.4. Risk Assessment Matrix

- Assess the acceptability of risks, cost, benefits etc. to stakeholders (government agencies, communities, economic sectors, etc.). Remember that people who deal regularly with risks view them differently from laypersons. This makes an interactive dialogue with stakeholders very important at this step to accurately determine the level of acceptability of the risk to the various stakeholder groups.
- Increase the dialogue with key stakeholders and begin to identify risk control, avoidance or prevention strategies that may be used to mitigate unacceptable risks.
- Document all important information.

Figure 2.5 illustrates the elements of risk assessment for climate change considerations. The Caribbean Climate Online Risk and Adaptation tooL (CCORAL) tool developed by CCCCC supports risk analysis and development of climate change adaptation measures for policies, programmes and plans. It provides guidance and links to relevant resources for each step of the analysis.

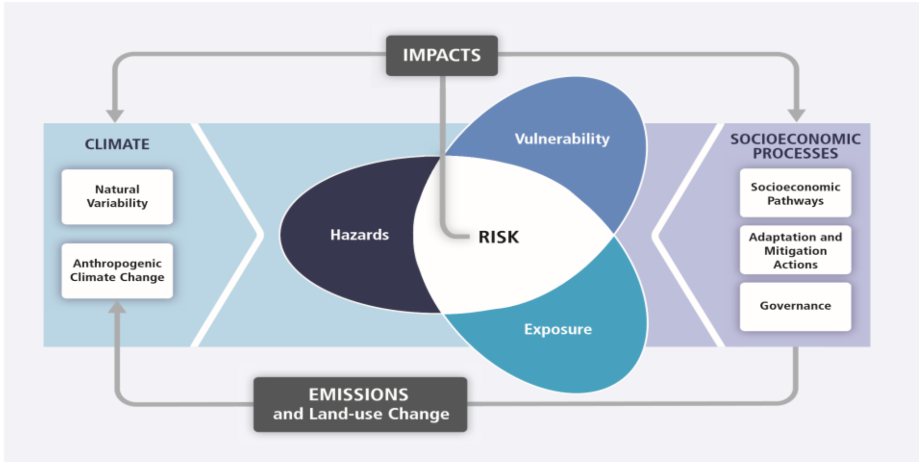

Figure 2.5. Illustration of the core concepts of the WGII AR5. Risk of climate-related impacts results from the interaction of climate related hazards (including hazardous events and trends) with the vulnerability and exposure of human and natural systems. Changes in both the climate system (left) and socioeconomic processes including climate change adaptation and climate change mitigation (right) are drivers of hazards, exposure, and vulnerability. Extracted from IPCC 2014.

The purpose of this particular exercise is to determine the relative frequency with which the various risk scenarios can be expected to occur over a given period of time. Hazards and impacts that are identified as low to medium risk would not require further assessment. Note that a low-impact or low-frequency hazard or impact does not automatically mean that the hazard or impact will be classified as low risk. Both low-impact but frequently occurring hazards and low-frequency but high impact hazards can be costly and destructive. The matrices provided assist with identifying all hazards and impacts that should be investigated further.

Upon conclusion of this step, the EIA Administrator records:

1. activities required to ensure compliance of the proposed project with existing environmental and development control regulations and legislation;
2. key environmental issues (including resettlement, impacts on the lives of indigenous peoples, and concerns about cultural assets);
3. anticipated natural hazard and short, medium and long term climate change impacts;
4. the project EIA category and the type of EIA/NHIA needed; and
5. recommended consultation with project-affected groups and other stakeholders.

2.3 Step 3 Scoping (Category A and Category B Study)

The purpose of the scoping step is to agree on the issues to be investigated in the EIA and on the scope of work (or terms of reference) to carry out those investigations. The terms of reference then serve as the roadmap for the actual work on the EIA, identify and prioritise significant impacts for assessment, and determine the resources and expertise required to undertake it. Guidelines for EIA should explicitly mention:

1. Vulnerability of projects to natural hazards, and

2. The disaster-related implications of particular environmental consequences of a project, for example, the implications of effects on forest and vegetation for the availability of water supplies (see Box 2.1).

Box 2.1. Sectoral checklists[21]

Many environmental assessment guidelines include checklists of environmental sustainability issues that could be relevant in assessing particular types of development intervention. The following list provides some examples pertaining to disaster risk that should be considered in undertaking environmental assessments of projects in hazard-prone areas:

- *Energy.* Impact of hydropower projects on natural water flow and flooding patterns.
- *Transport*. Impact of road construction and associated infrastructure on drainage systems and flooding patterns.
- *Urban development.* Impact of development on the capacity of services and utilities to prevent increased risk of flooding as could occur if, say, drainage systems are inadequate or refuse collection services are limited, resulting in dumping of garbage in drainage systems or waterways.
- *Mining*. Implications for droughts and floods of impact of mining operations on level of groundwater.
- *Agriculture.* Impact on soil erosion and consequences for levels of water retention, downstream siltation and flooding. Resilience of proposed projects in the event of rainfall deficits. Impact of proposed projects on the capacity of the local population to spread disaster-related and other risks.

If disaster risks are significant or the proposed project is likely to have a significant impact on vulnerability to natural hazards, further information and any related analysis required to inform the environmental assessment (or a fuller stand-alone hazards and vulnerability assessment if necessary) and to provide baseline data for subsequent monitoring and evaluation should then be identified (Provention Consortium in collaboration with CDB, 2007).

See Table 2.3 for requisite components of this step for the EIA and NHIA.

Table 2.3. EIA/NHIA Components of Step 3 (Scoping)

	EIA	NHIA
Objective	Identify and agree upon the critical issues to be addressed in the EIA and the information and analyses required for inclusion in the EIS to determine acceptability and feasibility of the project.	Identify and agree upon the critical issues to be addressed in the NHIA and the information and analyses required for inclusion in the EIS to determine acceptability and feasibility of the project.
Information needs	• Baseline data on project site. • Relevant legislation and institutions.	• Baseline hazard data on the project site. • Information on significant hazards and their potential impacts on the project. • Climate change assessments. Zone of influence/project boundaries identified in screening.
Process	Specify analyses that must be conducted to complete project assessment. Agree on the terms of reference/scope of work for the impact assessment.	Identify information needs regarding significant hazards and vulnerabilities.
Responsibility	Reviewing agency.	Reviewing agency.

[21] Adapted from Provention Consortium with CDB (2007).

In this “scoping” stage of the EIA process, agreement should be reached on the following aspects:

- Project Description and Definition of Spatial Boundaries – the definition of the project and its area of influence;
- Definition of Other Project Boundaries – the identification of temporal boundaries affecting project activities over the entire life cycle of the project (including time frame for natural hazard impacts that are to be evaluated), and the identification of regulatory, legislative, administrative and customary aspects affecting the project or project activities;
- Baseline Environmental Setting – data to be collected and monitored for the identification of ecological, climatic, cultural and social features relevant to the spatial and temporal boundaries of project activities;
- Natural Hazard Risk – data to be collected for the identification of natural hazards likely to impact the project area;
- Climate Change Scenario – where climate change has been identified as potentially impacting the project, projected climate change impacts must be determined for use in the detailed assessment; and
- Stakeholder involvement – the guidelines for stakeholder involvement, including frequency and kinds of involvement should be included in the scoping discussions.

A generic terms of reference with natural hazard considerations included is presented in Annex 2. These TOR are adapted from the generic draft terms of reference for an environmental impact statement (Statewide Environmental Assessments Unit, Department of Environment and Heritage Protection, State of Queensland, 2013).

2.4 Step 4 Assessment (Category A and Category B Study)

This step is guided by the EIA TOR developed during the scoping exercise. All EIAs are required to:

i. examine the project’s potential negative and positive environmental impacts (from construction through operations and decommissioning if relevant), compare them with those of feasible alternatives (including the “without project” situation), and recommend any measures needed to prevent, minimise, mitigate, or compensate for adverse impacts and improve environmental performance; and

ii. identify short, medium and long-term natural hazard impacts, evaluate social, economic, structural or environmental impacts arising from natural hazards, identify and evaluate appropriate hazard mitigation, climate change adaptation and management mechanisms, and recommend any measures needed to adapt (prevent, minimize or mitigate) or compensate for adverse natural hazard impacts.

See Table 2.4 for requisite components of this step for the EIA and NHIA.

Baseline and vulnerability information is used to determine if the potential impacts of the project and of natural hazards on the project are acceptable. Where these impacts are determined to be unacceptable, impact mitigation (including climate change adaptation) options must be identified to bring the impacts into an acceptable range. A preferred alternative that incorporates appropriate hazard mitigation and climate change adaptation options can then be developed and its feasibility determined. This is an iterative process that may be revisited multiple times before arriving at an acceptable preferred alternative, as once new hazard mitigation and climate change adaptation options are integrated into the project design, it will be necessary to revise the likely project impacts and its feasibility.

Table 2.4 EIA/NHIA Components of Step 4 (Assessment)

	EIA	NHIA
Objective	Fully assess potential environmental impacts of the project in the project area of influence and develop impact mitigation options.	Fully assess and characterise significant natural hazards, their potential impact on the project and potential effects of the project on hazards/hazard vulnerabilities in the project area of influence. Develop appropriate hazard impact mitigation options.
Information needs	Baseline data. Project options.	Hazard studies and maps indicating past incidence. Factors influencing hazard occurrence. Climate change scenarios.
Process	Establish baseline. Predict impacts. Evaluate environmental impact mitigation options. Select preferred alternative. Determine feasibility. Identify residual impacts.	Establish baseline. Predict impacts. Evaluate hazard impact mitigation and climate change adaptation options. Select preferred alternative. Determine feasibility. Identify residual impacts.
Responsibility	Proponent to undertake assessment using specialists (ecologists, engineers, sociologists), as appropriate.	Proponent to undertake assessment, including detailed vulnerability assessment, using specialists (engineers, climate experts), as appropriate.

Baseline and vulnerability information is used to determine if the potential impacts of the project and of natural hazards on the project are acceptable. Where these impacts are determined to be unacceptable, impact mitigation (including climate change adaptation) options must be identified to bring the impacts into an acceptable range. A preferred alternative that incorporates appropriate hazard mitigation and climate change adaptation options can then be developed and its feasibility determined. This is an iterative process that may be revisited multiple times before arriving at an acceptable preferred alternative, as once new hazard mitigation and climate change adaptation options are integrated into the project design, it will be necessary to revise the likely project impacts and its feasibility.

2.4.1 Establish baseline

A database of information is required to support the impact assessment. This includes a detailed description and characterization of the physical environment including natural hazards. Natural hazards likely to have a significant impact will have been identified during the screening step. Where they exist, some of this information should already be contained in country environmental analyses (Box 2.2) and relevant strategic environmental assessments (Box 2.3) (Provention Consortium with CDB (2007).

Detailed hazard assessment and mapping should be undertaken for these, according to existing best practice for the given hazard, taking into account relevant climate change modelling (e.g., how a rise in sea level might affect storm surges or how changes in precipitation might affect drought and flooding). Sources identified in Annex 1 should be explored for available hazard information. Depending on the type of hazard and the potential significance of the impacts, information available from such sources may be insufficient as a basis for design. Where relevant, findings of existing mathematical and computer-based hazard modelling exercises in the project area (for instance, modelling of earthquake, flood or windstorm scenarios) should be drawn upon. Such exercises, if lacking, should be undertaken for large projects in high-risk areas, using appropriate expertise to undertake site specific modeling. For example, a high value coastal development will require the input of a coastal engineer to model and map wave heights, storm surge and coastal erosion for storms of different return periods and different climate change scenarios.

The impact of the proposed development on the hazard should also be modeled, to inform the assessment of how the project will affect hazard impacts on adjacent existing and proposed development.

Box 2.2. Country environmental analysis[22]

Country environmental analysis (CEA) is a relatively new analytical tool that a number of multilateral and bilateral development organisations are beginning to apply, in particular to inform overall country programming. CEA provides systematic analysis of:

- key environmental issues most critical to the sustained development of a country and the achievement of the Millennium Development Goals and opportunities for overcoming constraints;
- the environmental implications of key development policies; and
- a country's environmental management capacity and performance.

The tool was developed in response to increasing focus on mainstreaming environmental issues into development policies and planning.

CEA provides an important opportunity to highlight disaster risks, where significant, and helps ensure that they are adequately addressed. All CEAs should include collation of basic hazard data and background information on past disaster losses to give a preliminary overview of the significance of disaster risk in a country and to provide information that can be drawn upon both in undertaking environmental assessment of individual projects and in country programming. United Nations Development Programme (UNDP) environmental guidelines, for instance, indicate that country environmental reviews should include baseline data on rainfall, climate, temperatures, seismic faults, cyclones and droughts.

Box 2.3. Strategic environmental assessment[23]

Strategic environmental assessment (SEA) is a tool for the integration of environmental considerations into policies, plans and programmes at the earliest stages of decision-making. SEA seeks to ensure that broad environmental considerations are integrated into these higher, strategic levels of decision-making taken prior to the identification and design of individual projects, ideally based in part on a participatory process. SEA is applied in some form by many multilateral and bilateral organisations and also by a number of governments. At the country programming level, it is sometimes referred to as CEA (see Box 2.2).

Like CEA, SEA can provide an important opportunity to highlight natural hazard-related issues, where relevant, and ensure that they are adequately addressed. SEA is also a potentially important tool in ensuring that adequate attention is paid to disaster risk in the design of policies, in particular since SEA should include the prioritisation of environmental issues in terms of their effect on economic development and poverty reduction. In hazard-prone countries, disaster and related risks can be a critical factor determining progress in both economic development and poverty reduction.

2.4.2 Predict impacts

Once the expected location, frequency and severity of hazard events have been determined for hazards of significance at the project site (baseline), the expected impacts need to be identified. Consider the potential effects of the project (during construction, operation and, if relevant, decommissioning) on the frequency, intensity and consequences of significant natural hazards and the impact of these hazards, in

[22] Adapted from Provention Consortium with CDB (2007).

[23] Adapted from Provention Consortium with CDB (2007).

turn, on the project. This requires a vulnerability assessment of the elements of concern in relation to the various hazards.

Vulnerability is determined by the characteristics of the potential vulnerable features, which may include:

- The proposed project itself
- Existing or proposed development in the vicinity (e.g. neighbouring users, critical facilities, settlements)
- Natural resources

Separate vulnerability assessments may be required for each hazard if a site is subject to multiple hazards, as the vulnerability of any one element will vary with hazards. Location of the element of concern is an important component in all types of vulnerability assessments. The type of vulnerability assessment will also vary depending on the nature of the project. The vulnerability of a structure will be structural, with determinants such as building design, materials and maintenance factored into the assessment. A community project will more likely require human or economic vulnerability assessments that factor in considerations such as demographics, strength of community organisations or local hazard awareness.

The preliminary hazard and vulnerability assessments undertaken earlier as part of the screening will be advanced. From an environmental perspective, the detailed vulnerability assessment should pay particular regard to the expected impact of the project on environmental factors identified as key determinants of any rising or falling underlying trends in vulnerability to natural hazards in the project area. Certain other aspects of the vulnerability assessment may be undertaken in part under other forms of project appraisal, such as engineering design, social impact assessment and economic analysis, as relevant. In such cases, the EIA team should be responsible for undertaking the initial screening process to determine what assessment is required and for providing relevant hazard information to the other appraisal teams. In other cases, vulnerability analysis from these other perspectives may be incorporated within the EIA process (Provention with CDB, 2007).

Consultation with stakeholders should also pursue information on natural hazards and related vulnerability. Even from a purely environmental perspective, vulnerability can be highly localised and it is, therefore, essential to obtain the views of the local community. Perceptions of risk can also influence behaviour, making it important to consult different stakeholders (Provention with CDB, 2007).

Climate change will affect hydro-meteorological hazards, and the recommended approach for impact prediction is:

- Predict impacts based on historical information and known trends.
- Analyse how climate change may affect these impacts e.g. how sea level rise will affect storm surge impacts; how changes is rainfall patterns will affect flooding or drought. If climate change impacts are likely to be significant, and the investment is sufficiently important, the input of a climate change expert should be sought, to downscale project-relevant climate change scenarios.

For multi-hazards, or hazards exacerbated by climate change, the potential for cumulative impacts should be assessed (see Section 3).

This more detailed vulnerability assessment will guide the selection of appropriate environmental and natural hazard mitigation, and climate change adaptation measures. Refer to Annex 3 for some publications that provide further guidance in risk assessment.

2.4.3 Evaluate hazard mitigation and climate change adaptation options

Environmental and natural hazard mitigation measures are selected to reduce the identified risks to an acceptable level. Natural hazard risk reduction measures can lower physical, social and environmental vulnerability by reducing either the magnitude or the frequency of hazard impacts. As shown in Fig 2.6, this is an iterative process, repeated until the risk is acceptable. This increases protection for people and property, minimizes dislocation, and reduces the costs of dislocation, loss of business, response and recovery.

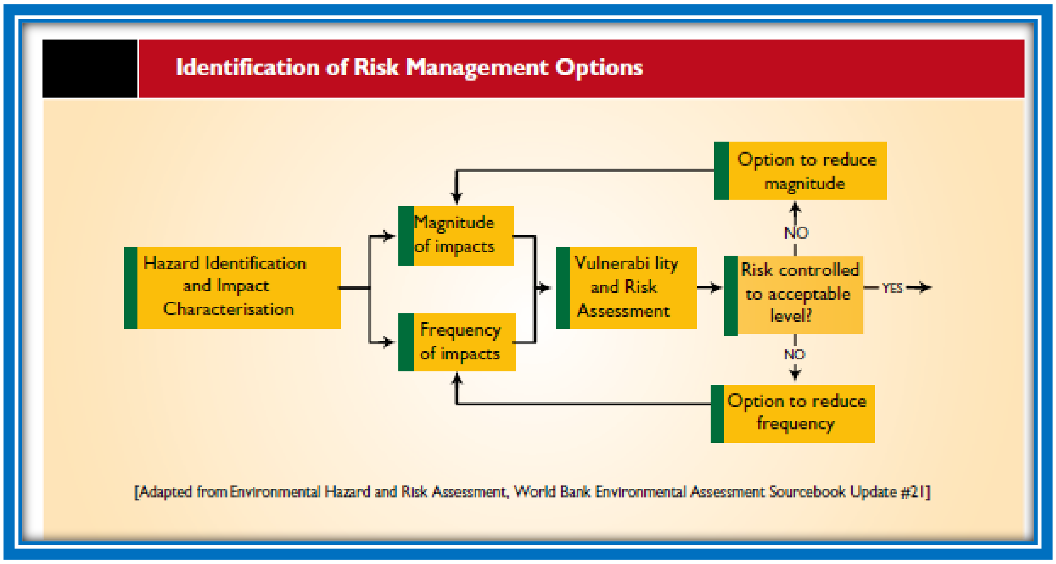

Figure 2.6. Identification of risk management options

Physical risk reduction measures include structural and non-structural measures such as re-design and relocation. Socio-economic measures strengthen the surrounding community's ability to respond to hazard impacts. Environmental risk reduction measures are designed to protect or strengthen the environmental systems that buffer or reduce the impact of natural hazards. Policy, legal and institutional options should also be considered.

Mitigation measures identified during environmental assessment, should ideally:

1. Enhance disaster management capabilities
2. Reduce hazard vulnerability of both people and economies
3. Include contingency plans to restore ecological resources
4. Maintain livelihood resources and ecological stability
5. Halt or reverse environmental degradation

(Provention Consortium in collaboration with CDB, 2007).The World Bank favors preventive measures over mitigatory or compensatory measures, whenever feasible (World Bank, 2013).

If climate change is expected to have a significant impact on the project, a project climate change adaptation plan should be developed to address such impacts on the project and its area of influence. This plan should be consistent with the National Climate Change Adaptation Policy and Plan formulated pursuant to the requirements of the United National Framework Convention on Climate change (UNFCC). Consultation with the National Climate Change Focal Point and affected communities may also add value. Nurse *et al* (2014) reported that:

- Adaptation to climate change generates larger benefit to small islands when delivered in conjunction with other development activities, such as disaster risk reduction and community-based approaches to development (medium confidence). Addressing the critical social, economic, and environmental issues of the day, raising awareness, and communicating future risks to local communities will likely increase human and environmental resilience to the longer term impacts of climate change.

- Climate change adaptation and climate change mitigation on small islands are not always trade-offs, but can be regarded as complementary components in the response to climate change (medium confidence). Examples of climate change adaptation-mitigation interlinkages in small islands include energy supply and use, tourism infrastructure and activities, and functions and services associated with coastal wetlands. Lessons learned from adaptation and mitigation experiences in one island may offer some guidance to other small island states, but diverse cultural, socioeconomic, ecological, and political values must be taken into account.

- The ability of small islands to undertake climate change adaptation and mitigation programs, and their effectiveness, can be substantially strengthened through appropriate assistance from the international community (medium confidence). However, such assistance should not drive the climate change agenda in small islands, as critical challenges confronting island governments and communities may not be addressed. Opportunities for effective adaptation can be found by, for example, empowering communities and optimizing the benefits of local practices that have proven to be efficacious through time, and working synergistically to progress development agendas.

Table 2.5 below identifies key regional climate risks (identified with *medium* to *high confidence)* and potential for adaptation. Regions presented here are Central and South American, Small Islands and Oceans. This is extracted from Field et al (2014). Refer to Annex 3 for some publications that provide further guidance in identification of adaptation options.

Adaptation is place- and context-specific. Appropriate risk reduction approaches will vary across all settings, in consideration of the dynamics of vulnerability and exposure, and their linkages with socioeconomic processes, sustainable development, and climate change. Examples of responses to climate change are presented in Table 2.6 (adapted from Field et al, 2014).

2.4.4 Select preferred alternative

The foregoing analyses will throw up a number of alternatives for consideration. All should meet the minimum applicable standards. Residual impacts should be assessed for each alternative.

The alternative finally selected should ideally result in:

- Least social/environmental impact
- Reduced vulnerability to natural hazards
- Satisfactory mitigation of natural hazard impacts, and adaptation to climate change.

The impact rating matrix provided in Section 2.2.2 can be used to compare the performance of the various alternatives under consideration *vis a vis* natural hazard impacts. The public should be consulted in selection of the preferred alternative.

Table 2.5. Key regional risks from climate change and the potential for reducing risks through adaptation and mitigation. Adapted from Assessment Box SPM.2 Table 1[24] (IPCC, 2014). For an extended summary of regional risks and potential benefits, see the Technical Summary Section B-3 and WGII AR5 Part B: Regional Aspects. (Field et al, 2014).

Key Risk	Adaptation issues and prospects	Climatic drivers	Timeframe	Risk and potential for adaptation (low =1; high =10)
CENTRAL AND SOUTH AMERICA				
Water availability in semi-arid and glacier melt dependent regions and Central America; flooding and landslides in urban and rural areas due to extreme precipitation *(high confidence)* [27.3]	• Integrated water resource management. • Urban and rural flood management (including infrastructural systems, better weather and runoff forecasts, and infectious disease control).	Warming trend Drying trend Snow cover Extreme precipitation	Present	Risk level with current adaptation:5 Risk level with high adaptation:3
			Near term (2030 – 2040)	Risk level with current adaptation:7 Risk level with high adaptation:5
			Long term (2080-2100) **2°C**	Risk level with current adaptation:9 Risk level with high adaptation:7
			Long term (2080-2100) **4°C**	Risk level with current adaptation:10 Risk level with high adaptation:8
Decreased food production and food quality *(medium confidence)* [27.3]	• Development of new crop varieties more adapted to climate change (temperature and drought). • Offsetting of human and animal health impacts of reduced food quality. • Offsetting of economic impacts of land-use change.	Extreme temperature Carbon dioxide fertilization Extreme precipitation Precipitation	Present	Risk level with current adaptation:7 Risk level with high adaptation:5
			Near term (2030 – 2040)	Risk level with current adaptation:9 Risk level with high adaptation:5

[24] Identification of key risks was based on expert judgment using the following specific criteria: large magnitude, high probability, or irreversibility of impacts; timing of impacts; persistent vulnerability or exposure contributing to risks; or limited potential to reduce risks through climate change adaptation or climate change mitigation. Each key risk is characterized as very low to very high for three timeframes: the present, near term (2030–2040), and longer term (2080–2100). In the near term, projected levels of global mean temperature increase do not diverge substantially for different emission scenarios. The risk levels integrate probability and consequence over the widest possible range of potential outcomes, based on available literature. These potential outcomes result from the interaction of climate-related hazards, vulnerability, and exposure. Each risk level reflects total risk from climatic and non-climatic factors. Key risks and risk levels vary across regions and over time, given differing socioeconomic development pathways, vulnerability and exposure to hazards, adaptive capacity, and risk perceptions. Risk levels are not necessarily comparable, especially across regions, because the assessment considers potential impacts and adaptation in different physical, biological, and human systems across diverse contexts. This assessment of risks acknowledges the importance of differences in values and objectives in interpretation of the assessed risk levels. For the longer term, risk levels are presented for two scenarios of global mean temperature increase (2°C and 4°C above preindustrial levels). These scenarios illustrate the potential for climate change mitigation and adaptation to reduce the risks related to climate change (IPCC, 2014)

Key Risk	Adaptation issues and prospects	Climatic drivers	Timeframe	Risk and potential for adaptation (low =1; high =10)
	• Strengthening traditional indigenous knowledge systems and practices.		Long term (2080-2100) **2ºC**	Risk level with current adaptation:9 Risk level with high adaptation:5
			Long term (2080-2100) **4ºC**	Risk level with current adaptation:10 Risk level with high adaptation:6
Spread of vector-borne diseases in altitude and latitude *(high confidence)*	• Development of early warning systems for disease control and climate change mitigation based on climatic and other relevant inputs. Many factors augment vulnerability. • Establishing programs to extend basic public health services.	Warming trend Extreme precipitation Extreme temperature Precipitation	Present	Risk level with current adaptation:9 Risk level with high adaptation:5
			Near term (2030 - 2040)	Risk level with current adaptation:9 Risk level with high adaptation:5
			Long term (2080-2100) **2ºC**	Risk level with current adaptation: not available Risk level with high adaptation: not available
			Long term (2080-2100) **4ºC**	Risk level with current adaptation: not available Risk level with high adaptation: not available
SMALL ISLANDS				
Loss if livelihoods, coastal settlements, infrastructure, ecosystem services, and economic stability (*high confidence)*	• Significant potential exists for adaptation in islands, but additional external resources and technologies will enhance response. • Maintenance and enhancement of ecosystem functions and services, and of water and food security. • Efficacy of traditional community coping strategies is expected to be substantially reduced in the future.	Drying trend Sea level Extreme precipitation Ocean acidification Damaging cyclone	Present	Risk level with current adaptation:3 Risk level with high adaptation:1
			Near term (2030 – 2040)	Risk level with current adaptation:5 Risk level with high adaptation:3
			Long term (2080-2100) **2ºC**	Risk level with current adaptation:7 Risk level with high adaptation:5
			Long term (2080-2100) **4ºC**	Risk level with current adaptation:9 Risk level with high adaptation:7
The interaction		Sea level	Present	Risk level with current

Key Risk	Adaptation issues and prospects	Climatic drivers	Timeframe	Risk and potential for adaptation (low =1; high =10)
of rising global mean sea level in the 21st century with high water level events will threaten low-lying coastal areas *(high confidence)*	• High ratio of coastal area to land mass will make adaptation a significant financial and resource challenge for islands. • Adaptation options include maintenance and restoration of coastal landforms and ecosystems, improved management of sols and freshwater resources, and appropriate building codes and settlement patterns.	Damaging cyclone		adaptation:5 Risk level with high adaptation:3
			Near term (2030 – 2040)	Risk level with current adaptation:7 Risk level with high adaptation:5
			Long term (2080-2100) **2°C**	Risk level with current adaptation:9 Risk level with high adaptation:7
			Long term (2080-2100) **4°C**	Risk level with current adaptation:10 Risk level with high adaptation:8
		THE OCEAN		
Distributional shift in fish and invertebrate species, and decrease in fisheries catch potential at low latitudes, e.g. in equatorial upwelling and coastal boundary systems and sub-tropical gyres *(high confidence)*	• Evolutionary adaptation potential of fish and invertebrate species to warming is limited as indicated by their changes in distribution to maintain temperatures. • Human adaptation options: large scale translocation of industrial fishing activities following the regional decreases (low latitudes) vs. possibly transient increases (high latitudes) in catch potential; Flexible management that can react to variability and change; Improvement of fish resilience to thermal stress by reducing other stressors such as pollution and eutrophication; Expansion of sustainable aquaculture and development of alternative livelihoods in some regions.	Warming trend Extreme temperature	Present	Risk level with current adaptation:3 Risk level with high adaptation:3
			Near term (2030 – 2040)	Risk level with current adaptation:5 Risk level with high adaptation:4
			Long term (2080-2100) **2°C**	Risk level with current adaptation:5 Risk level with high adaptation:4
			Long term (2080-2100) **4°C**	Risk level with current adaptation:7 Risk level with high adaptation:6
Reduced biodiversity, fisheries abundance, and coastal	• Evidence of rapid evolution by corals is very limited. Some corals may migrate to higher latitudes, but entire reef systems are not expected to	Warming trend Extreme temperature	Present	Risk level with current adaptation:5 Risk level with high adaptation:4

Key Risk	Adaptation issues and prospects	Climatic drivers	Timeframe	Risk and potential for adaptation (low =1; high =10)
protection by coral reefs due to heat-induced mass coral bleaching and mortality increases, exacerbated by ocean acidification, e.g. in coastal boundary systems and sub-tropical gyres *(high confidence)*	be able to track the high rates of temperature shifts. • Human adaptation options are limited to reducing other stresses, mainly by enhancing water quality, and limiting pressures from tourism and fishing. These options will delay human impacts of climate change by several decades but their efficacy will be severely reduced as thermal stress increases.	Damaging cyclone Ocean acidification	Near term (2030 – 2040)	Risk level with current adaptation:7 Risk level with high adaptation:7
			Long term (2080-2100) **2°C**	Risk level with current adaptation:9 Risk level with high adaptation:9
			Long term (2080-2100) **4°C**	Risk level with current adaptation:10 Risk level with high adaptation:10
Coastal inundation and habitat loss due to sea level rise, extreme events, changes in precipitation, and reduced ecological resilience, e.g. in coastal boundary systems and sub-tropical gyres *(high confidence)*	• Human adaptation options are limited to reducing other stresses, mainly by reducing pollution and limiting pressures from tourism, fishing, physical destruction and unsustainable aquaculture. • Reducing deforestation and increasing reforestation of river catchments and coastal areas to retain sediments and nutrients. • Increased mangrove, coral reef, and sea grass protection, and restoration to protect numerous ecosystem goods and services such as coastal protection, tourist value, and fish habitat	Warming trend Damaging cyclone Ocean acidification Sea level Extreme precipitation	Present	Risk level with current adaptation:5 Risk level with high adaptation:4
			Near term (2030 – 2040)	Risk level with current adaptation:7 Risk level with high adaptation:5
			Long term (2080-2100) **2°C**	Risk level with current adaptation:7 Risk level with high adaptation:5
			Long term (2080-2100) **4°C**	Risk level with current adaptation:9 Risk level with high adaptation:7

Table 2.6. Approaches for managing the risks of climate change. Adapted from Table SPM.1 (Field et al, 2014).
Note: These adaptation approaches should be considered overlapping rather than discrete, and they are often pursued simultaneously. Examples are presented in no specific order and can be relevant to more than one category (Field et al, 2014).

Overlapping Approaches	Category	Examples	Chapter References (IPCC, 2014)
Vulnerability and Exposure Reduction through development, planning, and practices including many low-regrets measures	Human development	Improved access to education, nutrition, health facilities, energy, safe housing & settlement structures, & social support structures; Reduced gender inequality & marginalization in other forms.	8.3, 9.3, 13.1-3, 14.2-3, 22.4
	Poverty alleviation	Improved access to & control of local resources; Land tenure; Disaster risk reduction; Social safety nets & social protection; Insurance schemes.	8.3-4, 9.3, 13.1-3
	Livelihood security	Income, asset, & livelihood diversification; Improved infrastructure; Access to technology & decision making fora; Increased decision-making power; Changed cropping, livestock, & aquaculture practices; Reliance on social networks.	7.5, 9.4, 13.1-3, 22.3-4, 23.4, 26.5, 27.3, 29.6, Table SM24-7
	Disaster risk management	Early warning systems; Hazard & vulnerability mapping; Diversifying water resources; Improved drainage; Flood & cyclone shelters; Building codes & practices; Storm & wastewater management; Transport & road infrastructure improvements.	8.2-4, 11.7, 14.3, 15.4, 22.4, 24.4, 26.6, 28.4, Box 25-1, Table 3-3
	Ecosystem management	Maintaining wetlands & urban green spaces; Coastal afforestation; Watershed & reservoir management; Reduction of other stressors on ecosystems & of habitat fragmentation; Maintenance of genetic diversity; Manipulation of disturbance regimes; Community-based natural resource management.	4.3-4, 8.3, 22.4, Table 3-3, Boxes 4-3, 8-2, 15-1, 25-8, 25-9, & CC-EA
	Spatial or land-use planning	Provisioning of adequate housing, infrastructure, & services; Managing development in flood prone & other high risk areas; Urban planning & upgrading programs; Land zoning laws; Easements; Protected areas.	4.4, 8.1-4, 22.4, 23.7-8, 27.3, Box 25-8
	Structural /physical	**Engineered & built-environment options:** Sea walls & coastal protection structures; Flood levees; Water storage; Improved drainage; Flood & cyclone shelters; Building codes & practices; Storm & wastewater management; Transport & road infrastructure improvements; Floating houses; Power plant & electricity grid adjustments.	3.5-6, 5.5, 8.2-3, 10.2, 11.7, 23.3, 24.4, 25.7, 26.3, 26.8, Boxes 15-1, 25-1, 25-2, & 25-8
		Technological options: New crop & animal varieties; Indigenous, traditional, & local knowledge, technologies, & methods; Efficient irrigation; Water-saving technologies; Desalinization; Conservation agriculture; Food storage & preservation facilities; Hazard & vulnerability mapping & monitoring; Early warning systems; Building insulation; Mechanical & passive cooling; Technology development, transfer, & diffusion.	7.5, 8.3, 9.4, 10.3, 15.4, 22.4, 24.4, 26.3, 26.5, 27.3, 28.2, 28.4, 29.6-7, Boxes 20-5 & 25-2, Tables 3-3 & 15-1
		Ecosystem-based options: Ecological restoration; Soil conservation; Afforestation & reforestation; Mangrove conservation & replanting; Green infrastructure (e.g., shade trees, green roofs); Controlling overfishing; Fisheries co-management; Assisted species migration & dispersal; Ecological corridors; Seed banks, gene banks, & other *ex situ* conservation; Community-based natural resource management.	4.4, 5.5, 6.4, 8.3, 9.4, 11.7, 15.4, 22.4, 23.6-7, 24.4, 25.6, 27.3, 28.2, 29.7, 30.6, Boxes 15-1, 22-2, 25-9, 26-2, & CC-EA
Adaptation		**Services:** Social safety nets & social protection; Food banks &	3.5-6, 8.3, 9.3,

Overlapping Approaches	Category	Examples	Chapter References (IPCC, 2014)
including incremental and transformational adjustments		distribution of food surplus; Municipal services including water & sanitation; Vaccination programs; Essential public health services; Enhanced emergency medical services.	11.7, 11.9, 22.4, 29.6, Box 13-2
	Institutional	**Economic options:** Financial incentives; Insurance; Catastrophe bonds; Payments for ecosystem services; Pricing water to encourage universal provision and careful use; Microfinance; Disaster contingency funds; Cash transfers; Public-private partnerships.	8.3-4, 9.4, 10.7, 11.7, 13.3, 15.4, 17.5, 22.4, 26.7, 27.6, 29.6, Box 25-7
		Laws & regulations: Land zoning laws; Building standards & practices; Easements; Water regulations & agreements; Laws to support disaster risk reduction; Laws to encourage insurance purchasing; Defined property rights & land tenure security; Protected areas; Fishing quotas; Patent pools & technology transfer.	4.4, 8.3, 9.3, 10.5, 10.7, 15.2, 15.4, 17.5, 22.4, 23.4, 23.7, 24.4, 25.4, 26.3, 27.3, 30.6, Table 25-2, Box CC-CR
		National & government policies & programs: National & regional adaptation plans including mainstreaming; Sub-national & local adaptation plans; Economic diversification; Urban upgrading programs; Municipal water management programs; Disaster planning & preparedness; Integrated water resource management; Integrated coastal zone management; Ecosystem-based management; Community-based adaptation.	2.4, 3.6, 4.4, 5.5, 6.4, 7.5, 8.3, 11.7, 15.2-5, 22.4, 23.7, 25.4, 25.8, 26.8-9, 27.3-4, 29.6, Boxes 25-1, 25-2, & 25-9, Tables 9-2 & 17-1
	Social	**Educational options:** Awareness raising & integrating into education; Gender equity in education; Extension services; Sharing indigenous, traditional, & local knowledge; Participatory action research & social learning; Knowledge-sharing & learning platforms.	8.3-4, 9.4, 11.7, 12.3, 15.2-4, 22.4, 25.4, 28.4, 29.6, Tables 15-1 & 25-2
		Informational options: Hazard & vulnerability mapping; Early warning & response systems; Systematic monitoring & remote sensing; Climate services; Use of indigenous climate observations; Participatory scenario development; Integrated assessments.	2.4, 5.5, 8.3-4, 9.4, 11.7, 15.2-4, 22.4, 23.5, 24.4, 25.8, 26.6, 26.8, 27.3, 28.2, 28.5, 30.6, Table 25-2, Box 26-3
		Behavioral options: Household preparation & evacuation planning; Migration; Soil & water conservation; Storm drain clearance; Livelihood diversification; Changed cropping, livestock, & aquaculture practices; Reliance on social networks.	5.5, 7.5, 9.4, 12.4, 22.3-4, 23.4, 23.7, 25.7, 26.5, 27.3, 29.6, Table SM24-7, Box 25-5
	Spheres of change	**Practical:** Social & technical innovations, behavioral shifts, or institutional & managerial changes that produce substantial shifts in outcomes.	8.3, 17.3, 20.5, Box 25-5
		Political: Political, social, cultural, & ecological decisions & actions consistent with reducing vulnerability & risk & supporting adaptation, climate change mitigation, & sustainable development.	14.2-3, 20.5, 25.4, 30.7, Table 14-1
Transformation		**Personal:** Individual & collective assumptions, beliefs, values, & worldviews influencing climate-change responses.	14.2-3, 20.5, 25.4, Table 14-1

2.4.5 Determine feasibility

Costs associated with implementation of proposed hazard mitigation and climate change adaptation measures have implications for project viability, and consideration of these need to be factored into the selection process. A cost-benefit analysis is a conceptual framework for the evaluation of investment projects. It differs from a straightforward financial appraisal in that it considers all gains (benefits) and losses (costs) regardless of to whom they accrue (although usually confined to the residents of any country). A benefit is then any gain in "utility"; a cost is any loss of utility as measured by the "opportunity cost" of the proposed project. In practice, many benefits or damages are not readily estimable in monetary terms (e.g. destruction of communities). Costs will be measured in terms of the actual money costs of the project. A Benefit Cost Analysis (BCA) will identify and incorporate into the feasibility analysis, the costs of additional protection for natural hazards and the benefits of damage and loss avoided. For comparison, benefits of the project without natural hazard protections must be reduced to account for potential loss. Several techniques exist, and a good description can be found in Chapter 2 of the Primer on Natural Hazard Management in Integrated Regional Development Planning (OAS, 1991).

The BCA, along with other non-financial methods such as interactive matrices, ranking and scaling-weighting methods, allows the decision-maker to determine not only the financial feasibility of a project, but also compare fundamentally similar alternatives so that the one with the highest ratio is implemented. However, to be applicable, all the significant impacts and potential benefits of the natural hazard mitigation project must be defined in financial terms. Good knowledge of non-market valuation techniques, as related to BCA, is required to efficiently conduct such an analysis.

2.5 Step 5 Develop Environmental Management and Monitoring Plan

The Environmental Management Plan should include a proposed work programme, budget, schedules, staffing and training requirements, and other necessary support services to implement the recommended mitigating measures.

The authority and capability of institutions at the local and national levels should be reviewed, and steps recommended to strengthen or expand them so that the management plans and any monitoring program in the EIA can be implemented. The recommendations may extend to new laws and regulations, new agencies or agency functions, inter-sectoral arrangements, management procedures and training, staffing, operation and maintenance training, budgeting, and financial support.

The role of Climate Change Focal Points and National Disaster Management Agencies involved in the review of any EIS and in any monitoring and evaluation should be outlined.

The plan must also outline a monitoring program to track actual impacts and performance of mitigation and adaptation measures. Within the context of natural hazards, this monitoring program is critical to ensure that the actual hazard impacts experienced by the project do not differ significantly from the impacts that were estimated in the EIA analyses. The program should be designed to monitor, within the project vicinity:

- natural hazards affecting the area;
- natural hazard impacts on key social, economic and environmental indicators; and
- impacts of the project on natural hazards.

The results from the monitoring program will assist in identifying and addressing unanticipated impacts. Results should be stored in a database that should be used to guide, evaluate and refine management, hazard mitigation and climate change adaptation measures and to evaluate project performance.

The monitoring program should be incorporated into an enforceable monitoring agreement.

A summary of EIA and NHIA required components is contained in Table 2.7.

Table 2.7. EIA/NHIA Components of Step 5 (Environmental Management and Monitoring Plan)

	EIA	NHIA
Objective	Develop management plan to satisfactorily mitigate potential adverse environmental impacts and enhance potential benefits, and a monitoring plan to ensure that measures are being implemented as planned, are preforming as anticipated, and can be adapted to improve performance if necessary.	Develop management plan to mitigate natural hazard impacts and adapt to climate change impacts, and develop an appropriate monitoring programme to ensure the implementation and effectiveness of the hazard mitigation/climate change adaptation programme.
Information needs	Preferred project alternative	Preferred project alternative
Process	Develop environmental management plan that incorporates the impact mitigation measures identified during assessment. Develop monitoring plans for environmental impacts and project implementation.	Develop environmental management plan that incorporates the hazard mitigation and climate change adaptation measures identified during assessment. Develop monitoring plans for environmental impacts and project implementation.
Responsibility	Proponent.	Proponent.

2.6 Step 6 Prepare Environmental Impact Statement (EIS)

The purpose of the EIS is to convey the results of the various analyses conducted during the assessment and to describe the preferred project alternative, and the impact mitigation and climate change adaptation measures that should be incorporated to address the identified natural hazard risks. The final report will incorporate the findings of the environmental, hazard and vulnerability assessments and will identify the impact mitigation, climate change adaptation, management and monitoring mechanisms necessary to minimise or eliminate negative effects on the environment from the project and significant impacts from the environment, including natural hazards, upon the project.

A table of contents for a typical EIS in contained in Part C, Annex 2. A summary of EIA and NHIA required components is contained in Table 2.8.

Table 2.8 EIA/NHIA Components of Step 6 (Environmental Impact Statement)

	EIA	NHIA
Objective	Finalize a project document that identifies the preferred alternative, includes necessary mitigation measures to address environmental impacts identified, including an appropriate management and monitoring programme for project implementation and impacts.	Finalize a project document that incorporates the hazard mitigation and climate change adaptation measures necessary to address natural hazard vulnerabilities and risks identified, including an appropriate management and monitoring programme for project implementation and impacts.
Information needs		
Process	Prepare a final EIS with the results of the environmental impact assessment. Prepare an Environmental management plan which includes identified mitigation measures, incorporated into project plan, and a Monitoring plan.	Prepare a final EIS with the results of the hazard and vulnerability assessments. Prepare an Environmental management and monitoring plan, which includes identified management, hazard mitigation and climate change adaptation measures, incorporated into project plan, and a Monitoring plan.
Responsibility	Proponent.	Proponent.

2.7 Step 7 Project Appraisal

A project appraisal of the natural hazard components of an EIA must confirm that:

- all potentially significant hazards, as identified in the EIA scoping, have been analyzed using appropriate methodologies;
- appropriate and sufficient impact mitigation and/or climate change adaptation measures have been identified and incorporated into project design for all potentially significant impacts identified in the detailed hazard and vulnerability assessments; and
- it is technically, financially and administratively feasible to implement the necessary natural hazard risk management measures in the proposed project.

A summary of EIA and NHIA required components is contained in Table 2.9.

Table 2.9 EIA/NHIA Components of Step 6 (Environmental Impact Statement)

	EIA	NHIA
Objective	Determine viability and acceptability of project against established criteria.	Determine viability and acceptability of project against established criteria.
Information needs	EIS	EIS
Process	Undertake technical review against established criteria. Approve or reject project. Develop conditions for approved project.	Undertake technical review against established criteria. Approve or reject project. Develop conditions for approved project.
Responsibility	Lead agency e.g. CDB or responsible authority (national level).	Lead agency e.g. CDB or responsible authority (national level).

2.8 Step 8 Implementation and Monitoring

The project proponent is responsible for ensuring that the project is developed in accordance with the provisions of the final (approved) Environmental Management Plan for the project.

Monitoring responsibilities as defined in the Environmental Monitoring Plan are typically shared between the project proponent and public agencies with statutory monitoring and enforcement responsibilities.

The proponent is required to submit reports in accordance with relevant legislation and the approved Monitoring Plan. The EIA Administrator ensures that regular reports are submitted by the project proponent outlining the results of any monitoring that has been undertaken by the proponent.

Lessons from project implementation and monitoring are to be captured by the EIA Administrator, to inform the design and implementation of similar projects in the future.

A summary of EIA and NHIA required components is contained in Table 2.10.

Table 2.10. EIA/NHIA Components of Step 8 (Implementation and monitoring)

	EIA	NHIA
Objective	Ensure that the specified impact mitigation and monitoring measures are implemented in the project and that the selected measures are appropriate.	Ensure that the specified hazard mitigation/climate change adaptation and monitoring measures are implemented in the project and that the selected measures are appropriate.
Information needs	Environmental Management and Monitoring Plans.	Environmental Management and Monitoring Plans.
Process	Ensure that recommended impact mitigation measures are included in project design and (where applicable) loan terms. Monitor implementation of specified measures. Monitor effectiveness of specified measures during implementation. Review reports of the project proponent and other agencies.	Ensure that hazard mitigation and climate change adaptation measures are included in project design and (where applicable) loan terms. Monitor implementation of specified measures. Monitor effectiveness of specified measures during implementation. Review reports of the project proponent and other agencies.
Responsibility	Proponent implements management plan. Proponent implements monitoring plan with support from public agencies as set out in the approved monitoring plan.	Proponent implements management plan. Proponent implements monitoring plan with support from public agencies as set out in the approved monitoring plan.

Section 3 Cumulative Effects

3.0 Introduction

The impact of any single development or natural hazard event may be considered insignificant when assessed in isolation, but may be significant when evaluated in the context of the combined effect of all reasonably foreseeable future development or natural hazard events that may impact on the project/activity in question. For this reason, the explicit assessment of cumulative effects is considered essential to the integration of natural hazard considerations into the EIA process. Assessment of cumulative effects is increasingly seen as representing best practice in conducting EIAs.

This discussion of cumulative effects focuses on the incremental changes required to the EIA (or in this case cumulative impact assessment) process, to fully address natural hazard considerations. Although cumulative impacts can result from either multiple development and/or natural hazard impacts over space and time, the primary focus here is on cumulative impacts from multiple natural hazard impacts (including climate change) or their interactions.

3.1 Cumulative Effects Defined

Cumulative effects are changes to the environment that are caused by a human action or natural event in combination with other past, present and future human actions and events. Cumulative effects are not necessarily much different from effects examined in an EIA. Many EIAs focus on a local scale, considering only the "footprint" or area covered by the proposed development. Some EIAs also consider the combined effects of various components (e.g., impacts of coastal development combined with shore-front protection on coastal ecosystems). A CEA simply enlarges the scale of the EIA assessment. See Box 3.1 for examples of cumulative natural hazard effects.

Box 3.1. Examples of cumulative natural hazard effects

Atmosphere:

Combined SO_2 emissions and increasing temperatures, resulting in increasing human health impacts.

Hydrology and water resources:

Combined flow volume reductions in a river system from 1. Changes in precipitation and 2. Increased evaporation, aggravated by irrigation, municipal and industrial water withdrawals.

Ecosystems and their goods and services:

Coral reef mortality within a marine management unit from increased sea level rise, increased water temperatures, and deteriorating coral ecosystem resilience due to ongoing anthropogenic activities.

Soils and land resources:

Loss of productive arable land due to several seasons of drought, compounded by anthropogenic activities (e.g. uncontrolled encroachment of urban development).

Human settlements:

Loss of housing in low-lying coastal areas due to sea level rise and storm surge from increased frequency/intensity of extreme events.

Insurance and other financial services:

Increased losses due to successive seasons of floods, droughts and extreme events.

Human health:

Changes in precipitation and temperature patterns, affecting incidence and location of outbreaks of vector-borne diseases.

Socio-economic development:

Impacts of revenue loss on fisher folk, agriculture sector employees, and the tourism sector due to sea level rise, climate pattern changes (temperature, precipitation, extreme events), and damage to natural ecosystems caused by improper coastal development.

Cumulative effects occur as interactions between actions and events, between actions/events and the environment, and between components of the environment. These "pathways" are the focus of a CEA. The magnitude of the combined effects along a pathway can be equal to the sum of the individual effects (additive effect) or can be an increased effect (synergistic effect).

3.2 Cumulative Assessment of Natural Hazard Effects

A cumulative effects assessment (CEA) is an assessment of cumulative effects. In contrast with the conventional EIA approach, CEAs are typically expected to:

- assess effects over a larger (i.e., "regional") area that may cross jurisdictional boundaries;
- assess effects over a longer period of time into the future;
- consider effects on Valued Ecosystem Components (VECs) due to interactions with other actions, and not just the effects of the single project under review;
- consider other past, existing and future (e.g., reasonably foreseeable) actions and events; and
- evaluate significance of effects beyond the local, direct effects.

Cumulative effects generally refer to impacts that are additive or interactive (synergistic) in nature and result from multiple activities over time, including impacts from the project/activity that is the subject of the EIA. An assessment of such effects is a critical element when addressing natural hazard considerations in view of the diversity of impacts (e.g., changes in precipitation, temperature, frequency of extreme events, etc.) and the protracted time horizon that must be considered. The challenge is to determine how large an area should be assessed, how long in time, and how to practically assess the (often complex) interactions among the actions or events. In the context of natural hazards, it must be recognised that cumulative effects:

1. are caused by the aggregate of past, present and future events acting upon the natural and human environment as altered by ongoing natural and anthropogenic activities;
2. are the total effect, including both direct (e.g. sea- level rise) and indirect (coastal flooding arising from sea-level rise) effects on a given resource, ecosystem and human community;
3. need to be analysed in terms of the specific resource, ecosystem, and human community being affected;
4. cannot be practically analysed beyond a reasonable boundary, but must focus on effects that are meaningful and that occur within a practical time frame;
5. may result from the accumulation of similar impacts (e.g. several years of drought) or the synergistic interaction of different impacts (e.g. sea level rise, flooding from increased precipitation, and increased storm surge following hurricane activity);
6. will last for many years beyond the life of the project;
7. should be assessed in terms of the capacities of the affected resource, ecosystem and human community, and the ability to mitigate or adapt to such impacts.

3.3 Cumulative Effects Assessment

Ideally, cumulative climate change effects should be assessed relative to a goal in which the effects are managed. Terms such as ecological carrying capacity, ecosystem integrity or resilience, long-term population viability and sustainable development are often cited as goals to be accomplished by CEAs. What these terms represent is important and their successful implementation would substantially improve the value of an assessment and significantly contribute towards the implementation of a successful climate change adaptation plan. However, expectations of what should be accomplished in a CEA often exceed what is reasonably possible given our knowledge of all natural hazard impacts, the resilience of natural ecosystems, available information, level of effort required to obtain more information, and the limits of analytical techniques in predicting the effects of natural hazard events on the environment. These terms should not be used in a CEA unless they are carefully defined; otherwise, the uncertainty associated with their meaning will later bring into question the usefulness of the CEA.

CEA analysis should be integrated into a number of EIA steps:

(i) Preliminary hazard and vulnerability assessment /Scoping
(ii) Assessment and evaluation, describing the affected environment and determining the consequences
(iii) Development of natural hazard mitigation and climate change adaptation alternatives

The following text in not intended to be an authoritative guide to CEAs since such guidance documents are readily available. What is presented below is step-by-step guidance on key issues and questions that need to be considered when undertaking assessments of cumulative natural hazard effects.

3.3.1 Preliminary hazard and vulnerability assessment/Scoping

The CEA is initiated through the identification of future natural hazard events and conditions (or combinations of such events and conditions) that might impact the proposed project/activity. During initial screening of the project, the range of natural hazard impacts in the project's area of influence should have been identified. The project team should identify and evaluate potential cumulative impacts from these. The following questions should be considered during screening, and answered more fully during project preparation/evaluation:

1. ***What are the foreseeable and likely cumulative natural hazard impacts that might affect the project?***

The combined effect of all reasonably foreseeable future hazard events that may impact on the project/activity in question be should identified and assessed. There are two main causes of uncertainty in such analyses:

a. the identification of foreseeable effects from natural hazard events on the project/activity within a reasonable time frame, and
b. the identification of likely combinations of natural hazard events and impacts within the given period of time.

"How far ahead in the future" to consider in an assessment of cumulative natural hazard effects depends on what the assessment is trying to accomplish. In practice, temporal boundaries often reflect the operational life or phases of the project under review (e.g., exploration, construction, operations, abandonment). If climate impacts are expected to be significant, it is pragmatic to use temporal boundaries and time-dependent changes in discrete units of time (e.g., as sequential time scenarios) that are consistent with internationally recognised periods for assessing climate change impacts. Climate scenarios based on the 2020, 2050, and 2080 timeframes will provide the most useful basis for undertaking the cumulative climate change effects assessments. Scenarios represent a point in time with specific disturbances and environmental conditions. Incremental changes between scenarios can then be compared to assess the relative contribution of various actions to overall cumulative effects within the study area.

Selection of future natural hazard including climate change events (or combinations of such events) must consider the certainty of whether the event (or combination of such events) will actually occur. The evaluation should categorize future events into three types:

- Certain: The event (or combination of events) will occur or there is a high probability the event (or combination of events) will occur.

- Reasonably Foreseeable: The event (or combination of events) may occur, but there is some uncertainty about this conclusion.
- Hypothetical: There is considerable uncertainty whether the event (or combination of events) will ever occur.

The selection of future natural hazard events to consider should at least reflect the certain scenario. The selection will typically be a compromise between under- representing the full extent of future events, and identifying and assessing an unreasonably large number of events. A sensible approach is to limit the CEA analysis to consideration of high risk events identified during the EIA scoping step.

2. How are Likely Combinations of Natural Hazard Events and Impacts Determined?

Global-scale events such as climate change must be assessed on the basis of likely significant impacts that might affect the project under consideration. However, in recognition of the complexities and often practical difficulty of scoping these events and effects (and combinations of climate change events over a given period of time), the CEAs should at least identify the contributing causes, attempt to quantify the magnitude of the event's contribution, and suggest appropriate natural hazard mitigation and climate change adaptation responses. In this way, decision- makers can account for the event's contribution within broad initiatives.

However, there remains the realities of the cause-effect relationships (known and perceived) from the natural hazard event (or combinations of such events). The practitioner must determine at what point an event is trivial or insignificant. The complexity of any relationship beyond one at the purely physical-chemical level often results in considerable reliance on best professional judgment and the consideration of risk. Practically, an adaptive approach may be followed when setting boundaries, in which the first boundary, often arrived at by an educated "guess", may be adjusted later if new information warrants this.

For high frequency events suspected of causing minimal effects due to short duration, low magnitude, irregular and unpredictable occurrences, or temporary duration, they may be too numerous to practically characterise individually. If so, it helps if they are categorized, for example, by:

- Nature of event over period of time (e.g. floods, droughts, hurricane activity, increased precipitation during the 2000-2020 year period);
- Impacts of a combination of events on single sector (e.g. flood and drought impacts upon agricultural sector during the 2000-2020 year period; sea-level rise and impacts from extreme events upon coastal resources during the 2000-2020 year period); and/or
- Combination of events in a single year on multiple sectors.

Any limitations based on information availability or reliability, or assumptions made, must be clearly stated. The implications for uncertainties in the assessment should be explained. A reasonable attempt to collect information must at least be demonstrated.

The scoping step is important as it assists the practitioner in beginning to understand one of the most fundamental cumulative effects assessment questions: what is affecting what? Good scoping in the initial stages of the study will mean that the assessment effort will focus on the most likely effects pathways of concern.

One approach is to first identify environmental components (e.g. air, water, biodiversity, human health) that may be affected by the various natural hazards impacting upon the project. Then, environmental and hazard components that may be affected by other actions in the region of interest (e.g. other anthropogenic activities within the spatial boundary) can be identified. The scoping could then proceed to focus on the relationships between specific impacts from various natural hazard events and specific ecosystem components.

Box 3.2. Scoping – A series of questions to be asked
1. Are the potential impacts of the natural hazard event (or combination of events), as well as other existing stressors, occurring so closely over time that the ability of the system to recover is exceeded, or the ecosystem resilience is irreparably affected? 2. Are the potential impacts of any single natural hazard event, along with other stressors from other climate change events, occurring within so close a geographical area that their effects overlap? 3. Could the impacts from combinations of hazard events interact among themselves, or interact with other existing or known future stressors, either additively or synergistically? 4. Could the potential impacts of the natural hazard event (or combination of events), affect key components of the environment? Have those components already been affected by other stressors from the same or other actions, either directly or indirectly or through some complex pathway? 5. Is the hazard event one of many of the same type (e.g. drought), producing impacts which are individually insignificant but which affect the environment in such a similar way that they become collectively important over the longer term? If the answer to any of these is yes, there is potential for cumulative natural hazard effects. The following should then be asked: 1. What are the potential impacts of the hazard event that could give rise to cumulative effects? 2. What is the appropriate scale to consider those impacts?

3.3.2 Assessment and Evaluation

A matrix describing various attributes affecting each valued ecosystem component is then completed. The attributes are: existing stressors affecting the valued ecosystem component; pathways of change (cause-effect linkages); consequences (i.e., resulting trends of valued ecosystem components); and contribution of the action to overall changes. Natural hazard mitigation and climate change adaptation measures are also identified.

The effects are evaluated, using best professional judgment, by asking if the identified changes affect the integrity of the environment. These changes are then compared with existing goals (e.g. ecological carrying capacity, ecosystem integrity or resilience).

Box 3.3. Assessment and evaluation – A series of questions to be asked
1. What are the environmental components (e.g. water, biodiversity, human health) that may be affected? 2. What parameters are best used to measure the effects on the environmental component? 3. What determines the present condition of key environmental components? 4. How will the proposed project, in combination with anticipated cumulative natural hazard events, affect their condition? 5. What are the probabilities of occurrence, probable magnitudes and probable durations of such cumulative hazard events? 6. What greater effect could key environmental components sustain before changes in condition become irreversible? 7. What degree of certainty can be attached to the estimates of occurrence and magnitudes of these predicted cumulative hazard events?

All information is documented, uncertainties identified, and feedback and monitoring requirements identified for inclusion in the final report.

3.3.3 Develop Environmental Management Plan

Managing cumulative effects in a cumulative natural hazard effects assessment requires, as a start, the same type of adaptation and monitoring measures that would be recommended in an EIA. Mitigating or adapting to a local natural hazard effect as much as possible is the best way to reduce cumulative effects; however, to be most effective, hazard mitigation, climate change adaptation, management and monitoring programs must be long term and regionally based.* This can be costly, require a few years to complete, and require broader data collection and decision-making involvement than has historically been the case with EIAs.

The hazard mitigation and climate change adaptation measures recommended in cumulative effects assessments may be broader in scope than those applied in traditional EIAs. They can be applied to developments other than the proposed development (e.g., through the establishment of integrated water resource management plans). Several administrative jurisdictions and stakeholders will usually fall within an assessment’s study area. In many cases, the co-operation of these other interests may be required if recommended adaptation measures are to be successfully implemented. Effective planning and management of CEA hazard mitigation and climate change adaptation, therefore, often imply the need for national stakeholder involvement to address national concerns. Considerable reliance is placed on national efforts to implement adaptation programs for cumulative climate change effects, such as initiatives to create coordinating bodies that direct or recommend further land use, monitoring and other effects-related research. Participants are usually selected from government departments, stakeholder groups and commercial interests. The objectives of these initiatives are generally to protect ecosystems that are under stress, and disperse permanent and transient human activities to reduce the magnitude of cumulative effects.

Recommendations for national initiatives of this type may be the only means of mitigating and adapting to complex cumulative effects issues. It is generally unreasonable and impractical to expect a single proponent to bear the burden of adaptation measures to address effects attributable to other actions and events in the region. Often it is more appropriate for regulatory agencies to initiate and implement the necessary national-scale initiatives, with project proponents providing data relevant to their project’s effects.

3.4 Placement of the Cumulative Effects Assessment in the Environmental Impact Assessment Submission

There are at least four options for placing the CEA:

1. The most common approach is within a separate “CEA chapter” after the EIA portion;
2. as a stand-alone document, separately bound from the EIA report;
3. integrated within the EIA as a unique sub-section, appearing at the end of each major section assessing effects on major environmental components (e.g. water, air, vegetation); or
4. fully integrated with the EIA as cross-sectoral issues are raised and examined.

The approach taken will depend on the practitioner’s philosophy of cumulative effects (i.e., as inseparable from the EIA or as a unique and different view) and on which approach is most readily accomplished given the division of labour used in assembling the assessment report.

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Annexes

Contents

Annex 1. Typical sources of existing hazard and hazard map information

Source	Information available
1. Local or site-specific mapping[25]. This may be available from any of those listed in 2. or 3. below if the area has been the subject of other proposals.	Information sufficient to estimate potential hazard impacts
2. Regional scale mapping and other hazard information. Available from regional agencies such as: • Caribbean Institute for Meteorology and Hydrology (CIMH)[26] • Caribbean Disaster and Emergency Management Agency (CDEMA) • Caribbean Tsunami Information Centre • CARIBSAVE • CCCCC • CARPHA • IICA • CARDI • Development Banks • OAS • UWI o Seismic Research Centre (SRC), St. Augustine o CERMES, Cavehill o Climate Studies Group, Mona (CSGM) o Institute for Sustainable Development, Mona[27]	Presence or absence of the hazard in the general vicinity. Notes: 1. Agencies such as CIMH will make data available to practitioners, and this may be at a fee depending on what is required. Access to CIMH resources is restricted. 2. A number of agencies, such as CIMH and CARIBSAVE also provide professional services for a fee. 3. UWI-CERMES provides access to publications, some of which are relevant to this project (see details listed below this table). 4. SRC provides access to volcanic and seismic hazard maps they have developed (see details listed below this table). 5. Climate Studies Group (Mona) provides a listing of their publications but many of these are not readily accessed (see details listed below this table). 6. Agencies such as CCCCC and CARIBSAVE provide a wealth of information on their websites. CCCCC is also working on a number of tools (e.g. weather generator, drought assessment tool) that will be launched in early 2016 and freely accessible thereafter. 7. CDEMA provides online access to some of its reports.

[25] Site specific hazard assessments should be undertaken for high occupancy density developments or critical infrastructure, in particular for seismic risk.

[26] The Caribbean Institute for Meteorology and Hydrology (CIMH) is a training and research organisation. The role and mission of the CIMH is to improve the meteorological and hydrological services and to assist in promoting the awareness of the benefits of these services for the economic well-being of CMO countries. This is achieved through training, research and investigations, and the provision of specialised services and advice. The Institute is affiliated with the Cave Hill Campus of the University of the West Indies. The Institute was designated as a Regional Meteorological Training Centre by the World Meteorological Organisation (WMO) in 1978 in recognition of the high standard of its training programmes. Students are trained in branches of meteorology such as weather observing, forecasting, radar and satellite meteorology, instrument maintenance, agrometeorology, and climatology, and in operational hydrology. The primary functions of the Institute are to:

- Provide facilities for the training of various categories of meteorological and hydrological personnel
- Operate as a centre of research in meteorology and hydrology and associated sciences
- Operate as contractors and consultants on various meteorological and hydrological projects
- Maintain a service for the upkeep, repair, and calibration of meteorological instruments
- Provide advice to participating governments on meteorological and hydrological matters
- Collect, analyse, and publish meteorological and hydrological data

[27] ISD was established by the University of the West Indies (UWI) in 2006 to assist Caribbean countries address issues of sustainable development and to promote, foster, reinforce, and facilitate efforts to achieve sustainable development in the region for the benefit of

Source	Information available
Details of some of the publications available through a number of these agencies is provided below this table.	8. CIMH is working with CCCCC on the CREAD (Caribbean data management) platform, funded by IADB. This should be operational by the end of 2015.
3. Local agencies such as: • National, local disaster agencies (governmental and NGO) • Local Councils • National and community-based planning offices • National environment offices • National meteorology offices • Environmental NGOs • National Trusts • Development Banks • Insurance companies or associations	Disaster history, descriptions and examples of impacts, specific area investigations previously undertaken. National Communications on Climate Change published by national Climate Change Focal Points.
4. Local agencies such as: • Public Works Department • Utilities	Damage and repair history in the vicinity of the project site
5. Persons from the area, such as: • Neighbours • Long term residents of the area.	Indigenous knowledge of hazards – frequency and type(s) of impacts

Some of the resources available through regional agencies

Agency	Resources/Project	Output
Seismic Research Centre (UWI St. Augustine) (SRC) **http://uwiseismic.com**	**PROBABILISTIC SEISMIC HAZARD ANALYSIS**	A probabilistic seismic hazard analysis has been performed in order to compute probabilistic seismic hazard maps for the Eastern Caribbean region, Barbados and Trinidad (10-19°N, 59-64°W). It is recommended that the seismic hazard analysis summary and guidelines for use of the maps be viewed prior to using the new maps (2009). http://uwiseismic.com/seishaz.aspx
	RISK ATLAS PROJECT	The plate tectonic setting of the Caribbean region makes it susceptible to geological hazards such as earthquakes, the impact of which can be intense and widespread, as demonstrated by the 2010 Magnitude 7.0 earthquake in Haiti. Most of the earthquakes that have occurred in the past that could have caused significant damage have been centred away from densely populated areas, but increased

present and future generations. The mandate of the ISD is to play a leadership role in capacity building, and improving the coordination of environmental and development activities in the region. The ISD comprises the **Centre for Policy Studies in Sustainable Development**, the **Environmental Management Unit**, the **Disaster Risk Reduction Centre** and the **Unit in Sustainable Tourism and Hospitality**. The work of these entities focus on research in select areas and engage dialogue with stakeholders (including policymakers and key decision makers) with a view to fostering the incorporation of sustainability and resilience actions into national, sub-national and sectoral strategies, plans, policies and programmes. The entities under the ISD have near-complete autonomy in their operations. The Institute facilitates collaborative research, teaching and outreach activities among its entities. http://www.uwi.edu/isd

Agency	Resources/Project	Output
		vulnerability and our present-day understanding of the seismic hazard of the Caribbean region indicate that the earthquake threat is very significant. As the islands of the regions pursue their individual developmental agendas an increasing percentage of its building stock, population and infrastructure will become exposed to the seismic risk. Implementing mitigation measures and reducing vulnerability are the most effective mechanisms to reduce the potentially devastating impact of future strong and major earthquakes. The primary objective of the project is to develop a methodology for seismic risk assessment in the Caribbean for three pilot States: Jamaica, Grenada and Barbados. It aims to provide guidelines and open-source software for the estimation of earthquake loss using available socio-economic data.
	VOLCANIC HAZARD ATLAS OF THE LESSER ANTILLES – MULTIMEDIA VERSION	Published by the Seismic Research Unit in May 2005, the Volcanic Hazard Atlas of the Lesser Antilles (VHA), is a comprehensive reference work summarizing the current state of knowledge of each 'live' volcano in the volcanic islands of the Lesser Antilles.
	GLOBAL EARTHQUAKE MODEL (GEM) CARIBBEAN	The Global Earthquake Model (GEM) was launched with assistance from the Organization for Economic Cooperation and Development (OECD) in 2009 and is a global collaborative effort that brings together state-of-the-art science, national, regional and international organisations and individuals aimed at the establishment of uniform and open standards for calculating and communicating earthquake risk worldwide. The development of Regional Programmes (RPs) is the main mechanism by which the GEM tools will be transferred with a view to creating a uniform globally used standard. The RPs will involve local experts using GEM software and tools, who generate local data and validate the data and standards that are being created on the global level. RPs have already been established in Europe, the Middle East and Central Asia. In 2011 the GEM Foundation engaged the Seismic Research Centre to promote the GEM vision in the Caribbean.
	TRINIDAD & TOBAGO SEISMIC MICROZONATION STUDIES PROJECT[28]	Both Trinidad and Tobago are susceptible to earthquakes, the impact of which can be intense and widespread. Implementing mitigation measures and reducing vulnerability are proven mechanisms for reducing the potentially devastating impact of future strong and major earthquakes. The application of building codes and appropriate land use policies are most effective when applied at the planning and design stages of projects. However before such mitigation measures can be applied, the seismic hazard has to be quantified at the national and local scale. The Project seeks to establish and maintain a seismic microzonation database in Trinidad and Tobago, and is crucial to the implementation of effective disaster risk reduction measures for earthquakes in the country. It caters for the production of maps that detail the different levels of a specified geotechnical hazard that

[28] Similar projects have been recently completed or are underway by SRC in other urban centres across the region

Agency	Resources/Project	Output
		may be triggered by an earthquake.
		SRC publications can be downloaded from http://uwiseismic.com/Downloads/
Climate Studies Group (CSG), Mona		CSG publications are listed on https://www.mona.uwi.edu/physics/csgm/publications Some publications can be downloaded from the CSGM PUBLIC PORTAL https://www.mona.uwi.edu/physics/csgm/public-portal
Centre for Resource Management and Environmental Studies (CERMES), UWI Cavehill		Publications can be downloaded from the http://www.cavehill.uwi.edu/cermes/news/technical-reports.aspx
CARIBSAVE		Publications can be downloaded from the http://www.intasave.org/documents/Publications/Climate-Change-Science,-Policy-and-Practice/
CCCCC		The clearing house has numerous documents listed. http://clearinghouse.caribbeanclimate.bz/ There is also the CCORAL tool available at http://ccoral.caribbeanclimate.bz/ This is a Caribbean focused tool to help make climate resilient decisions.
Caribbean Disaster and Emergency Management Agency (CDEMA)		Documents are available at http://www.cdema.org/index.php?option=com_joomdoc&view=docman&gid=83&task=cat_view&Itemid=231
The Caribbean Meteorological Organisation (CMO)		The objectives of the CMO are the promotion and co-ordination of regional activities in the fields of meteorology and allied sciences.
Caribbean Institute for Meteorology and Hydrology (CIMH)[29]	**ENHANCING RESILIENCE TO REDUCE VULNERABILITY IN THE CARIBBEAN" (ERC) PROJECT**	Barbados and the Organization of Eastern Caribbean States (OECS) territories are highly vulnerable to a range of hazards. With climate change, it is anticipated that the effects of a number of these will worsen. There is a need for support in building capacity for information and diagnostic systems, and response mechanisms to facilitate decision making for enhanced disaster risk reduction. The main objective is to strengthen national and regional DRR mechanisms associated with natural, environmental and technological hazards, within the broader context of hydrometeorology and climate change; and for effective disaster recovery through capacity building for early warning systems and institutional collaboration for disaster management and response. **Main Outputs:**

[29] The CIMH is the education, training, and research arm of the CMO.

Agency	Resources/Project	Output
		• Sustainable network for real time decision support centers to facilitate early warning and post disaster recovery established and fully integrated into national and regional planning. • Strengthened national disaster mechanisms to incorporate best practices in volunteerism, and enhanced institutional capacities. • Support to enhancing regional tsunami public awareness programme in support of the EWS through the establishment of the Caribbean Tsunami Information Centre (CTIC).
	CARIBBEAN REGIONAL CLIMATE CENTRE (RCC)	The WMO Caribbean RCC: (i) Currently manages, archives and disseminates the climate data of Member States of the Caribbean Meteorological Organization (CMO). This service is being expanded to all Member States of the WMO Caribbean RCC. (ii) Develops and publishes climate outlooks for the Caribbean region in the Caribbean Precipitation Outlook and outlooks from the Caribbean Drought and Precipitation Monitoring Network. (iii) Liaises with national and regional stakeholders in the development and delivery of critical climate services and products in the fields of Health; Disaster Risk Reduction; Agriculture and Food Security; and Water Resources. (iv) Facilitates real time data sharing and acquisition between participating states and regional and international organizations. (v) Conducts research and development necessary to sustain the actions of critical climate sectors in participating states. In addition, the WMO Caribbean RCC conducts and supports fundamental research in topical climatology. (vi) Supports human capacity development in climate science and its applications in applications in participating states through the development of long-term and short-term training programmes and international and regional attachments.
	Publications are also listed on the CIMH website	
NOAA	Caribbean Digital elevation Models (2011)	These models are for Puerto Rico and USVI, available at https://www.ngdc.noaa.gov/mgg/coastal/caribbean_dem_catalog.pdf
Department of Disaster Management (DDM), Government of the Virgin Islands	Documents available on the DDM website	Department of Disaster Management, Government of the Virgin Islands, 2012. Handbook for homeowners and property developers, 2012 edition; Disaster Digest - Historic Hazard Impacts, A pictorial review of local and regional events.

Agency	Resources/Project	Output
Environmental Management Agency, EMA	Documents available on the website http://www.ema.co.tt/	

Annex 2 Generic Draft Terms of Reference for EIA (including Natural Hazard Considerations)

Guidance to finalising the Terms of Reference

Adapted from Statewide Environmental Assessments Unit, Department of Environment and Heritage Protection, State of Queensland, 2013.Downloaded from http://www.dilgp.qld.gov.au/assessments-and-approvals/terms-of-reference.html on November 26, 2015.

If a project has been categorised as having the potential to cause environmental, social or economic impacts, the project proponent must prepare an environmental impact statement (EIS). The draft terms of reference (TOR) for the EIS are prepared by the agency with statutory authority. They set out the general and specific matters the project proponent must address when preparing the EIS. Each project's draft TOR are prepared based on the generic TOR provided below. Where necessary, the draft TOR are modified to ensure the proponent addresses the project's environmental impacts.

Consultation to finalise TOR

Government advisory/referral agencies are usually invited to comment on whether the draft TOR adequately cover all the matters the project proponent must address when preparing the EIS. In some instances, the agency with statutory authority may also seek comments from the public. Although the length of this consultation phase is not usually prescribed in the legislation, the agency with statutory authority and its referral agencies should endeavour to complete this within 20 working days.

Meetings with advisory agencies

During the consultation period, the agency with statutory authority may arrange meetings between the project proponent and advisory/referral agencies to:

- explain the EIS process, including the agencies' roles
- enable the proponent to outline the key elements of the project, its potential impacts and possible mitigation strategies
- solicit feedback from agencies on matters of interest or concern that should be addressed in the EIS.

Finalising the TOR

The agency with statutory authority is required to finalise the TOR as soon as practicable after the consultation closes or, if the draft TOR were not publicly notified, as soon as practicable after advising the project proponent that an EIS is required.

Revising the TOR

Terms of reference may be revised if:

- there are significant changes to the project concept or design
- significant new issues emerge during the preparation of the EIS.

Depending on the nature and extent of these changes, another round of comment by the advisory agencies may be required on the amendments required to the TOR.

Generic TOR for EIA

These generic Terms of Reference have been adapted from the Generic draft terms of reference for an environmental impact statement published by the Statewide Environmental Assessments Unit, Department of Environment and Heritage Protection, State of Queensland (2013). They should be tailored to respond to project-specific requirements before being finalised.

Contents

Part A About these terms of reference

1 Statutory basis

This section draws attention to the project environmental and social impact assessment information requirements of the *(specify Act)* administered by the *(specify Department).* While these terms of reference (TOR) aim to seek information corresponding to these requirements, proponents should confirm that the EIS addresses all statutory requirements, and also meets the relevant information requirements of any other relevant agency, such as an external financing agency or a local Council.

The TOR apply to the assessment of projects that require assessment under the (*environmental impact statement (EIS))* process requirements set out in *(specify Section)* of *(specify Act)*.

The EIS process applies to site-specific development applications for undertaking projects that meet any of *(specify Department)'*s EIS requirements. If the project is to proceed, it is particularly important that the EIS provide all the information needed to enable the issuing of a development approval for the project.

Part B Content of the EIS

1 General approach

1.1 For the purposes of the EIS process, 'environment' is defined in *(specify Section and specify Act).*

1.2 The EIS should give priority to the critical matters associated with the project (specified in section 7 of this TOR).

1.3 The detail in which the EIS deals with matters relevant to the project should be proportional to the scale of the impacts on environmental values. When determining the scale of an impact, consider its intensity, duration, cumulative effect, irreversibility, the risk of environmental harm, management strategies and offsets provisions.

2 Mandatory requirements of an EIS

2.1 **D**escribe the project including all aspects subject to this assessment. Provide details of the proponent of the project, including details of any joint venture partners. The project description should include all on- and off-site activities relevant to the project including construction, operation and decommissioning activities. If the delivery of the project is to be staged, the nature and timing of the stages should be fully described

2.2 For all the relevant matters, the EIS must identify and describe the environmental values that must be protected. Environmental values are specified in *(list relevant environmental legislation, policy and guidelines e.g. Environmental Protection Act, Public Health Act, water quality standards).*

2.3 The assessment should cover both the short and long-term scenarios and state whether any relevant impacts are likely to be irreversible. Also discuss scenarios of unknown, unpredictable impacts.

2.4 Provide all available baseline information relevant to the environmental risks of the project. Provide details about the quality of the information provided, in particular: the source of the information; how recent the information is; how the reliability of the information was tested; and any uncertainties in the information.

2.5 Provide detailed strategies in regard to all critical matters for the protection, or enhancement as desirable, of all relevant environmental values in terms of outcomes and possible conditions that can be measured and audited. In general, the preferred hierarchy for managing likely impacts is: (a) to avoid; (b) to minimise or mitigate; and (c) if necessary, and possible, to offset.

2.6 Impact minimisation measures should include ongoing monitoring and proposals for an adaptive management approach, as relevant, based on monitoring. The proposed measures should give confidence that, based on current technologies, the impacts can be effectively minimised over the long-term.

2.7 Each matter assessed in the EIS (as described in sections 7 and 8 of this TOR) should include a concise summary of the potential impacts of the project and the measures proposed by the proponent to avoid, minimise, mitigate and/or offset those impacts.

2.8 For unproven elements of a resource extraction or processing process, technology or activity, identify and describe any global leading practice environmental management, where available.

2.9 Describe the extent to which the construction and operation of the project would:

a) meet all statutory and regulatory requirements of the State.

b) Be consistent with State policies, plans and guidelines, current and publicly available at the time the draft EIS is provided to the *(specify Department).*

If there is conflict, provide supporting information on any merit in allowing that conflict to occur.

3 Further requirements of an EIS

3.1 The assessment and supporting information should be sufficient for the *(specify Department)* to decide whether an approval should be granted. Where applicable, sufficient information should be included to enable approval conditions to be decided.

3.2 To the extent of the information available, the assessment should endeavour to predict the cumulative impact[30] of the project on environmental values over time and in combination with impacts created by the activities of other adjacent and upstream and downstream developments and landholders—as detected by baseline monitoring. This will inform the decision on the EIS and the setting of conditions. The absence of a comprehensive cumulative impacts analysis need not be fatal to the project. The EIS should also outline ways in which the cumulative impact assessment and management could subsequently be progressed further on a collective basis.

3.3 Include a consolidated description of all the proponent's commitments to implement management measures (including monitoring programs). Should the project proceed, these should be able to be carried over into the approval conditions as relevant.

3.4 Provide all geographical coordinates throughout the EIS in latitude and longitude against the *(specify national datum)*.

3.5 An EIS should also describe the expected benefits and opportunities associated with the project.

3.6 An appropriate public consultation program is essential to the impact assessment process. The proponent should consult with local and government authorities, and potentially affected local communities.

3.7 The EIS should describe the consultation that has taken place and how the responses from the community and agencies have been incorporated into the design and outcomes of the project.

3.8 Include, as an appendix, a public consultation report. The report should detail how the public consultation plan was implemented including the results.

4 Executive summary

4.1 The executive summary should describe the project and convey the most important and preferred aspects and environmental management options relating to the project in a concise and readable form. It should use plain English, avoid jargon, be written as a stand-alone document and be structured to follow the EIS. It should

[30] Cumulative impact is defined as 'combined impacts from all relevant sources (developments and other activities in the area)'.

be easy to reproduce and distribute on request to those who may not wish to read *(or purchase)* the whole EIS.

5 Introduction

5.1 Clearly explain the function of the EIS, why it has been prepared and what it sets out to achieve. Include an overview of the structure of the document.

Project proponent

5.2 Describe the proponent's:

a) full name and postal address (including details of any joint venture partners)

b) the nature and extent of business activities

c) experience

d) environmental record, including a list of any breach of relevant environmental laws during the previous 10 years

e) environmental, health, safety and community policies.

The environmental and social impact assessment process

5.3 Provide an outline of the environmental and social impact assessment process, including the role of the EIS in the decision making process. The information in this section is required to ensure EIS readers are informed of the process to be followed and are aware of any opportunities for input and participation.

5.4 Inform the reader how and when properly made public submissions on the EIS will be addressed and taken into account in the decision-making process.

Project approvals process

5.5 Provide an outline of the approvals required to enable the project to be constructed and operated. Explain how the environmental and social impact assessment process (and the EIS itself) informs the issue of leases/licences/permits/approvals required by the proponent before construction can commence. Provide a flow chart indicating the key approvals and opportunities for public comment.

6 Legislative, Regulatory and Related Considerations

6.1 Describe the pertinent regulations and standards governing environmental quality, health and safety, protection of sensitive areas, protection of endangered species, siting, land use control, etc., at international, national, and where relevant at the local levels including relevant Multilateral Environmental Agreements (MEAs). *(The TOR should specify those that are known and require the consultant to investigate for others).*

7 Project description

Proposed development

7.1 The EIS must describe and illustrate at least the following specific information about the proposed project:

a) project title

b) project description

c) design criteria of projects (e.g. building codes used)

d) project objectives

e) expected capital expenditure

f) rationale for the project

g) the nature and scale of activities to be undertaken and whether it is a greenfield or brownfield site

h) the regional and local context of the project's footprint (with maps at suitable scales)

i) relationship to other major projects and/or developments (of which the proponent should reasonably be aware)

j) workforce numbers to be employed by the project during its various phases

k) where personnel would be accommodated and, where relevant, the likely recruitment and rostering arrangements to be adopted

l) proposed construction staging and likely schedule of works.

Site description

7.2 Provide real property descriptions of the project land and adjacent properties; any easements; any tenures; and identification number of any lease for the project land that is subject to application. Key transport, state-controlled roads, rail, air, port/sea and other infrastructure in the region relevant to the project and to the site should be described and mapped.

7.3 Describe and illustrate the topography of the project site and surrounding area, and highlight any significant features shown on the maps. Maps should have contours at suitable increments relevant to the scale, location, potential impacts and type of project, shown with respect to the *(specify height and other datum*).

7.4 Describe and illustrate specific information about the proposed project including the precise location of the proposed development in relation to designated and protected areas *such as erosion-prone areas, coastal areas, marine park/reserve boundaries, World Heritage Areas, (specify as appropriate)*.

7.5 Where relevant, describe and map in plan and cross-sections the geology and landforms, including catchments, of the project area. Show geological structures, such as aquifers, faults and economic resources that could have an influence on, or be influenced by, the project's activities.

7.6 Where relevant, describe, map and illustrate soil types and profiles of the project area at a scale relevant to the proposed project. Identify soils that would require particular management due to wetness, erosivity, depth, acidity, salinity or other feature.

7.7 Plans and drawings provided must be detailed enough to enable the *(specify planning authority)* and advisory agencies to adequately assess the application.

Climate

7.8 Describe the site's climate patterns that are relevant to the environmental assessment, with particular regard to discharges to water and air and the propagation of noise. Climate information should be presented in a statistical form including long-term averages and extreme values, as necessary. Characterise the extent and quality of available data, explaining significant information deficiencies. *If possible, give the TOR for studies to obtain the missing information (Identify the types of special studies likely to be needed for this project category).*

Socio-cultural environment

7.9 Describe population; community structure; employment; distribution of income, goods and services; recreation; public health; tribal peoples; customs, aspirations and attitudes; socio-economic activities.

Proposed construction and operations

7.10 Describe the following information about the proposal:

a) all pre-construction activities (e.g. vegetation clearing, site access, interference with watercourses and floodplain areas, including wetlands, interference with the land/sea interface)

b) existing infrastructure and easements on the potentially affected land

c) the proposed construction methods, associated equipment and techniques

d) location, design and capacity of water supply, telecommunications, power generation and transmission infrastructure

e) any infrastructure alternatives, justified in terms of ecologically sustainable development (including energy and water conservation)

f) hours of operation for proposed construction works, including night time works

g) the sequencing and staging of activities

h) the capacity of high-impact plant and equipment, their chemical and physical processes, and chemicals or hazardous materials to be used

i) the known locations of new or altered works and structures and infrastructure necessary to enable the construction and operation of the development

j) location of quarry operations the project may source materials from

k) the range of land uses and site layout

l) built form and design specifics

m) operation detail e.g. hours of operation for project components

n) the commissioning process including landscaping and rehabilitation of affected areas after construction

o) management structure of final development (e.g. body corporate)

p) infrastructure requirements (e.g. roads, electricity, telecommunications, water, sewerage)

q) location and scale of parking requirements

Infrastructure requirements

Objectives.

The project should provide necessary infrastructure to service the development that:

a. maintains or enhances services to existing users

b. ensures any required works are compatible with existing infrastructure.

7.11 This section should detail, with concept and layout plans, requirements for new infrastructure, or the upgrading and relocating of existing infrastructure to service the project. Infrastructure to be considered should include water supply, energy supply, telecommunications, stormwater, waste disposal and sewerage.

7.12 Describe the typical service corridors or clearances for sewerage and recycled water mains in relation to other services.

8 Assessment of critical matters

(The final TOR will include additional site-specific requirements that must be addressed in the EIS. The requirements will be developed from the description of the project given in the initial development application and take account of comments made by government agencies and members of the community on the draft TOR)

8.1 This section sets out the scope of critical matters that should be given detailed treatment in the EIS. A critical matter is an aspect of the proposal that is reasonably expected to have one or more of the following characteristics:

a) a high or medium probability of causing serious or material environmental harm or a high probability of causing an environmental nuisance

b) considered contentious in the public domain, for example, has been the subject of extensive media coverage and/or there is a public perception that an activity has the potential to cause serious or material environmental harm or an environmental nuisance(regardless of the likelihood of occurrence)

8.2 The final scope of critical matters will be determined by the (responsible Department) when finalising the TOR. In the course of preparing the EIS, information may become available that warrants a change of scope.

Land use

Objectives

Development should be designed and operated to:

a. improve environmental outcomes
b. contribute to community wellbeing
c. contribute to social, economic and environmental sustainability

Information requirements—land use

8.3 Provide a copy of the proposed plan of development (or local area plan) explaining how the plan may vary the *(specify)* planning scheme.

8.4 Discuss the compatibility of the project with the surrounding area and the *(specify)* region, taking into consideration the proposed measures that would be used to avoid or minimise impacts. The discussion should include:

a) existing and proposed land uses, in and around the planning area, referring to regional plans and the local government planning scheme
b) any tenures overlying and adjacent to the project site, and any to be applied for as part of this project
c) State interests
d) Locational factors influencing choice of site.

8.5 Discuss the proposal in the context of the *(specify)* statutory regional plan.

8.6 Describe and illustrate the visual impact of the construction and operation of the project. Include major views, view sheds, outlooks, and features contributing to the amenity of the area, including assessment from private residences.

8.7 Present feasible alternatives of the project's configuration (including individual elements) that may improve environmental outcomes. The concept of alternatives extends to siting, design, technology selection, construction techniques and phasing, and operating and maintenance procedures. Compare alternatives in terms of potential environmental impacts; capital and operating costs; suitability under local conditions; and institutional, training and monitoring requirements. When describing the impacts, indicate which are irreversible or unavoidable and which can be mitigated, managed or addressed under an appropriate climate change adaptation plan. To the extent possible, quantify the costs and benefits of each alternative, incorporating the estimated costs of any associated mitigation/adaptation measures. Include the alternative of not constructing the project, in order to demonstrate environmental conditions without it. Identify the preferred alternative. Discuss the consequences of not proceeding with the project.

8.8 outline how the project will maintain or enhance general public access to or along the foreshore, unless this is contrary to the protection of coastal resources or public safety.

8.9 If the project may impact on:

a) living areas in regional communities
b) high quality agricultural areas
c) strategic cropping land or

d) regionally important environmental areas

provide the studies and approach to addressing the requirements in relation to these.

8.10 Detail any known or potential sources of contaminated land. Describe how any proposed land use may result in land becoming contaminated.

8.11 Identify existing or potential native title rights and interests possibly impacted by the project and the potential measures for managing those impacts.

Flora and fauna

Objective

Matters of environmental significance are valued and appropriately safeguarded to support healthy and resilient ecosystems and ensure the sustainable, long-term conservation of biodiversity and the social, economic, cultural and environmental benefits it provides.

Information requirements

8.12 Describe the likely impacts on the biodiversity and natural environmental values of affected areas arising from the construction, operation and eventual decommissioning of the project (where known). Take into account any proposed avoidance and/or mitigation measures. The assessment should include, but not be limited to, the following key elements:

a) matters of state environmental significance and national environmental significance

b) terrestrial and aquatic ecosystems (including groundwater-dependent ecosystems) and their interaction

c) biological diversity including listed flora and fauna species and regional ecosystems

d) the existing integrity of ecological processes, including habitats of threatened, near-threatened or special least-concern species

e) the integrity of landscapes and places, including wilderness and similar natural places

f) actions of the project that would require an authority (e.g. water abstraction or discharge permits) and/or would be assessable development for the purposes of *(specify any other relevant environmental legislation).*

g) chronic, low-level exposure to contaminants or the bio-accumulation of contaminants

h) impacts on native fauna due to proximity to the site and site impacts (e.g. lighting, noise, waste).

8.13 Propose practical measures for protecting or enhancing natural values, and assess how the nominated quantitative indicators and standards may be achieved for nature conservation management. In particular, address measures to protect or preserve any threatened or near-threatened species.

8.14 Discuss strategies for protecting RAMSAR wetlands; and discuss any obligations imposed by State legislation or policy or international treaty obligations.

8.15 Assess the need for buffer zones and the retention, rehabilitation or planting of movement corridors, and propose measures that would avoid the need for waterway barriers, or propose measures to mitigate the impacts of their construction and operation.

8.16 Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed.

8.17 Where legislation or policy requires and offset for a significant residual impact on a particular natural environmental value, the offset proposal(s) shall be presented in a form consistent with relevant legislation and policy.

Water quality

Objective

Development is planned, designed, constructed and operated to protect environmental values of *(specify country)* waters and supports the achievement of water quality objectives.

Information requirements

8.18 Describe the hydrology within the study area and the adjoining tidal waterways in terms of water levels, discharges and freshwater flows. Detail the interaction of freshwater flows with different tidal states.

8.19 Detail the chemical and physical characteristics of surface waters and groundwater within the area that may be affected by the project. Include a description of water quality variability associated with climatic and seasonal factors, variability of freshwater flows and extreme flows.

8.20 Identify the quantity, quality and location of all potential discharges of water and wastewater by the project, whether as point sources (e.g. controlled discharges) or diffuse sources (e.g. irrigation to land of treated sewage effluent).

8.21 Describe the proposed management of existing and/or constructed water bodies on the project site to maintain water quality, including any proposed exchange of tidal water.

8.22 Assess the potential impacts of any discharges on the quality and quantity of receiving waters taking into consideration the assimilative capacity of the receiving environment and the practises and procedures that would be used to avoid or minimise impacts.

8.23 Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed. Describe mitigation strategies and contingency plans for:

a) potential accidental discharges of contaminants and sediments during construction and operation

b) stormwater runoff from the project facilities and associated infrastructure

c) flooding of relevant river systems, the effects of tropical cyclones and other extreme events.

Hazards, health and safety

Objectives

a. The risk of, and the adverse impacts from, natural hazards are avoided, minimised or mitigated to protect people and property and enhance the community's resilience to natural hazards.

b. Developments are to be appropriately located, designed and constructed to minimise health and safety risks to communities and individuals and adverse effects on the environment.

Information requirements

General

8.24 Describe the potential risks to people and property that may be associated with the project in the form of a preliminary risk assessment for all components of the project and in accordance with relevant standards. The assessment should include:

a) potential hazards, accidents, spillages, fire and abnormal events that may occur during all stages of the project, including estimated probabilities of occurrence

b) identifying all hazardous substances to be used, stored, processed or produced and the rate of usage

c) potential wildlife hazards

d) assessment of vulnerability of the project to natural hazards (e.g. cyclone, storm surge, flooding, bushfire, landslide, shoreline erosion) and climate change including the frequency, magnitude and distribution of any natural hazard or climate change element affecting the spatial or temporal boundaries of the proposed project. Assemble, evaluate and present baseline data on the relevant natural hazard/climate change characteristics of the study area that are relevant to project siting or design, or to the formulation of mitigation or adaptation measures. Include information on any changes anticipated before the project commences.

e) distinction between significant positive and negative impacts, direct and indirect impacts, cumulative impacts, and immediate and long-term impacts. Identify impacts which are unavoidable or irreversible. Wherever possible, describe impacts quantitatively, in terms of social/environmental costs and benefits.

f) how the project may potentially affect hazards away from the project site (e.g. changing flooding characteristics).

8.25 Outline measures required to ensure that the proposed project avoids release of hazardous materials as a result of a natural hazard event.

8.26 Provide details on the safeguards that would reduce the likelihood and severity of hazards, consequences and risks to persons, within and adjacent to the project area(s). Identify the residual risk following application of mitigation measures. Present an assessment of the overall acceptability of the impacts of the project in light of the residual uncertainties and risk profile.

8.27 Provide an outline of the proposed integrated emergency management planning procedures (including evacuation plans, if required) for the range of situations identified in the risk assessment developed in this section.

8.28 Outline any consultation undertaken with the relevant emergency management authorities, including the Local Disaster Management Group.

Erosion-prone areas

8.29 If the project proposes permanent buildings or structures in a coastal area, detail how coastal erosion risks are avoided or mitigated, and identify any development free buffers.

Storm surge inundation

8.30 Describe storm surge inundation risk for a range of annual exceedance probabilities for the site, and assess (through hydrodynamic modelling) how the project any affect storm tide hazard vulnerability of nearby premises. Take into consideration potential sea-level rise scenarios.

8.31 The assessment should consider all infrastructure associated with the project including levees, roads and linear infrastructure and all proposed measures to avoid or minimise risks to life, property, community (including damage to other properties) and the environment during storm surge events.

Flooding

8.32 Describe flood risk for a range of annual exceedance probabilities (including Probably Maximum Flood) for the site, and assess how the project may change flooding characteristics. Take into consideration potential sea-level rise scenarios. Include a discussion of historical events.

8.33 The assessment should consider all infrastructure associated with the project including levees, roads and linear infrastructure and all proposed measures to avoid or minimise risks to life, property, community (including damage to other properties) and the environment during flood events.

Social and economic

Objectives

The construction and operation of the project should aim to:

a. avoid or mitigate adverse social and economic impacts arising from the project

b. capitalise on opportunities potentially available for capable local industries and communities where this does not have a significant negative impact on the project or reduce the net economic benefits to the State.

Information requirements

8.34 Describe the likely social impacts (positive and negative) on affected communities taking into account proposed mitigation measures.

8.35 Identify the relevant stakeholders (local and regional) and the likely economic impacts arising from each key stage of the construction and operation of the project. Proponents should quantify economic impacts where suitable data and methodology can be applied. Otherwise these should be assessed qualitatively.

8.36 The economic analysis could consider but is not limited to potential impacts the project may have on:

a) labour demand, including the ability for labour to be drawn from the existing local workforce, and the potential effects this may have on local businesses.

b) relevant prices, which might include wages, input costs and/or household goods and services.

9 Assessment of routine matters

Matters to be assessed in an EIS fall into 2 categories: critical or routine. The division of critical and routine matters is determined in consultation with the proponent; however, the (specify responsible Department) makes the final decision.

9.1 The following subsections list the routine matters for projects. In some cases, not all the matters may be relevant, while in others the list may not be exhaustive.

9.2 For each routine matter identified below, the level of detail should be proportional to the risk or magnitude of impacts. As a minimum, the proponent should supply sufficient information that confirms the risks/impacts are not significant.

Air

Objective
Development is planned, designed, constructed and operated to protect the environmental values of air.

Information requirements

9.3 Fully describe the characteristics of any contaminants or materials that may be released as a result of the construction or operations of the proposal, including point source and fugitive emissions. Emissions (point source and fugitive) during construction, commissioning, operations and upset conditions should be described.

9.4 Predict the impacts of the releases from the activity on environmental values of the receiving environment using recognised quality assured methods. The description of impacts should take into consideration the assimilative capacity of the receiving environment and the practices and procedures that would be used to avoid or minimise impacts. The impact prediction must:

a) address residual impacts on the environmental values (including appropriate indicators and air quality objectives) of the air receiving environment, with reference to sensitive receptors[31]. This should include all relevant values potentially impacted by the activity.

b) address the cumulative impact of the release with other known releases of contaminants, materials or wastes associated with existing development and possible future development (as described by approved plans and existing project approvals).

c) quantify the human health risk and amenity impacts associated with emissions from the project for all contaminants.

31 For example, the locations of existing residences, places of work, schools, etc, agricultural or ecologically significant areas/species that could be impacted.

9.5 Describe the proposed mitigation measures and how the proposed activity will be consistent with best practice environmental management. Where a government plan is relevant to the activity or site where the activity is proposed, describe the activity's consistency with that plan.

9.6 Describe how the achievement of the objectives would be monitored, audited and reported, and how corrective actions would be managed.

Noise and vibration

Objective
Development is planned, designed, constructed and operated to protect the environmental values of the acoustic environment.

Information requirements

9.7 Fully describe the characteristics of the noise and vibration sources that would be emitted when carrying out the activity (point source and general emissions). Noise and vibration emissions (including fugitive sources) that may occur during construction, commissioning, upset conditions, and operation should be described.

9.8 Predict the impacts of the noise emissions from the activity on the environmental values of the receiving environment, with reference to sensitive receptors[10], using recognised quality assured methods. Discuss separately the key project components likely to present an impact on noise and vibration for the construction and operation phases of the project.

9.9 Taking into account the practices and procedures that would be used to avoid or minimise impacts, the impact prediction must address the:

a) activity's consistency with the objectives

b) cumulative impact of the noise with other known emissions of noise associated with existing development and possible future development (as described by approved plans)

c) potential impacts of any low-frequency (<200 Hz) noise emissions.

9.10 Describe how the proposed activity, and in particular, the key project components describe above, would be managed to be consistent with best practice environmental management for the activity. Where a government plan is relevant to the activity, or the site where the activity is proposed, describe the activity's consistency with that plan.

9.11 Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed.

Water resources

Objectives

The construction and operation of the project should aim to meet the following objectives:

a. equitable, sustainable and efficient use of water resources

b. environmental flows, water quality, in-stream habitat diversity, and naturally occurring inputs from riparian zones support the long term maintenance of the ecology of aquatic biotic communities

c. the condition and natural functions of water bodies, lakes, springs, watercourses and wetlands) are maintained—including the stability of beds and banks of watercourses

d. volumes and quality of groundwater are maintained and current and lawful users of water (such as stock and domestic users) and other beneficial uses of water (such as spring flows and ground water dependent ecosystems) are not adversely impacted by the development.

Information requirements

9.12 Provide details of any proposed impoundment, extraction, discharge, injection, use or loss of surface water or groundwater. Identify any approval or allocation that would be needed under the (*specify legislation).*

9.13 Detail any significant diversion or interception of overland flow. Include maps of suitable scale showing the location of diversions and other water-related infrastructure.

9.14 Develop hydrological models as necessary to describe the inputs, movements, exchanges and outputs of all significant quantities and resources of surface water and groundwater that may be affected by the project. The models should address the range of climatic conditions that may be experienced at the site, and adequately assess the potential impacts of the project on water resources. The models should include a site water balance. This should enable a description of the project's impacts at the local scale and in a regional context including proposed:

a) changes in flow regimes from structures and water take

b) alterations to riparian vegetation and bank and channel morphology

c) direct and indirect impacts arising from the development.

9.15 Provide information on the proposed water usage by the project, including details on:

a) the ultimate supply required to meet the demand for full occupancy of the development including timing of demands

b) the quality and quantity of all water supplied to the site during construction and operational phases based on minimum yield scenarios for water reuse, rainwater reuse and any bore water volumes

c) a water balance analysis

d) a site plan outlining actions to be taken in the event of failure of the main water supply.

9.16 Describe proposed sources of water supply given the implication of any approvals required under the (specify legislation). Estimated rates of supply form each source (average and maximum rates) must be given and proposed water conservation and management measures must be described.

9.17 Determination of potable water demand must be made for the project, including temporary demands during the construction period. Include details of any existing town water supply to meet such requirements. Detail should also be provided to describe any proposed on-site water storage and treatment for use by the site workforce during construction and operational phases.

9.18 Provide detailed designs for all infrastructure utilised in the treatment of on-site water including how any on-site water supplies are to be treated, contaminated water is to be disposed of and any decommissioning requirements and timing of temporary water supply/treatment infrastructure is to occur.

9.19 Describe how the development will impact or alter the *(specify regional water strategy)* and *Council water policy (if applicable)*.

Biosecurity

Objectives

The construction and operation of the project should aim to ensure:

a. the spread of weeds and pest animals is minimised

b. existing weeds and pests are controlled.

Information requirements

9.20 Propose detailed measures to control and limit the spread of pests and weeds on the project site and adjacent areas. This includes declared plants under the *(specify plant/animal protection legislation)*, weeds of national significance and designated pests under the *(specify where these are designated)*.

Waste management

Objective

Any waste transported, generated, or received as part of carrying out the activity is managed in a way that protects all environmental values.

Information requirements

9.21 For wastes besides wastewater (which is addressed in paragraph 7.20), describe all the expected significant waste streams from the proposed project activities during the construction and operational phases of the project.

9.22 Define and describe the objectives and practical measures for protecting or enhancing environmental values from impacts by wastes. Take into account best practice waste management strategies.

9.23 Assess the proposed management measures against the preferred waste management hierarchy, namely: avoid waste generation; cleaner production; recycle; reuse; reprocess and reclaim; waste to energy; treatment; disposal. This includes the generation and storage of waste.

9.24 Describe how nominated quantitative standards and indicators may be achieved for waste management, and how the achievement of the objectives would be monitored, audited and managed.

9.25 Provide details on natural resource-use efficiency (such as energy and water), integrated processing design, and any co-generation of power and by-product reuse as shown in a material/energy flow analysis.

Cultural heritage

Objective

The construction and operation of the project should aim to ensure that the nature and scale of the project does not compromise the cultural heritage significance of a heritage place or heritage area.

Information requirements

9.26 Undertake research/studies as required to describe impacts on indigenous cultural heritage, taking into account the practices and procedures that would be used to avoid or minimise impacts. Develop a Cultural Heritage Management Plan.

9.27 For non-indigenous historical heritage, undertake a study of, and describe, the known and potential historical cultural and landscape heritage values of the area potentially affected by the project. Any such study should be conducted by an appropriately qualified cultural heritage practitioner. Provide strategies to mitigate and manage any negative impacts on non-Indigenous cultural heritage values and enhance any positive impacts.

Transport

Objectives

The construction and operation of the project should aim to:

a. maintain the safety and efficiency of all affected transport modes for the project workforce and other transport system users
b. minimise and mitigate impacts on the condition of transport infrastructure
c. ensure any required works are compatible with existing infrastructure and future transport corridors.

Information requirements

9.28 The EIS should include a clear summary of the total transport task for the project, including workforce, inputs and outputs, during the construction and operational phases.

9.29 Present the transport assessment in separate sections for each project-affected mode (road, rail, air and sea) as appropriate for each phase of the project.

9.30 Provide sufficient information to allow an independent assessment of how existing transport infrastructure will be affected by project transport at the local and regional level.

9.31 Include details of the adopted assessment methodology for impacts on roads within the road impact assessment report.

9.32 Discuss and recommend how identified impacts will be mitigated. Mitigation strategies may include works, contributions or management plans and are to be prepared in close consultation with relevant transport authorities (including local government).

10 Environmental management plan

10.1 Prepare a management plan including proposed work programmes, budget, schedules, staffing and training requirements, and other necessary support services to implement the recommended mitigating measures.

10.2 Review the authority and capability of institutions at the local and national levels and recommend steps to strengthen or expand them so that the management plans and any monitoring program in the EIA can be implemented. The recommendations may extend to new laws and regulations, new agencies or agency functions, inter-sectoral arrangements, management procedures and training, staffing, operation and maintenance training, budgeting, and financial support.

10.3 Outline the role of Climate Change Focal Points and National Disaster Management Agencies involved in the review of any EIS and in any monitoring and evaluation.

11 Monitoring Plan

11.1 Prepare a detailed plan to monitor the implementation of the management plan and the impacts of:

(a) the project during construction and operation, and

(b) climate change during all phases of the project (design, construction, operation, abandonment and decommissioning).

11.2 Include in the plan an estimate of capital and operating costs and a description of other inputs (such as training and institutional strategy).

12 List of references

13 Appendices to the EIS

13.1 Appendices should provide the complete technical evidence used to develop assertions and findings in the main text of the EIS; the list of EIS preparers; and records of Inter-Agency and Public/ NGO Communications.

13.2 No significant issue or matter should be mentioned for the first time in an appendix—it must be addressed in the main text of the EIS.

13.3 Include a table listing the section of the EIS where each requirement of the TOR is addressed.

13.4 Include a glossary of terms and a list of acronyms and abbreviations.

Part C Generic Structure for the EIS Report

I. Executive Summary
II. Introduction
III. Legislative, regulatory and related considerations
IV. Project description
V. Assessment of critical matters
VI. Assessment of routine matters
VII. Cumulative Effects Assessment
VIII. Environmental Management Plan
IX. Environmental Monitoring Program
X. References
XI. Appendices

Annex 3 Some additional references (with abstracts or summaries)

Climate change and disaster mitigation tools and data

Baur, T., 2012. Identification and documentation of currently available tools, data and products that could be provided through a web portal if possible. Caribbean Weather Impacts Group: Supporting risk based decision making. Project funded by the Climate and Development Knowledge Network (CDKN).

This review seeks to give an overview of current and best practice in the area of online services for climate change-related data provisioning. It gathers a list of 58 services currently online that depend on historic and long-term future climate observations and projections and individually reviews the characteristics of 12 tools available from the region. This deliverable is intended to inform the first CARIWIG Stakeholder Workshop, where a structured dialogue with stakeholders will determine user requirements for climate web service provision. A summary report will then inform development of climate web services for the Caribbean.

Chin Sang, J., 2015. The Status of Climate Change Data: A Case Study for Trinidad and Tobago United Nations Framework Convention on Climate Change Fellowship Programme.

This study aims to review and determine the status of data used in informing climate change adaptation programmes within Trinidad and Tobago for the purposes of identifying gaps and making recommendations for greater efficiency, including adherence to guidelines and standards by the UNFCCC and their collaborating systematic observation bodies and considerations for regional downscaling of international data models, such as from the IPCC. The approach involved a review of literature and liaisons with key persons to provide insight into the present climate data situation for Trinidad and Tobago, as well as the Caribbean region, with reference to a specific on-going climate change adaptation project. Systematically observed data was the focus of the review but the study also touched briefly on the data used in a recent socio-economic analysis of climate change adaptation in Trinidad and Tobago.

CDERA, 2007. Storm Surge Toolkit for Township Planning Strategies: Adaptation for Climate Change and Disaster Mitigation in the Caribbean. Prepared for the Inter-American Development Bank and the Caribbean Disaster Emergency Response Agency.

The Toolkit presents methodologies for the evolution of four main themes which are considered essential to disaster risk management and reduction:

1. Risk Assessment (steps and methodology to be followed in the preparation of a Risk Assessment)
2. Institutional Issues (institutional and governance structures required for risk management)
3. Awareness Raising and Improved Preparedness
4. Prevention and Mitigation Measures (structural and nonstructural approaches)

Vulnerability and Capacity Assessment

Tetra Tech Inc, 2014. Climate Change Data and Risk Assessment Methodologies in the Caribbean. TECHNICAL NOTE No. IDB-TN-633. Inter-American Development Bank Environmental Safeguards Unit.

Available from

https://publications.iadb.org/bitstream/handle/11319/6453/Climate%20Change%20Data%20and%20Risk%20Assessment%20Methodologies%20for%20the%20Caribbean.pdf

The purpose of this paper is to:

(1) propose a step-wise process to assess climate change risks to IDB projects and

(2) identify tools and methodologies to support the risk assessment process specific to the Caribbean region.

The pilot risk assessment process focuses on the direct and indirect risks to projects from three climate-induced hazards: sea level rise, hurricanes (including storm surge), and flooding (both coastal and riverine) because these hazards are considered to pose the greatest threat to the Caribbean region. Further consideration was given to the types of projects most vulnerable to climate risk, including infrastructure projects; projects that involve investments in, or rely substantially on, natural resources (such as water and agriculture); and projects that rely on other infrastructure (such as national transportation infrastructure for tourism).

This paper builds on the efforts in recent years to understand climate variability and change and related risks in the Caribbean, including that conducted under the CCCCC and the IDB-World Bank Pilot Program for Climate Resilience in the Caribbean. It identifies and summarizes information that is most salient to evaluating site-specific climate risks. The paper relied on existing information and did not involve field research.

CARE International, 2009. Climate Vulnerability and Capacity Analysis Handbook (downloaded from http://www.careclimatechange)

In order to ensure that development programs reduce people's vulnerability to climate change, it is important to understand who is vulnerable to its effects and why. This information is then applied to the design, implementation, monitoring and evaluation of activities. CARE's approach to climate change adaptation is grounded in the knowledge that people must be empowered to transform and secure their rights and livelihoods. It also recognizes the critical role that local and national institutions, as well as public policies, play in shaping people's adaptive capacity. The Climate Vulnerability and Capacity Analysis (CVCA) methodology helps users to understand the implications of climate change for the lives and livelihoods of the people served. By combining local knowledge with scientific data, the process builds people's understanding about climate risks and adaptation strategies. It provides a framework for dialogue within communities, as well as between communities and other stakeholders. The results provide a solid foundation for the identification of practical strategies to facilitate community-based adaptation to climate change. The main objectives of the CVCA are to analyze vulnerability to climate change and adaptive capacity at the community level, and to combine community knowledge and scientific data to yield greater understanding about local impacts of climate change.

Pulwarty, R., and Hutchinson, N., 2008. Vulnerability and Capacity Assessment Methodology. A guidance manual for the conduct and mainstreaming of climate change vulnerability and capacity assessments in the Caribbean Region. Caribbean Community Climate Change Centre (CCCCC). Available from http://www.caribbeanclimate.bz

The vulnerability and capacity assessments (VCA) methodology described 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 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, a rapid assessment methodology is also presented, to provide an outline of the steps that should be taken in any event and also to provide an example of a conceptual model that can guide the process.

GFDRR, Disaster Risk Management in Latin America and the Caribbean Region: GFDRR Country Notes

Latin America and the Caribbean Region (LCR) is exposed to a wide variety of natural hazards, many of which are regularly aggravated by the recurrent El Niño/ENSO phenomenon. The global trend toward increasing climate variability is likely to exacerbate many of these hazards. The World Bank Natural Disaster Hotspots study indicates that seven among the world's top 15 countries exposed to three or more hazards are located in LCR. Similarly, 15 among the world's top 60 countries exposed to two or more hazards are LCR countries. The concentration of geophysical and hydrometeorological hazards points to the needs to include disaster risk management (DRM) as a key element in development programs in the region. The Latin American and Caribbean governments have long recognized the need to address disaster risk, and their efforts "to develop the tools to effectively mainstream disaster risk management into development activities" have evolved over the last few decades. Over the last decade, governments, intergovernmental, non-governmental, and development organizations have gradually shifted the focus of their efforts towards ex-ante approaches to disaster risk management, with a special focus on disaster risk reduction via reducing vulnerability, capacity building, better information, and institutional strengthening. This publication aims to provide a brief overview of the DRM strides made in several LCR countries to date. It provides country notes organized by country priority levels determined by the GFDRR:

- two GFDRR Priority Countries (Haiti and Panama),
- four Donor Earmarked Non-Core Countries (Colombia, Costa Rica, Ecuador, and Guatemala), and
- a number of countries which do not at present appear in the GFDRR priority country lists but where GFDRR has been working with the governments (Antigua and Barbuda, Belize, Bolivia, Dominica, Dominican Republic, El Salvador, Grenada, Honduras, Jamaica, Nicaragua, Peru, St. Kitts and Nevis, St. Lucia and St. Vincent and the Grenadines.

Impacts

Cambers, G., Claro, R., Juman, R., Scott, S., 2008. Technical Report No. 382 Climate Change Impacts On Coastal And Marine Biodiversity In The Insular Caribbean. Report of Working Group II, Climate Change and Biodiversity in the Insular Caribbean. Caribbean Natural Resources Institute, 2008.

The report provides an overview supported by a detailed bibliography, of the known and/or likely impacts of climate change on coastal and marine ecosystems, and identifies several constraints and gaps in the existing knowledge. It goes on to develop a 10 year research agenda focusing on the knowledge gaps. The research agenda has been designed to involve persons from all walks of life (youth, the general public, government professionals and scientists, etc.) on the premise that climate change affects everyone, and there is a need to involve all society in learning about the issues, sharing information and taking appropriate measures. The agenda includes research, monitoring of change, information sharing, and specific activities focused on conservation and ecosystem resilience building. Existing institutional capacity and the policy framework for biodiversity conservation and climate change are also discussed. The report with its assessment of the current state of knowledge regarding the impact of climate change on coastal and marine biodiversity also provides a qualitative baseline against which future progress can be assessed.

Taylor, M. A., Chen, A. A., Bailey, W., in association with the Climate Studies Group, Mona, University of the West Indies and Caribbean Environment and Health Institute, 2009. Review of Health Effects of Climate Variability and Climate Change in the Caribbean. The Mainstreaming Adaptation to Climate Change Project of The Caribbean Community Climate Change Centre (CCCCC). Available from http://www.caribbeanclimate.bz

The projected rise of even a few degrees Celsius in this century will likely affect the earth's ecosystems which have evolved within a narrow band of climatic-environmental conditions. Human health is one of the areas likely to be affected. Climate variability and change already contribute to the global burden of disease. With the projections of an altered future climate, this contribution is expected to grow. The main categories of adverse health impacts of climate change include the direct effects of climatic extremes, viz., thermal stress and weather disasters, and the various direct and indirect effects mediated by climatic influences on local crop yields and fisheries and on respiratory diseases and infectious disease transmission, such as those related to vector-borne infectious diseases. Climate change is, then, a significant and emerging threat to public health. Since the impacts of climate on human health will not be evenly distributed around the world, it is imperative that the full impact of climate change on human health be assessed and necessary adaptation options recommended. Developing country populations, and in particular Small Island States such as those in the Caribbean region, are considered to be particularly vulnerable. This document is an initial attempt at assessing the impact of climate variability and change on human health within the Caribbean region. A brief overview of Caribbean climate variability and change is given. The linkages between climate and health in general are briefly explored. An assessment is made of the likely threats on human health in the Caribbean of the projected future changes in regional climate. An identification and review of some of the institutions that are directly or indirectly involved in health and well-being in the Caribbean region is done. Recommendations for adaptation are offered, as are recommendations for addressing the potential impact of climate variability and change on human health in the Caribbean. An attempt is made to also identify actions to be taken at the regional, national and local levels.

Climate change adaptation, Disaster mitigation and management

Farrell, D., Nurse, L., and Moseley, L., date unknown. Managing Water Resources in the Face of Climate Change: A Caribbean Perspective.

The water resources sector on most islands is one that will be strongly impacted by climate change. With:

- increasing demand for potable water,
- sea-level rise that may flood lowlands and cause seawater intrusion into coastal aquifers,
- variability in climate , with more intense rainstorms resulting both in increased run-off (leading to increased flooding) and reduced recharge leading to aquifer depletion.

These impacts will have a negative effect on other vital aspects of regional economies such as the tourism, recreational, agricultural and industrial sectors. Unfortunately, adequate management of water resources on many Caribbean islands is sorely lacking. In many cases baseline data that may be used to track changes is sparse or non-existent. This paper explores the probable effect climate change will have on water resources in the Caribbean, the fall-out from these effects and strategies for mitigating potential negative impacts.

Climate and Development Knowledge Network (2012) Managing climate extremes and disasters in Latin America and the Caribbean: Lessons from the SREX report. CDKN, available online at www.cdkn.org/srex.

The Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) was commissioned by the Intergovernmental Panel on Climate Change (IPCC) in response to a recognised need to provide specific advice on climate change, extreme weather and climate events ('climate extremes'). This summary highlights the key findings of the SREX report including an assessment of the science and the implications of this for society and sustainable development. The SREX report considers the effects of climate change on extreme events, disasters, and disaster risk management (DRM). It examines how climate extremes, human factors and the environment interact to influence disaster impacts and risk management and adaptation options (see Figure 1). The SREX report considers the role of development in exposure and vulnerability, the implications for disaster risk, and the interactions between disasters and development. It examines how human responses to extreme events and disasters could contribute to adaptation objectives, and how adaptation to climate change could become better integrated with

DRM practice. The SREX report represents a significant step forward for the integration and harmonisation of the climate change adaptation, disaster risk management and climate science communities. The summary includes material directly taken from the SREX report, but it also presents synthesis messages that are the views of the authors of the summary and not necessarily those of the IPCC. The authors hope that the result will illuminate the SREX report's vital findings for decision makers in Latin America and the Caribbean, and so better equip them to make sound investments to reduce disaster risk in a changing climate.

Wilkes, A., Tennigkeit, T., Solymosi, K., 2013. Mitigation of Climate Change in Agriculture Series 7.National integrated mitigation planning in agriculture: A review paper. Food and Agriculture Organization of the United Nations (FAO). Available from www.fao.org/publications.

This review of national greenhouse gas (GHG) mitigation planning in the agriculture sector has two objectives:

(i) to provide national policy makers and others in the agriculture sector with an overview of national mitigation planning processes and aid then in identifying the relevance of these processes for promoting agricultural development;

(ii) (ii) to provide policy makers and advisors involved in low-emission development planning processes with an overview of mitigation planning in the agriculture sector and in particular to highlight the relevance of agriculture to national mitigation plans and actions.

Adaptation Partnership, 2011. Review of Current and Planned Adaptation Action: The Caribbean Antigua and Barbuda, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts & Nevis, Saint Lucia, Saint Vincent & the Grenadines, and Trinidad & Tobago. http://www.adaptationpartnership.org/

The goal of the Adaptation Partnership is to encourage effective adaptation by serving as an interim platform to catalyze action and foster communication among the various institutions and actors engaged in the effort to scale up adaptation and resilience around the world. The Adaptation Partnership initiated a Review of Current and Planned Adaptation Action to provide a baseline understanding of who is doing what on adaptation in three developing regions—Africa, Asia-Pacific, and Latin America and the Caribbean—and in priority adaptation sectors. Based on available resources, it seeks to provide a rapid assessment of: priority interests and adaptation needs; efforts by governments to support adaptation though policy and planning; the scope of international support for adaptation efforts in different countries and sectors; and potential gaps in adaptation efforts at the country and regional levels. This document presents a review of current and planned adaptation action in the Caribbean, covering the countries of Antigua and Barbuda, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago. The review first provides an overview of adaptation action at a regional level, highlighting commonalities and differences between these countries. The appendices that follow discuss adaptation action taking place in each country.

CRFM, 2013. McConney, P., J. Charlery, M. Pena. Climate Change Adaptation and Disaster Risk Management in Fisheries and Aquaculture in the CARICOM Region. Volume 2 – Regional Strategy and Action Plan. *CRFM Technical & Advisory Document*, No. 2013 / 8. 29 p.

This report is the second of four outputs in this initiative of CRFM and FAO on 'Climate change adaptation and disaster risk management in fisheries and aquaculture in the CARICOM region'. The aim is to develop a strategy and action plan for integrating DRM, CCA and fisheries and aquaculture, with a focus on small-scale fisheries (SSF) and small-scale aquaculture. This volume sets out strategic actions "to strengthen regional and national cooperation and develop capacity in addressing climate change impacts and disasters in the fisheries and aquaculture sector". It draws upon key regional policy instruments on fisheries, aquaculture, climate change and disasters. Ultimately it will be important for there to be linkages between the enhanced Implementation Plan and critical fisheries and aquaculture policy at the regional and national levels.

Roberts, D., 2013. Status of Disaster Risk Management Plans for Floods, Hurricanes and Drought In The Agriculture Sector. A Caribbean Perspective. FAO Sub-regional Office (Barbados). Available from www.fao.org/publications.

This report presents the findings of a study commissioned by the Food and Agriculture Organization of the United Nations (FAO) to review the status of development and implementation of disaster risk management (DRM) plans for the agriculture sector throughout the Caribbean. Specifically, the assignment was designed to achieve the following objectives:

- determine the availability of DRM plans for droughts, hurricanes and floods in the agriculture sector throughout 20 Caribbean countries, namely: Anguilla, Antigua and Barbuda, the Bahamas, Barbados, Belize, British Virgin Islands, Cuba, Dominica, the Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago and Turks and Caicos; and
- review existing plans to identify best practices, shortcomings, challenges and areas where development agencies may assist countries to complete and implement these plans.

The report prioritises activities required to develop or complete plans in those countries without, and for developing capacity for implementation within the sector.

Chatenoux, B. and Wolf, A.,2013. Ecosystem based approaches for climate change adaptation in Caribbean SIDS. UNEP/GRID-Geneva and ZMT Leibniz Center for Tropical Marine Biology, pp.64.

Existing climate variability and global climate change are major threats to sustainable development in the Caribbean. Hurricanes, storm surges and extreme rainfall events cause major damage to the assets of coastal populations, infrastructure and ecosystems. Climate projections suggest that SLR and increasing sea water temperature will continue, and intensity and frequency of extreme weather events are likely to increase. Ecosystem based Adaptation (EbA) approaches, combining both engineered and community based benefits, are promising to prepare SIDS for future climate change scenarios.

This review:

1) Identifies Caribbean SIDS which are highly dependent ontheir marine ecosystems and are particularly vulnerable to climate change related risks and

2) Provides a recommendation on SIDS which are most suited for EbA approaches including restoration and climate change adaptation efforts.

The selection was based on an assessment of the most important coastal ecosystems, namely mangrove forests, seagrass meadows and coral reefs.

UNISDR, 2009. Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action. United Nations secretariat of the International Strategy for Disaster Reduction (UNISDR), Geneva, Switzerland, 213 pp.

The document proposes main elements of a drought risk reduction framework in line with the priorities of the Hyogo Framework, namely

i) policy and governance,
j) drought risk identification and early warning,
k) awareness and education,
l) reducing underlying factors of drought risk, and
m) mitigation and preparedness, as well as cross-cutting issues.

Hannah, L., Ikegami, M., Hole, D., Seo, C., Butchart, S., Peterson, A., Roehrdanz, P., 2013. Global Climate Change Adaptation Priorities for Biodiversity and Food Security. PLOS ONE. Vol. 8, Issue 8. Available from www.plosone.org

International policy is placing increasing emphasis on adaptation to climate change, including the allocation of new funds to assist adaptation efforts. Climate change adaptation funding may be most effective where it meets integrated goals, but global geographic priorities based on multiple development and ecological criteria are not well characterized. This paper shows that human and natural adaptation needs related to maintaining agricultural productivity and ecosystem integrity intersect in ten major areas globally, providing a coherent set of international priorities for adaptation funding. An additional seven regional areas are identified as worthy of additional study. The priority areas are locations where changes in crop suitability affecting impoverished farmers intersect with changes in ranges of restricted-range species. Agreement among multiple climate models and emissions scenarios suggests that these priorities are robust. Adaptation funding directed to these areas could simultaneously address multiple international policy goals, including poverty reduction, protecting agricultural production and safeguarding ecosystem services.

Acclimatise, 2013. Public procurement: integrating climate change adaptation. Briefing Note.

Even though it is still not certain how our climate will change in the coming years and decades, the combination of current increasing vulnerabilities and impacts together with a growing body of scientific knowledge, make a changing climate a foreseeable risk to project delivery. This can no longer be ignored, and the implications for best practice in procurement need to be taken into account. This note summarises why it is important to build climate resilience into procurement and how these considerations can be included in existing procurement processes to ensure long-term delivery of public projects.

Tompkins, E., Nicholson-Cole, S., Hurlston, L., Boyd, E., Brooks Hodge, G., Clarke, J., Gray, G., Trotz, N., Varlack, L., 2005. Surviving climate change in small islands: A guidebook. Produced by the Tyndall Centre for Climate Change Research, UK, as part of a project: 'XOT 005 Preparing for and adapting to climate change in the UK Overseas

Territories'. Copies available on the internet at: http://www.tyndall.ac.uk/

This guidebook provides information, ideas, tools and techniques for those who need to start taking action today to prepare for climate change. It is primarily aimed at government officers who would like to learn more about climate change, its impacts and preparedness options. It has been written to assist those with little knowledge of, or exposure to, climate change. An important message in this guidebook is that communities and governments can best prepare by building on their existing strengths and good practice. While the guidebook has been prepared specifically for people on small islands, the general approach described may also be a useful approach for people in other geographic locations.

This guidebook provides guidance as follows:

- Why be concerned about climate change?
- Understanding climate change risks
- Assessing vulnerability and structuring an adaptation plan
- Implementing a climate change adaptation strategy
- Further information including links to other resources

International Bank for Reconstruction and Development /The World Bank, 2013. Building Resilience Integrating Climate and Disaster Risk into Development. The World Bank Group Experience.

This report shows why building climate resilience is critical for the World Bank Group's goals to end extreme poverty and build shared prosperity, and why it should be front and center of the development agenda. By focusing on the Bank's experience in climate and disaster resilient development, the report intends to contribute to international discussions of loss and damage from climate change. The report calls for the international development community to work across disciplines and sectors to build long-term resilience, reduce risk and avoid climbing future costs. It emphasizes the necessity of building and empowering institutions for the sustained effort needed for making development climate and disaster resilient. By highlighting best practices, it shows how financial instruments and intervention programs, along with disaster preparedness expertise are helping nations prepare for a more changeable world. The report notes that building resilience is effective, but often requires a higher initial investment.[32] State-of-the-art weather warning systems require new technology and highly trained staff. Relocating people from unsafe areas is expensive and can bring cultural and social disruptions, which can create new risks. The World Bank Group believes that climate-related disasters can be reduced and investment costs curtailed if partners collaborate across disciplines to make climate and disaster resilience part of their day-to-day development work.

The World Bank, 2014. The World Development Report (WDR). Risk and Opportunity Managing Risk for Development.

The World Development Report (WDR) focuses on the process of risk management, addressing these questions: why is risk management important for development, how should it be conducted, what obstacles prevent people and societies from conducting it effectively, and how can these obstacles be overcome? The WDR 2014's value added resides in its emphasis on managing risks in a proactive, systematic, and integrated way. These characteristics underscore the importance of forward looking planning and preparation in a context of uncertainty. They also highlight the necessity to address all relevant risks jointly, using all available tools and institutions. From a policy maker's perspective, a proactive, systematic, and integrated approach to managing risks involves striking a proper balance between the contribution from the state and the contribution from individuals, civil society, and the private sector, with the goal of ensuring that these contributions are coordinated and complementary. The WDR 2014 argues that risk management can be a powerful instrument for development—not only by building people's resilience and thus reducing the effects of adverse events but also by allowing them to take advantage of opportunities for improvement. The WDR 2014 is not devoted to a detailed analysis of specific risks. Its framework, however, can be implemented to address particular, relevant sets of risks in given regions and countries. Focusing on the process of

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[32] The report indicates that it costs up to 50 percent more to design and build safer buildings and infrastructure after a disaster.

risk management allows the WDR 2014 to consider the synergies, trade-offs, and priorities involved in addressing different risks in different contexts, with the single motivation of boosting development.

Economics of Climate Change

United Nations Economic Commission for Latin America and the Caribbean, Sub-regional Headquarters for the Caribbean, 2011. The Economics of Climate Change in the Caribbean, Summary report.

The Caribbean is particularly vulnerable to climate change impacts due to the geographic location of many of these States in the hurricane belt, and the concentrations of populations and economic infrastructure in coastal zones. The sub-region is also dependent on a narrow range of economic activities, including agriculture and tourism, which are intimately linked to the environment, making them highly susceptible to external shocks. Thus, climate change is of direct relevance to economic development planning in these countries. Estimates of the economic cost of climate change to Caribbean economies are useful in developing adaptation and mitigation strategies within the context of national and sub-regional development policies and plans. Apart from obvious costs such as those related to the replacement value of infrastructure due to increased intensity of tropical cyclones, there are real costs, such as productivity loss, potential relocation of persons living near coastlines, and increased resources for dealing with frequent flooding. Indeed, the range of anticipated impacts on key economic sectors in the Caribbean will have implications for overall quality of life in the sub-region, and more so among poor and vulnerable groups. Uncertainty margins are large because of the long time frames involved in dealing with complex natural phenomena, feedback processes, non-linear impacts and asymmetric consequences.

The action to be taken by Caribbean countries in adapting to climate change need to be mainstreamed into national development policies and plans if they are to support national visions. The report captures the results of the studies conducted during the Review of the Economics of Climate Change in the Caribbean (RECCC) project to date. The results of the economic assessments of the impacts of climate change on the agricultural, coastal and marine, energy and transportation, health, freshwater resources and tourism sectors in the Caribbean sub-region are presented. The report concludes with an examination of adaptation strategies and key policy recommendations for policymakers.

Simpson, M.C.1,2, Scott, D.2,3, Harrison, M4., Sim, R.3, Silver, N.5, O'Keeffe, E.6, Harrison, S.4, Taylor, M.7, Lizcano, G.1, Rutty, M.3, Stager, H.2,3, Oldham, J.3, Wilson, M.7, New, M.1, Clarke, J. 2, Day, O.J.2, Fields, N.2, Georges, J.2, Waithe, R.2, McSharry, P.1 (2010) Quantification and Magnitude of Losses and Damages Resulting from the Impacts of Climate Change: Modelling the Transformational Impacts and Costs of Sea Level Rise in the Caribbean (Full Document). United Nations Development Programme (UNDP), Barbados, West Indies. Report available from The CARIBSAVE Partnership website. Accessed from http://caribsave.org/index.php?id=5.

This report, commissioned by the UNDP Barbados and the OECS, focuses on the

(1) improving climate change modelling for taking informed decisions, and

(2) improving predictions of impacts on key sectors and assessing adaptation measures.

Specifically, the report provides a detailed and vigorous assessment of the losses and damages associated with SLR impacts on the population, ecosystems and key economic sectors in CARICOM. Advancements in understanding the consequences of SLR at the regional level were accomplished through:

- utilisation of newly available higher resolution geospatial data of coastal areas (satellite based Digital Elevation Models);
- improved inventories of coastal infrastructure and other assets at risk;
- the first quantification of the extent of SLR-induced erosion risk in unconsolidated coastal areas;
- a more comprehensive understanding of combined SLR and storm surge risk; and,
- the first quantification of the extent and cost of structural protection works required to protect coastal cities in CARICOM countries from SLR.

The economic implications of the impacts of climate change and required adaptation are being increasingly quantified to better inform international negotiations regarding adaptation assistance. This study provides the most detailed analysis to date of the damages and costs associated with SLR for the CARICOM nations. The methodology incorporates top-down and bottom-up approaches (i.e., macro, meso- and micro-scales analyses) to model impacts on the economies of each CARICOM country individually. A unique strength of this economic study is that it is based on the most detailed geographic reality of coastal geomorphology and development that determine vulnerability to SLR.

Such in-depth information is essential for the Caribbean States to strategically reduce vulnerability, through investment, insurance, planning, and policy decisions, and inform negotiations regarding adaptation assistance under the Copenhagen Accord that was agreed at COP15 in Copenhagen.

Acclimatise, 2013. Guidance for Ministries of Finance for consideration of all climate related risks in the evaluation of annual expenditure proposals submitted by line ministries. Briefing Note.

The need to integrate current climate variability into public budgetary and fiscal arrangements has been widely recognised in the disaster risk reduction arena with the development of specific guidance and methodologies for decision-makers (e.g. the UNDP guidance for damage loss assessments). However, only recently has attention been turned to the need to consider future climate risks. Climate change can no longer be ignored given the growing evidence about increasing vulnerabilities and impacts and their implications for fiscal stability and macroeconomic policy. This note summarises why it is important to build climate resilience into national fiscal and budgetary frameworks and provides 10 initial steps for finance ministries on how these considerations can be included in the annual review process of expenditure proposals submitted by line ministries. As a subsequent step, countries will need to consider the undertaking of a Climate Public Expenditure and Institutional Review with a view to mainstream climate change aspects into the budget process.

World Bank 2010. Natural Hazards, UnNatural Disasters. The Economics of Effective Prevention. The World Bank and the United Nations.

Every disaster is unique, but each exposes actions—by individuals and governments at different levels—that, had they been different, would have resulted in fewer deaths and less damage. Prevention is possible, and this report examines what it takes to do this cost-effectively. The report looks at disasters primarily through an economic lens. Economists emphasize self-interest to explain how people choose the amount of prevention, insurance, and coping. But lenses can distort as well as sharpen images, so the report also draws from other disciplines: psychology to examine how people may misperceive risks, political science to understand voting patterns, and nutrition science to see how stunting in children after a disaster impairs cognitive abilities and productivity as adults much later. Peering into the future, the report shows that growing cities will increase exposure to hazards, but that vulnerability will not rise if cities are better managed. The intensities and frequencies of hazards in the coming decades will change with the climate, and the report examines this complicated and contentious subject, acknowledging all the limitations of data and science.

Mitchell, T., Mechler, R., Harris, K., 2012. Tackling exposure: Placing disaster risk management at the heart of national economic and fiscal policy. Climate and Development Knowledge Network CDKN)

The number of disasters is increasing. When combined with upward trends in losses from economic disasters, it is clear that paying for disaster relief and recovery at such large scales is unsustainable, in both human and financial terms. Economic exposure to disasters is increasing faster than per capita gross domestic product (GDP), and the impacts of climate change on the severity and frequency of hazards will accentuate existing trends in disaster losses in the future. While support for effective disaster relief and recovery must remain, there should be a greater emphasis on proactive efforts to reduce risk, based on comprehensive risk assessments and the integration of risk-reduction measures into national economic and development planning. The paper examine tools and approaches for integrating disaster risk management into economic and fiscal policy.

Wilkinson, E., Brenes, A., 2014. Risk-informed decision-making: An agenda for improving risk assessments under HFA2. Climate and Development Knowledge Network CDKN)

Climate extremes with climate changes, and changing patterns of exposure and vulnerability are creating new geographic distributions of risk that need to be addressed explicitly through public policy. Disaster risk assessments are produced and promoted on the basis that they provide the information, analysis and knowledge needed to make sound choices and investments that reduce the human impact of environmental hazards. This paper provides useful insights into the use of risk-related information in public investment decisions to manage risk, adapt to climate change and promote development. This paper is therefore of relevance to the global disasters agreement, which is currently in preparation to succeed the Hyogo Framework for Action (HFA) 2005– 2015. These findings are particularly relevant to national and local government officials who make risk management decisions; their international development partners, and scientists and consultant who conduct the assessments.

Results from these studies suggest that there are technical, operational and institutional obstacles to the uptake of recommendations. These need to be recognised and understood when designing and implementing risk assessment projects. Technical capacities and alignment with other development priorities and political cycles all need to be taken into account, if risk assessment data are to have a posotive influence on development, adaptation, and risk management policies and practices. The paper embeds its analysis in a broad set of challenges around implementing disaster risk management and adaptation policies. It presents a number of recommendations on how to conceive and conduct risk assessments that can clearly convey the main messages – and thus be more easily translated into effective risk management decisions.