The Programme for Building Regional Climate Capacity in the Caribbean (BRCCC Programme)

Component 4.1: Development of the Regional Climate Centre (RCC)

Technical Area III: Development of Seasonal Forecasting Capabilities to apply to Climate-Sensitive Sectors in the Caribbean

CONCEPTUAL FRAMEWORK AND METHODOLOGY

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October 2015

About the Caribbean Institute for Meteorology and Hydrology (CIMH)

The CIMH is an Institution of the Caribbean Community (CARICOM) and the technical Organ of the Caribbean Meteorological Organization (CMO). The mandate of the CIMH is to assist in improving and developing the National Meteorological and Hydrological Services (NMHSs), as well as, providing the awareness of the benefits of Meteorology and Hydrology for the economic well-being of the CIMH Member States. This is achieved through training, research, investigations, and the provision of related specialized services and advice. The specific functions of CIMH include:

1. **World Meteorological Organization (WMO) Regional Training Centre (RTC):** CIMH trains professionals in operational meteorology and hydrology and the climate sciences. CIMH is also responsible for the delivery of courses for the completion of the BSc Degree in Meteorology at the University of the West Indies.

2. **Centre for research in Meteorology, Hydrology, Climatology and Associated Sciences**: The Institute is the leading institution in the English-speaking Caribbean engaged in focused and inter-disciplinary research in tropical meteorology, tropical climatology, hydrology and water resources management. This often necessitates collaboration with other relevant regional national and international organisations.

3. **Regional Climate and Hydrological Data Centre**: Since its inception, the Institute has been used by Member States of the CMO as a location for the region's climate data archive. As part of this responsibility, the Institute is responsible for collecting the region's climate data, quality assuring the data, archiving the data and disseminating the data to regional and international stakeholders.

4. **Regional Instrument Centre (RIC)**: In its capacity as the RIC for Member States of the CMO, the Institute supports instrument calibration, instrument maintenance and repair, identification of appropriate instruments for the region and instrument procurement and installation. In addition, the Institute conducts training programmes in instrument maintenance and calibration for persons from and outside of the region. The Institute is also active in research and development leading to the development of new instruments and better instrument maintenance programmes.

5. **Regional Centre of Excellence for Training in Satellite Meteorology:** CIMH is one of the network of thirteen training Centres of Excellence worldwide established by WMO that actively participating in the Virtual Laboratory for Training and Education in Satellite Meteorology (VLab) programme. These Centres are working together to improve the utilization of data and products from meteorological and environmental satellites.

6. **Regional Climate Centre:** CIMH has already established itself as the primary provider of climate services and products to the several socio-economic sectors in the Caribbean. Seeking to establish itself as a WMO Regional Climate Centre for the Caribbean, CIMH launched the Demonstration Phase in April 2013, as it builds toward full designation.

7. **Caribbean Centre for Climate and Environmental Simulations (CCCES)**: The CCCES was established in 2014 at the CIMH through support from the USAID BRCCC Programme. The CCCES is part of the region's strategy to build and sustain regional resilience to the risk posed by climate change, increasing climate variability, extreme weather and increasing environmental degradation and change. The CCCES addresses resilience in these areas by providing CARICOM scientists, engineers and researchers with state-of-the-art computations resources to conduct complex simulations and analyses within and across disciplines on a range of scenarios (cover varying spatial and temporal scales) to adequately identify, bound and mitigate the drivers of risk to the social and economic development of the Caribbean.

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LIST OF ACRONYMS

Acronym	Definition
AMC	Applied Meteorology and Climatology
BRCCC	Building Regional Climate Capacity in the Caribbean
CARDI	Caribbean Agricultural Research & Development Institute
CAMI	Caribbean Agrometeorological Initiative
CARICOM	Caribbean Community
CariCOF	Caribbean Climate Outlook Forum
CARIWIN	Caribbean Water Initiative
CCCES	Caribbean Centre for Climate and Environmental Simulations
CDEMA	Caribbean Disaster Emergency Management Agency
CDM	Comprehensive Disaster Management
CDPMN	Caribbean Drought Precipitation Monitoring Network
CID	Climate Impacts Database
CIMH	Caribbean Institute for Meteorology and Hydrology
CoE	Center of Excellence
CMI	Caribbean Meteorological Institute
CMO	Caribbean Meteorological Organization
CARPHA	Caribbean Public Health Authority
CTO	Caribbean Tourism Organization
CARIWIN	Caribbean Water Initiative
CDPMN	Caribbean Drought and Precipitation Monitoring Network
CRM	Climate Risk Management
DEWIS	Drought Early Warning Information System
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DSS	Decision Support System
ENSO	El Niño-Southern Oscillation
EWIS	Early Warning Information System
EWISACTs	Early Warning Information System across Climate Timescales
EWS	Early Warning System
GFCS	Global Framework for Climate Services
IRAP	International Research Applications Program
IWRM	Integrated Water Resources Management
NMHS	National Meteorological and Hydrological Services
LoA	Letter of Agreement
RCC	Regional Climate Center
RCOF	Regional Climate Outlook Forum
SPI	Standardised Precipitation Index
USAID	United States Agency for International Development
UN	United Nations

UNISDR	United Nations International Strategy for Disaster Reduction
WIP	Work and Implementation Plan
WMO	World Meteorological Organization

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LIST OF DEFINITIONS

Technical Term	Definition
Climate	Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.
Climate variability	Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate at all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).
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 historical range or distribution of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes'.
Climate change	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, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.
Climate monitoring	This is continuous observation and assessment of accurate, long-term records of the atmosphere and other climate indicators (e.g. global mean Earth surface temperature and precipitation). This monitoring is done to keep track of variability of the earth's climate over different time scales, from seasons to decades to thousands of years and more and to understand the impacts the changes can have on all aspects of life: environment, economy and society. By carefully monitoring the climate, the effects of extreme events can be chronicled and mitigated. Monitoring also allows for the detection of climate change, its driving forces as well as its impacts around the world.
Climate prediction/forecasting	A climate prediction or climate forecast is the result of an attempt to produce (starting from a particular state of the climate system) an estimate of the actual evolution of the climate in the future, for example, at seasonal, interannual or decadal time scales. Because the future evolution of the climate system may be highly sensitive to initial conditions, such predictions are usually probabilistic in nature.
Climate risk	Climate risk can be defined qualitatively as the likelihood of unfavourable impacts occurring as a result of severe climate events interacting with vulnerable environmental, social, economic, political or cultural conditions. It can also be defined more quantitatively, as the product of the probability of a given climate event occurring and the adverse consequences of this. As such, climate risk originates from a dynamic combination of climate hazards (e.g. extent and duration of extreme temperatures or rainfall) and the vulnerabilities (propensity Or predisposition to be adversely affected) of exposed elements (e.g.

Technical Term	Definition
	communities, economic or societal sectors or ecosystems).
Climate risk management (CRM)	A systematic and coordinated process in which climate information is used to reduce the risks associated with climate variability and change, and to take advantage of opportunities, in order to improve the resilience of social, economic and environmental systems.
Climate data	Historical and real-time climate observations along with direct model outputs covering historical and future periods
Climate product	A derived synthesis of climate data which allows access to useful climate information that is suited to particular needs of the end-users, as well as, practical guidance on how they can use it. It encompasses a range of activities that deal with generating and providing information based on past, present and future climate and on its impacts on natural and human systems. Climate products cover a range of information from climate observations and information, such as temperature, precipitation, wind velocity, soil temperatures and other climate information.
Climate information	Climate information refers to knowledge and advice about the past, present and future characteristics of the Earth's climate and at all relevant time and space scales. It is a broad term that includes summary statistics, historic time-series records, near-real-time monitoring, predictive information from daily weather to seasonal to inter-annual time scales, and climate change scenarios.
Climate services	Climate services are climate information prepared and delivered to meet users' needs. It requires appropriate engagement along with an effective access mechanism and must respond to user needs.
Disaster	Disasters are severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.
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.
Disaster risk management (DRM)	Processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development.
Disaster risk reduction (DRR)	Denotes both a policy goal or objective, and the strategic and instrumental measures employed for anticipating future disaster risk; reducing existing exposure, hazard, or vulnerability; and improving resilience.
Disaster management	Social processes for designing, implementing, and evaluating strategies, policies, and measures that promote and improve disaster preparedness, response, and recovery practices at different organizational and societal levels.
El Niño-Southern Oscillation (ENSO)	The term El Niño was initially used to describe a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. It has since become identified with a basin-wide warming of the tropical Pacific Ocean east of the dateline. This oceanic event is associated with a fluctuation of a global-scale tropical and subtropical surface pressure pattern called the Southern Oscillation. This coupled atmosphere-ocean phenomenon, with preferred time scales of 2 to about 7 years, is collectively known as the El Niño-Southern Oscillation. It is often measured by the surface pressure anomaly difference between Darwin and Tahiti and the sea surface temperatures in the central and

Technical Term	Definition
	eastern equatorial Pacific. During an ENSO event, the prevailing trade winds weaken, reducing upwelling and altering ocean currents such that the sea surface temperatures warm, further weakening the trade winds. This event has a great impact on the wind, sea surface temperature, and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world, through global teleconnections. The cold phase of ENSO is called La Niña.
Early Warning Information System (EWIS)	The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities, and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.
Early Warning Information System across Climate Timescales (EWISACTs)	An Early Warning Information System (EWIS) that operates across climate timescales from daily, monthly seasonal to decadal and centuries and beyond. It spans the full gamut of climate hazards including extreme events.
Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this document, the term hazard usually refers to climate-related physical events or trends or their physical impacts.
Impacts (Consequences, Outcomes)	In this document, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. 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.
Outlook	A term referring to a scenario of climatic and economic and social conditions over a coming season or two, usually developed by consensus among a group of experts and mainly used in the context of Regional Climate Outlook Forums.
Regional Climate Centre (RCC)	The roles and activities of regional climate centres will vary according to the specific interests and needs of the region. Minimally, a regional climate centre would carry out the following *operational activities*: • Interpreting and assessing relevant seasonal analysis, prediction and climate change scenario products from global centres; • Making use of seasonal forecast verification data provided by the World Meteorological Organization system of regional climate centres and lead centres, distributing relevant verification information to climate service users and providing feedback to global centres; • Generating regional and sub-regional tailored products relevant to user needs, including seasonal outlooks and downscaled global climate change scenarios; • Verifying quantitative seasonal and other forecast products, including exchanging basic forecasts and historical data; • Generating ‘consensus’ statements relating to regional or sub-regional forecasts • Providing users with on-line access to climate products/services as agreed on a regional basis; • Assessing use of the regional centre’s products and services using feedback from users; • Performing climate diagnostics including analysis of climate variability and

Technical Term	Definition
	extremes at regional and sub-regional scales; • Establishing an historical reference climatology for the region and/or sub-regions; • Implementing a regional climate watch; • Developing regional climate datasets, gridded where applicable; and • Providing climate database and archiving services at the request of national authorities. Minimally, a RCC would also carry out the following *non-operational activities*: • As, and if requested by national governments, developing user forums for key climate user sectors within the region; • Providing scientific guidance on reanalysis, regionally downscaled analysis and climate change scenarios that are available through the centre; • Providing information on methodologies and product specifications for regionally agreed mandatory products and providing guidance for their use; • Coordinating training for climate service users in interpreting and using regionally agreed mandatory products, including seasonal predictions and climate change scenarios; • Giving strong support to vital, regional climate research initiatives which will be key to service creation and improvement; and • Monitoring and responding to user feedback.
Regional Climate Outlook Forum (RCOF)	In several regions of the world, countries cooperate to produce a consensus seasonal climate outlook in a similar manner through periodic Regional Climate Outlook Forums. The forum concept was initiated at a workshop held in Victoria Falls, Zimbabwe in October 1996 and has developed progressively into an important element of the global capability for seasonal prediction. Convened by regional and international organizations at key seasons of the year, these forums bring together climate experts and sector representatives from agriculture, food security, water management, etc, to review climate prediction information, develop consensus-based outlooks and raise awareness of emerging or potential regional impacts. The regional climate forums help ensure consistency in access to and interpretation of climate information for groups of countries having similar climatological and socio-economic characteristics. They generate improved understanding and interpretation of available climate prediction information and promote more coherent action among scientists, sectoral users, extension agencies and policy-makers.
Spatial and temporal scales	Climate may vary on a large range of spatial and temporal scales. Spatial scales may range from local (less than 100 000 km^2), through regional (100 000 to 10 million km^2) to continental (10 to 100 million km^2). Temporal scales may range from seasonal to geological (up to hundreds of millions of years).
Vulnerability	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.
Weather	The state of the atmosphere at a given time and place, with respect to variables such as temperature, moisture, wind velocity and barometric pressure.

Source: IPCC (2012), (IPCC, 2013), (IPCC, 2014), Martínez et al. (2012), UNISDR (2009), WMO (2011a), WMO (2014c)

EXECUTIVE SUMMARY

The Caribbean region has been increasing its resilience to the impacts of weather and climate-related hazards for more than 40 years. However, the main sectoral drivers of socio-economic development of Caribbean states remain highly reliant on and sensitive to climate. Regional statistics indicate that weather and climate-related events are associated with more socio-economic damage and loss cumulatively than other types of natural hazards. The adverse impacts of climate variability, extremes and change therefore pose a serious threat to the future of the region.

To address these impacts going forward, the American People, through the United States Agency for International Development (USAID), are funding a new Programme to build regional climate capacity in the Caribbean (BRCCC Programme) for adaptation to climate variability and change with a primary focus on Guyana and the islands of the Eastern Caribbean. Among other things, the Programme features a collaborative partnership between the World Meteorological Organization (WMO) and the Caribbean Institute for Meteorology and Hydrology (CIMH) in developing seasonal forecasting capabilities in six climate sensitive sectors, namely, Agriculture and Food Security, Water, Disaster Risk Management, Health, Energy and Tourism.

Climate variability and change occur on timescales ranging from sub-seasonal to seasonal to interannual to decadal and beyond. Climate information then, is related to specific timescales and can be short-term (dekadal, monthly, seasonal, annual), mid-term (annual to multi-year) or long-range (decades in the future) in nature. Appropriate and timely sector specific, environmental, and climate information at relevant spatial and temporal scales can be particularly helpful to anticipate, prepare for and respond to climate-related risks and opportunities.

Sectoral Early Warning Information Systems across Climate Timescales (EWISACTs) hold the potential to be of great value because they can provide early warning of potential impacting climatic events that may have implications for a wide range of climate sensitive sectoral decisions. For the Caribbean region, the formalization of the development of sectoral EWISACTs is a landmark initiative which has three (3) specific objectives, namely:

1. To design, develop and deliver an increased range of sector driven climate products and services;
2. To design, develop and deliver integrated decision-support processes and tools; and
3. To design, develop and deliver capacity building and training programs in support of climate services.

The development of sectoral EWISACTs in the Caribbean will contribute to the implementation of the five pillars of the Global Framework for Climate Services (GFCS). In the long-term, CIMH will pursue six (6) concrete methodological steps as follows:

1. Establish and maintain/foster governance mechanisms at regional and national levels;
2. Baseline and continue to monitor users' needs and providers' capacity;
3. Develop new and improve existing impact models;
4. Develop, test and validate sectoral EWISACTs products and prototypes;
5. Integrate product prototypes within Decision Support Systems (DSS) and platforms; and
6. Strengthen capacity to provide and utilize climate information.

Four (4) short-term outcomes that are expected as a result of this process under the BRCCC Programme are as follows:

1. Established relationships between meteorologists/climatologists, scientists from other sectors and policymakers from across sectors;
2. Initiation of the development, deployment and platform integration of sector specific forecasting/planning models in the form of early warning systems;
3. Enhanced institutional capacity; and
4. Enhanced adaptive capacity.

The USAID's support for the BRCCC Programme is fundamental to the continued evolution of climate services in the Caribbean. At the end of this Programme, climate sensitive sectors will be in a better position to incorporate climate information at relevant spatial and temporal scales to make evidence-based decisions.

1.0 Climate Sensitivity in the Caribbean

The climate of the Caribbean is characterised predominantly by two seasons (the wet and dry seasons); and generally small temperature changes. The principal income earners for the socio-economic development of Caribbean states are very reliant on its climatological pattern. For example, touristic offerings are promoted as being available year-round due average annual temperatures usually being in the range of 24°C - 32°C - ideal for recreation and visitor comfort. In the case of agriculture, for most rain-fed crops, the crop season spans the length of the Wet season (which typically runs from May to November annually) with the type of crops and cultivars usually selected to match anticipated rainfall.

The sectors are also sensitive to climate variability and weather extremes. For example, periods of significantly above normal rainfall values (a contributing factor to increased flood potential) and below normal rainfall values (a major contributing factor of droughts) have historically had devastating consequences on the Caribbean economy. At the drought end, insufficient water supplies has led to crop failure, the increased incidence of bush fires, the breakout of vector borne diseases, reduced industrial activity and reduced energy production. On the other hand, floods have led to landslides, damage to property, displacement of populations and also failure of critical infrastructure (e.g., roads and bridges).

The impacts of climate variability, extremes and change, therefore pose a serious threat to the social and economic development of the Caribbean region (Farrell, 2012). Research shows that in the Caribbean, weather and climate-related events are associated with more economic damage and loss cumulatively than other types of natural hazards. According to CDEMA (2013), for the period 1950-2008, wind storms accounted for 60%, flooding accounted for 25% while drought accounted for 5% of natural hazard events in the Caribbean. In 2004, Hurricane Ivan caused losses equivalent to 200% of national Gross Domestic Product in Grenada; floods in Guyana in 2005 were associated with losses of 60% of country GDP; while Hurricane Tomas accounted for losses in the order of 60% of GDP in Saint Lucia in 2010 (Farrell, 2012; WMO, 2013a). Moreover, in 2009/2010, the most severe drought in 50 years reduced crop production, increased bush fires, and led to widespread water shortages and an increase in food prices across many islands (Farrell, Trotman, & Cox, 2010). A World Bank report estimates future annual direct losses[1] in the region due to climate-related disasters as follows: 1) USD 2.6 billion due to wind damage; 2) USD 363.1 million due to flood damage; and 3) USD 3.7 million due to drought (Toba, 2009). These observed impacts and estimates of future loss and damage present a compelling socio-economic case for action.

2.0 The Concept of Climate Risk Management (CRM)

Climate Risk Management (CRM) is a term used for a large and growing body of work, bridging the disaster risk management, climate change adaptation and development sectors, amongst

[1] Values given in 2007 US dollars.

many others (Pulwarty, 2013). The WMO has proposed a definition of CRM as "a systematic and coordinated process in which climate information is used to reduce the risks associated with climate variability and change, and to take advantage of opportunities, in order to improve the resilience of social, economic and environmental systems" (Martínez et al., 2012). CRM is complementary to the practice of evidence-based decision-making which is a fundamental principle for many socio-economic sectors which rely on appropriate and timely sector specific, environmental, and climate information at relevant spatial and temporal scales to make informed decisions (WMO, 2014b).

3.0 A Conceptual Framework for Sectoral Early Warning Information Systems across Climate Timescales (EWISACTs)

Weather and climate information can be particularly helpful to anticipate, prepare for and respond to risks on various timescales to address problems associated with weather extremes, climate variability, as well as, climate change (WMO, 2014b).

3.1 Weather and Climate Timescales

Unlike weather which occurs on timescales ranging from minutes to two weeks, climate variability and change[2] occur on timescales ranging from sub-seasonal (ranging from 1-3 months) to seasonal (ranging from 3-9 months) to interannual to decadal and beyond (see Figure 1).

[2] The full definitions of weather, climate, climate variability and climate change can be found in the List of Definitions provided on pages 7-10 of this document.

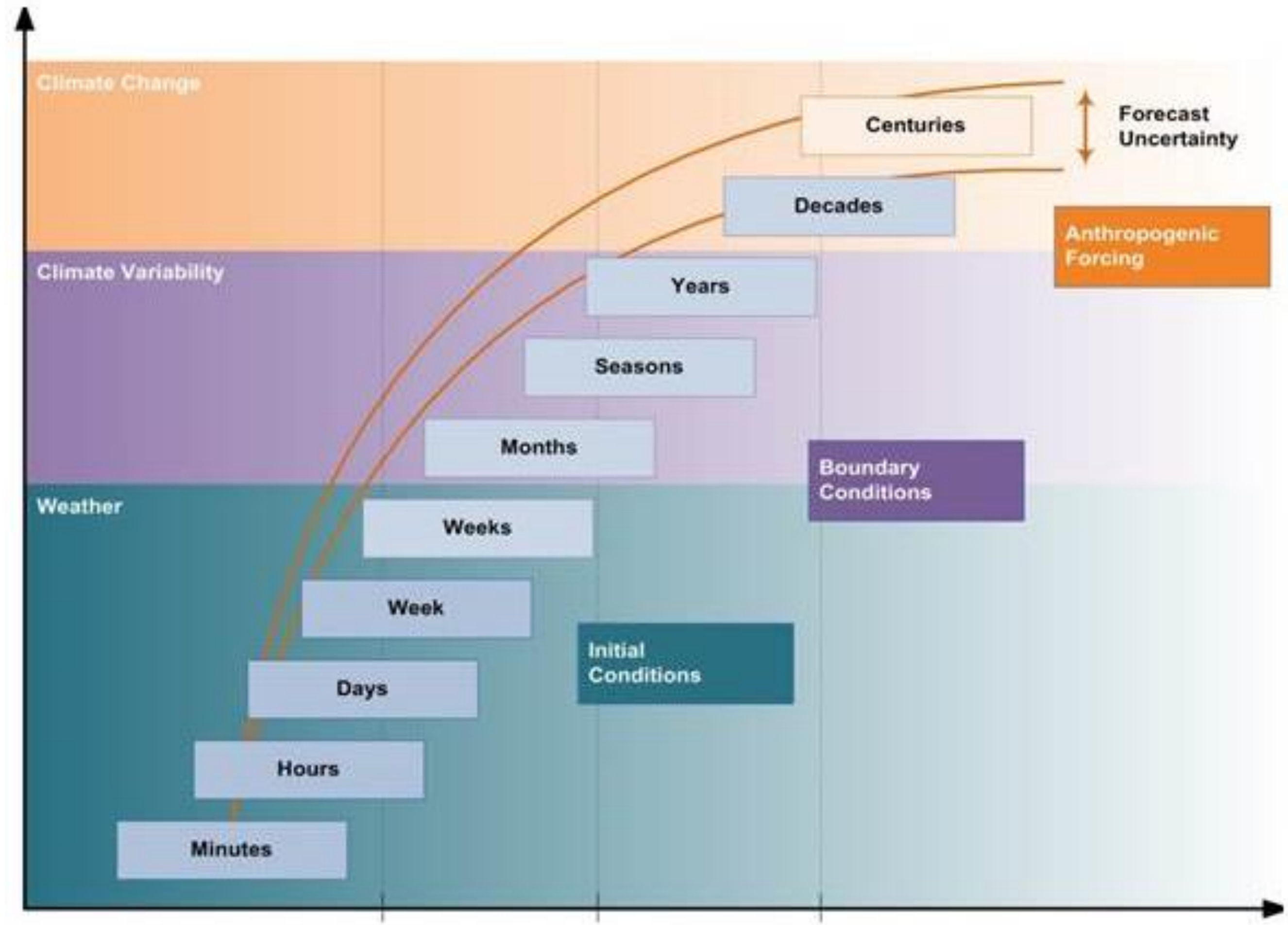

Figure 1. Generalised Climate Prediction Framework showing the weather to climate continuum. Source: WMO (2013b)

However, sectoral end-users infrequently distinguish between the weather and climate timescales. In fact, they are likely to view climate services as part of the continuum from weather services in a context where the most effective way to manage long-term climate risks to a sector is often through building on services that help to manage more acute weather-related risks (WMO, 2014b).

Climate services enable decision-makers and communities to assess, and prevent or prepare for, potential harmful weather and climate events or take advantage of potential opportunities; while weather services enable action in response to specific events as they become imminent (WMO, 2014a). In this way, climate services complement the role of weather services and can be particularly effective when integrated with weather services (WMO, 2014a).

3.2 Early Warning Information Systems (EWIS)

The United Nations International Strategy for Disaster Reduction (UNISDR) notes that early warning information such as forecasts, enables "individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss" (UNISDR, 2009). At the regional level, EWIS are recognized by the *Regional Comprehensive Disaster Management (CDM) Strategy and Programming Framework 2014-2024* [3] and the *Implementation Plan for the 'Regional Framework for Achieving Development Resilient to Climate Change'* [4] as critical to the effective management of climate-related disasters and adaptation to climate variability, extremes and change.

EWIS must be people and location centric, and integrate four major elements (Pulwarty & Sivakumar, 2014; UNISDR, 2009; WMO, 2014a):

1. Knowledge of the risks faced;
2. Technical monitoring and warning service;
3. Dissemination of meaningful warnings to those at risk; and
4. Public awareness and preparedness to act.

Early warning information via well-defined and structured climate services can enable Caribbean socio-economic sectors to adapt to climate variability, and paves the way for enhanced resilience to future climate change. Creating a culture of the use of data-driven climate information is one of the first steps toward climate adaptation (Van Meerbeeck et al., 2015).

3.3 Sectoral EWISACTs

Weather and climate information relate to specific timescales relevant for sectoral decision-making illustrated in Figure 2.

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[3] Developed by the Caribbean Disaster Emergency Management Agency (CDEMA) in 2014.

[4] Developed by the Caribbean Community Climate Change Centre (CCCCC) in 2011.

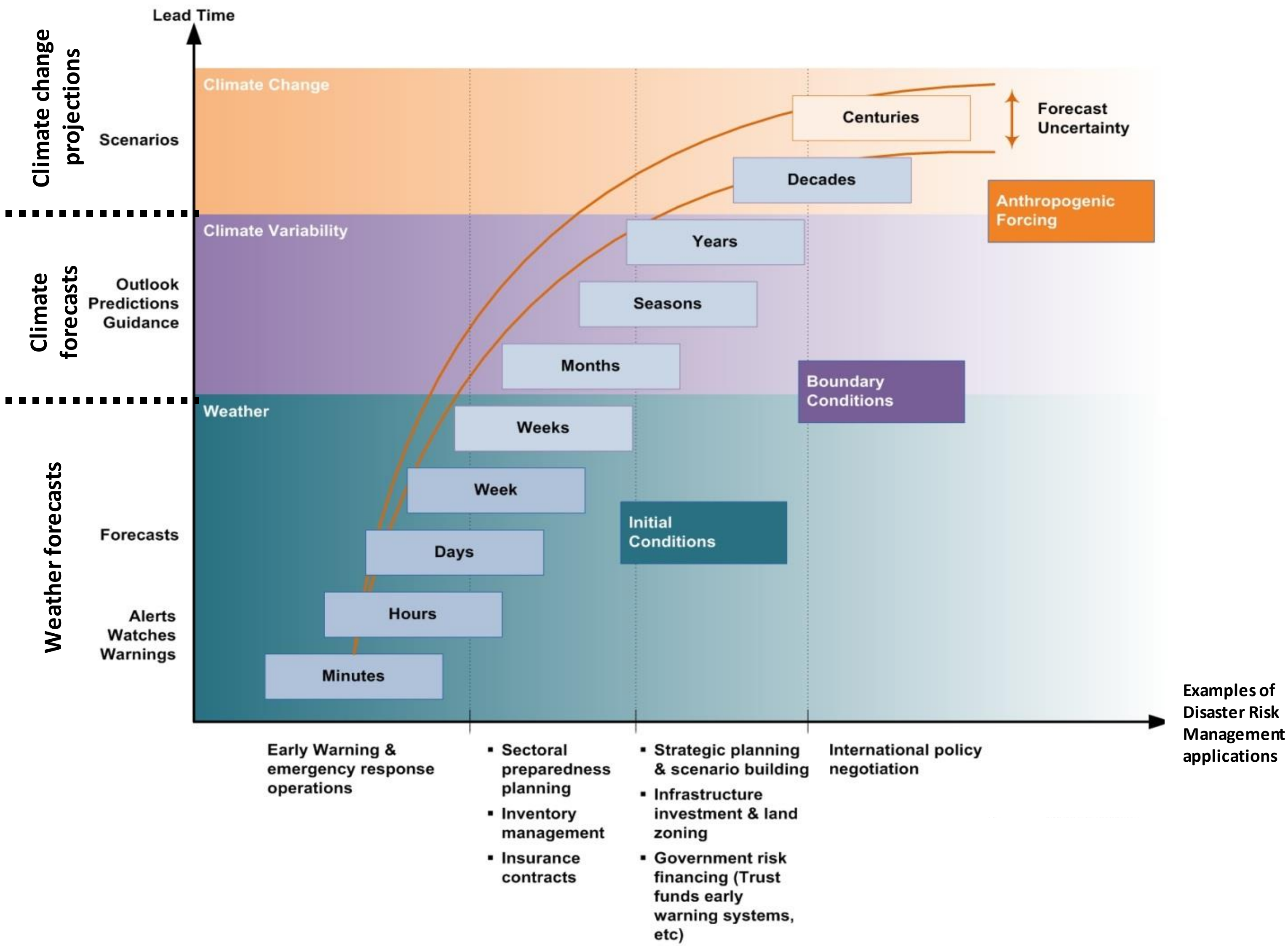

Figure 2. Types of information relevant for sectoral decision-making across weather and climate timescales (in Disaster Risk Management).
Source: Adapted from WMO (2013b)

Climate information provided several weeks, months, years and decades ahead[5] holds the potential to be of great value to a wide range of sectoral decisions, wherever the outcomes are heavily influenced by climate. This is because they can provide early warning of potential impacting climatic events that may have implications (for example, in terms of potential risks and/or opportunities) for sector specific management decisions.

Ultimately, end-users need help to focus on relevant time scales for decision-making with an emphasis on days to decades, including seasonal and inter-annual variability, but also including long-term adaptation to climate change (WMO, 2014a). Matching sectoral decision-making cycles to appropriate and/or relevant timescales and forecast products therefore becomes important as sectors have heterogeneous needs in this regard.

4.0 Evolution of climate services – international and regional perspectives

4.1 International Level

At its Fourteenth Session in 2009, the World Meteorological Organization (WMO) Commission for Basic Systems (CBS) requested the WMO Public Weather Service Program (PWSP), to provide special assistance to WMO Members to improve their national Public Weather Service programs by providing guidance on now-casting and multi-hazard warnings with the aim of strengthening the capacity of the National Meteorological and Hydrological Services (NMHSs) to reduce the impact of disasters. However, a more cohesive overarching global framework was required that could provide a structured approach to dealing with climate-related hazards in such a way that is service oriented to the different needs of multiple stakeholders. The WMO and its partners crystallised the recognition of the need to support a range of decision-makers with relevant, actionable climate information for climate risk management at the World Climate Conference-3 (WCC-3, 31 August to 4 September, 2009, Geneva, Switzerland) (Martínez et al., 2012). At that time, thousands of scientists and decision-makers from climate and other disciplines decided to establish a Global Framework for Climate Services (GFCS) - a United Nations (UN)-led initiative spearheaded by the WMO to guide the development and application of science-based climate information and services in support of decision-making. The vision of the GFCS is to "enable society to better manage the risks and opportunities arising from climate variability and change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice" (WMO, 2011b, 2014c). As of 2015, the GFCS has five initial priority sectors which are namely: 1) agriculture and food security, 2) water, 3) health, 4) disaster risk reduction and 5) energy. The GFCS recognizes that many countries lack policies and institutions or human resources with the right skills to enable them to take advantage of new or existing climate data and products or create national user interface groups to establish national dialogue on these issues. In particular, Small Island

[5] Differentiated from weather forecasts which provide forecasts up to 2 weeks ahead.

Developing States (SIDS) and other developing countries are the ones least capable in this regard, and therefore are one of the primary targeted beneficiaries of climate services.

4.2 Regional Level

A regional cornerstone to the implementation of the GFCS is the provision of reliable seasonal climate forecasts. The rationale is that such forecasts will help manage and mitigate substantial risks posed by (and reap the potential benefits of) climate variability on socio-economic sectors. As such, seasonal climate forecasting forms a first-hand approach to climate risk management as such forecasts provide early warnings for potential events impacting climate- sensitive sectors within a few months following their issuance (Van Meerbeeck, Farrell, & Trotman, 2013).

Since its inception as the Caribbean Meteorological Institute (CMI) in 1967, the CIMH has been used by the 16 Member States of the Caribbean Meteorological Organization (CMO) as a repository for the region's climate data archive. In this role, CIMH has been providing data delivery, for example, through the production of monthly climate data summaries, as a climate service, through its climate archives for over 40 years. It also provides climate information derived from climate databases, for instance, in terms of climate monitoring. The climate data sets produced through this activity have spanned a sufficiently long enough time to start delivering other climate services since 2000.

In 2007, CIMH created an Applied Meteorology and Climatology (AMC) section to convert compiled regional data to products (See Appendix 1 – for a summary of products developed to date). In the recent past, CIMH has engaged a few socio-economic sectors in the Caribbean in an effort to integrate climate information into their decision-making. For example, the Caribbean Water Initiative (CARIWIN) implemented during 2007-2012 engaged water resource managers in Grenada, Guyana and Jamaica to improve their capacity in the use of the principles of Integrated Water Resources Management (IWRM); hydrometeorological data processing and management; use of field instrumentation; and water policy.

The establishment of the Caribbean Drought and Precipitation Monitoring Network (CDPMN) in 2009, marked the beginning of a regional effort to develop a Caribbean Drought Early Warning Information System (DEWIS). The CDPMN provides the Caribbean Drought Bulletin, Standardized Precipitation Index (SPI) maps and SPI Outlook as a means of drought and excessive seasonal rainfall monitoring.

The 2009/2010 drought event triggered the development of the national DEWIS to provide potentially useful seasonal climate information to help sectoral decision-makers particularly in the agriculture, water management and disaster risk management sectors to better understand the relative chances that extreme climate events would occur in upcoming months (Guido et al., 2014).

In February 2010, CIMH began to implement the Caribbean AgroMeteorological Initiative (CAMI) in partnership with the WMO, the Caribbean Agricultural Research & Development Institute (CARDI) and ten (10) National Meteorological Services. This three (3) year initiative marked CIMH's first attempt at interfacing with the agricultural sector through the Meteorological Services. Interaction with farmers provided them with information communicated in a manner that was useful and usable. One of the major outcomes of CAMI was the development of regional and national agro-meteorological bulletins to help inform the agriculture sector of recent events and the three month seasonal forecast (Trotman, 2012).

June 2010 saw the re-establishment of the Caribbean Climate Outlook Forum (CariCOF), the Caribbean's version of a RCOF, after a long hiatus[6]. This event was critical to the establishment of a reliable network for the provision of consensus rainfall outlooks, as well as, the training of personnel at CIMH and the NMHSs in the art and science of seasonal forecasting. CariCOF Assemblies held each year since 2012, have expanded sectoral engagement. The forum brings together national and regional meteorological service professionals and decision-makers to produce and discuss seasonal climate forecasts issued for the Wet/Hurricane season, and since 2014, for the Dry season (CIMH, 2014a, 2014b; Van Meerbeeck et al., 2013). Through interaction with sectoral users and policymakers, CariCOF assesses the likely implications of the outlooks on socio-economic sectors in the Caribbean and explores sector-specific applications of the outlooks. This Assembly also reviews barriers to the use of climate information, experiences and successful lessons. At the CariCOF 2013, where some emphasis was placed on information communication, the CariCOF Climate Outlook Newsletter was developed and disseminated as the main product, designed to effectively convey the key messages of the outlooks to primary users.

In 2013, CIMH in collaboration with CDEMA, and the region's national DRM agencies and their stakeholders began to develop the Caribbean Climate Impacts Database (CID) - an inventory of geo-referenced, historical climate-related impacts. The repository contains impact data for 17 Caribbean countries with some records dating as far back as 1780. The CID also has a sectoral focus and archives impacts affecting five climate sensitive sectors – agriculture and food security, water, disaster risk management, health, and tourism. It addressed the disconnect between climate and disaster impacts and the response to impacts at the national and sectoral levels by the inclusion of available response mechanisms and standard operating procedures. This database was launched in June 2015 at the Wet Season CariCOF.

By 2014, the CariCOF Drought Outlook was developed as the first demand-driven climate outlook product that forms part of an alerting system for drought several months ahead of time.

Also in that year, the Caribbean Centre for Climate and Environmental Simulations (CCCES), was established at the CIMH, provides Caribbean Community (CARICOM) scientists, engineers and

[6] The CariCOF was first convened in 1998. A key outcome of this forum, was the formulation and communication of a seasonal rainfall outlook.

researchers with state-of-the-art computational resources to conduct complex simulations and analyses within and across disciplines on a range of scenarios (cover varying spatial and temporal scales) to adequately identify, bound and mitigate the drivers of risk to the social and economic development of the Caribbean.

The 2015 Wet Season CariCOF saw the launch of two new operational products: 1) the CariCOF Caribbean Coral Reef Watch, and 2) the CariCOF Wet Days and Wet Spells Outlook. The CariCOF Caribbean Coral Reef Watch maps and explains the current and expected coral reef bleaching situation across the entire region. The CariCOF Wet Days and Wet Spells Outlook forecasts the frequency of wet days, as well as, 3- and 7-day wet spells over the next 3 months and contextualises the forecasts with respect to historical observations (Van Meerbeeck & Mason, 2015).

However, making generic climate information available is only the first step. This information must be further translated into products that make sense of the information in relation to the sector specific risks associated with the climatic hazard (see Figure 3).

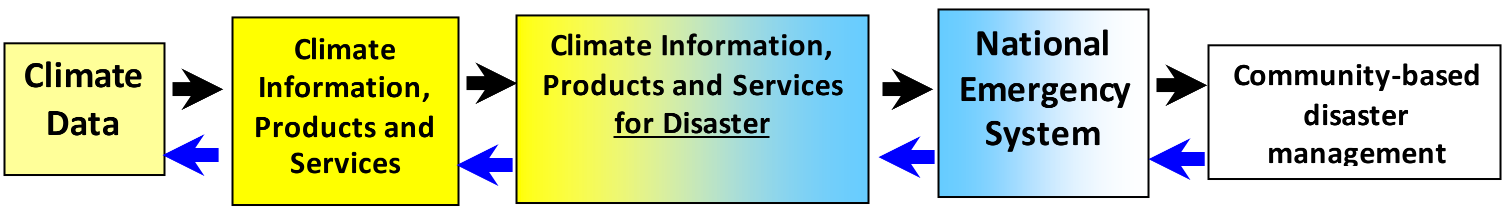

Figure 3. Example of the climate information chain (in Disaster Risk Management)
Source: Pulwarty (2013)

Clear and direct explanations of what the information means for sectoral risks, along with communication about uncertainty is essential. However, with the exception of the Agroclimatic Bulletin, most climate products produced by the CIMH are generic and are yet to be tailored to sector specific contexts.

Through structured investments to build its capacity in the near future, the CIMH will significantly expand and enhance the current range of climate products and services, advance their sector-specific tailoring, as well as, expand and enhance the efficiency of its service delivery mechanisms. This will be accomplished under the auspices of the GFCS and specifically within the context of the development of sectoral EWISACTs. The United States Agency for International Development (USAID) support for the Building Regional Climate Capacity in the Caribbean (BRCCC) Programme is therefore fundamental to the continued evolution of climate services in the Caribbean.

5.0 The Programme for Building Regional Climate Capacity in the Caribbean (BRCCC Programme)

The Caribbean region has been increasing its resilience to the impacts of weather and climate-related hazards for more than 40 years. To address these impacts going forward, the American People, through the USAID, are funding a new programme to build regional capacity for adaptation to climate variability and change in the Eastern Caribbean, in partnership with the WMO and the CIMH. Under an agreement signed in January 2014, USAID will provide funding support over three years (2014-2017) to the WMO, which will work in partnership with CIMH, to amongst other things, support the establishment of a WMO designated Regional Climate Centre (RCC) for the Caribbean, housed at CIMH (WMO, USAID, & CIMH, 2014).

The funds being provided are to strengthen the CIMH to support its ability through:

1. Supporting institutional enhancements;
2. Increasing the range of products and services delivered to stakeholders;
3. Enhancing human and technical capacities at the CIMH and in NMHSs in the Caribbean; and
4. Improving service delivery mechanisms to national, regional and international stakeholders.

Since April 2013, CIMH has been in the demonstration phase of becoming the WMO RCC for the Caribbean. WMO RCCs are Centres of Excellence (CoE) that produce regional climate products and services including short-, medium- and long-range forecasts in support of regional and national climate information needs. The information produced and capacity developed by CIMH enables CMO Member States to deliver better climate services to national and regional users. It is expected that through the implementation of Programme Component I - Technical Area III, the BRCCC Programme will improve the range and use of climate-related products and services at the appropriate spatio-temporal scales to sectoral decision-makers.

This Technical Area has four (4) Outcome Areas as follows:

1. Established relationships between meteorologists/climatologists, scientists from other sectors and policymakers from across sectors;
2. Initiation of the development, deployment and platform integration of sector specific forecasting/planning models in the form of early warning systems;
3. Enhanced institutional capacity; and
4. Enhanced adaptive capacity.

5.1 Development of Sectoral EWISACTs in the Caribbean

CIMH has a longstanding history as regional driver (and focal point) in establishing the value of hydrological, meteorological and climate services for the Agriculture and Food Security, Water, the Disaster Risk Management and more recently, the Health sectors. While continued attention will be paid to these sectors, special focus will be placed on interfacing with the Tourism and Energy sectors. This will represent a significant expansion of the number of sectors being served, as well as, the number and range of products currently being produced and accessed by sectoral decision-makers.

Recognising that a common interest among various sectoral users is that of damage and loss reduction and/or prevention, the goal of sectoral EWISACTs is to achieve full "end-to-end" integration between climate forecasts and early sectoral decision-making related to CRM. In the climate information chain, this begins at the end of the provider with the analysis of climate-related vulnerabilities in the operational processes of users; continues with the co-development of products and services to address underlying vulnerability; and the delivery by providers of user-defined impact prediction products and services at the spatial and temporal resolutions required by users. The idea is that focusing on meeting user-needs for climate information and collaboratively developing products, can enhance not only the quality of information available to sectors, but the actual uptake and routine use of climate information. Component I, Technical Area III of the BRCCC Programme which seeks to develop EWISACTs devotes a lot of attention to this problem. Working with six climate sensitive sectors, a substantial amount of effort will be spent working with national and regional sectoral entities to identify their climate service needs and develop appropriate products and services to address these.

5.1.1 Goal

The overarching goal of the development of sectoral EWISACTs is to improve the seasonal climate forecasting capacity of users in six climate sensitive sectors in the Caribbean.

5.1.2 Principles

Three principles will guide the development process of sectoral EWISACTs, namely that the process will:

1. Make better use of existing meteorological/climatological services and information platforms;
2. Capitalise on and align with existing sectoral activities, structures and other relevant regional initiatives that provide synergies with the climate services agenda; and
3. Produce deliverables through a consultative process whereby experts from the NMHSs, key decision-makers, and practitioners from the six priority climate sensitive sectors, as well as, relevant partners supporting climate services in the region will interact to identify, co-produce, co-implement and evaluate climate information services.

5.1.3 Objectives

The three main objectives in the development of sectoral EWISACTs are:

1. To design, develop and deliver an increased range of sector driven climate products and services;
2. To design, develop and deliver integrated decision-support processes and tools; and
3. To design, develop and deliver capacity building and training programs in support of climate services.

5.1.4 Structure

In the Caribbean, sectoral EWISACTs will contribute to the implementation of the GFCS at the regional level. The GFCS therefore is the overarching structure within which sectoral EWISACTs will be developed with this generalised structure expected to be tailored for each sector. This is an appropriate framework since: 1) the five functional components or pillars of the GFCS are envisioned to address the entire chain for the production, management, delivery and application of climate information and services for early warning (Figure 4); and 2) the pillars of the GFCS implicitly reflect the 4 major elements of an EWIS[7].

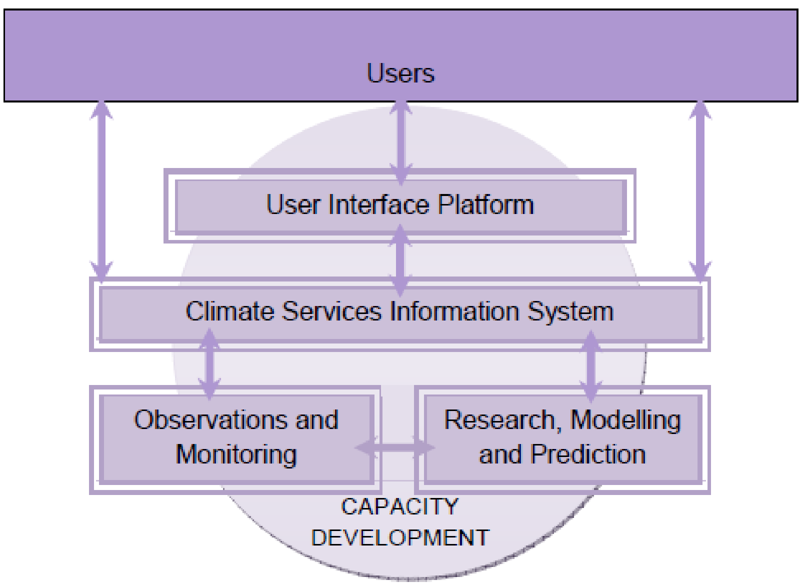

Figure 4. The Five Pillars of the GFCS
Source: WMO (2014b)

Each pillar of the GFCS is described in Table 1.

[7] As articulated by several authors, these are: 1) Knowledge of the risks faced; 2) Technical monitoring and warning service; 3) Dissemination of meaningful warnings to those at risk; and 4) Public awareness and preparedness to act.

Table 1. The Five Pillars of the GFCS

GFCS Pillar	Description
Observations and Monitoring (OBS)	Scientific and technical systems that ensure that climate observations and other data, including metadata, required to meet the wants and needs of end users are collected, managed, disseminated and its utility assessed
Research, Modelling and Prediction (RES)	Scientific and technical systems that foster research towards continually improving the scientific quality of climate information and services, providing an evidence base for the impacts of climate change and variability and for the value of using climate information
Climate Services Information System (CSIS)	The mechanism through which information about climate (past, present and future) is routinely collected, stored and processed to generate and deliver products and services that inform often complex decision-making
User Interface Platform (UIP)	A structured means for users, climate researchers and climate information providers to interact at all levels
Coordination and Capacity Development (CD)	Mechanisms that support the interpretation, translation and use climate information to support decision making; identified in the other pillars

Source: WMO (2014c)

The five GFCS pillars form a coherent, complete system with very strong inter-linkages. The implementation of sectoral EWISACTs in six climate sensitive sectors in the Caribbean region will recognize and capitalize on these connections, enabling the development of products and services that are based on users' needs and that are derived from high quality scientific and technical systems (GFCS Implementation Plan, 2011).

5.1.5 Methodology

The CIMH methodology to develop sectoral EWISACTs reflects the process of CRM described in Martínez et al. (2012). It is underpinned by an approach that fosters consultation, collaboration and partnership in the co-development of climate products and services for integration into regional and national sectoral EWISACTs. The sectoral EWISACTs development process recognizes that this agenda requires long-term planning and implementation even beyond the duration and scope of the BRCCC Programme. Nevertheless, a series of initial actions can be undertaken in the short-term under the BRCCC Programme through the implementation of the Work and Implementation Plan (WIP) 2015-2016 for Component 4.1, Technical Area III (Mahon, Rankine, & Trotman, 2015) (see Appendix 2). Thus, in the long and near-term, CIMH will pursue six concrete methodological steps as follows:

1. ***Establish and maintain governance mechanisms at regional and national levels***

<u>CIMH long-term vision</u>:

Step 1 addresses the need to establish governance mechanisms that foster significant and genuine user ownership of the sectoral EWISACTs development process. Ownership is essential for the successful implementation of sectoral EWISACTs and the sustainability of its Outcomes. In this context, one of the keys to the success of sectoral EWISACTs is the early establishment of a representative stakeholder governance mechanism. At the regional level, the Consortium of

Regional Sectoral EWISACTs Coordination Partners is envisioned to serve as an integrated, sector-based approach to the development of sectoral EWISACTs in six climate sensitive sectors (CIMH, 2015). Reducing the impacts that weather and climate have on the various socio-economic sectors has multiple benefits and requires significant interaction between the various sectoral disciplines. The Consortium can play a vital role in this as a formal, inter-sectoral collaboration mechanism that allows for the identification of areas of joint complementary work and overlapping interests as a basis for partnership. This is necessary given that stand-alone actions and policies for each sector are less effective and may even have adverse consequences for other sectors. For example, poor management of water resources can adversely impact on water quality and quantity for the agriculture and health sectors, leading respectively to crop failure and the break out of vector-borne and other communicable diseases. The Consortium also provides a discussion and action space where providers such as CIMH in its role as a WMO designated RCC interacts with each climate sensitive sector. The Consortium seeks to take advantage of existing institutional networks and programs and build an alliance for climate services using existing institutional networks and structures. This alliance, and more broadly the Consortium's sustainability, will be strengthened by mutual incorporation of the work of the Consortium into the strategic operations of the lead agencies that comprise it.

There is also recognition that governance mechanisms are also weak at the national level. To address this, it is proposed that a centralized National Sectoral EWISACTs Committee (NSEC) be established to coordinate the delivery of sector oriented climate services within each CMO Member State. NSECs are envisioned to be a national, multi-partite committee of providers (represented by the NMHS), and users (represented by the national portfolio Ministry for the respective 6 climate sensitive sectors, as well as, by private sector Associations, where applicable). NSECs will capitalize on adhoc coordination relationships that may already exist in a few CMO Member States that have convened National Climate Outlook Forums (NCOFs) within recent times. In their role and purpose, NSECs are intended at the national level to mirror the Consortium arrangement which operates at the regional level. Thus, the members of the NSEC will collaborate on the development and implementation of national sectoral EWISACTs; on the design, development and delivery of tailored national climate products and services in six climate-sensitive sectors; on identifying critical gaps and opportunities for inter-sectoral linkages and synergies at the national level; and on facilitating the visibility of sectoral EWISACTs at the national level. Recognising that capacity levels for national coordination of the delivery of climate services are largely embryonic throughout CMO Member States, in the short-term, CIMH will serve as a technical Observer organization to the NSEC formation and coordination process.

<u>BRCCC Programme Scope</u>:

At the regional level, Consortium of Regional Sectoral EWISACTs Coordination Partners will be established and chaired by the CIMH for the duration of the BRCCC programme. It is expected that Consortium partners will sign LoAs for formal collaboration on the climate services agenda.

An online, interactive forum will be setup for Consortium members to interact. At the national level, efforts will be made to test the establishment of NSECs in 1-2 CMO Member States.

2. ***Baseline and continue to monitor user needs and provider capacity***

CIMH long-term vision:

Climate information must be transferred to stakeholders in a form that can be readily used. For specialized outputs, like those to be produced through sectoral EWISACTs, the needs and capabilities of endusers to incorporate climate information in routine decisions must be understood and routinely monitored over time. Routinely assessing CIMH's capacity, as well as, the capacity of national Met offices to deliver climate services is also necessary (Trotman & Van Meerbeeck, 2013). However, knowledge regarding enduser needs in climate sensitive sectors in the Caribbean, as well as, provider capacity is not presently empirically robust. Thus, the second step revolves around the need to have a clear understanding of user needs for climate products and services, and provider capacity to satisfy user needs across time.

BRCCC Programme Scope:

There are two (2) main dimensions that should be pursued in the short-term:

2a. A baseline assessment of users' needs for climate products and services; and
2b. A baseline assessment of providers' capacity to deliver climate services.

Formal baselines around each dimension are needed since the Caribbean is formally at the start of its GFCS implementation process, and specifically at the start of its development of sectoral EWISACTs. Some work done through CariCOFs 2012-2014, the Regional Workshop on Climate Services at the National Level for the Caribbean convened in May 2013 in Port of Spain, Trinidad (Trotman & Van Meerbeeck, 2013), as well as, the IRAP Workshop convened in May 2014 (Guido et al., 2014) have produced information from which future sectoral EWISACTs efforts can draw. However, under the BRCCC Programme, a Report that systematically baselines user needs and providers' capacity to deliver climate products that satisfy users' needs will be developed. Such a systematic assessment has never been conducted before and will go a long way in increasing understanding of how climate information can be best integrated in sectoral decision-making.

3. ***Develop new and improve on existing impact forecasting/prediction models for the Caribbean context***

CIMH long-term vision:

Early warning of impending hazards are most effective when complemented by information on the risks posed by the hazards, as well as pathways for effective actions. In this context therefore, for decision support to be effective, planning must define prescribed actions linked to forecasts of risks and expected impacts. Thus, the third major step attempts to make sectoral forecast information more relevant to decision-makers. This can be done by developing new models (where necessary) and improving on existing impact forecasting and prediction models (where possible) by for example, calibrating them to the sectoral context in the Caribbean.

For the impact models, various sectoral and other environmental variables (e.g. vegetation state, soil moisture, river levels and stream flow) are at least as important as climate information. A core task will be the collection of multiple variables and also the integration of socio-economic indicators from sectoral surveillance/monitoring with climate and environmental observations. Improvements made on the prediction impacts are likely to have a direct and positive effects on the overall performance of the prediction system, and the value of forecast information to sectors. This is particularly so in cases where forecast models explicitly account for impact processes and their feedbacks.

There are also clear advantages of approaching this step starting from an evaluation of users' needs (assessed in Step 2a) and using this information to inform the development of impact forecasting systems.

<u>BRCCC Programme Scope</u>:

The development of sector-specific forecasting models is inherently complex and must be anchored in a robust knowledge of climate thresholds for sectoral operations. Thus, CIMH and its partners will focus efforts on addressing the limited number of sector-specific climate indices for the Caribbean context. Existing sector specific climate indices may be recalibrated for the Caribbean based on an assessment of sector specific climate risk. Alternatively, where appropriate, new climate indices may be developed or co-developed. These climate indices are expected to contribute to impact models and eventually will shape future sector-specific climate product prototypes.

Research on how climate either negatively or positively impacts climate-sensitive sectors will also be conducted. The research will seek to correlate past physical and socio-economic impacts associated with past forecasts in order to better understand the link between climate information and expected impacts. This enhanced understanding is expected to contribute to a matching of appropriate response strategies to deal with potential impacts. A new web-based user interface tool will be designed to enable sector users to link current forecasts to appropriate response strategies. The interface tool and the research that underpins it is likely to enhance sectoral adaptive capacity.

4. ***Develop, test and validate sectoral EWISACTs products***

<u>CIMH long-term vision</u>:

This step involves the development and refinement of climate information products. In some cases, products will be new prototypes but in other cases, existing products may be tailored. Products developed at the regional level may also need to be customized to meet country or sector specific needs, while national products may need to be upscaled for region-wide application. In all cases, development, testing and refinement will be carried out in close consultation with and using feedback from sectoral end-users.

BRCCC Programme Scope:

Although limited action will be undertaken directly on developing, testing and validating sectoral EWISACTs products, CIMH will advance the research that is necessary to identify user needs for specialised climate information, as well as, to quantify the impact of existing climate information on sectoral decision-making as a pathway to understanding how to provide products that are better suited to user needs.

*5. **Integrate climate products within DSS platforms***

CIMH long-term vision:

Ultimately, both existing and planned climate products, may be integrated into the Caribbean's version of the Dewetra platform - a Pan Caribbean, real-time, integrated risk-based data fusion and decision support platform for weather, climate and hydrological information. Hosted at the CIMH, Dewetra has great potential to deliver climate products and services at the national and regional levels. As a key component of the UIP, the web-based Caribbean Dewetra platform has been established and, is already being utilized. For example, in a recent preliminary survey of 15 NMHSs in the Caribbean, all respondents indicated that they were aware of the platform, while 35% reported that they had used it (Mahon, Rankine, Trotman, & Petrie, Forthcoming). Moreover, at the regional sectoral level, the Caribbean Disaster Emergency Management (CDEMA) Coordinating Unit already views the Caribbean Dewetra platform as the operational platform to be utilized going forward within its 18 Participating States[8]. Improvements required relate to the expansion of the Platform into the other five climate sensitive sectors, the integration of sectoral DSSs with the Dewetra platform, as well as, the expansion of the Caribbean Dewetra Platform application to the broader Caribbean Region.

BRCCC Programme Scope:

The process towards integrating climate products will be initiated through the development of a Report which will explore data sharing possibilities and the integration of sectoral datasets

[8] It should be noted that there is significant overlap of the 18 CDEMA Participating States with the 16 CMO Member Countries.

contained within sectoral DSSs (eg. CARPHA's CARISURV health surveillance system; CTO's MIST; and the CCCCCs Database Management for a Regional Integrated Observing network for Environmental Change in the Wider Caribbean) into one common platform - Dewetra.

6. ***Strengthen capacity to provide and utilize climate information***

CIMH long-term vision:

Finally, there is a need for continued education, training and outreach to strengthen provider capacity to develop climate information, as well as, to strengthen end-user capacity to integrate climate information into routine sectoral operations. Moreover, this final step seeks to address the currently low levels of knowledge about the science of climate variability and change, the concepts of the RCC, EWISACTs, climate products and services amongst sectoral decision-makers in climate sensitive sectors. A sustained programme of training and capacity building will have to be undertaken, both at the regional level and within CMO Member States. This will require the support of all agencies within the Consortium, their affiliate members, international development partners and donors.

BRCCC Programme Scope:

The conduct of national sectoral EWISACTs Outreach Workshops is seen as a vital avenue for strengthening sectoral capacity to access, interpret and use climate information and transform sectoral users into 'climate smart' professionals (see Appendix 2). Sectoral users also need access to expert advice and support to help them select and properly apply climate information. In the near-term, CIMH will increase the number of avenues that facilitate provider and user technical interfaces on this agenda through technical meetings such as the biennial CariCOF. The Institute will also develop a suite of generic and sector specific communication products and materials that inventory and describe products relevant to generic and specific sectoral applications. Moreover, to facilitate the building of climate capacity to provide and use climate information in the long-term, a strategic sectoral EWISACTs Plan of Action 2017-2027 will be developed. Finally, case study briefs demonstrating how existing climate information has been integrated into sectoral decision-making will be developed.

5.1.6 Benefits of Sectoral EWISACTs

The development of sectoral EWISACTs is expected to provide: 1) a range of benefits across sectors, as well as, 2) a range of sector specific benefits to individual sectors (see Table 2).

Table 2. Benefits of Sectoral EWISACTs to Climate Sensitive Sectors

Sector	Illustrative Range of Benefits
All	• Needs that were met in an *ad hoc* fashion by a growing pool of sources of data products, services and information are met in a more routine and coordinated manner, avoiding duplication of efforts and reducing costs; • Improved climate-related decisions can be communicated through sources sectoral users already know and trust; • Improved access to accurate and reliable climate information; • Climate information is provided in formats and with content enabling direct use in sectoral decision-making; and • Sector partners are supported with appropriate climate information and services to help them achieve their priorities in addressing climate risks.
Agriculture and Food Security	• Increased and more reliable agricultural productivity through crop simulation modelling; • Early warning of impending food crises; and • Improved understanding of the timing of outbreaks of crop pests and diseases through pest and disease modelling/monitoring and enhanced capacity in plant protection.
Water	• More appropriate and robust design and construction of water-related structures such as culverts, bridges and dams, thus safeguarding large investments; • Improved water resources management and prioritized allocation of resources to the wide variety of water demand sectors, including urban water supplies, irrigation systems, flood storage capacities, etc.; and • A wide cross-section of users in other climate sensitive sectors benefit from anticipatory-as opposed to reactive-water management as informed by water sector EWISACTs.
Disaster risk management	• Enhanced lead-time to disseminate warnings of approaching short-, middle- and long-range climate-related hazard forecasts; • Information available to support disaster risk financing (including weather index-based insurance), allowing users in other climate-sensitive sectors (e.g. agriculture) to achieve increased livelihood security; and • Capacity developed to produce maps of potential flooding.
Health	• A better understanding of the current patterns and burdens of diseases, that are linked to the environment and climate; • Integrated Health Early Warning Systems for improved preparedness; and • Improved performance and management of health risk assessment, integrated epidemiological surveillance and environmental monitoring, health emergency risk management and health service delivery.
Energy	• Improved planning for periods of increased energy demand required for cooling systems due to higher temperatures; • Advanced warning of reduction in wind, hydro and solar energy production; and • Advanced warning of potential damage to energy infrastructure from recurrent climatic events and adaptation to more intense future climatic events.
Tourism	• Enhanced use of historical climate information for strategic planning of tourism infrastructure, including: location analysis for new resorts, architectural and landscape design for new and planned resorts; • Develop new destination-marketing strategies that deliver a competitive advantage regardless of climatic conditions; and • Increased application of innovative weather derivatives and index insurance products to reduce climate-related revenue loss.

Source: Adapted from Scott and Lemieux (2010) and WMO (2014c)

6.0 Conclusion

Climate informed sectoral decisions are those that incorporate climate information at relevant spatial and temporal scales to make evidence-based decisions. Sectoral EWISACTs hold the potential to be of great value because they can provide early warning of potential impacting climatic events that may have implications for a wide range of climate sensitive sectoral decisions.

This document presented the Conceptual Framework and Methodology for the development of the sectoral EWISACTs component of the Programme for Building Regional Climate Capacity in the Caribbean (BRCCC Programme). In doing so, it commented on the climate reliance and sensitivity of six of the region's key socio-economic sectors; introduced the concepts of Climate Risk Management and the role of sectoral EWISACTs in making climate informed sectoral decisions, described the evolution of climate services at the global and regional levels and the role of the BRCCC Programme in this ongoing evolution. Finally, the document elaborated on the goal, principles, objectives, structure and methodology associated with the development of sectoral in the Caribbean context. Benefits of sectoral EWISACTs development to each climate sensitive sector were also noted.

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APPENDICES

Appendix 1: CIMH Climate Products and Tools

The CIMH produces a range of 13 climate products and tools that can be grouped into three categories:

1. Communication products;
2. Technical tools; and
3. Technical products.

The tables below describes each product and/or tool, as well as, provides details regarding accessing them.

Product family	Product name	Description	Access
Communication Products	CariCOF Caribbean Outlook Newsletter	Summarises recent and expected seasonal climate events and their impacts across the entire region	Operational product released monthly on the 1st of the month. Access latest at: http://rcc.cimh.edu.bb/long-range-forecasts/caricof-climate-outlooks/
	CDPMN Caribbean Drought Bulletin	Maps and explains the current and expected drought situation across the entire region	Operational product released monthly around the 10th of the month. Access latest at: http://rcc.cimh.edu.bb
	CariCOF Caribbean Coral Reef Watch	Maps and explains the current and expected coral reef bleaching situation across the entire region	Operational product released monthly around the 10th of the month. Access latest at: http://rcc.cimh.edu.bb/long-range-forecasts/caricof-climate-outlooks/
	Agroclimatic Bulletins	Summarises and contextualises recent and expected seasonal climate events for agriculture researchers, policymakers, extension officers and farmers at the regional level for 10 CMO Member States and at the country level for 7 countries	Operational products released at various times and intervals. Access latest at: http://rcc.cimh.edu.bb/climate-bulletins/agriculture/

Product family	Product name	Description	Access
Technical Tools	Monthly Weather Summaries	Provide a bi-annual overview of monthly means of weather observations at the main weather stations in the all CMO Member States	Access at: http://www.cimh.edu.bb/?p=home#monthly.summaries
	Caribbean Climate Database	Archives hydrological and meteorological data, as well as, provides access to and basic analysis options on the stored data for 16 CMO Member States	To be accessed at: http://rcc.cimh.edu.bb/ as of January 2015)
	Caribbean Climate Impacts Database	Archives, maps and links physical and socio-economic impacts to past climate events, as well as provides Standard Operating Procedures for planning, mitigation and response across the historically British Caribbean	Access at: http://rcc.cimh.edu.bb/cid/
	Caribbean Dewetra Platform	An online, geospatial multi-hazard platform which can overlay the occurrence of different hydrometeorological hazards, as well as, marine and terrestrial weather and climate observations and outlooks, with geographical information (mainly covering the historically British Caribbean)	Access at: http://cimh.edu.bb/erc/home/

Product family	Product name	Description	Access
Technical Products	CDMPN Drought and Precipitation Monitors	Monitors ongoing rainfall deficits or excesses across the entire region over the past 1, 3, 6 and 12 months	Operational products released monthly around the 10th of the month. Access latest at: http://rcc.cimh.edu.bb/cdpmn/
	CariCOF Precipitation and Temperature Outlook	Predicts the overall amount of rainfall, as well as, the overall minimum, mean and maximum temperature across the region for the next 3 to 6 months in terms of probabilities of being below-, near- or above-normal with each category historically occurring as frequently	Operational product released monthly on the 1st of the month. Access latest at: http://rcc.cimh.edu.bb/long-range-forecasts/caricof-climate-outlooks/
	CariCOF Drought Alert Outlook	Provides an outlook of drought alert levels and corresponding action levels 3 months ahead of time, as well as, for the year	Operational product released monthly on the 1st of the month. Access latest at: http://rcc.cimh.edu.bb/long-range-forecasts/caricof-climate-outlooks/
	CariCOF Wet Days and Wet Spells Outlook	Forecasts the frequency of wet days, as well as, 3- and 7-day wet spells over the next 3 months and contextualises the forecasts with respect to historical observations	Operational product released monthly on the 1st of the month. Access latest at: http://rcc.cimh.edu.bb/long-range-forecasts/caricof-climate-outlooks/
	Caribbean Climatology Products	Summarises and maps the statistical characteristics of weather station records of monthly and 3-monthly rainfall, as well as minimum, mean and maximum temperatures across the entire region for the reference period 1981-2010 and for the entire periods of record	Access at: http://rcc.cimh.edu.bb/climate-monitoring/caribbean-climatology/

Appendix 2: High Level Summary of the Sectoral EWISACTs WIP

The Work and Implementation Plan (WIP) for Component 4.1, Technical Area III: *Development of Seasonal Forecasting Capabilities to apply to Climate-Sensitive Sectors* of the Building Regional Climate Capacity in the Caribbean Programme (BRCCC Programme) recognizes that there are limitations and gaps within the provider and sectoral user communities related to the development of seasonal forecasting capabilities in the agriculture and food security, water, disaster risk management, health, tourism and energy sectors in the Caribbean region. The intention is to design sector specific products, services and capacity building efforts that begin to address these gaps. These efforts and their tangible outputs underpin the development of sectoral Early Warning Information across Climate Timescales (EWISACTs) by the Caribbean Institute for Meteorology and Hydrology (CIMH) and its regional sectoral partners in the Caribbean.

The WIP is for the period June 2015 - December 2016 (18 months). It proposes the development of several outputs to address eight (8) gaps across four (4) Outcome Areas (OAs). The Table below provides a summary.

Outcome Area	Gap Ref.	Current Gap(s)	Outputs	Targets	Timeline
I. *Established relationships between meteorologists/ climatologists, scientists from other sectors and policymakers from across sectors*	1.1	Limited number of sectors (e.g., agriculture and food security, water, disaster risk management, health) in which awareness and use of climate products has been mainstreamed	1.1.1 Communication package of generic and sector specific products and materials	• 4-6 sector specific webpages developed and accessible • 10 product information sheets • 4-6 general and sector-specific infographics	Q3 2015 - Q2 2016
	1.2	Limited number of technical sectoral interfaces at the regional and national levels	1.2.1 Sector specific technical sessions at regional technical meetings such as the Caribbean Climate Outlook Forum (CariCOF) General Assemblies 2015-2016	• Sector specific programming (4-6 sector sessions) by December 2016 • 30-50% increase in sectoral participants' knowledge of climate information, products and services (based on pre and post knowledge evaluations)	Q3 2015 – Q4 2016
			1.2.2 A series of regional cross-sectoral and/or sector specific technical webinars	• 4-6 cross-sectoral and/or sector-specific regional webinars convened	Q12016- Q4 2016
			1.2.3 National Sectoral	• 3-5 National Sectoral	Q42016 –

Outcome Area	Gap Ref.	Current Gap(s)	Outputs	Targets	Timeline
			EWISACTs Workshops	EWISACTs Workshops convened • 30-50% increase in participants' knowledge of climate information, products and services (based on pre versus post knowledge	Q2 2016
	1.3	Ad hoc sectoral relationships	1.3.1 LoAs signed between CIMH and sector specific regional agencies for formal collaboration on the climate services agenda	• 4-6 LoAs signed	Q1 2015 – Q1 2016
II. *Initiation of the development, deployment and platform integration of sector specific forecasting/planning models in the form of early warning systems*	2.1	No standardized decision support system (DSS) to support sectoral Early Warning Information System Across Climate Timescales (EWISACTs)	2.1.1 Report exploring data sharing and integration of sectoral datasets and sectoral DSSs into/with the Caribbean Dewetra platform	• Report shared by email, presentation and available for download from RCC website by December 2016	Q12016- Q2 2016
	2.2	Limited number of sector specific climate indices and impact models for the Caribbean context	2.2.1 Sector specific climate index/indices developed and/or co-developed	• 3-5 sector specific climate index/indices	Q12016– Q4 2016
III. *Enhanced institutional capacity*	3.1	Insufficient baselines (re: user needs, provider capacity) to inform product tailoring and development in the short- and long-term	3.1.1 Research report baselining user needs and providers' capacity to deliver climate products that satisfy user needs	• Baseline report shared by email, presentation and available for download from RCC website by December 2016	Q32015– Q4 2016
			3.1.2 Sectoral EWISACTs Plan of Action 2017-2027	• Sectoral EWISACTs Plan of Action 2017-2027 shared by email, presentation and available for download from RCC website by December 2016	Q32016- Q4 2016
	3.2	Lack of governance	3.2.1 Governance mechanisms at the	• Regional coordination mechanism with 6	Q22015- Q4 2015

Outcome Area	Gap Ref.	Current Gap(s)	Outputs	Targets	Timeline
		mechanisms anchored in and driven by sectoral partners and the regional and national contexts	regional level (e.g., the Consortium of Regional Sectoral EWISACTs Coordination Partners)	sectoral partners established and functioning by December 2016	
			3.2.2 Consortium landing page and associated functionalities (e.g., members only area accessible through login)	• Consortium landing page and associated functionalities developed and functional by December 2016	Q12016–Q4 2016
			3.2.2 Governance mechanisms at the national level (e.g., National Sectoral EWISACTs Committees)	• 1-2 National Sectoral EWISACTs Committees established and functioning by December 2016	Q42015–Q4 2016
IV. *Enhanced adaptive capacity*	4.1	Weak linkages between climate forecasts, impact and concrete action	4.1.1 Report on the relationship between climate and sectoral productivity, historical climate impacts and sectoral response; and the impact of climate outlooks on sectoral response	• Research Report shared by email, presentation and available for download from RCC website by December 2016	Q42015-Q3 2016
			4.1.2 Design of a web-based user interface tool enabling users to correlate forecasts to past impacts and appropriate response strategies	• 1 interface tool designed	Q12016–Q4 2016
	4.2	Little documented evidence of how climate information improves sectoral decision-making in the Caribbean	4.2.1 Case study briefs demonstrating how existing climate information has been incorporated into sectoral	• 4-6 case study briefs developed and published	Q12016–Q4 2016

Outcome Area	Gap Ref.	Current Gap(s)	Outputs	Targets	Timeline
			decision-making		

Appendix 3: The 'Climate Smart' sector professional

A range of professional skills are needed by sectoral end-users to access, interpret and use climate information, including the need to understand:

The relevance of ENSO to human activities and welfare;

- The concept of climate risk management to development;
- Key sectoral dynamics and their relationship with climatic factors;
- The multiple ways in which climate impacts a specific sector through increased hazards and vulnerability, resulting in increased risk of sectoral impacts, including emergencies and disasters;
- The variability in space and time of climate-sensitive sectoral risks;
- The value of applied climate information in sectoral decision-making;
- Uncertainty, and the probabilistic nature of climate service information products; and
- How sectoral risks can be reduced with prevention, preparedness, and response measures.

Source: Adapted from WMO (2014b)