DESIGN + ENVIRONMENT

PHASE 1: GAP ANALYSIS AND ACTION PLAN REPORT

Database Management System for A Regional Integrated Observing Network for Environmental Change in the Wider Caribbean

IDB project: ATN/OC-12554-RG

Submitted to: Dr. Mark Bynoe Mr. Earl Green
Caribbean Community Climate Change Centre

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For the 5C DMS project DE has brought on the Mona Geomatics Institute from the University of the West Indies in Jamaica. Mona Geomatics Institute's depth of regional experience and GIS capabilities will help to bring forth the best solutions for the Caribbean.

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LIST OF TERMS AND ABBREVIATIONS

ACCC	Adapting to Climate Change in the Caribbean Project
AILEG	Analysis and Investment for Low-Emission Growth
ASCII	American Standard Code for Information Interchange
AWS	Automated Weather Station
BERDS	Biodiversity and Environmental Resource Data System (Belize)
BOD	Biological Oxygen Demand
CADM	Caribbean Disaster Management Plan
CaRA	Caribbean Regional Association
CARDI	Caribbean Agriculture Research and Development Institute
CARIBHYCOS	Caribbean Hydrological Cycle Observation System
CARICOM	Caribbean Community
CariCOOS	Caribbean Coastal Ocean Observing System
CARIWIG	Caribbean Weather Impacts Group
CARIWIN	Caribbean Water Initiative
CATHALAC	Centro del Agua del Trópico Húmedo para America Latina y el Caribe
CATIE	Centro Agronómico Tropical de Investigacion y Enseñanza
CCCCC	Caribbean Community Climate Change Centre
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CDB	Caribbean Development Bank
CDC	Civil Defense Commission
CDEMA	Caribbean Disaster and Emergency Management Agency
CDERA	Caribbean Disaster Emergency Response Agency
CDPMN	Caribbean Drought and Precipitation Monitoring Network
CIMH	Caribbean Institute for Meteorology and Hydrology
CINVESTAV	Center for Research and Advanced Studies of the National Polytechnic
CITES	Convention In Trade of Endangered Species
CPACC	Caribbean Planning for Adaptation to Climate Change Project
CRCOF	Caribbean Regional Climate Outlook Forum
C-READ	Caribbean Regional Environmental and Atmospheric Data Management System
CSDP	Caribbean Satellite Disaster Pilot Project
CURLA-UNAH	National Autonomous University of Honduras
CZMA	Coastal Zone Management Authority (Belize)
CZMAI	Coastal Zone Management Authority and Institute (Jamaica)
CZMU	Coastal Zone Management Unit (Barbados)
DE	DE Design + Environment Inc.
DEM	Digital Elevation Model
DEWETRA	Real time data and information system for hydrometeorological risk forecasting, environmental monitoring, and disaster risk management
DMS	Database Management System
DO	Dissolved Oxygen
DOWASCO	Dominica Water and Sewerage Company Limited
DSL	Digital Subscriber Line (high speed Internet connection)
EFJ	Environmental Foundation of Jamaica
EMDAT	International Disaster Database
ERC	Enhancing Resilience to Climate Change Project
FAO Guyana	Food and Agriculture Organization (Guyana)
FC	Fecal Coliform
GCM	Global Climate Model
GEF IWCAM	Global Environmental Facility Integrated Watershed and Coastal Area Management Project
GIS	Geographic Information System

GOES	Geostationary Operational Environmental Satellite
GWI	Guyana Water Incorporated
IADB	Inter-American Development Bank
IDF Curves	Intensity Duration Frequency Curves
IEO	International Office of Epizootics
IICA	Inter-American Institute for Cooperation on Agriculture (Dominica)
ISD	Institute for Sustainable Development (Jamaica)
ISO	International Standards Association
IT	Information Technology
JAD Session	Joint Application Development Session
JBI	Jamaican Bauxite Institute
LIC	Land Information Centre (Belize)
LICJ	Land Information Council of Jamaica
MACC	Mainstreaming Adaptation to Climate Change Project
MGI	Mona Geoinformatics Institute
MGU	Marine Geology Unit – University of West Indies, Jamaica
MMA-ADA	Mahaica, Mahaicony, Abary/ Agricultural-Development-Authority
MNRA	Ministry of Natural Resources and Agriculture (Belize)
MOAF	Ministry of Agriculture and Forestry (Dominica)
MOH	Ministry of Health (Belize)
MWLECC	Ministry of Water, Land, Environment, and Climate Change
NAREI	National Agricultural Research Extension Institute (Guyana)
NASA	National Aeronautics and Space Agency
NEMO	National Emergency Management Organization (Saint Lucia)
NEPA	National Environment and Planning Agency (Jamaica)
NGO	Non Governmental Organizations
NLA	National Land Agency of Jamaica
NOAA	National Oceanographic and Atmospheric Agency
NOx,	Nitrogen Oxides
NWA	National Works Agency of Jamaica
NWC	National Water Commission (Jamaica)
ODPEM	Office of Disaster Preparedness and Emergency Management (Jamaica)
OECS	Organization of Eastern Caribbean States
PDSI	Palmer Drought Severity Index
PIOJ	Planning Institute of Jamaica
PM10	Particulate Matter (10 micron diameter)
PPCR	Pilot Project for Climate Resilience
RADA	Rural Agricultural Development Authority (Jamaica)
RAMMB	Regional Mesoscale Meteorology Branch (Saint Lucia)
RRACC	Risk to Human and Natural Assets Resulting from Climate Change
RUBIS	Exclusive Distributor of Shell Energy Products in Jamaica
SDC	Social Development Commission of Jamaica
SOx,	Sulphur Oxides
SPI	Standard Precipitation Index
SST	Sea Surface Temperature
T1	High Speed Internet Connection
TAC	Technical Advisory Committee
TIDE	Toledo Institute for Development and the Environment
TSP	Total Suspended Particles
UB	University of Belize
UNAM	National Autonomous University of Mexico
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNISDR	United Nations International Strategy for Disaster Reduction
US AID	United States Agency for International Development
UTECH	University of Technology (Jamaica)

UWI	University of the West Indies
WASA	Water and Sewage Authority (Belize)
WINDALCO	West Indies Alumina Company (Jamaica)
WMO	World Meteorological Organization
WRA	Water Resource Authority (Jamaica)
WRMA	Water Resource Management Authority (Saint Lucia)

1. Introduction

1.1 Executive Summary

The purpose of this report is to outline the findings of the Gap Analysis task of phase 1 of the C-READ (Caribbean Regional Environmental and Atmospheric Data) management system project awarded to DE Design + Environment Inc. The Gap Analysis was one of the main activities outlined in the terms of reference for the first phase of this project.

This consultancy is financed under the Regional Public Goods Project, ***Database Management System for a Regional Integrated Observing Network for Environmental Change in the Wider Caribbean (ATN/OC-12554-RG)***, financed by the Inter-American Development Bank.

The goal of the Gap Analysis was to establish a comprehensive list of stakeholders for this project and to then determine what the status of environmental and atmospheric monitoring was in the partner countries and in the Caribbean region as a whole. Our team took the opportunity to broaden the scope of the Gap Analysis to address a variety of issues that relate to different aspects of this project such as technological capacity, priorities for monitoring, data sharing protocols, educational requirements, and climate change adaptation policy concerns. The main vehicle for addressing these questions was the electronic survey that was designed and conducted by our team. This survey was filled in by numerous stakeholder organizations in each of the partner countries: Barbados, Belize, Guyana, Dominica, Saint Lucia, and Jamaica. An in-person stakeholder workshop was conducted on June 13, 2013 in Kingston, Jamaica, whereupon stakeholder groups from Jamaica were invited to discuss key issues from the electronic survey and the project as a whole. This workshop helped to clarify how we would move forward. The execution of the electronic survey helped to mobilize the project and has in fact commenced the outreach process right from the first stage. By developing such an extensive stakeholder engagement process for the e-survey we have in essence helped to raise awareness about this project and give it a distinct 'fingerprint' amongst the many ongoing initiatives related to climate change in the Caribbean region.

This report will briefly explain the background for this project, objectives of the Gap Analysis, the methodology, results, and the implications for the design of the C-READ management system. Our team also conducted a review of related projects that will be included in this report. The outreach component of this project (stated as part of the third phase) actually commenced with the initiation of the stakeholder engagement for the electronic survey. Hence we have advanced on the project further than anticipated if seen from the overall scope of work.

1.2 Background and Context

The populations and environments in island nations in the wider Caribbean are facing increasing threats due to unchecked development, population growth, land- and sea- based sources of pollution, natural disasters, and environmental change induced from climate change. Impacts on the environment include loss of biodiversity and habitat, coastal erosion, sea level rise, and coral bleaching. Socio-economic risks are growing as a result of environmental changes and some notable examples include threats to tourism revenues, faltering food security, and disruption and instability of economies due to natural disturbances. There is currently no integrated observing network that can capture relevant environmental data and facilitate regional and national analysis of these problems. Cohesive and comprehensive environmental and hydro-meteorological data is key to adaptation and planning in the Caribbean. C-READ will be a central component to a monitoring network that is planned to provide standardized, value-added data products for assessing, predicting, and forecasting environmental change in the Caribbean region.

The C-READ project fits within the mandate of the CARICOM Regional Strategy for Climate Change (2009 – 2015), which has the goal of reducing vulnerability of natural and human systems to climate change impacts. There are a series of other projects that are operating in synchrony with the C-READ project and it should be noted that the DE team is looking for ways of integrating with these other initiatives rather than duplicating efforts. An example of this synergy is the Pilot Project for Climate Resilience (PPCR) project, which aims to assess regional data management systems and practices related to adaptation and resilience to climate change in Grenada, Haiti, Jamaica, Saint Lucia, the Commonwealth of Dominica and Saint Vincent and the Grenadines. The C-READ project is aligned with the work conducted under the PPCR and part of the project implementation process is to identify initiatives that are complementary, such as the Caribbean Risk Management Project (2012-2103) and also work conducted by NGOs and private sector organizations operating in the Caribbean region.

1.3 Objectives of Gap Analysis

The gap analysis focused on the six participating countries with a review and identification of existing geospatial instrumentation and monitoring infrastructure. The review first documented existing monitoring technology and then identified desired improvements for each partner country. Operational data acquisition, archival processes, quality assurance procedures, compilation, and technological capacity were also documented. The desired outputs for the C-READ management system were also queried. The following key issues will be addressed with the gap analysis:

- Status of climatic and meteorological monitoring systems
- Gaps in climatic and meteorological monitoring systems
- Status of hydrological monitoring systems
- Gaps in hydrological monitoring systems
- Status of environmental monitoring systems
- Gaps in environmental monitoring systems
- Status of geospatial data
- Gaps in geospatial data
- National policy issues supported by environmental monitoring

- Climate change priorities
- Data sharing protocols
- Desired data products
- Technical and administrative capacity needs for environmental monitoring
- Educational shortcomings related to climate change
- Inventory of information technology related to environmental monitoring
- IT specifications for database management systems
- IT specifications for geospatial monitoring technology

The above list of points, drawn from the electronic survey, covers issues that are to be addressed in all three phases of the project and therefore will move the project forward significantly.

2. Approach and Methodology

2.1 Overarching Principles

The C-READ project focuses on **inclusivity**, **applicability**, and **efficacy**, as being three over-arching principles. It is fundamentally important to have a design process that includes key stakeholders and other groups that may be peripherally involved with either using the C-READ or contributing data to it. Currently, one of the biggest challenges for environmental data management in the Caribbean is the deficit of data sharing between agencies within countries and regionally. By putting forth a very inclusive process for assessing the needs of a broad array of stakeholders, the DE team hopes to encourage participation and sharing of information to help inform decision-making related to shared resources in the Caribbean. The inclusivity principle will also apply to aligning the C-READ project with related projects in the region. The goal is not to replicate efforts, rather to integrate them and maximize benefits through collaboration and cooperation.

The C-READ must be applicable. The **applicability** principle must run throughout all components of the project. The system is to be ***demand driven***. Throughout the Gap Analysis and stakeholder engagement our team has aimed to determine specifically what the user group requirements are and build the system accordingly. This will be critical to ensuring uptake of the C-READ by stakeholders. In fact, fortifying the C-READ value proposition relies on this system being user-focused and demand driven. The C-READ project is founded on the mandate to facilitate decision making related to climate change adaptation in the Caribbean and it is imperative that the conceptual design of this system be clearly focused on this outcome.

The C-READ must effectively aid stakeholders in the partner countries with their capability to make knowledge-based decisions related to environmental impacts and climate change. This requires that the appropriate data is being gathered in each of the countries, the data is stored in an appropriate format for integrating into the database, the database is robust and has archival processes and redundant back ups, the requested queries can be performed, and data can be retrieved and displayed as meaningful information that is useful to the users. All of these expectations constitute the C-READ fulfilling the principle of operating with **efficacy**.

2.2 Review of Related Projects

One of the first steps in the commencement of the C-READ project was a review and meta-analysis of existing projects. A reoccurring theme from the interviews that were conducted during the Inception Period there was that it was not advisable to try and "re-invent the wheel" with this project. In order to avoid this it is important to review what has been done and what is currently in development with respect to environmental monitoring, climate change adaptation, and disaster risk response. The CCCCC was instrumental in starting this review process by providing a list of similar projects that they were affiliated with.

During the inception period, key organizations were identified and targeted meetings were made through which parallel projects were identified. Recipients of the electronic survey were asked about other organizations that may be working in parallel to the objectives of the C-READ project. The results of these discussions were summarized in a table in this report with a project description, relevance to C-READ project, and the direct synergies between the two projects. This table, found in Annex 1, will help in the C-READ design process to identify where there can be integration between existing data bases, clearinghouses, and integration platforms.

2.3 Stakeholder Assessment

The stakeholders for this project are critically important since the ultimate goal is to create a database management system that is useful for them. Connecting with stakeholders from the outset of this project was of utmost importance. The primary stakeholders are the participating countries whose representatives comprise the Board of Management and the Technical Advisory Committee. There were also members from regional organizations such as NOAA and CATHALAC, and CIMH represented on the TAC. For both advisory boards, each member was asked to provide a list of recommended organizations that should be consulted in each country. This list ranged from representatives of relevant government agencies and private sector companies to non-governmental organizations. The final list of stakeholders had 140 individuals representing a cross section of perspectives and interests. This list is a very good starting point and is a pool that can be drawn from and grown in the development of the C-READ management system in the following design and outreach phases of the project. A full list of stakeholders engaged in the first phase of this project can be found in **Annex C** of this report.

2.4 Workshop Design and Execution

An in-person stakeholder workshop was conceived and executed in Kingston, Jamaica by DE's regional project partner, Mona Geomatics Institute. In order to get a good perspective on how different stakeholders would initially receive our requests for information and the prospect of a new environmental monitoring system, we felt that the survey should be tested on a small group of individuals who represented different agencies that would conceivably contribute to a Caribbean-wide system. The Mona Geomatics Institute team, based in Kingston, Jamaica, contacted a variety of organizations ranging from the governmental agencies such as the Meteorological Service of Jamaica, to research organizations such as the Climate Studies Group Mona of UWI, to private sector organizations such as Rubis Energy Jamaica Ltd. This cross-section of different groups was indicative of what was expected for each of the partner countries. The representatives were invited for a one-day session that would focus on the issues addressed in the Gap Analysis and Regional Plan of Action. The workshop was held on Thursday June 13, 2013 at the Ministry of Forests of Jamaica and was attended by representatives from 14 different organizations. Valuable insights on the C-READ project and particularly the structure and format of the electronic survey were gleaned from this workshop. Full details are summarized in the workshop report prepared by the Mona Geomatics Institute team, which can be found in **Annex D** of this report.

2.5 Electronic Survey Design

The central tool to the gap analysis is the electronic survey that was designed specifically to address key issues related to existing monitoring infrastructure, shortcomings of current monitoring systems, priorities for climate change adaptation, and other project-related items. The survey was created in one excel file and was rather lengthy in its first version. One of the outcomes of the stakeholder workshop in Kingston was that the survey should be divided into three files that cover management, technical, and information technology issues. The information required for each of those general areas was so specific that it would require the input of different department in a given organization and it therefore made more sense to have the survey divided accordingly.

The survey was designed to provide our team with specific detailed information on current monitoring systems and their specifications, information technology capacity, and management priorities for climate change adaptation, monitoring, and data sharing. The questions were constructed wherever possible to provide quantitative results such that we can summarize variables across the Caribbean. However, in many cases the nature of the issue was qualitative and therefore required a qualitative response.

2.6 Implementation and Analysis of Survey

Stakeholders from each of the partner countries were contacted and provided electronic copies of the three survey files as well as a set of example surveys with answers filled in. They were given at least three weeks to fill in the survey and return it to a designated member of our team. The rates of response and breakdown of sectors that replied is shown in Table 1. The organizations selected were based on their relevance and potential interest in using and benefiting from C-READ. The key sectors were Environment, Agriculture, Water, and Ocean and Coastal. Disaster Management, Infrastructure, health, finance, and industry-focused organizations were also included in the list of stakeholders.

Table 1: Summary of respondents to electronic survey in Jamaica

Country	# Organizations Contacted	# Survey Respondents	Sector Representation (%)
Jamaica	41	22	32% Environment, 18% Industry, 10% Agriculture, 10% Water, 5% Emergency Management, 5% Planning, 5% Mapping, 5% Oceans and Coast, 5% Health, 5% Research
Belize	18	7	44% Oceans and Coast, 14% Environment, 14% Agriculture, 14% Health, 14% Mapping
Dominica	13	5	40% Environment, 40% Agriculture, 20% Water
Saint Lucia	9	6	34% Agriculture, 16.5% Environment, 16.5% Infrastructure, 16.5% Water, 16.5% Emergency Management
Guyana	13	5	40% Agriculture, 20% Environment, 20% Water, 20% Mapping
Barbados	18	5	40% Environment, 20% Agriculture, 20% Emergency Management, 20% Finance

Jamaica had the largest number of survey respondents. The responses that we did receive were very well done and have provided us with a solid data set with respect to monitoring for climate change and environmental quality. The following tables indicate specifically which organizations responded from each of the partner countries.

Table 2: Summary of respondents to electronic survey in Jamaica

Organization	E-Survey Completion
UWI Mona Climate Studies Group	Management, Technical
Forestry Department	Management, Technical, IT
Meteorological Office	Management, Technical, IT
Ministry of Agriculture and Fisheries	Management, Technical
Ministry of Water, Land, Environment, and	Management

Climate Change	
National Environment and Planning Agency	Management, Technical, IT
National Water Commission	Management, Technical, IT
Office of Disaster Preparedness and Emergency Management	Management, Technical, IT
Planning Institute of Jamaica	Management, Technical, IT
Rural Agricultural Development Authority	Management
Water Resources Authority	Management, Technical, IT
Chevron Caribbean	Management
University of West Indies – Institute for Sustainable Development	Management, Technical, IT
Jamaica Bauxite Institute	Management, Technical, IT
University of West Indies – Marine Geology Unit	Management, Technical, IT
National Land Agency	Management, Technical, IT
National Works Agency	Management, Technical, IT
Rubis	Management
Social Development Commission	Management, Technical
West Indies Alumina Company (WINDALCO)	Management, Technical, IT
Environmental Foundation of Jamaica	Management
UNEP – Caribbean Regional Coordinating Unit	Management

Table 3: Summary of respondents to electronic survey in Belize

Organization	E-Survey Completion
Coastal Zone Management Authority	Management, Technical
Healthy Reefs	Management, Technical, IT
Ministry of Natural Resources and Agriculture	Management, Technical, IT
National Meteorological Service	Management, Technical, IT
Land Information Centre	Technical
Ministry of Health	Management, Technical, IT
TIDE (Toledo Institute for Development and the Environment)	Management, Technical, IT

Table 4: Summary of survey respondents for Dominica

Organization	E-Survey Completion
Ministry of Agriculture and Forestry	Management
Ministry of Environment, Natural Resources, Physical Planning and Fisheries	Management
Inter-American Institute for Cooperation on Agriculture	IT
Dominica Water & Sewerage Company	Management, IT
Dominica Meteorological Service	Management, Technical, IT

Table 5: Summary of respondents to electronic survey in Saint Lucia

Organization	E-Survey Completion
IICA (Inter-American Institute for Cooperation on Agriculture)	Technical, IT
Saint Lucia Meteorological Services, Ministry of Infrastructure, Port Services &	Management, Technical, IT

Transport	
Ministry of Infrastructure, Port Services & Transport	IT
National Emergency Management Organization	Management, IT
Water Resource Management Agency	Technical, IT
Ministry of Agriculture Food Production, Fisheries & Rural Development	Management, Technical, IT

Table 6: Summary of survey components filled out by stakeholders in Guyana

Organization	E-Survey Completion
FAO Guyana	Management, IT
GWI (Guyana Water Incorporated)	Management, Technical
Guysuco	Management, IT, Technical
Hydrometeorological service of Guyana	Management, IT, Technical
Guyana Lands and Survey Commission	Management, IT, Technical

Table 7: Summary of survey respondents for Barbados

Organization	E-Survey Completion
Barbados Meteorological Service	Management, Technical, IT
CARDI - Barbados	Management, Technical, IT
Caribbean Development Bank	Management
CIMH	Technical, IT
Department of Emergency Management	Management, Technical

The e-survey itself was designed in such a way that we could gather data and input from management teams who would be setting policy and direction, technical teams responsible data gathering and instrumentation, and IT teams who would be tasked with providing and managing IT infrastructure. In some cases the survey results are very quantitative, such as documenting the specific number of hydromet stations or GIS data sets stored. In other cases the survey questions are far more qualitative and are trying to assess the opinion or recommendations of the given stakeholder. The survey responses and the survey itself can be found in the file named: **C_READ_ESURVEY.zip** that was submitted with this report.

This data set serves as the foundation for the gap analysis and is the first step in the user requirements for the design of the C-READ system. This is also a very important first step in outreach to the Caribbean community to give this project an identity and hopefully a welcome reception. The responses for each country were reviewed and appropriate means of representing the data were conceived based on the feedback. In some cases these are bar graphs showing different quantities, in other cases they are anecdotal summaries of the qualitative responses. The results of the analysis can be seen in section 5 of this report. The goal of this phase of the project is to assess where gaps are in relation to environmental data monitoring and management in the Caribbean and this was therefore a primary goal upon reviewing the e-survey responses.

2.7 Methodology for Identifying Gaps

A systematic process involving assessing a baseline or desired future state, analyzing the current condition, evaluating what the difference between the desired and current state (i.e. the gap), outlining the possible causes of the gap, and ultimately what remedial action could be taken to address the gap. This process was undertaken for each of the partner countries of C-READ based on the data that was gathered from the e-survey. There are different dimensions to the C-READ system and each needed to be reflected in the breakdown of gaps. They are:

1. Data management and gathering

2. Data sharing, analysis and reporting on environmental change

3. IT and human resource capacity for monitoring environmental change

In the above breakdown, instrumentation for gathering data has been included in section 1. Section 2 was largely assessed based on the amount of research and collaboration that was occurring in each partner country as reported in the e-survey. The third section represented the capability within each country based on technological infrastructure (number of computers, software availability, internet connectivity) and human resource capacity (number of programmers and GIS technicians). There were ten categories of function that were determined from the e-survey responses. Examples of these include "Category 1: Meteorological and Hydrological Data and Projections", or "Category 4: Coastal Zone and Ocean". Within each category a number of key issues were identified based on their relevance and importance to environmental monitoring and the development of C-READ. For each of these issues a desired state was established based on an overall assessment of the different countries and the stated purpose of C-READ in the terms of reference of this project. Jamaica has overall the most progress with respect to environmental monitoring and data analysis and through the workshop held on June 13, 2013 in Kingston the Mona Geomatics Institute team was able to assess baseline desired states for the different issues. This is not to say that all participating countries need to replicate what Jamaica is doing, rather, Jamaica's status, and our ability to do an in depth review through the workshop, allowed us to see what an ideal future state may be for C-READ. These 'future states' were then reviewed in light of the results of the electronic surveys from all organizations that replied.

Gaps were evaluated in each country for the three major areas: data management and gathering; data sharing, analysis and reporting; and IT and human resource capacity. Matrices were then designed that outlined the current status, desired future state, gaps, reasons for gaps, and the proposed remedial actions for a series of issues that were determined to be priorities. The current state was assessed for each country by examining the survey responses. This was then compared against a desired future state. If there were shortcomings between the current state and the desired state, this was then articulated as a 'gap'. Potential contributing factors to these gaps were determined through review of the survey responses and related literature. In some cases it was not clear what the

contributing factors to the gaps were so we had to speculate. The remedial actions were suggested based on our knowledge of the situation and also the projected plan for developing C-READ. In many cases the remedial actions were to be addressed in the design phase of C-READ. The e-survey turned out to be a very significant part of the assessment of the functional requirements of the database management system. These remedial actions are thus action items for phase 2.

3. Identification of Gaps

3.1 Gaps in Jamaica

Gaps in Data Gathering, Management, and Sharing

Table 8: Summary of Gaps Identified in Data Gathering in Jamaica

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 1: Meteorological and Hydrological Data and Projections					
Precipitation and general meteorological monitoring	Of the survey respondents that replied, there are currently 8 different organizations that gather time series and 2 that gather GIS meteorological data. The Jamaican Met Service manages a total of close to 200 rain gauges, 4-6 climate stations, 4 intensity loggers and 51 AWS. The NWC has 3 weather stations and WINDALCO has one manual station.	Minimum of electronic management and transfer of data from all functioning AWS and rain gauges to a centralized repository. There should be adequate coverage of the landscape (according to experts input) and proper maintenance and upkeep to ensure continuity in the supply of data. Processed averages should be easily accessible on line.	Survey respondents indicate that most organizations store their precipitation data electronically (spreadsheets) but transmission processes vary between paper and electronic. Key stakeholders indicated that there is a lack of coverage and consistency for precipitation and other meteorological data.	There are a number of rain gauges and met stations currently in place, but the issues with sparse data appears to be due to difficulties with maintenance, data gathering, and transmission. The AWS's were installed by four different companies through four different projects as indicated in Dr. Depradine's[1] report. The result is inconsistent recording. Data transmission may also be a system fault since although essentially all data is gathered electronically it is sometimes transferred on paper.	The current network of meteorological monitoring should first be closely evaluated for the consistency in data supply, the format of the data, methods of data transfer, and maintenance protocols. Based on this evaluation, and an expert assessment of the quantity of stations, an operational plan can be generated and also a possible increase in AWS, if warranted. Given that meteorological monitoring is undertaken by multiple organizations, collaboration and standardization of processes is extremely important here.

[1] Dr. Colin Depradine, Consultant, "Assessment of (Climate Relevant) Data Collection and Management System (DRAFT)". Submitted to the Caribbean Community Climate Change Center.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Climate modeling and forecasting	The Jamaican Met Service produces 24 Hour Weather Forecasts, Four Day Outlooks, Aviation Forecasts and Marine Forecasts. The UWI Climate Studies Group manages daily, monthly, seasonal and annual model data for current and future periods, summary statistics, graphs, maps, and IDF curves.	There should be adequate coverage of the landscape (according to experts input) and proper maintenance to ensure continuity in the supply of modeled data. Processed models and forecast outputs should be easily accessible on line.	Access to modeled and forecast products.	Reasons for lack of access to modeled information were not gleaned from survey responses.	The current network of climate modeling and forecasting should first be closely evaluated for the type of forecast and models that are most useful, consistency in data supply, the format of the data, methods of data transfer, and maintenance protocols. Based on this evaluation, an operational plan can be generated. Further, given that modeling is undertaken by multiple organizations, collaboration and standardization of processes/ products is extremely important here.
Hydrological monitoring	5 entities reported to sample or manage time series hydrological data, including the Jamaican Met Service, MWLECC, NWC, WRA and JBI. The WRA is responsible for the management of Jamaica's water resources and monitors stream flow at over 100 stations on major rivers-daily, monthly, annual flows, flow duration analysis and trends. NWC has over 400 water treatment plants island wide and these plants all monitor a total of 16 parameters.	It would be ideal for all stations to be loggers in order to allow for continuous data collection and thereby improved temporal resolution and data quality. There should be adequate coverage of the water resources and proper maintenance and upkeep to ensure continuity in the supply of data. Attribute data e.g. rivers- width, depth, water volume; watershed information should be attached to the hydrology datasets. Processed outputs should be easily accessible on line.	A number of rivers of interest, especially in the eastern sections of the island could utilize additional stations to improve the spatial resolution. There are also temporal and spatial data gaps owing to data not being recorded manually by responsible persons. Background (upstream) data absent in most locations. There is a lack of common standards and methods by which data is acquired and processed. Need for improvement in the Laboratory infrastructure and equipment.	A significant amount of stations owned by the WRA are manual stations, which have to be read by someone in the field. Heavy rains and storms, in particular for eastern parishes, wash many stations away. In addition there are some stations in the Blue Mountain Range where the rainfall is the highest in the island that had to be abandoned due to a lack of funds to access them. Data collected by UNEP is on regional scale and project driven. Other data is compiled related to process - policies, laws, institutions etc.	The current network of hydrological monitoring should first be assessed for spatial coverage, consistency in data supply, the format of the data, methods of data transfer, and maintenance protocols. Based on this evaluation, and an expert assessment of the quantity of stations and laboratory infrastructure, an operational plan can be generated, inclusive of standards. Given that hydrological monitoring is undertaken by multiple organizations, collaboration and standardization of processes is extremely important here.
Category 2: Hazards and Risks					
Drought Risk Assessment	The Met Service undertakes drought monitoring and seasonal precipitation forecast.	There should be adequate coverage of drought monitoring locations across the landscape (according to experts input). Outputs should be easily accessible on line.	Gaps were not gleaned from survey responses.	Gaps were not gleaned from survey responses.	The current network of drought monitoring should first be closely evaluated for the consistency in data supply, the format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Flood Risk Assessment	WRA has inundation geospatial information and NWA also has similar GIS flood prone areas.	Island-wide inland flooding dataset easily accessible on line.	Flood modeling and projections is a requested product; however not easily available online.	Reasons for gaps were not specifically identified for inland flooding in survey responses.	The current network of inland flooding data managed by various organizations should be evaluated for the consistency in data supply, the format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated which will address any issues in data discrepancies, collaboration amongst organizations, data sharing and standardization of methods and analysis. The plan will provide a framework for future work in order to ultimately create a comprehensive flooding dataset for the island.
Hurricane and Storm Surge Impact Analysis	The Met Service undertakes hurricane reporting. ODPEM has storm surge models for selected coastal towns and MGU manages coastal hazard assessments.	Island-wide hurricane and storm surge dataset easily accessible on line.	Spatial coverage across the entire coast for storm surge is lacking.	Storm surge models undertaken are for selected areas of interest and are project-driven in some cases.	The current network of storm surge data and hurricane reporting by various organizations should first be closely evaluated for the consistency in data supply, the format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated which will address any issues in data discrepancies, collaboration amongst organizations, data sharing and standardization of methods and analysis.
Disease and Pest Risk and Distribution	RADA has data on pest surveillance, pest damage/ infestation.	Comprehensive repository of pest surveillance and infestation data, readily available online.	Specific gaps were not gleaned from survey responses.	Specific gaps were not gleaned from survey responses.	Assessment of pest data for format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Saline intrusion	NWC manages saline intrusion data.	Island-wide saline intrusion dataset easily accessible on line.	Gaps were not gleaned from survey responses.	Gaps were not gleaned from survey responses.	The current network of saline intrusion data should first be closely evaluated for the consistency in data supply, the format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated, and this will provide a framework for future work in order to ultimately create a comprehensive saline intrusion dataset for the island.
Oil spills	CHEVRON collects data if an oil spill occurs.	Island-wide oil spill data easily accessible on line.	Gaps were not gleaned from survey responses.	Gaps were not gleaned from survey responses.	The current oil spill data should be evaluated for consistency, format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated.
Category 3: Geographical and Biophysical Environment					
Topography	NEPA has topographical GIS data.	Island-wide topography data easily accessible on line.	Gaps were not gleaned from survey responses.	Gaps were not gleaned from survey responses.	The current topography data should be evaluated for consistency, format, method of data creation, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Ecosystems and Biodiversity (Terrestrial)	NEPA collects data on species distribution (particularly endemics and endangered) and forest cover. A Ph.D. student at UWI is collecting abundance data on lizards and arthropods in the Hellshire Hills Dry Forest (Climate Studies Group). In addition to managing forest data, Forestry reported that when doing biinventury survey, any animal present in the area is recorded (e.g. lizards, birds etc.). ISD has data on economic values and ecosystem services, whilst EFJ has a collection of data on endangered and endemic species.	Island-wide terrestrial species dataset easily accessible on line.	More readily/easily available remote sensing data and field data on species diversity/change. Few spatial data on species, data on species population size and distribution, currency of data, identification of key or indicators species, regular monitoring. Data on Ecosystem services not collected, data on ecosystem health not collected or if collected not made available. Majority of data collected is not shared.	Reasons for gaps were not specifically identified for species data. Likely reasons for the lack of this data are limited resources such as funds, software, expertise etc. As suggested by the survey responses, if data is collected, it is not shared and this would certainly prevent comprehensive databases to be created.	The current network of terrestrial species data managed by various organizations should first be closely evaluated for the consistency in data supply, the format of the data, methods of data collection, transfer, accessibility and maintenance protocols. Focus will have to be made on the type of data collection (remote sensing vs. in situ data collection especially), coverage and the minimum data resolution and format (raster vs. vector) required for use. Based on this evaluation, an operational plan can be generated which will address any issues in data discrepancies, collaboration amongst organizations, data sharing and standardization of methods and analysis. The plan will provide a framework for future work in order to ultimately create a comprehensive species (flora and fauna) dataset for the island. Given that terrestrial species diversity data is managed by multiple organizations, collaboration and standardization of processes is extremely important here.
Air quality	NEPA has 3 automatic stations setup in Kingston, measuring NOx, SOx, PM10, TSP. JBI has data on air emissions and ambient monitoring data.	Coverage of similar automatic air quality stations across the entire the island, with similar electronic download mechanisms. In addition, air quality measurements to include toxic gases in atmosphere. Processed outputs should be easily accessible on line.	Only 3 stations exist in one Parish, namely Kingston, and no other parish. There is currently no extensive arrangement to measure the type and quantity of toxic gases in the atmosphere (with exception of JBI monitoring).	Lack of resources to setup additional air quality stations such as those already in place in Kingston may be a possible restriction. Similarly, there is generally a lack of instruments to measure toxic gases these.	The current network of air quality monitoring in Kingston and at JBI locations must be assessed in terms of data consistency, format, methods of data transfer, and maintenance protocols. Based on this evaluation, a decision will need to be made whether the current setup may be replicated or if changes are required in order to expand the monitoring across the island. The possibility for monitoring toxic gases must also be addressed here. Ultimately, the evaluation will be used to create an operational plan, which will also identify other locations suitable for air quality monitoring.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 4: Coastal Zone and Ocean					
Coastal Zone Monitoring – Beach profile/ coastal change	NEPA manually measures beach profiles at 6 locations across the island. Results are recorded on paper and transmitted to spreadsheet. MGU maps the geology and physical features of coastlines, measures beach profiles, collects bathymetry of the island shelf, and undertakes time series analysis of coastal changes using satellite imagery and aerial photography.	Adequate coverage of coastal locations (according to experts input), to include beaches, as well as other important coastal areas. Standardized mechanisms to monitor change and proper maintenance and upkeep to ensure continuity in the supply of data. Outputs should be easily accessible on line.	NEPA only has 6 beach profile monitoring locations across the island and indeed there is an urgent need for additional locations. Survey responses included a lack of island wide, coastal zone data and this suggests the need for data for areas other than beaches, such as mangroves, rocky chores, cliffs etc. However MGU stated to collect a number of important datasets related to coastal zone change; however no indication of the locations was given.	Reasons for gaps were not specifically identified for coastal zone data. However lack of resources (human, equipment, financial etc.) may be a likely factor that contributes to the small number of locations that NEPA monitors. Coastal zone change cannot be monitored automatically and the current electronic storage of results by NEPA is commendable. Coastal zone data does exist at organizations other than NEPA and MGU, being able to ascertain the type of data is crucial.	The current network of coastal change monitoring undertaken by NEPA and MGU (and any other entities) should first be closely evaluated for the consistency in data supply, the format of the data, methods of data collection, transfer and analysis, and maintenance protocols. Based on this evaluation, and an expert assessment of the quantity of stations as well as the type of coastal zone data to be acquired, an operational plan can be generated and an increase in locations, if warranted. It is also necessary to conduct further research in order to determine which other entities collect coastal zone data and ascertain how this data may be combined with that from NEPA and MGU in order to build a comprehensive repository of coastal zone data. Indeed, collaborations amongst organizations and data standards are important and must be addressed in the operational plan.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Coastal Zone Monitoring - Mangroves	NEPA monitors the extent of sea grass and mangroves. EFJ has information pertaining to wetlands e.g. replanting of red white and black mangroves along Port Royal main road. UNEP has information pertaining to impacts on coastal and marine ecosystems, status of coastal and marine ecosystems.	A comprehensive system of mangrove mapping for the island that will record mangrove health, as well as species identification and population estimates. Standardized management and transfer of data from all locations must be done to a centralized repository and processed outputs should be easily accessible on line.	Great deficit exists in data on marine species of all types, even those of economic importance. More readily/easily available remote sensing data and field data on species diversity/change. Few spatial data on species, data on species population size and distribution, currency of data, identification of key or indicators species, regular monitoring, collection of field data (NOT remote sensing data) ground truthing. Data collected on ecosystem health if collected, not made available. Capacity to measure changes does not exist. National standards for data collection and reporting do not exist.	Reasons for gaps identified in the survey were not given, however lack of resources (human, equipment, financial etc.) may be a likely factor that contributes to the lack of data that currently exists. Further, as suggested by the survey responses, if data is indeed collected, it is not shared and this would certainly prevent comprehensive databases to be created. Data collected by UNEP is on regional scale and project driven. Other data is compiled related to process - policies, laws, institutions etc.	The current network of mangrove data managed by various organizations should first be closely evaluated for the consistency in type of information, data supply, format of the data, methods of data collection, transfer, accessibility and maintenance protocols. Focus will have to be made on the type of data collection (remote sensing vs. in situ data collection especially), coverage and the minimum data resolution and format (raster vs. vector) required for use. Based on this evaluation, an operational plan can be generated which will address any issues in data discrepancies, collaboration amongst organizations, data sharing and standardization of methods and analysis. The plan will provide a framework for future work in order to ultimately create a comprehensive mangrove dataset for the island.
Coastal Zone Monitoring - Seagrass	NEPA monitors the extent of sea grass and mangroves. UNEP has information pertaining to impacts on coastal and marine ecosystems, status of coastal and marine ecosystems.	A comprehensive system of seagrass mapping for the island, that will record ecosystem health, as well as species identification and population estimates. Standardized management and transfer of data from all locations must be done to a centralized repository and processed outputs should be easily accessible on line.	Great deficit exists in data on marine species of all types, even those of economic importance. More readily/easily available remote sensing data and field data on species diversity/change. Few spatial data on species, data on species population size and distribution, currency of data, identification of key or indicators species, regular monitoring, collection of field data (NOT remote sensing data) ground truthing. Data collected on ecosystem health if collected, not made available. Capacity to measure changes does not exist. National standards for data collection and reporting do not exist.	Reasons for gaps identified in the survey were not given, however lack of resources (human, equipment, financial etc.) may be a likely factor that contributes to the lack of data that currently exists. Further, as suggested by the survey responses, if data is indeed collected, it is not shared and this would certainly prevent comprehensive databases to be created. Data collected by UNEP is on regional scale and project driven. Other data is compiled related to process - policies, laws, institutions etc.	The current network of seagrass data managed by various organizations should first be closely evaluated for the consistency in data supply, type of information, the format of the data, methods of data collection, transfer, accessibility and maintenance protocols. Focus will have to be made on the type of data collection (remote sensing vs. in situ data collection especially), coverage and the minimum data resolution and format (raster vs. vector) required for use. Based on this evaluation, an operational plan can be generated which will address any issues in data discrepancies, collaboration amongst organizations, data sharing and standardization of methods and analysis. The plan will provide a framework for future work in order to ultimately create a comprehensive mangrove dataset for the island.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Ocean Monitoring - Coral reef	Across the island, 36 locations exist at which live coral coverage is estimated by NEPA. Transmission is done by paper; however data ultimately recorded in a spreadsheet. UNEP has information pertaining to impacts on coastal and marine ecosystems, status of coastal and marine ecosystems.	A comprehensive system of coral reef monitoring stations across the island that will record coral reef health, as well as species identification and population estimates. Standardized management and transfer of data from all locations must be done to a centralized repository and processed outputs should be easily accessible on line.	Great deficit exists in data on marine species of all types, even those of economic importance. As stated in survey responses, few spatial data on species, data on species population size and distribution, currency of data, identification of key or indicators species, regular monitoring, collection of field data (NOT remote sensing data) ground truthing. Data collected on ecosystem health if collected, not made available. Capacity to measure changes does not exist. National standards for data collection and reporting do not exist.	Reasons for gaps identified in the survey were not given, however lack of resources (human, equipment, financial etc.) may be a likely factor that contributes to the lack of data that currently exists. Further, as suggested by the survey responses, if data is indeed collected, it is not shared and this would certainly prevent comprehensive databases to be created. Data collected by UNEP is on regional scale and project driven. Other data is compiled related to process - policies, laws, institutions etc.	The current network of coral reef monitoring should first be closely evaluated for the consistency in data supply, the format of the data, methods of data transfer, and maintenance protocols. Based on this evaluation, and an expert assessment of the quantity of stations, an operational plan can be generated and also a possible increase in locations, if warranted. It is also necessary to conduct further research in order to determine which other entities collect coral reef data and ascertain how this data may be combined with that from NEPA in order to build a comprehensive repository of coral reef data. Indeed, data standards are important and must be addressed in the operational plan.
Ocean Monitoring - Sea temperature	NEPA manages 27 automatic stations at which sea temperature is recorded.	Adequate coverage of the coastal waters surrounding the island (according to experts input) and proper maintenance and upkeep to ensure continuity in the supply of data. Processed outputs should be easily accessible on line.	No specific gaps were identified by the survey; however continuous, update and availability of complete datasets are a general gap identified that may be applicable here. Spatial coverage may also be a likely problem.	If problems with data do exist, then difficulties with maintenance, data gathering, and transmission may be a likely reason.	The current network of sea temperature monitoring must be assessed in terms of data consistency, format, methods of data transfer, and maintenance protocols. Based on this evaluation, and an expert assessment of the quantity of stations, an operational plan can be generated and also a possible increase in stations, if warranted.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Ocean Monitoring - Tides	The Jamaican Met Service collects sea level data.	Minimum of electronic management and transfer of data from tide gauges to a centralized repository. There should be adequate coverage of the island (according to experts input) and proper maintenance and upkeep to ensure continuity in data supply. Processed outputs should be easily accessible on line.	Lack of island wide tidal data.	Reasons for gaps were not specifically identified for tidal / sea level data.	Assessment of current sea level data monitoring locations, methodologies, products and maintenance protocols. Research pertaining to current methods of automatic tide monitoring in the region and worldwide should first be done in order to assist in preparing an operational plan that will propose data collection and management procedures.
Ocean Monitoring - Bathymetry	MGU maps the geology and physical features of coastlines, measures beach profiles, and collects bathymetry of the island shelf. NEPA has bathymetric maps.	Comprehensive bathymetric dataset for the island within the Exclusive Economic Zone easily accessible on line.	Lack of island wide, high definition bathymetry of the Exclusive Economic Zone.	Reasons for gaps were not specifically identified for bathymetry. However it is known that site-specific bathymetric data for various localities cross the island exist at various organizations (such as engineering and environmental firms), as well as more general bathymetric data from Admiralty charts. Access to these datasets, differences in date acquisition, resolution (detail), and data collection pose complications for combining these various datasets into one comprehensive dataset.	The current network of bathymetric surveys and available data managed by various organizations should first be closely evaluated for the consistency in data supply, the format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated which will address any issues in data discrepancies, collaboration amongst organizations, data sharing and standardization of methods and analysis. The plan will provide a framework for future work in order to ultimately create a comprehensive bathymetric dataset for the island.
Category 5: Land Cover and Land Use					
Land Cover and Land Use	Forestry manages land cover GIS data for the island, which is readily available online.	Up-to-date land cover dataset for the island easily accessible on line.	Land cover dataset is not up-to-date.	Reason for gap was not gleaned from survey responses.	Assessment of current land cover data for format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated, which will provide a framework for the update of the land cover dataset.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Protected Areas and Parks	NEPA and Forestry manage protected area boundaries.	Comprehensive protected areas dataset for the island easily accessible on line.	Specific gaps were not gleaned from survey responses.	Specific gaps were not gleaned from survey responses.	Assessment of current protected area data for format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated, which will provide a framework for the creation of the complete protected areas dataset.
Category 6: Agriculture and Food Security					
Agriculture: Productivity	RADA manages a farmer database/ crop production estimates. Also, a Ph.D. student is collecting yield data for sweet potatoes for plots in three locations (Climate Studies Group). MOAH manages data on production levels, cost of production, type of crops/livestock enterprises. Forestry has data as a part of land cover dataset.	Comprehensive repository of agricultural production data, readily available online.	Specific gaps were not gleaned from survey responses.	Specific gaps were not gleaned from survey responses.	The current network of agricultural production data from various entities must be assessed in terms of data consistency, format, methods of data transfer, and maintenance protocols. Based on this evaluation, an operational plan can be generated which will address any issues in data discrepancies, collaboration amongst organizations, data sharing and standardization of methods and analysis. The plan will provide a framework for future work in order to ultimately create a comprehensive repository for the island.
Soil Quality	Information regarding soil quality was not gleaned from survey responses.	Comprehensive soil quality dataset for the island easily accessible on line.	Specific gaps were not gleaned from survey responses.	Specific gaps were not gleaned from survey responses.	Consultation with stakeholders will be required in order to identify entities managing soil quality information. Following this, an assessment soil quality data for format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated, which will provide a framework for the creation of the complete soil quality dataset.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 7: Water: Availability, Quality, and Use					
Availability	WRA monitors groundwater levels and change of storage in aquifers at 3300 points, trends and availability; abstraction from surface and ground water sources and impact on availability and quality; water quality to assess impact of the allocation process and industry, settlement and all development activities; rainfall -- total and intensity series to determine water resources balance, recharge and availability. In addition, WINDALCO has well and surface water surveys in Linstead Basin and UNEP has water availability data.	A comprehensive repository of water availability data. This system should combine the existing efforts of WRA, NWC, WINDALCO and UNEP.	A number of rivers of interest, especially in the eastern sections of the island could utilize additional stations to improve the spatial resolution. There are also temporal and spatial data gaps owing to data not being recorded manually by responsible persons. Background (upstream) data absent in most locations. There is a lack of common standards and methods by which data is acquired and processed.	A significant amount of stations owned by the WRA are manual stations, which have to be read by someone in the field. Heavy rains and storms, in particular for eastern parishes, wash many stations away. In addition there are some stations in the Blue Mountain Range where the rainfall is the highest in the island that had to be abandoned due to a lack of funds to access them. Data collected by UNEP is on regional scale and project driven. Other data is compiled related to process - policies, laws, institutions etc.	The current network of monitoring should first be assessed for data parameters, spatial coverage, consistency in data supply, the format of the data, methods of data transfer, and maintenance protocols. Based on this evaluation, and an expert assessment of the quantity of stations and laboratory infrastructure, an operational plan can be generated, inclusive of standards. Given that water availability monitoring is undertaken by multiple organizations, collaboration and standardization of processes is extremely important here.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Water Quality	There are currently over 200 stations measuring the following parameters: NO3, PO4, FC, BOD, DO. These stations are managed by NEPA and are downloaded manually to paper, then stored in spreadsheets. Water quality parameters are sampled by NWC (pH, Turbidity, Dissolved Oxygen, Salinity, Phosphate, Nitrogen, Fecal coliforms, Total coliforms) at > 400 water treatment plants, as well as through their Water Safety Plan (WSP). These are a mixture of manual and automatic stations. UNEP has information on pollution of the coastal/ marine environment, pollutant loads, level of sediment discharges and water quality. NWC monitors waste water discharge into coastal areas.	A collective system of automatic water quality sampling that will allow for electronic download and storage of data at a centralized repository. This system should combine the existing efforts of NEPA, and NWC. The island-wide water quality arrangement must also be spatially efficient, meaning that stations are placed in optimal locations.	No specific gaps were identified by the survey. However, the survey indicated that the majority of the NEPA and NWC data is stored electronically (spreadsheets, database, ASCII), with some being stored on paper at NWC. Data download is solely manual for the NEPA stations and a mixture of download mechanisms for NWC. Indeed any manual process allows for the introduction of data errors and can lead to back-logged data if human resources are not available to undertake the data download.	There are currently over 600 stations (NEPA and NWC), however some are manual stations. If data backlog exists, then the type of data transmission may be the source of this, since although ultimately all data is stored electronically it first has to be transferred by paper. Further, since two entities currently collect water quality data, discrepancies in method of collection, formatting etc. may arise. Data collected by UNEP is project driven and other data is compiled related to process - policies, laws, institutions etc.	The current network of water quality monitoring should first be closely evaluated for the consistency in data supply, the format of the data, methods of data transfer, and maintenance protocols. This is extremely important since two entities currently sample water quality and it is important that the data recorded is done using standardized methods. Based on this evaluation, and an expert assessment of the quantity and suitability of station locations, an operational plan can be generated, if warranted. Given that water quality is collected extensively by two organizations, collaboration and standardization of processes is extremely important here.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Water Use	WRA and NWC both monitor groundwater levels and abstraction data (the amount of water being pumped from the ground. WRA measures groundwater levels and change of storage in aquifers at 3300 points, trends and availability; abstraction from surface and ground water sources. In addition, WINDALCO has well and surface water surveys in Linstead Basin and UNEP has water availability data.	A comprehensive repository of water availability data. This system should combine the existing efforts of WRA, NWC, WINDALCO and UNEP.	Data is submitted to WRA by the owners of the wells. Because the onus of gathering this data lies solely on the owners of these wells, the abstraction data may have spatial gaps. Owners fail to submit data monthly as is stipulated, or where the data submitted is not of ideal quality. The ideal situation is to have the WRA monitor groundwater abstraction. There is a lack of common standards and methods by which data is acquired and processed.	Due to a lack of human resources and sufficient funding, WRA is not always able to collect data in person. Data collected by UNEP is on regional scale and project driven. Other data is compiled related to process - policies, laws, institutions etc.	The current network of water use data should first be assessed for data parameters, spatial coverage, consistency in data supply, the format of the data, methods of data transfer, and maintenance protocols. Based on this evaluation, and an expert assessment of the quantity of stations, an operational plan can be generated, inclusive of standards. Given that water usage information is collected by multiple organizations, collaboration and standardization of processes is extremely important here.
Category 8: Energy: Use, Generation, Availability					
Energy Use	NWC has a record of high-energy users. JBI has data on fuel consumption, type, and quantity. CHEVRON undertakes monthly testing at specific sites and reports to NEPA on a quarterly basis. RUBIS has volume data for various petroleum fuels sold.	Comprehensive repository of energy usage data, readily available online.	Specific gaps were not gleaned from survey responses.	Specific gaps were not gleaned from survey responses.	The current network of energy usage data should first be closely evaluated for the consistency in data supply, the format of the data, methods of data transfer, and maintenance protocols. This is extremely important since multiple entities currently manage energy usage and it is important that the data recorded is done using standardized methods. Based on this evaluation, an operational plan can be generated.
Renewable energy resources	The Jamaican Met Service measures Wind Speed, Solar Radiation, Solar Energy and Sunshine. WRA is involved with the development of Hydropower and the allocation/impact on water resources.	Comprehensive repository of renewable resources data, readily available online.	Specific gaps were not gleaned from survey responses.	Specific gaps were not gleaned from survey responses.	Assessment of renewables data for format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 9: Socio-Economic Status					
Industry Activity	Information regarding industrial activity was not gleaned from survey responses.	Comprehensive repository for industry information for the island easily accessible on line.	Specific gaps were not gleaned from survey responses.	Specific gaps were not gleaned from survey responses.	Consultation with stakeholders will be required in order to identify entities managing industrial activity information. Following this, an assessment of the data for format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated, which will provide a framework for the creation of the complete industrial activity dataset.
Socio-economic Status	Poverty Maps (1991, 2001) are created by PIOJ. Squatting data related to lands controlled by the Forestry Department is collected by Forestry. NEPA also has socio-economic maps.	Up-to-date socio-economic dataset for the island easily accessible on line.	Specific gaps were not gleaned from survey responses.	Specific gaps were not gleaned from survey responses.	Assessment of all data from various organizations for format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated, which will provide a framework for the update of the poverty dataset.
Category 10: Critical and Emergency Infrastructure					
Disaster Response	Information regarding disaster response was not gleaned from survey responses.	Comprehensive repository for disaster response information for the island easily accessible on line.	Specific gaps were not gleaned from survey responses.	Specific gaps were not gleaned from survey responses.	Consultation with stakeholders will be required in order to identify entities managing disaster response information. Following this, an assessment of the data for format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated, which will provide a framework for the creation of the complete disaster response dataset.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Maintenance and Security of Critical Infrastructure	NLA has information pertaining to roads and civic features, whilst NWA manages bridge and road data, and NWC houses infrastructure specific to water distribution. SDC also manages community asset data. ODPEM manages GIS data for emergency shelters.	Repository for island-wide critical civic features dataset easily accessible on line.	Specific gaps were not gleaned from survey responses.	Specific gaps were not gleaned from survey responses.	The critical civic features data from various organizations should be evaluated for consistency, format of the data, methods of data collection, transfer and analysis, accessibility of datasets and maintenance protocols. Based on this evaluation, an operational plan can be generated.

Gaps in Data Analysis and Reporting for Environmental Change

Table 9: Summary of Gaps Identified in Data Analysis and Reporting for Environmental Change in Jamaica

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Agency collaboration	86% organizations participate in research collaboration. Institutions collaborate primarily with the tertiary institutions including The University of the West Indies (UWI), the University of Technology (UTECH) and Northern Caribbean University. In addition, a number of organizations also collaborate with primary and secondary schools and other research groups such as the Caribbean Maritime Institute, Caribbean Institute for Meteorology and Hydrology and the Centre for Resource Management and Environmental Studies.	Standardized and continuous collaboration amongst government, private, NGO, academic and other aligned agencies.	Although 86% of organizations reported to collaborate with other organization, limited access to data was an evident gap throughout the survey. Access (online or otherwise) to historical and current data is lacking. In many cases, data are not made freely available by agencies.	Some agencies do have private and restricted datasets, whilst others are governed by data sharing policies or MoUs.	Consultation with stakeholders should be had in order to determine which datasets are most needed and should be made freely available and online, in addition to required formats. Further consultation will also be needed with entities that would provide required information and discuss any possible data usage restrictions, formats etc. These consultations will lead to specific guidelines for the data sharing framework and recommendations for a centralization database/ repository of information or sources of information.

Table 10: Summary of Gaps Identified in IT and HR Capacity for Monitoring Environmental Change in Jamaica

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Data storage and systems backup	Though varied amongst organizations, the combined physical capacity of the existing computer systems in Jamaica appears adequate. Large organizations such as NWC, NLA, NWA and WINDALCO have as many as 400 or more computers, whist smaller organizations, such as ISD, JBI and MGU have less than ten computers and did not have any servers installed. NLA has the greatest number of servers (60), and this is a combination of physical (30) and virtual (30) servers.	Rationalization and coordination of equipment and processes.	Inadequate data storage capacity and systems backup. Additionally, general workflow within organizations is adversely affected by power outages experienced at regular intervals.	Likely reason is lack of financial resources.	Discuss whether data backup/ storage may be incorporated as part of data sharing guidelines and specifically as part of a central repository. Make recommendations for in-organization and national mechanisms for systems backup.
Software	On computing systems, web browsers include Internet Explorer (versions 6.0, 8.0 and 9.0), Firefox 12 and Google Chrome. On servers, the web server software included IIS (versions 5.0, 6.0, 7.0 and 7.5) and Apache Tomcat (versions 2.2.14 and 7.0), whilst the server software used were: IBM WebSphere, ArcGIS, ASP.NET, PHP 5.3.1, ACCPAC, BizPay, MS Exchange, MS Office, AutoCAD, HRMIS and AS400. Microsoft SQL Server (2000, 2005 and 2008), Clidata, Oracle, MySQL 5.1.41 and AS400/ Access were the data server software listed to be in use on servers.	Software packages and OS that are capable of working with the platform chosen for C-READ.	Insufficient software licenses.	Likely reason is lack of financial resources.	Ascertain from consultation with stakeholders, which software are used and to prioritize these in terms of required licenses. Compare these software packages and determine if there is consistency across the island and or region and make recommendations for standardized software usage and possible open-source options. This may be included in data management standards.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Internet connectivity	All participating organizations have Internet connection: 5 utilize solely DSL, 3 solely fibre/ T1 connections and the remaining 5 utilize a mixture of ADSL/ DSL, cable, fibre and T1.	Sufficient connection that provides a continuous and relatively high volume of data transfer (for large data sets that need to be uploaded or downloaded to the C-READ servers).	No apparent gaps as of yet	N/A	N/A
Roles	On average, the users group is by far the largest group of IT roles identified (41 users per entity). Technical support roles were specified to be for networks and users and this role comprises, on average, 2 persons per entity. The role of administrator was a mixture of system, database and network administrators (1 administrator per entity). In addition, an average of 1 programmer or software developer, 1 person within management and 1 GIS technician (technicians, analysts and information officers) per entity were identified.	At a minimum each organization should have persons who can provide IT support to GIS technicians.	No training for enhanced application of statistical rigor to data.	Limited human and financial resources are a likely cause.	A policy that speaks to the minimum of staff and support that allows us to stay in touch with technological advances.
GIS capability	12 organizations collect various GIS datasets and this gives some indication of GIS capabilities. 3 organizations possess persons who were knowledgeable about GeoNode (WRA, ISD and WINDALCO); however as stated by one organization, while persons may not have working knowledge of Geonode, other geospatial tools are used.	At minimum, all organizations should become familiar with simple geospatial tools.	Some organizations do have GIS skillsets, or the required software.	Limited human and financial resources are a likely cause.	Ascertain from consultation with stakeholders, the level of GIS competence at each organization. Based on this evaluation, an operational plan that speaks to minimum training requirements can be generated.

3.2 Gaps in Belize

Gaps in Data Gathering, Management, and Sharing

Table 11: Summary of Gaps Identified in Data Gathering in Belize

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 1: Meteorological and Hydrological Data and Projections					
Precipitation and general meteorological monitoring	Of the survey respondents that replied, there are currently 2 different organizations that gather time series and 2 that gather GIS meteorological data: the MNRA (Ministry of Natural Resources and Agriculture) and the Belize National Meteorological Service. There was only one met station reported by the Belize Met Service in the survey but they indicate they have over 25 manual stations that they collect data from. The MNRA did not give specific information about details of the precipitation monitoring they do.	Minimum of electronic management and transfer of data from all functioning AWS and rain gauges to a centralized repository. There should be adequate coverage of the landscape (according to experts input) and proper maintenance and upkeep to ensure continuity in the supply of data. Processed averages should be easily accessible on line.	The current data sets are collected manually and then transferred to an electronic repository. Some of this data is available on the web or upon request. Historical data is largely on paper, making queries difficult. A credible respondent indicated that the current coverage of precipitation monitoring is inadequate and that at least 50 more stations are required as well as an audit of maintenance of current stations.	The current situation in Belize is not terribly bad. There is reasonable coverage and the data is electronically transferred and accessible. Historical data is still in hardcopy format due to natural technological progress. Problems with maintenance and quality of data may be due to a lack of training or the need for a review of monitoring systems.	The first step is to review the current network and ensure that all stations are accounted for and that they are well-maintained and producing credible, high quality data. A complete list of all stations and the data transfer protocol will be required. If there is a need for historical analysis, then the older data will need to be digitized. With a clear understanding of the maintenance status and details of all stations, a review can be conducted in regards to density of stations. For instance, a respondent indicated that high-value areas, such as along the coastline, should have a greater monitoring station density. This will need to be analyzed independently and according to WMO standards for meteorological data gathering. Only once a very clear view of the current monitoring network and its maintenance program has been established, should a plan for adding additional stations be discussed. The integration with C-READ can be done regardless of new stations being added. The data monitoring points, the data they provide, its format, and transfer protocols need to be documented.
Climate modeling and forecasting	Precipitation outlooks are produced based on ten agro-meteorology stations across the country. A data set from 1979 to 2012 is used with	Survey respondents indicated that they wanted to see climate change impacts on Belize, specifically with	Currently there are precipitation projections, but the coastal areas and high-risk regions such as around Belize City seem to be underserved.	It is not clear what the responsible factors are for shortcomings in modeling and forecasting.	The CCCCC Clearinghouse has an online platform with some of the modeling data available online in the form of interactive maps and in ASCII and NECDF formats. This data is

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
	input from global models, observations, climate predictability tool, and subjective input. The outputs are for three-month periods. The Met Service also produces four-day forecasts, marine and aviation forecasts, and weather summaries.	respect to agricultural productivity, coral reef health, and potential for drought. The future state would be such that climate models can be used with historical precipitation data and other data sets to project where impacts may be. This data should be accessible to C-READ users in a format that will be understandable and useful for other stakeholders in Belize.			available to organizations in Belize and should be incorporated into or linked to C-READ.
Hydrological monitoring	Of the survey respondents, the Belize Met Service is the only organization that reported they gather time-series hydrological data. The met service has 28 stations that monitor river levels (4 automatic, 24 manual). Two survey respondents indicated that they gather GIS data for hydrological monitoring: Belize Met Service and the Coastal Zone Management Authority. There are provisions for flood and drought warning. Drought warnings are based on SPI (Standard Precipitation Index).	There are areas in Belize that are not properly monitored (Temash and Sarstoon). The goal is to have proper coverage of hydrological monitoring across all regions in Belize. Integrated Water Resource Management is said to be a goal of Belize. This would require data sharing and better means of assessing impacts on water abduction from watersheds in Belize. Accurate flood and drought risk data should be available to organizations that need it. The Met Service indicated they would like to be able to have high spatial resolution drought maps and time series analysis of regional hydro-met change and land cover change.	The current hydrological monitoring system is fairly basic. There is limited capability for future projections and that data that is gathered is primarily stream level information from rivers in the major watersheds. This data is gathered manually. The hydrological data that is gathered could be presented more effectively in a geospatial format. Time series data could be shown in conjunction with other GIS-based data. More advanced monitoring and modeling products might be useful.	The main causal factor appears to be a lack of investment in hydrological monitoring and modeling that would thus provide capacity in this area. For instance, easy access to digital hydrological data would be helpful as would hydrological forecasting / modeling.	The C-READ can help to fulfill some of these requirements. For instance, with data sharing agreements in place, hydrological data that is digitally stored and gathered by the Met Service can be integrated into the database. Data products such as water levels in certain regions could be built into the C-READ, resulting in map output. Similarly, regional analysis could be achieved through having global and regional climate model output built into C-READ. These models could be augmented by Belize's hydrological data, resulting in data products such as drought risk and risk to agriculture, reefs, and coastal zones. Key personnel at the Belize Met Service as well as other relevant agencies in should review the functional requirements and use cases of the C-READ system and provide input. The key will be to ensure sufficient time series, GIS, and modeled data is supplied for Belize.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 2: Hazards and Risks					
Drought Risk Assessment	The main form of data gathering and sharing for drought risk in Belize is with the SPI (Standard Precipitation Index). Precipitation values are the key input data set to this index. There may be more sophisticated data requirement for drought analysis such as soil moisture, for example. This data is gathered by the Met Service.	The desired future state would be to have high spatial resolution analysis that can address drought risk assessment. In addition to the drought risk, there needs to specific focus on risk to key areas such as agricultural productivity and water availability. Relevant data sets should be integrated where appropriate.	The current drought risk model for Belize is based solely on the precipitation data collected. This has some gaps. Additional data sets will need to be integrated with SPI in order to fulfill desired monitoring outcomes in Belize.	The main contributing factors are a lack of integration of existing data sets.	C-READ will aim to address this lack of data integration between relevant agencies. The processing of identifying functional requirements, inputs and outputs, and use cases will help to clarify what data and integration is required. In some cases it may mean connecting with regional data sources.
Flood Risk Assessment	The Belize National Met Service is currently responsible for flood forecasting and warning. There is no clear indication of what data they are using and products they are producing.	High-resolution flood warning data is required. Hydrological data that allows for reporting effectively on floods is necessary. This may require more sophisticated source data than is currently being gathered (stream levels).	There currently is no clear source of data for flood risk in Belize.	There is a lack of integration of hydrological, meteorological and other infrastructural data in order to produce high value flood risk data products.	The existing hydrological data needs to be queried to address the immediate needs. Through the process of analyzing functional requirements the C-READ system can attempt to address the immediate and longer term needs for flood risk assessment. For example, connecting topography, with hydrological and infrastructural data sets.
Hurricane and Storm Surge Impact Analysis	The Belize National Met Service has links to a variety of information sources that track storms: Hurricane Tracker from the Weather Channel, NOAA's National Hurricane Center, NOAA's satellite IR and VS data from GOES, and NASA's 30 min IR loop. A historical record of storms and their impacts on Belize is also available.	Organizations seek to minimize the impacts and disruptions caused by storms. In order to do this each country needs to have an understanding of the critical infrastructure and populations that are at risk and then have adaptive mechanisms to achieve this. Storm tracking data must be of an adequate resolution to connect with other	The data for storm surge is available but it is difficult to connect it with other data sets to establish risk parameters. For instance, damage to the coastal zone and reefs are of importance to stakeholders in Belize. Connecting this data with other critical data sets such as vulnerable communities, industries, or ecosystems is currently lacking. The complete data sets for vulnerable areas may also be lacking.	There is not a platform for connecting this data together and then providing the desired data products.	The C-READ design process will identify functional requirements such as specific data products and queries. Data gaps for assessing risks posed by storms to ecosystems, communities, and industries will be assessed in the functional requirements and data inputs and outputs specification. For example, according to hydrological analysis and contour maps, which communities are most vulnerable to floods and damages resulting from storms?

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
		relevant social and economic data to produce risk products. The storm path and surge data should be in a format that can be integrated with these other data sets. Additionally, each country needs to be able to identify what other data is relevant for risk reduction in their territory.			
Disease and Pest Risk and Distribution	Of the survey respondents, the Ministry of Health was the one that expressed most concern about disease transmission. Data on human health is managed by the MOH and shared amongst institutions according to defined protocols and agreements. Risks posed to human health as a result of climate change and environmental toxins are of primary concern. The other ministries did not indicate that they monitor for invasive species or other pests.	Risk posed to human health as a result of climate change and other environmental impacts need to be understood and consistently monitored. The risk of invasive species to agriculture and ecosystems needs attention and mechanisms to facilitate environmental management procedures.	The survey respondents did not indicate that they monitored for invasive species. This should be further explored. The MOH is interested in monitoring potential human health risks posed by climate change. This needs further exploration as to what data is required to sufficiently monitor for this risks.	There is currently integration between water quality monitoring and human health impacts. However, integration between other departments / ministries to address disease and pest risk is limited. This could be due to the fact that many of these risk areas need to be better understood before establishing data requirements and monitoring protocols.	The design process of the C-READ system will aim to establish what ecological and human risk factors are of primary importance. The data requirements will then be established.
Category 3: Geographical and Biophysical Environment					
Topography	The LIC (Land Information Centre) of the Ministry of Natural Resources and Agriculture is responsible for managing topography data for Belize. They currently have a raster data set that is shared with other ministries and organizations (CIMH included). The data is derived from ASTER and is NAD	Topography data should be of sufficient spatial resolution and in a file format that can be integrated with other data sets, process models, and model output products.	The topography data is sufficient for the analysis that is required.	N/A	N/A

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
	1927 zone 16 N at 30 m spatial resolution.				
Ecosystems and Biodiversity (Terrestrial)	There are various groups that are monitoring different types of ecosystems and biodiversity. It depends on their mandate as to what they focus on. Coastal Zone Management Authority and Institute monitors coastal biodiversity and ecosystems. They use the BERDS system (http://www.biodiversity.bz). Healthy Reefs analyzes the health of reefs (biodiversity included). The LIC has land cover and land use information. TIDE has some species monitoring programs.	There should be a comprehensive data set for ecosystems and biodiversity that cannot only serve as an up-to-date reference, but also be used in conjunction with other data sets. In order to understand risks posed to ecosystems and biodiversity we need to be able to integrate these data sets with hydrological, climate, and infrastructural development data sets.	BERDS is a good start at establishing a clearinghouse mechanism in Belize for biodiversity and ecosystems. There needs to be the ability to link these data sets with those that are gathered by other institutions such as the Met Service (and others)	The survey respondents indicated that the cause for limitation of data gathering and integration was because of a lack of funding. This may be the case, but what first needs to be determined is what the ideal analytical framework is and what is then required to realize it.	The C-READ development process can help to identify which key functions are required for data analysis related to biodiversity and ecosystems and also what data is required for each. For example, survey respondents indicated they would like to see a means of assessing the impact of climate change on ecosystem services in Belize. We can take this requirement and start to ascertain which data sets exist in BERDS and what other data we need. We can then look at the functional requirements and create methods for doing queries to address this issue.
Category 4: Coastal Zone and Ocean					
Coastal Zone Monitoring	The CZMA (Coastal Zone Management Authority and Institute) is the primary organization responsible for monitoring the status of the coastal zone. There are NGOs such as Healthy Reefs and the Toledo Institute the monitor specific items within the coastal zone. They have cooperative relationships with other ministries and share GIS data. The CZMA has a water quality-monitoring program, which has 75 stations in the coastal zone, which measure various physiochemical variables. However, it is not clear if this monitoring program is still active. The new additions to the integrated coastal zone management plan include	Coastal zone data should be accessible and usable by relevant stakeholders. Due to the integrated nature of coastal zone management a variety of data sets that come from different agencies may be required: biodiversity, inundation, tourism, etc.	The stakeholders indicated that there were gaps in the extent of environmental monitoring that is conducted in Belize. However, in looking at the extent of monitoring that different groups do, the real gap may be in the amount of data sharing rather than the extent of monitoring. There are individual studies and water and reef monitoring that were reported as being conducted by the CZMA but this data does not seem integrated or overly accessible. The	The gap appears to be due to a lack of an institution or system that can integrate the many different efforts that are underway in environmental monitoring. This does have financial implications as there needs to be financing to support an effort such as this, however, it could be the fact that an integrated database management system simply does not exist that can accommodate coastal zone data.	The functional requirements for coastal zone management that have been determined thus far for the C-READ management system are a starting point for addressing the data gaps. One area that needs particular attention is in the impacts of climate change on the coastal zone. The new ecosystem service based models for the coastal zone should be examined in the design of C-READ. Additionally, the Belize Integrated Coastal Zone Management Plan 2013 should also be consulted to assess where regional data can support these national objectives. The InVEST model was used extensively and this model output should inform C-READ development (http://www.coastalzonebelize.org/?page_id=681).

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
	GIS-supported ecosystem service models to re-assess coastal zones and to do risk assessments. The two models used thus far are the coastal vulnerability and lobster fisheries.				
Ocean Monitoring	The CZMAI is the main governmental organization in Belize responsible for monitoring the health of the oceans. There is an extensive water quality monitoring program. Specific species such as lobsters and manatees are monitored as are the vitality of fish stocks. Innovative modeling exercises have helped to develop management plans based on ecosystem services. Ocean monitoring (temperature and health of species) will be part of the future of coastal zone management in Belize.	Key physical, chemical, and biological variables need to be gathered in order to continuously monitor the health of the oceans in the Caribbean. Of particular concern are sea surface temperature, currents and activity (inundations), species data, and coral reef information.	There are significant monitoring and modeling activities underway, however, regional environmental data could augment these efforts – for example downscaled output from global climate models. Sharing of this data could be improved as well.	It is not clear what the contributing factors that have led to this gap in data are but the key issue reported is a lack of funding to help extend monitoring.	The C-READ system design process can help to identify specifically which regional Caribbean data sets are required to help national monitoring efforts.
Ocean Monitoring - Bathymetry	The CZMAI has a GIS layer called a DEM. It is not clear if this DEM is land only or includes bathymetry.	Comprehensive bathymetric dataset for the island, easily accessible on line.	Bathymetry is required in order to determine what flood risks there are due to inundations.	Further investigation is required to determine cause of gap (or if there truly is a gap).	Further investigation into the extent of the DEM is required. This will occur in the design phase of C-READ.
Category 5: Land Cover and Land Use					
Land Cover and Land Use	The Land Information Centre of the Ministry of Natural Resources and Agriculture is responsible for assessing land cover and land use. They have reported a number of different GIS data sets they use.	Land cover and land use data should be extensive, covering national and regional priorities as well as key socio-economic and biophysical phenomenon relevant to each national stakeholder. Climate change and environmental impacts should be addressed in	There is a lack of capability in assessing the impacts of environmental change and climate change on land cover in Belize.	It could be that there has been a lack of investment in climate change impacts on land cover.	The work that has been done by the CZMAI on using InVEST to conduct ecosystem service-based analysis on ocean-based natural resources could be replicated on the terrestrial ecosystems. In the development of C-READ this type of land cover and land use monitoring will be addressed in the system functional specifications. Data such as remotely sensed imagery, and model output from system such as InVEST will be identified.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
		the data sets.			
Protected Areas and Parks	Protected areas boundary data are managed by the LIC. Organizations such as TIDE, Healthy Reefs, and the Belize Audubon Society monitor the health of protected areas.	Data for protected areas boundaries and health should be electronically accessible and stored. Impacts on these systems due to environmental change and climate change should be addressed.	The stakeholder survey showed no there are no reported means of assessing impacts of climate change on protected areas in Belize.	It could be that there has been a lack of investment in climate change impacts on protected areas.	The design phase of C-READ can address how to assess climate and environmental impacts on protected areas. This will require further consultation with relevant stakeholders.
Category 6: Agriculture and Food Security					
Agriculture: Productivity	The Ministry of Natural Resources and Agriculture of Belize gathers production, cost, and yield of production data. Compiled data is shared via production reports created on a monthly basis.	Data related to agricultural productivity and health as well as should be regularly gathered in a consistent and quality assured way. It is particularly important for this data to be suitable for assessing impacts of regional climate and environmental change on agriculture.	This data is currently shared, it could be integrated with climate change impact data to better understand risks posed to the country.	An integrated platform for data sharing and analysis does not currently exits in Belize.	The C-READ system can look to enhance the resilience of agricultural productivity in Belize by giving analytics related to climate change impacts on agriculture. This can be addressed in the design phase of C-READ.
Soil Quality	The Ministry of Natural Resources and Agriculture of Belize collects soil quality data to inform productivity for agriculture.	Soil quality data needs to comprehensive enough to indicate the type, productivity, and status of different regions. Spatial resolution may vary depending on the heterogeneity of the landscapes. Data should be made available to organizations concerned with food security and planning and other relevant stakeholders.	Soil data products are shared but are not part of an integrated platform that can be used to assess climate change and environmental impacts on soil quality.	An integrated platform for data sharing and analysis does not currently exits in Belize.	The C-READ system can look to enhance the quality of soil management in Belize by giving analytics related to impacts on soil. This can be addressed in the design phase of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 7: Water: Availability, Quality, and Use					
Availability	The Hydrology Unit in the Belize Met Service is responsible for monitoring the availability of water resources (28 stations). The WASA (Water and Sewage Authority) is responsible for developing and maintaining water works and for ensuring the supply and sustainable use of water resources. The Belize Water Service is responsible for the provision of potable water to urban population (and some rural). The Rural Water Unit is responsible for drilling wells in rural areas. The Rural Water Supply and Sanitation Unit is responsible for delivery of potable water to rural communities.	Data for water available should be regularly collected and made available electronically to relevant stakeholders. Impacts of climate or environmental change should be reflected in this data.	There are drought indices produced by the Met Service but scenarios of the impacts of climate change on water resources are currently not in place.	The resources have not been allocated for doing integrated analysis of the impact of climate and environmental change on water resources.	There are several different aspects of water availability that could be addressed but the most pressing is having a good understanding of the impacts that environmental and climate change have on water resources. The development of the C-READ system will focus on this issue in the development of functional requirements.
Water Quality	The Ministry of Health monitors bore wells and other water abstractions in order to serve as indicators of the quality of available drinking water. This is done in conjunction with the National Water Quality Laboratory.	Water quality data should cover all key parameters such as nitrates, phosphates, coliform, BOD, and others. The data should be made available to relevant stakeholders and electronically stored.	Water quality data is gathered and managed and is shared on an as needed basis. Stakeholders indicated that there were not enough monitoring stations. However further investigation of the monitoring system is required before citing this as a distinct gap in data.	The reason cited by stakeholders for this gap in monitoring is a lack of funding for monitoring stations.	The first step is to assess specifically what the status of the current water quality monitoring program is between the Met Service, the Belize Water Service, the Rural Water Unit, the MOH, and WASA. Once it is clear how, where, and when water quality is monitored then this functionality for data integration can be considered for C-READ.
Water Use	Water use is monitored by WASA. It is not clear if they share this data.	Different stakeholders likely collect water use data. However the protocols for collecting this data should be consistent. Central management and integration of this data can help with getting a cohesive understanding of national water use.	N/A	N/A	The collection process for water use data should be examined in the development of C-READ. If it is warranted by the key stakeholders in Belize, then integration of this data into C-READ could occur. It should be based on the relevance of this issue to the overall objectives of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 8: Energy: Use, Generation, Availability					
Energy Use	The Belize Ministry of Energy, Science & Technology and Public Affairs – Public Utilities Commission, are the overall governing organizations for energy use in Belize. Belize Electricity Limited is the primary distributor of electricity in Belize. These organizations were not identified as stakeholder on the initial survey.	Energy use data is useful for climate change mitigation processes as well as for general environmental management procedures. In nations that have energy conservation policies, gathering this data is essential.	Since there is no survey response from the relate agencies, it is hard to say if there are gaps in data.	N/A	If it is determined that energy use is an essential data set for C-READ, then BEL should be contacted and consulted about what data they store for energy use and how they collect it.
Category 9: Socio-Economic Status					
Industry Activity	The Ministry of Industry and Trade as well as the Ministry of Economic Development are likely responsible for gathering data related to industrial and economic activity. These organizations were not consulted in the first phase of the electronic survey of stakeholders.	Data related to industrial activity should be gathered where relevant. What is particularly important is that data is acquired for industries that are exposed to risks posed by environmental and climate change. Tourism is one example.	Since there is no survey response from the relate agencies, it is hard to say if there are gaps in data.	N/A	If it is determined that vulnerability of different sectors to environmental and climate change is an essential function for C-READ, then these ministries should be consulted. The appropriate data sets should be identified and integrated into C-READ.
Socio-economic Status	None of the survey respondents from Belize indicated they gathered socio-economic data. The Ministry of Economic Development	An overarching goal of the C-READ is to support climate change adaptation. An essential part of understanding where vulnerabilities are is based on socio-economic data. This data should be gathered in such a way that it can reflect which communities or areas are exposed to risks from climate change.	Since there is no survey response from the related agencies, it is hard to say if there are gaps in data.	N/A	The appropriate department in the Ministry of Economic Development should be identified in the design phase of the C-READ system. The format of data collected as well as the means by which it is (or is not) shared will need to be addressed if it is to be incorporated into C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 10: Critical and Emergency Infrastructure					
Disaster Response	The Ministry of Health and National Met Service both indicated community vulnerability and disaster response as priorities. Organizations responsible in Belize are: the Belize National Emergency Management Organization, CDEMA, the Red Cross, and the Belize Emergency Response Team.	Data related to vulnerable areas as well as disaster impact management needs to be readily accessible and available to response teams. This implies that the data should be electronic, centrally stored, and easily deployed to relevant groups.	The requested community vulnerability and drought risk maps are currently not available in Belize.	There has not been the investment and integration of data required to produce these data products.	The appropriate organizations for emergency response should be identified in the design phase of the C-READ system. The exact format and types of data required to produce emergency response products can then be clarified.
Maintenance and Security of Critical Infrastructure	The above emergency response organizations should be consulted with respect to which critical infrastructure needs assessment. Food provision is one that has been identified by survey respondents as has water availability.	Critical infrastructure should be identified and data relating to its status should be monitored so as to ensure that it continues to function.	The critical infrastructure to be monitored was not identified in the initial survey (except for drought). Therefore, it is difficult to identify gaps.	N/A	The appropriate organizations for emergency response should be identified in the design phase of the C-READ system. The specific critical infrastructure should be identified and required data sets for monitoring be established.

Gaps in Data Analysis and Reporting for Environmental Change

Table 12: Summary of Gaps Identified in Data Analysis and Reporting for Environmental Change in Belize

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Agency collaboration	67% of the survey respondents indicated that they engage in some form of research collaboration. The institutions that they collaborate with are: Smithsonian Institution, UNAM, CINVESTAV, UB, CURLA-UNAH, CIMH, and Texas A&M University. In terms of collaborative sharing of data, most organizations that responded indicated that they maintain all the ownership rights but are open to sharing if proper agreements and sharing protocols are put in place.	Standardized and continuous collaboration amongst government, private, NGO, academic and other aligned agencies.	The most significant gap here is the fact that data sharing has not been widespread in Belize. The Met Service shares data with CIMH through formal agreements, but other than that, there have not been many opportunities for sharing. The NGOs that replied are doing some very interesting sampling and the integration of that data with governmental data sets could result in a greater capacity for adaptive environmental management.	To date there have been limited opportunities for data sharing and collaboration between multiple parties. The focus has largely been on biparty sharing of data on a project-by-project basis.	Sharing of data and inter-agency collaboration will have to be examined within the context of the specific problems that need to be solved. Early meetings in Belize revealed that there has to be a 'value proposition' for the organizations if they are to share their data. Eg. what do they get if they share their data. There will likely be limitations as to what data can and cannot be shared. These details will need to be sorted out in Phase 2 when the protocols for the system inputs and outputs are determined.

Gaps in IT and Human Resource Capacity for Monitoring Environmental Change

Table 13: Summary of Gaps Identified in IT and HR Capacity for Monitoring Environmental Change in Belize

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Data storage and systems backup	The data storage and back up capacity varied throughout organizations that responded to the e-survey. The Ministry of Health had the most servers and computers (10) and (60) respectively. The other organizations that responded had fairly limited computational resources – max 25 computers and 1 server.	Rationalization and coordination of equipment and processes. Computational power to use a web-based application that draws upon different data sources (C_READ)	Backup resources are limited and proponents use fairly basic software packages.	A number of the respondents have limited resources (Met Service and NGOs). This is likely the main factor that contributes to this.	The backup requirement will need to be assessed for the organizations depending on their role in contributing data. The storage of critical data for C-READ will need to be evaluated. It is likely that there will be a central repository of data.
Software	Computers are outfitted with Windows 7 and XP as well as Mac OS. Servers are running Linux, Centos 6.4 and and Windows 2003 as well as Apache / Jetty / Tomcat web server software.	Software packages and OS that are capable of working with the platform chosen for C-READ.	No apparent gap as of yet.	N/A	The design process for C-READ will need to address software requirements for the stakeholder groups. The software choice should be accessible and preferable have a low entry cost (nothing in terms of PHP/MySQL and GeoNode).
Internet connectivity	All participating organizations have a DSL Internet connection	Sufficient connection that provides a continuous and relatively high volume of data transfer (for large data sets that need to be uploaded or downloaded to the C-READ servers).	No apparent gaps as of yet	N/A	The design process will need to recognize any bandwidth limitations in Belize.
Roles	The survey respondents indicated that there were not significant human resources for programming and GIS. There were not GIS personnel reported by survey respondents.	At a minimum each organization should have persons who can provide IT support to GIS technicians.	No training for enhanced application of statistical rigor to data.	Limited human and financial resources are a likely cause.	A policy that speaks to the minimum of staff and support that allows us to stay in touch with technological advances. The requirements for programming personnel will need to be examined in the sustainability and outreach component of the C-READ project.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
GIS capability	Knowledge of GIS appears to be a weakness in the organizations that responded to the e-survey. However, it could be that this skill was simply not properly reported as 6 of 7 survey respondents indicated that they gather or manage geospatial data.	At minimum, all organizations should become familiar with simple geospatial tools.	Very little GIS capability reported by survey respondents. However, 6 of 7 indicated they have GIS data.	Limited human and financial resources are a likely cause.	Ascertain from consultation with stakeholders, the level of GIS competence at each organization. Based on this evaluation, an operational plan that speaks to minimum training requirements can be generated. Training can be laid out in the C-READ sustainability plan.

3.3 Gaps in Dominica

Gaps in Data Gathering, Management, and Sharing

Table 14: Summary of Gaps Identified in Data Gathering in Dominica

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 1: Meteorological and Hydrological Data and Projections					
Precipitation and general meteorological monitoring	There were three stakeholder groups that replied to the survey that sample time series precipitation data. The Met Service, DOWASCO, and the Ministry of Agriculture and Forestry reported that they monitored for precipitation. The Met Service documented three stations; DOWASCO indicated they have 5 (expanding to 9) automated weather stations. Stakeholders did indicate that the complex topography of Dominica made it difficult to have complete coverage of meteorology with only a limited amount of monitoring stations. The World Bank PPCR project is promoting a local network for hydromet data sharing. The Forestry Department also has 10 conventional stations from which data is supplied to the Met Service.	Minimum of electronic management and transfer of data from all functioning AWS and rain gauges to a centralized repository. There should be adequate coverage of the landscape (according to experts input) and proper maintenance and upkeep to ensure continuity in the supply of data. Processed averages should be easily accessible on line.	There are AWS in place but stakeholders indicated that the spatial coverage is not sufficient. Also there are ongoing initiatives to encourage data sharing. The consistency and quality of data needs to be reviewed to see how much of a gap there is (if any).	The stakeholders indicated that it was due to a lack of human and financial resources that they do not have the spatial coverage of precipitation data they desire. This needs to be assessed.	In the design process for C-READ, the exact number of hydromet stations should be determined as well as the continuity and quality of data they provide. Additionally, the regional network of data sharing sponsored by the World Bank PPCR could be a good platform to collaborate with. Their program will be reviewed in the C-READ design process. The goal will be to create synergistic activities with that program.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Climate modeling and forecasting	The respondents did not indicate that they currently perform climate change scenarios using any models. However they do have digital records of the precipitation and temperature data they gather.	The future state would be such that climate models can be used with historical precipitation data and other data sets to project where impacts may be. This data should be accessible to C-READ users in a format that will be understandable and useful for stakeholders	There are no models being used for projecting the impacts of climate change on Dominica. Stakeholders did indicate that they would like this type of predictive modelling capability.	Presumably this is due to a lack of investment in human resources and technological infrastructure. However, the Met Service did indicate that they collaborate with CIMH, CCCCC, UWI, and WMO.	In the process of determining functional requirements of the C-READ DMS, climate modelling should be incorporated. Included in this function will be the capability to assess climate impacts on infrastructure and natural resources.
Hydrological monitoring	Of the survey respondents, only one reported that they record time series hydrological data: DOWASCO. According to Dr. Depradine's report the CARIBHYCOS project supplied six automatic rainfall stations that contribute to hydrological monitoring but there are a lack of personnel for retrieving the data. There are manual stream gauges on the five main rivers. There is one automatic gauge on one river but it is not working properly and does not supply continuous data.	The goal is to have proper coverage of hydrological monitoring across all regions. Integrated Water Resource Management should be a goal and this would require data sharing and better means of assessing impacts on water abduction from watersheds. Accurate flood and drought risk data should be available to organizations that need it.	The gap that is cited by stakeholders is the shortcoming of continuous data from stream gauges. They recommended that additional automatic stations be sourced. They do however have central storage of water data that comes from 5 automatic hydromet stations. The data is stored at the stations until downloaded and then integrated into HYDRAS software.	The cause of this perceived gap may not be due to a lack of physical technology but perhaps processes for maintaining and gathering data from existing systems.	Rather than assume that additional automatic hydrological monitoring equipment will solve the gap of sparse coverage of hydrological monitoring data, it is recommended that a thorough review of existing infrastructure be performed. This way, the best form of data acquisition can be ascertained. For instance, it may even be best to have only manual stream gauges and a small team of personnel who have the responsibility to retrieve data from them and maintain them. This overview should take place, at least through some directed questions to DOWASCO, the Met Service, and participants from CARIBHYCOS during the design phase of C-READ. The integration of HYDRAS with C-READ will need to be explored

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 2: Hazards and Risks					
Drought Risk Assessment	The survey respondents that indicated they were interested in drought risk assessment were: Ministry of Agriculture and the Met Service. Currently it does not appear that there are metrics being used for drought risk. However, There is a GeoNode in Dominica, which could serve as a collaborating partner on producing GIS-based drought maps.	The desired future state would be to have high spatial resolution analysis that can address drought risk assessment. In addition to the drought risk, there needs to specific focus on risk to key areas such as agricultural productivity and water availability. Relevant data sets should be integrated where appropriate.	There are no comprehensive data products that give drought risk in Dominica.	The hydrological monitoring system is in development and do not seem able to readily provide data products to address drought risk.	The projects such as CARIBHYCOS, PPCR, and C-READ can help to provide an integrated data management platform that can provide this information. The C-READ development process will build drought risk into its functional requirements. Collaboration with the CIMH Drought monitor will be essential in developing the drought risk assessment platform.
Flood Risk Assessment	Hydrological data is being gathered but it does not seem apparent that it is being integrated into a management system that can connect topography and hydrological processes – resulting in flood risk.	High-resolution flood warning data is required. Hydrological data that allows for reporting effectively on floods is necessary. This may require more sophisticated source data than is currently being gathered (stream levels).	There are no comprehensive data products that give flood risk in Dominica.	The hydrological monitoring system is in development and do not seem able to readily provide data products to address flood risk. However, many stakeholder countries have requested that C-READ be able to provide data products that indicate areas of vulnerability to flood and other natural occurrences.	The projects such as CARIBHYCOS, PPCR, and C-READ can help to provide an integrated data management platform that can provide this information. The C-READ development process will build flood risk into its functional requirements.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Hurricane and Storm Surge Impact Analysis	There is no explicit reference to storm surge and impact analysis that is currently conducted by the Met Service of Dominica. The National Hurricane Centre, CDEMA, and CIMH all coordinate with the Met Service so there is flow of information about general risks.	Organizations seek to minimize the impacts and disruptions caused by storms. In order to do this each country needs to have an understanding of the critical infrastructure and populations that are at risk and then have adaptive mechanisms to achieve this. Storm tracking data must be of an adequate resolution to connect with other relevant social and economic data to produce risk products. The storm path and surge data should be in a format that can be integrated with these other data sets. Additionally, each country needs to be able to identify what other data is relevant for risk reduction in their territory.	There do not seem to be comprehensive data products that provide storm surge impact analysis for Dominica.	The most likely cause of this is a lack of integrated data sets and monitoring infrastructure to supply these reports.	The projects such as CARIBHYCOS, PPCR, and C-READ can help to provide an integrated data management platform that can provide this information. The C-READ development process will build storm surge risk into its functional requirements. This will include mapping vulnerable infrastructure.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Disease and Pest Risk and Distribution	None of the survey respondents gave specific details as to what current monitoring they do for pest control. The Ministry of Agriculture and Forestry did set pest control as a very high priority for C-READ. The Ministry of Health was not a respondent on the e-survey but should be consulted with respect to disease control data.	Risk posed to human health as a result of climate change and other environmental impacts need to be understood and consistently monitored. The risk of invasive species to agriculture and ecosystems needs attention and mechanisms to facilitate environmental management procedures.	Gaps were not identified due to lack of response on this issue in the survey	N/A	Further consultation on disease and pest control will be required for Dominica. This can be done in the review of functional requirements for C-READ in the design phase.
Category 3: Geographical and Biophysical Environment					
Topography	Survey respondents did not indicate that topography data was available digitally. DOWASCO did suggest that high resolution digital topography would be useful to integrate with hydrological models such as CAUHSI and HEC-RAS (comment from Mr. Jerry Meier)	Topography data should be of sufficient spatial resolution and in a file format that can be integrated with other data sets, process models, and model output products.	Gaps were not identified due to lack of response on this issue in the survey.	N/A	Specific questions should be asked of relevant ministries in Dominica about whether or not they have topographical data. This can be done in the review of functional requirements for C-READ in the design phase.
Ecosystems and Biodiversity (Terrestrial)	Survey respondents did not indicate that ecosystems and biodiversity data was gathered. The Ministry of Agriculture and Forests as well as Environment, Natural Resources, Physical Planning and Fisheries would be obvious groups to follow up with on this.	There should be a comprehensive data set for ecosystems and biodiversity that cannot only serve as an up-to-date reference, but also be used in conjunction with other data sets. In order to understand risks posed to ecosystems and biodiversity we need to be able to integrate these data sets with hydrological, climate, and infrastructural development data sets.	Gaps were not identified due to lack of response on this issue in the survey	N/A	Specific questions should be asked of relevant ministries in Dominica (as mentioned) about whether or not they have ecosystems and biodiversity data. This can be done in the review of functional requirements for C-READ in the design phase.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 4: Coastal Zone and Ocean					
Coastal Zone Monitoring	DOWASCO mentioned that they periodically gather water quality data near outfall from the wastewater treatment plant. The Met Service has indicated a deep interest in assessing the impacts of climate change on coastlines. So there is an interest in coastal zone monitoring, but respondents did not indicate that they are gathering much data at this stage.	Coastal zone data should be accessible and usable by relevant stakeholders. Due to the integrated nature of coastal zone management a variety of data sets that come from different agencies may be required: biodiversity, inundation, tourism, etc.	Gaps were not identified due to lack of response on this issue in the survey	N/A	Specific questions should be asked of relevant ministries in Dominica (as mentioned) about whether or not they have coastal zone management data. This can be done in the review of functional requirements for C-READ in the design phase.
Ocean Monitoring	The Ministry of Environment, Natural Resources, Physical Planning and Fisheries would be the obvious group that would gather this kind of data. Unfortunately, they did not respond to the survey.	Key physical, chemical, and biological variables need to be gathered in order to continuously monitor the health of the oceans in the Caribbean. Of particular concern are sea surface temperature, currents and activity (inundations), species data, and coral reef information.	Gaps were not identified due to lack of response on this issue in the survey	N/A	Specific questions should be asked of relevant ministries in Dominica (as mentioned) about whether or not they have ocean monitoring data. This can be done in the review of functional requirements for C-READ in the design phase.
Category 5: Land Cover and Land Use					
Land Cover and Land Use	The Ministry of Environment, Natural Resources, Physical Planning and Fisheries does collect data related to land cover types and different land uses as does the Ministry of Agriculture and Forestry. No details were provided as to the specific nature of this data (meta data for GIS) though.	Land cover and land use data should be extensive, covering national and regional priorities as well as key socio-economic and biophysical phenomenon relevant to each national stakeholder. Climate change and environmental impacts should be addressed in the data sets.	Gaps were not identified due to lack of detail specification of the data.	N/A	Specific questions should be asked of the Ministry of Environment, Natural Resources, Physical Planning and Fisheries as well as the Ministry of Agriculture and Forestry in regards to the specific types of land cover and land use data they collect. If it is GIS data, the complete specification will be required (projection, resolution, etc). This can be done in the review of functional requirements for C-READ in the design phase.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Protected Areas and Parks	The Ministry of Environment, Natural Resources, Physical Planning and Fisheries does collect data related to protected areas and parks – both terrestrial and marine. The format of this data was not specified and needs further clarification.	Data for protected areas boundaries and health should be electronically accessible and stored. Impacts on these systems due to environmental change and climate change should be addressed.	Gaps were not identified due to lack of detail specification of the data.	N/A	Specific questions about the format of the data they store protected areas and parks in need to be resolved. This can occur in the design phase of the project.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 6: Agriculture and Food Security					
Agriculture: Productivity	The Ministry of Agriculture and Forestry collects data related to agricultural productivity based on weather (bimonthly) and for agriculture (monthly). They are in the process of implementing a GIS-based system.	Data related to agricultural productivity and health as well as should be regularly gathered in a consistent and quality assured way. It is particularly important for this data to be suitable for assessing impacts of regional climate and environmental change on agriculture.	There was not sufficient enough detail provided by the MOAF to determine where there were gaps. However, it seems that they have significant capacity in agricultural monitoring. One area that will likely need attention is gathering and analyzing data related to climatic change and its impacts on agriculture.	Presumably a lack of infrastructure has resulted in the fact that there is not integrated analysis for climate change impacts on agriculture. A GIS system is just being implemented, hence there are still some steps to be taken in order to have robust impact analysis performed.	Specific detail about the nature of agricultural data that the Ministry of Agriculture and Forestry needs to be clarified in the design process of C-READ. Consultation with the ministry in the establishment of functional requirements will be necessary.
Soil Quality	The Ministry of Agriculture and Forestry indicated that a desired data product would be a soil type database. One can assume that this is currently not in place then.	Soil quality data needs to comprehensive enough to indicate the type, productivity, and status of different regions. Spatial resolution may vary depending on the heterogeneity of the landscapes. Data should be made available to organizations concerned with food security and planning and other relevant stakeholders.	It appears that accurate and available soil type data is not currently available.	It is not clear why this is currently in place.	The provision for soil data management can be provided in C-READ. The GIS interface will be particularly useful for soil mapping. Populating the database will have to be done by the Ministry of Agriculture and Forestry.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 7: Water: Availability, Quality, and Use					
Availability	DOWASCO is responsible for monitoring water resources in Dominica. There is a fairly sophisticated integrated model for water monitoring. There is a planned deployment of new technology for monitoring and management of water via the Carib HYCOS project and also PPCR.	Data for water available should be regularly collected and made available electronically to relevant stakeholders. Impacts of climate or environmental change should be reflected in this data.	The main gap is the fact that there needs to be integration of the activities between C-READ's development and those that are planned with PPCR and Carib HYCOS.	The different projects are new and therefore unaware of each other's directions. Hence the disconnect	Key personnel with PPCR and Carib HYCOS should be consulted with respect to how C-READ can work in tandem with their initiatives. Nick Calendar and Jerry Meier are two contacts with the World Bank and Jean-Pierre Briquet is with the Carib HYCOS project.
Water Quality	Water Quality data is gathered by laboratory staff at DOWASCO and stored in their database in excel format.	Water quality data should cover all key parameters such as nitrates, phosphates, coliform, BOD, and others. The data should be made available to relevant stakeholders and electronically stored.	There does not seem to be a significant shortcoming in water quality data.	N/A	N/A

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Water Use	DOWASCO would be responsible for water use data, however their survey response did not detail what data they used.	Different stakeholders likely collect water use data. However the protocols for collecting this data should be consistent. Central management and integration of this data can help with getting a cohesive understanding of national water use.	There was not sufficient enough data provided by survey respondents to indicate where the data gap exists.	N/A	Further consultation with DOWASCO will be required in order to address this issue.
Category 8: Energy: Use, Generation, Availability					
Energy Use	No survey respondents indicated they gathered data related to energy use.	Energy use data is useful for climate change mitigation processes as well as for general environmental management procedures. In nations that have energy conservation policies, gathering this data is essential.	N/A	N/A	Further consultation with relevant ministries will be required in the development of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 9: Socio-Economic Status					
Industry Activity	No survey respondents indicated they gathered data related to industrial activity.	Data related to industrial activity should be gathered where relevant. What is particularly important is that data is acquired for industries that are exposed to risks posed by environmental and climate change. Tourism is one example.	N/A	N/A	Further consultation with relevant ministries will be required in the development of C-READ.
Socio-economic Status	No survey respondents indicated they gathered data related to socio-economic status.	An overarching goal of the C-READ is to support climate change adaptation. An essential part of understanding where vulnerabilities are is based on socio-economic data. This data should be gathered in such a way that it can reflect which communities or areas are exposed to risks from climate change.	Hazard risk analysis and vulnerability assessments will require socio-economic data.	It is possible that the ministries who manage this data simply were not able to respond.	Further consultation with relevant ministries will be required in the development of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 10: Critical and Emergency Infrastructure					
Disaster Response	The Ministry of Agriculture and Forestry and the Met Office both requested disaster risk data products. The MOAF recommended that risk to human settlements be a data product of C-READ. Met Service of Dominica. The National Hurricane Centre, CDEMA, and CIMH all coordinate with the Met Service in relation to disaster response.	Data related to vulnerable areas as well as disaster impact management needs to be readily accessible and available to response teams. This implies that the data should be electronic, centrally stored, and easily deployed to relevant groups.	The requested community vulnerability and drought risk maps are currently not available in Dominica.	There has not been the investment and integration of data required to produce these data products.	The appropriate organizations for emergency response should be identified in the design phase of the C-READ system. The exact format and types of data required to produce emergency response products can then be clarified.
Maintenance and Security of Critical Infrastructure	The above emergency response organizations should be consulted with respect to which critical infrastructure needs assessment. Food provision is one that has been identified by survey respondents, as has water availability.	Critical infrastructure should be identified and data relating to its status should be monitored so as to ensure that it continues to function.	The critical infrastructure to be monitored was not identified in the initial survey (except for drought). Therefore, it is difficult to identify gaps.	N/A	The appropriate organizations for emergency response should be identified in the design phase of the C-READ system. The specific critical infrastructure should be identified and required data sets for monitoring to be established.

Gaps in Data Analysis and Reporting for Environmental Change

Table 15: Summary of Gaps Identified in Data Analysis and Reporting for Environmental Change in Dominica

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Agency collaboration	Two of the survey respondents indicated that they collaborate with research institutions. The institutions are: Portsmouth University in Wales, Local high schools and college, UWI, and CIMH. There is a fair amount of collaboration underway with PPCR and the HYCOS project. There is a loose working group focused on environmental monitoring and data sharing.	Standardized and continuous collaboration amongst government, private, NGO, academic and other aligned agencies.	There is a fair degree of ongoing collaboration but due to this activity there is an increased requirement for standardization and protocol for sharing of information if C-READ is to tap into these networks.	The many collaborative projects that are currently occurring have their own processes and standards for sharing data. This needs to be connected to C-READ if there is to be data sharing.	Consultation with stakeholders should be had in order to determine which datasets are most needed and should be made freely available and online, in addition to required formats. Further consultation will also be needed with entities that would provide required information and discuss any possible data usage restrictions, formats etc. These consultations will lead to specific guidelines for the data sharing framework and recommendations for a centralization database/ repository of information or sources of information.

Gaps in IT and Human Resource Capacity for Monitoring Environmental Change

Table 16: Summary of Gaps Identified in IT and HR Capacity for Monitoring Environmental Change in Dominica

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Data storage and systems backup	There was a disproportionate amount of computing and storage capacity amongst the survey respondents. DOWASCO reported having 55 computers and 8 servers whereas the Met Service had only 14 computers and no servers (reported). IICA indicated that they had 2 computers and no servers.	Rationalization and coordination of equipment and processes. Computational power to use a web-based application that draws upon different data sources (C_READ)	There may be issues with storage capacity and server capacity for some of the organizations in Dominica.	Likely reason is lack of financial resources.	Discuss whether data backup/ storage may be incorporated as part of data sharing guidelines and specifically as part of a central repository. Make recommendations for in-organization and national mechanisms for systems backup.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Software	Computers are outfitted with Windows 7, 8, XP, and Vista. Applications being used are those such as: Microsoft Office, AutoCAD, Personnel Manager, Dynamics GP, and Bill Master.	Software packages and OS that are capable of working with the platform chosen for C-READ.	No apparent gap as of yet.	N/A	The design process for C-READ will need to address software requirements for the stakeholder groups. The software choice should be accessible and preferable have a low entry cost (nothing in terms of PHP/Myself and GeoNode).
Internet connectivity	All participating organizations have a DSL Internet connection	Sufficient connection that provides a continuous and relatively high volume of data transfer (for large data sets that need to be uploaded or downloaded to the C-READ servers).	No apparent gaps as of yet	N/A	The design process will need to recognize any bandwidth limitations in Dominica.
Roles	There was not sufficient data provided from the survey to address this.	At a minimum each organization should have persons who can provide IT support to GIS technicians.	N/A	N/A	N/A
GIS capability	There was not sufficient data provided from the survey to address this.	At minimum, all organizations should become familiar with simple geospatial tools.	N/A	N/A	N/A

3.4 Gaps in Saint Lucia

Gaps in Data Gathering, Management, and Sharing

Table 17: Summary of Gaps Identified in Data Gathering in Saint Lucia

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 1: Meteorological and Hydrological Data and Projections					
Precipitation and general meteorological monitoring	Of the survey respondents that replied, there are currently 3 different organizations that gather time series meteorological data: the Met Service of Saint Lucia and the Ministry of Agriculture, Food Production, and Fisheries, and the WRMA. There were 32 data acquisition stations reported by survey respondents. The key issue identified by groups was the fact that there was a lack of integration of met data.	Minimum of electronic management and transfer of data from all functioning AWS and rain gauges to a centralized repository. There should be adequate coverage of the landscape (according to experts input) and proper maintenance and upkeep to ensure continuity in the supply of data. Processed averages should be easily accessible on line.	The data being collected is in some cases disparate. It needs to be better integrated.	Separate organizations are collecting data with no mechanisms for data sharing.	C-READ will aim to address this lack of data integration between relevant agencies. The processing of identifying functional requirements, inputs and outputs, and use cases will help to clarify what data and integration is required. In some cases it may mean connecting with regional data sources. In other cases it will be focused on inter-agency data sharing within Saint Lucia. Precipitation data from Saint Lucia is important to understanding regional atmospheric processes and the impacts of climate change. Data sets need to be standardized both for sound monitoring and data sharing nationally, but also for integrating data from different countries. C-READ will serve as a platform for integrating and sharing this data. The existing data gathering and management infrastructure present with the national water information system can be built upon with C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Climate modeling and forecasting	The Met Service produces forecasts and connects with other organizations (NOAA) for storm tracking. There currently does not appear to be a systematic effort to run different climate scenarios in order to predict areas of concern.	The future state would be such that climate models can be used with historical precipitation data and other data sets to project where impacts may be. This data should be accessible to C-READ users in a format that will be understandable and useful for stakeholders	There are no models being used for projecting the impacts of climate change on Saint Lucia. Stakeholders did indicate that they would like this type of predictive modelling capability.	Presumably this is due to a lack of investment in human resources and technological infrastructure. However, the Met Service did indicate that they collaborate with CIMH and WMO.	In the process of determining functional requirements of the C-READ DMS, climate modelling should be incorporated. Included in this function will be the capability to assess climate impacts on infrastructure and natural resources.
Hydrological monitoring	The WRMA reported it gathered hydrological data from 3 automated stations.	The goal is to have proper coverage of hydrological monitoring across all regions. Integrated Water Resource Management should be a goal and this would require data sharing and better means of assessing impacts on water abduction from watersheds. Accurate flood and drought risk data should be available to organizations that need it.	The gap identified by WRMA was the fact that they lacked consistent data from the sensors. This is in part due to inaccessibility.	The network of hydrological monitoring stations may need evaluation.	A review of the hydrological data – historically and geographically – will help to determine how C-READ can best use this data. Changes to sensor upkeep might be suggestions that come out of that review. The C-READ should possibly include Best Practice Guidelines for data collection and sensor maintenance in order to standardize practices across the region and improve the quality of the data. This suggestion is valid for met data and water quality data as well.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 2: Hazards and Risks					
Drought Risk Assessment	There is fairly comprehensive hydrological and meteorological data being gathered by the Met Service and the WRMA. It is not clear what drought indices are being processed at this point. There is a lack of integration between the data sets and this may inhibit a true perspective on drought assessment.	The desired future state would be to have high spatial resolution analysis that can address drought risk assessment. In addition to the drought risk, there needs to specific focus on risk to key areas such as agricultural productivity and water availability. Relevant data sets should be integrated where appropriate.	The gap appears to be a lack of integration of met and hydrological data that will allow drought indices to be calculated.	The causal factors appear to be the parallel development of different monitoring systems by different agencies.	Although there is a lack of integration, there are programs and projects in place to improve this (PPCR, Carib HYCOS). The C-READ should work in parallel with these projects and the Drought Monitor at CIMH. The key will be to bring added value through integration with other regional data sets and to not replicate efforts of the projects running in parallel in Saint Lucia.
Flood Risk Assessment	As per above, there is extensive hydrological and met data being gathered in Saint Lucia that is essential for flood risk mapping. With the integrated monitoring systems and models that are being developed through Carib HYCOS and PPCR, flood risk analysis should be feasible. One thing that is lacking is good topographical data.	High-resolution flood warning data is required. Hydrological data that allows for reporting effectively on floods is necessary. This may require more sophisticated source data than is currently being gathered (stream levels).	The gap is in the capability to integrate existing precipitation and hydrological data with infrastructure, topography, and other relevant land cover data to produce risk maps.	The causal factors appear to be the parallel development of different monitoring systems by different agencies and the corresponding need for integration.	The flood risk functionality can be built into C-READ. The development of this functionality can happen in parallel complementary projects that are happening in Saint Lucia (PPCR, Carib HYCOS).

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Hurricane and Storm Surge Impact Analysis	The Saint Lucia Met Service has storm tracking links on the website to NOAA's Tropical Weather Outlook (http://www.nhc.noaa.gov/ and satellite images from the Regional and Mesoscale Meteorology Branch (RAMMB). What are lacking are the connections of surge impacts to settlements in Saint Lucia.	Organizations seek to minimize the impacts and disruptions caused by storms. In order to do this each country needs to have an understanding of the critical infrastructure and populations that are at risk and then have adaptive mechanisms to achieve this. Storm tracking data must be of an adequate resolution to connect with other relevant social and economic data to produce risk products. The storm path and surge data should be in a format that can be integrated with these other data sets. Additionally, each country needs to be able to identify what other data is relevant for risk reduction in their territory.	Infrastructure and topographical data needs to be connected with storm surge hydrological data in order to assess risks. This is currently not happening.	The causal factors appear to be a lack of integration between storm surge warnings and infrastructural data – this could be due to a lack of resources or technology to do so.	Storm surge risk can be built into C-READ by connecting topographical and coastal zone data (GIS – based) with storm surge data. This will be explored in the determination of functional requirements for C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Disease and Pest Risk and Distribution	Disease and pest risk was not cited in the survey responses as an issue for which a significant amount of data is currently being gathered.	Risk posed to human health as a result of climate change and other environmental impacts need to be understood and consistently monitored. The risk of invasive species to agriculture and ecosystems needs attention and mechanisms to facilitate environmental management procedures.	The feedback indicates that not a significant amount of pest and disease risk data is being collected. However, further investigation with the Ministry of Health will be required to ascertain the current status.	Further investigation with the Ministry of Health will be required to ascertain the current status.	The results of further investigation with the Ministry of Health will indicate how best to gather this data for Saint Lucia.
Category 3: Geographical and Biophysical Environment					
Topography	Survey respondents did not indicate that topography data was gathered.	Topography data should be of sufficient spatial resolution and in a file format that can be integrated with other data sets, process models, and model output products.	Topographic data such as DEM's need to be gathered.	Further investigation with the appropriate ministries is required in order to determine why this data has not been gathered.	A recommendation will be made in the development of C-READ to have topographic data accessed for each country. This could be in the form of RadarSat DEM's and does not necessarily need to be high spatial resolution Lidar data at this point.
Ecosystems and Biodiversity (Terrestrial)	The WRMA does gather watershed GIS data but no ecosystems and biodiversity data was reported. The Ministry of Agriculture, Food Production, Fisheries, and Rural Development appears to be the ministry that would be responsible for this data.	There should be a comprehensive data set for ecosystems and biodiversity that cannot only serve as an up-to-date reference, but also be used in conjunction with other data sets. In order to understand risks posed to ecosystems and biodiversity we need to be able to integrate these data sets with hydrological, climate, and infrastructural development data sets.	Ecosystems and biodiversity data were not reported as being collected.	Further investigation with the Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required in order to determine why this data has not been gathered.	Mapping of ecosystems and biodiversity is an important function of C-READ. Further discussions with the Ministry of Agriculture, Food Production, Fisheries, and Rural Development will need to take place in the development of this functionality for C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 4: Coastal Zone and Ocean					
Coastal Zone Monitoring	Saint Lucia currently does not have an official coastal zone management department. They are working on building capacity in this area and are in close collaboration with Barbados. Hence, the data acquisition processes from Barbados should be consulted for Saint Lucia.	Coastal zone data should be accessible and usable by relevant stakeholders. Due to the integrated nature of coastal zone management a variety of data sets that come from different agencies may be required: biodiversity, inundation, tourism, etc.	Since no coastal zone management data was reported as being gathered, there is a fairly significant gap compared to the desired baseline state.	There has been a lack of capacity in coastal zone management in Saint Lucia. This has contributed to the deficit in data collection.	The coastal zone management data acquisition procedures for Barbados will be examined and then cross-referenced to Saint Lucia. In the design process of C-READ functionality will be specified and also the steps to a basic working capacity for Saint Lucia will be outlined.
Ocean Monitoring	There was no reported data monitoring of the ocean environment on the part of survey respondents.	Key physical, chemical, and biological variables need to be gathered in order to continuously monitor the health of the oceans in the Caribbean. Of particular concern are sea surface temperature, currents and activity (inundations), species data, and coral reef information.	It is difficult to ascertain where the gaps are since survey respondents did not indicate any ocean data gathered.	N/A	Further follow up with the Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required in order to determine the exact extent of ocean monitoring. Co-management and monitoring with Barbados could be a desired outcome.
Category 5: Land Cover and Land Use					
Land Cover and Land Use	The only GIS or land cover related data reported was watershed data.	Land cover and land use data should be extensive, covering national and regional priorities as well as key socio-economic and biophysical phenomenon relevant to each national stakeholder. Climate change and environmental impacts should be addressed in the data sets.	Further consultation with relevant agencies such as the Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required.	N/A	Consultation with the Ministry of Agriculture, Food Production, Fisheries, and Rural Development and other relevant agencies will be required in the C-READ design development process.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Protected Areas and Parks	No survey respondents indicated that protected area data was being gathered.	Data for protected areas boundaries and health should be electronically accessible and stored. Impacts on these systems due to environmental change and climate change should be addressed.	There was not projected area data gathered. Further consultation with Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required.	N/A	Further consultation with Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required in design phase of C-READ.
Category 6: Agriculture and Food Security					
Agriculture: Productivity	Food security was cited as a priority for the Ministry of Agriculture, Food Production, Fisheries, and Rural Development but there was no explicit reference to agricultural productivity data that was collected.	Data related to agricultural productivity and health as well as should be regularly gathered in a consistent and quality assured way. It is particularly important for this data to be suitable for assessing impacts of regional climate and environmental change on agriculture.	Further consultation with Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required in order to determine the true gap in data.	N/A	Further consultation with Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required in design phase of C-READ.
Soil Quality	Food security was cited as a priority for the Ministry of Agriculture, Food Production, Fisheries, and Rural Development but there was no explicit reference to soil quality data that was collected.	Soil quality data needs to comprehensive enough to indicate the type, productivity, and status of different regions. Spatial resolution may vary depending on the heterogeneity of the landscapes. Data should be made available to organizations concerned with food security and planning and other relevant stakeholders.	Further consultation with Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required in order to determine the true gap in data.	N/A	Further consultation with Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required in design phase of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 7: Water: Availability, Quality, and Use					
Availability	There is fairly extensive hydrological and meteorological data gathered by WRMA and the Met Service. This data would be able to inform water availability. Sharing and transmission of this data are problematic.	Data for water available should be regularly collected and made available electronically to relevant stakeholders. Impacts of climate or environmental change should be reflected in this data.	The sharing and integration of hydrological and meteorological data could inhibit adequate analysis of water availability.	A lack of a centralize data management system could have contributed to this fragmentation.	Further consultation with WRMA and the Met Service is required in the development of C-READ.
Water Quality	The only comment related to water quality that was submitted by survey respondents was the fact that a national water quality lab is necessary for all water quality agencies. There was no indication of specifically what data was gathered and how it was.	Water quality data should cover all key parameters such as nitrates, phosphates, coliform, BOD, and others. The data should be made available to relevant stakeholders and electronically stored.	Further consultation with WRMA is required.	N/A	Further consultation with WRMA is required in the development of C-READ.
Water Use	The WRMA is the main organization responsible for managing the sustainable use of water resources in Saint Lucia. They indicate that water licensing is part of their mandate. The WRMA did not report what data they gathered in this regard.	Different stakeholders likely collect water use data. However the protocols for collecting this data should be consistent. Central management and integration of this data can help with getting a cohesive understanding of national water use.	It is not possible to determine the gap without an understanding of the current processes for gathering (or not gathering) this data.	N/A	Further consultation with WRMA is required in the development of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 8: Energy: Use, Generation, Availability					
Energy Use	No survey respondents indicated they gathered data related to energy use.	Energy use data is useful for climate change mitigation processes as well as for general environmental management procedures. In nations that have energy conservation policies, gathering this data is essential.	N/A	N/A	Further consultation with relevant ministries will be required in the development of C-READ
Category 9: Socio-Economic Status					
Industry Activity	No survey respondents indicated they gathered data related to industrial activity.	Data related to industrial activity should be gathered where relevant. What is particularly important is that data is acquired for industries that are exposed to risks posed by environmental and climate change. Tourism is one example.	N/A	N/A	Further consultation with relevant ministries will be required in the development of C-READ.
Socio-economic Status	No survey respondents indicated they gathered data related to socio-economic status.	An overarching goal of the C-READ is to support climate change adaptation. An essential part of understanding where vulnerabilities are is based on socio-economic data. This data should be gathered in such a way that it can reflect which communities or areas are exposed to risks from climate change.	N/A	N/A	Risk and vulnerability indices are key data products requested in Saint Lucia and other partner countries. Further consultation with relevant ministries will be required in the development of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 10: Critical and Emergency Infrastructure					
Disaster Response	NEMO is the front line agency responsible for disaster response in Saint Lucia. They themselves do not gather data but collaborate with the front line agencies that collect this data. Further discussion with NEMO will be required to determine exactly which data sets they use.	Data related to vulnerable areas as well as disaster impact management needs to be readily accessible and available to response teams. This implies that the data should be electronic, centrally stored, and easily deployed to relevant groups.	N/A	N/A	N/A
Maintenance and Security of Critical Infrastructure	NEMO is the front line agency responsible for disaster response in Saint Lucia. They themselves do not gather data but collaborate with the front line agencies that collect this data. Further discussion with NEMO will be required to determine exactly which data sets they use.	Critical infrastructure should be identified and data relating to its status should be monitored so as to ensure that it continues to function.	N/A	N/A	N/A

Gaps in Data Analysis and Reporting for Environmental Change

Table 18: Summary of Gaps Identified in Data Analysis and Reporting for Environmental Change in Saint Lucia

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Agency collaboration	67% of the survey respondents indicated that they engage in some form of research collaboration. The institutions that they collaborate with are: McGill University, CIMH, and the University of the West Indies. In terms of collaborative sharing of data, organizations indicated that they were ready and willing to collaborate and share data.	Standardized and continuous collaboration amongst government, private, NGO, academic and other aligned agencies.	There does not seem to be a significant gap here due to the willingness of organizations to share and collaborate.	N/A	Sharing of data and inter-agency collaboration will have to be examined within the context of the specific problems that need to be solved. These details will need to be sorted out in Phase 2 when the protocols for the system inputs and outputs are determined.

Gaps in IT and Human Resource Capacity for Monitoring Environmental Change

Table 19: Summary of Gaps Identified in IT and HR Capacity for Monitoring Environmental Change in Saint Lucia

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Data storage and systems backup	The data storage and back up capacity varied throughout organizations that responded to the e-survey. The Ministry of Infrastructure had the most servers and computers (3) and (250) respectively. The other organizations that responded had fairly limited computational resources – max 18 computers and no server.	Rationalization and coordination of equipment and processes. Computational power to use a web-based application that draws upon different data sources (C_READ)	Backup resources are limited and proponents use fairly basic software packages.	A number of the respondents have limited resources (Met Service and NGOs). This is likely the main factor that contributes to this.	The backup requirement will need to be assessed for the organizations depending on their role in contributing data. The storage of critical data for C-READ will need to be evaluated. It is likely that there will be a central repository of data.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Software	Computers are outfitted with Windows (7, XP), Mac OS, Linux, and QNX4. Servers are running Windows Server 2003 / 2008, HP prolient ML 150 G6, Linux, and Smoothwall 3.	Software packages and OS that are capable of working with the platform chosen for C-READ.	No apparent gap as of yet.	N/A	The design process for C-READ will need to address software requirements for the stakeholder groups. The software choice should be accessible and preferable have a low entry cost (nothing in terms of PHP/MySQL and GeoNode).
Internet connectivity	Four participants reported having DSL, one with a T1/Fibre and the other a dial up connection.	Sufficient connection that provides a continuous and relatively high volume of data transfer (for large data sets that need to be uploaded or downloaded to the C-READ servers).	There are some respondents that indicated that they have a very slow internet connection. This may prove to be a problem for functions that require the transfer of large amount of data.	N/A	The design process will need to recognize any bandwidth limitations in Saint Lucia.
Roles	The survey respondents indicated that they had very few developers and GIS personnel.	At a minimum each organization should have persons who can provide IT support to GIS technicians.	No training for enhanced application of statistical rigor to data. Very limited development and GIS personnel.	Limited human and financial resources are a likely cause.	A policy that speaks to the minimum of staff and support that allows us to stay in touch with technological advances. The requirements for programming personnel will need to be examined in the sustainability and outreach component of the C-READ project.
GIS capability	Knowledge of GIS appears to be a weakness in the organizations that responded to the e-survey. However, there are two organizations that indicated they had in-house knowledge of GeoNode.	At minimum, all organizations should become familiar with simple geospatial tools.	There was some GIS capability as reported by survey respondents but there could be more.	Limited human and financial resources are a likely cause.	Ascertain from consultation with stakeholders, the level of GIS competence at each organization. Based on this evaluation, an operational plan that speaks to minimum training requirements can be generated. Training can be laid out in the C-READ sustainability plan.

3.5 Gaps in Guyana

Gaps in Data Gathering, Management, and Sharing

Table 20: Summary of Gaps Identified in Data Gathering in Guyana

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 1: Meteorological and Hydrological Data and Projections					
Precipitation and general meteorological monitoring	Two survey respondents indicated that they collect time series precipitation data - the Hydromet Service of Guyana and Guysuco. Guyana has also been developing a national water information system. This can serve as a solid base for expansion and integration with C-READ.	Minimum of electronic management and transfer of data from all functioning AWS and rain gauges to a centralized repository. There should be adequate coverage of the landscape (according to experts input) and proper maintenance and upkeep to ensure continuity in the supply of data. Processed averages should be easily accessible on line.	The most significant gap in hydromet data gathering is not necessarily in the amount of stations, but more in the proper integration of data sets together. CLIDATA, spreadsheets, and even paper format are used by different organizations.	Different groups have different standards, software, and protocols.	A thorough review of the data specifications for each organization and the desired data products will be conducted in the design phase of C-READ. This analysis will allow for suggestions as to how to connect these data sets in a coherent way that produces high value data products. Precipitation data from Guyana is important to understanding regional atmospheric processes and the impacts of climate change. Data sets need to be standardized both for sound monitoring and data sharing nationally, but also for integrating data from different countries. C-READ will serve as a platform for integrating and sharing this data. The existing data gathering and management infrastructure present with the national water information system can be built upon with C-READ.
Climate modeling and forecasting	Guyana has established a Climate Change Action Plan. This appears to have incorporated some analysis related to GCM output and the potential impacts on the country. At the very least, there is familiarity with these issues. The forecasting data and products are similar to those of other partner countries.	The future state would be such that climate models can be used with historical precipitation data and other data sets to project where impacts may be. This data should be accessible to C-READ users in a format that will be understandable and useful for stakeholders	The direction being taken with the climate change action plan needs to be addressed in the function of C-READ. There should not be misalignment between the priorities of the two projects.	The projects (C-READ and Guyana Climate Change Action Plan) have been implemented independently. They can be aligned.	A thorough analysis of the climate projections and mitigation / adaptation programs and policies for Guyana will be conducted. The outcome will help to create a blueprint for C-READ system functionality in this regard. The work being done through the 5C clearinghouse could be incorporated here.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Hydrological monitoring	GWI reported they received data from 3 stations. The Met service reported 77 stations that they collected hydrological data from.	The goal is to have proper coverage of hydrological monitoring across all regions. Integrated Water Resource Management should be a goal and this would require data sharing and better means of assessing impacts on water abduction from watersheds. Accurate flood and drought risk data should be available to organizations that need it.	The one key issue that was identified for Guyana was the fact that the monitoring coverage is skewed to the coastal areas and the central part of the country is not as well monitored.	It is difficult to saw what the causal factor is given the limited information in the survey response.	An expert should determine the appropriate spatial density of hydrological sensors for this country's landscapes. The survey respondent indicated that they did not have sufficient staffing. Based on this, an analysis of human resource requirements should be enacted. This will be part of the process for phase 3 of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 2: Hazards and Risks					
Drought Risk Assessment	The Met Service of Guyana indicated that useful functionality for C-READ would be drought risk indices would be desired. There is no indication in their e-survey response nor on their website that these indices are currently calculated.	The desired future state would be to have high spatial resolution analysis that can address drought risk assessment. In addition to the drought risk, there needs to specific focus on risk to key areas such as agricultural productivity and water availability. Relevant data sets should be integrated where appropriate.	There appear to be no comprehensive data products that give drought risk in Guyana.	GWI and the Met Service of Guyana are do collect hydromet data. The challenge appears to have been integrating this data in to an integrated platform that will give them drought risk.	C-READ can be the platform through which hydrological and meteorological data integration can occur for Guyana. The functional requirements assessment in the needs assessment should determine how the existing data that is gathered in Guyana could be integrated to create geospatially oriented drought indices. C-READ should collaborate with Guyana Met Service and the CIMH Drought Monitor to establish a platform for the calculation of these indices.
Flood Risk Assessment	The Guyana Lands and Surveys Commission does not seem to have topographical GIS data. This will be essential for doing flood risk. The hydrological and meteorological data is robust, however.	High-resolution flood warning data is required. Hydrological data that allows for reporting effectively on floods is necessary. This may require more sophisticated source data than is currently being gathered (stream levels).	There is no topographical data reported in the e-survey responses. Although there is extensive hydrological and meteorological data collected by the Guyana Met Service, it does not seem to be integrated in a way that can produce flood risk data products.	The challenge appears to have been integrating this data in to an integrated platform that will give provide flood risk.	C-READ can be the platform through which hydrological and meteorological data integration can occur for Guyana. The functional requirements assessment in the needs assessment should determine how the existing data that is gathered in Guyana could be integrated to create geospatially oriented flood risk maps. Topography data with hydrological data will be essential for this.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Hurricane and Storm Surge Impact Analysis	Extensive hydrological data is being gathered but it does not seem apparent that it is being integrated into a management system that can connect topography and hydrological processes – resulting in flood risk.	Organizations seek to minimize the impacts and disruptions caused by storms. In order to do this each country needs to have an understanding of the critical infrastructure and populations that are at risk and then have adaptive mechanisms to achieve this. Storm tracking data must be of an adequate resolution to connect with other relevant social and economic data to produce risk products. The storm path and surge data should be in a format that can be integrated with these other data sets. Additionally, each country needs to be able to identify what other data is relevant for risk reduction in their territory.	There do not seem to be comprehensive data products that provide storm surge impact analysis for Guyana.	The most likely cause of this is a lack of integrated data sets and monitoring infrastructure to supply these reports.	The C-READ development process will build storm surge risk into its functional requirements. This will include mapping vulnerable infrastructure.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Disease and Pest Risk and Distribution	One of the respondents that was most interested in disease and pest distribution was Guysuco. They collect data as part of their integrated pest management strategy. It does not appear that this data is widely shared.	Risk posed to human health as a result of climate change and other environmental impacts need to be understood and consistently monitored. The risk of invasive species to agriculture and ecosystems needs attention and mechanisms to facilitate environmental management procedures.	According to the survey respondents, there is not a widely used pest and disease data management system. Further consultation with the Ministry of Health will be required though.	There may be a lack of integration and data management solutions that has caused this gap. In addition, the risk of invasive species as result of climate change is a relatively new phenomenon.	Biodiversity and invasive species data will be built into the function of C-READ. Relevant agencies such as the Ministry of Health, NATREI, and Guyana Forests Commission will need to be consulted to assess what pest and disease data they are gathering.
Category 3: Geographical and Biophysical Environment					
Topography	No e-survey respondents indicated they gathered topographical data.	Topography data should be of sufficient spatial resolution and in a file format that can be integrated with other data sets, process models, and model output products.	Topography data should be available through the Guyana Lands and Survey Commission.	It is not clear why topographical data is not available for Guyana.	Specific questions should be asked of relevant ministries in Guyana about whether or not they have topographical data. This can be done in the review of functional requirements for C-READ in the design phase.
Ecosystems and Biodiversity (Terrestrial)	The Guyana Lands and Survey Commission collects land cover data. A number of organizations expressed interest in having biodiversity data available to them but none of them reported that they were gathering it.	There should be a comprehensive data set for ecosystems and biodiversity that cannot only serve as an up-to-date reference, but also be used in conjunction with other data sets. In order to understand risks posed to ecosystems and biodiversity we need to be able to integrate these data sets with hydrological, climate, and infrastructural development data sets.	There was no report of biodiversity data being gathered.	It is not clear why biodiversity data was not reported. Other agencies in Guyana should be consulted.	Specific questions should be asked of relevant ministries in Guyana (as mentioned) about whether or not they have ecosystems and biodiversity data. This can be done in the review of functional requirements for C-READ in the design phase.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 4: Coastal Zone and Ocean					
Coastal Zone Monitoring	GWI monitors water availability in the Coastal Zone. Organizations such as NAREI, the Guyana Mangrove Project, and the Guyana Environmental Protection Agency have interests in the coastal zone. However, many of them did not respond to the electronic survey.	Coastal zone data should be accessible and usable by relevant stakeholders. Due to the integrated nature of coastal zone management a variety of data sets that come from different agencies may be required: biodiversity, inundation, tourism, etc.	Coastal zone data aside from water quality data was very sparse.	Further investigation is required with NAREI and the Environmental Protection Agency to determine the extent of coastal zone data they gather.	The aforementioned agencies will be contacted in the process of determining functional requirements for C-READ.
Ocean Monitoring	The Environmental Protection Agency as well as the Ministry of Agriculture (Fisheries Department) are the organizations that have primary concerns of the ocean environment.	Key physical, chemical, and biological variables need to be gathered in order to continuously monitor the health of the oceans in the Caribbean. Of particular concern are sea surface temperature, currents and activity (inundations), species data, and coral reef information.	Gaps were not identified due to lack of response on this issue in the survey	N/A	The aforementioned agencies will be contacted in the process of determining functional requirements for C-READ.
Category 5: Land Cover and Land Use					
Land Cover and Land Use	Lands and Survey Commission of Guyana gathers land cover data is gathered by the. Climate change impacts do not appear to be monitored.	Land cover and land use data should be extensive, covering national and regional priorities as well as key socio-economic and biophysical phenomenon relevant to each national stakeholder. Climate change and environmental impacts should be addressed in the data sets.	Impacts on land cover due to environmental and climate change do not appear to be addressed.	It appears that climate modelling is not applied to land cover impacts.	C-READ will build in the functionality to apply climate model output to land cover to examine the effects of climate change.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Protected Areas and Parks	The Lands and Survey Commission of Guyana gathers protected areas and natural parks data and stores it in a GIS	Data for protected areas boundaries and health should be electronically accessible and stored. Impacts on these systems due to environmental change and climate change should be addressed.	Protected area boundaries are stored. It is not clear what kind of other monitoring occurs.	N/A	C-READ will examine how impacts of environmental and climate change on national parks can be investigated in Guyana.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 6: Agriculture and Food Security					
Agriculture: Productivity	Impacts of environmental and climate change on agriculture were cited as priorities for the Ministry of Agriculture / Meteorology but there was no explicit reference to agricultural productivity data that was collected.	Data related to agricultural productivity and health as well as should be regularly gathered in a consistent and quality assured way. It is particularly important for this data to be suitable for assessing impacts of regional climate and environmental change on agriculture.	Further consultation with Ministry of Agriculture, Meteorology is required in order to determine the true gap in data.	N/A	Further consultation with Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required in design phase of C-READ.
Soil Quality	Impacts of environmental and climate change on agriculture were cited as priorities for the Ministry of Agriculture / Meteorology but there was no explicit reference to agricultural productivity data that was collected.	Soil quality data needs to comprehensive enough to indicate the type, productivity, and status of different regions. Spatial resolution may vary depending on the heterogeneity of the landscapes. Data should be made available to organizations concerned with food security and planning and other relevant stakeholders.	Further consultation with Ministry of Agriculture, Meteorology is required in order to determine the true gap in data.	N/A	Further consultation with Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required in design phase of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 7: Water: Availability, Quality, and Use					
Availability	Both GWI and the Guyana Met Service collect data that indicates what the level of water availability is.	Data for water available should be regularly collected and made available electronically to relevant stakeholders. Impacts of climate or environmental change should be reflected in this data.	There is no integration of water quality data between organizations that gather it.	This lack of integration could be due to the fact that there was no platform for sharing data up to now.	C-READ will attempt to address data sharing gaps by serving as a common platform.
Water Quality	GWI and Guysuco gather water quality data.	Water quality data should cover all key parameters such as nitrates, phosphates, coliform, BOD, and others. The data should be made available to relevant stakeholders and electronically stored.	There is no integration of water quality data between organizations that gather it.	This lack of integration could be due to the fact that there was no platform for sharing data up to now.	C-READ will attempt to address data sharing gaps by serving as a common platform.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Water Use	GWI is the organization responsible for gathering water use data.	Different stakeholders likely collect water use data. However the protocols for collecting this data should be consistent. Central management and integration of this data can help with getting a cohesive understanding of national water use.	No water use data was reported by GWI.	N/A	Further consultation with GWI will be required to determine what water use data they gather and how it can be incorporated into C-READ.
Category 8: Energy: Use, Generation, Availability					
Energy Use	No survey respondents indicated they gathered data related to energy use.	Energy use data is useful for climate change mitigation processes as well as for general environmental management procedures. In nations that have energy conservation policies, gathering this data is essential.	N/A	N/A	Further consultation with relevant ministries will be required in the development of C-READ.
Category 9: Socio-Economic Status					
Industry Activity	No survey respondents indicated they gathered data related to industrial activity.	Data related to industrial activity should be gathered where relevant. What is particularly important is that data is acquired for industries that are exposed to risks posed by environmental and climate change. Tourism is one example.	N/A	N/A	Further consultation with relevant ministries will be required in the development of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Socio-economic Status	No survey respondents indicated they gathered data related to socio-economic status.	An overarching goal of the C-READ is to support climate change adaptation. An essential part of understanding where vulnerabilities are is based on socio-economic data. This data should be gathered in such a way that it can reflect which communities or areas are exposed to risks from climate change.	Hazard risk analysis and vulnerability assessments will require socio-economic data.	It is possible that the ministries who manage this data simply were not able to respond.	Further consultation with relevant ministries will be required in the development of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 10: Critical and Emergency Infrastructure					
Disaster Response	Emergency response organizations, namely the Civil Defence Commission, did not respond to the survey.	Data related to vulnerable areas as well as disaster impact management needs to be readily accessible and available to response teams. This implies that the data should be electronic, centrally stored, and easily deployed to relevant groups.	It was difficult to ascertain where data gaps where due to a lack of response from the CDC.	N/A	The appropriate organizations for emergency response should be identified in the design phase of the C-READ system. The exact format and types of data required to produce emergency response products can then be clarified.
Maintenance and Security of Critical Infrastructure	Emergency response organizations, namely the Civil Defence Commission, did not respond to the survey.	Critical infrastructure should be identified and data relating to its status should be monitored so as to ensure that it continues to function.	It was difficult to ascertain where data gaps where due to a lack of response from the CDC.	N/A	The appropriate organizations for emergency response should be identified in the design phase of the C-READ system. The exact format and types of data required to produce emergency response products for critical infrastructure can be clarified in the design phase of C_READ.

Gaps in Data Analysis and Reporting for Environmental Change

Table 21: Summary of Gaps Identified in Data Analysis and Reporting for Environmental Change in Guyana

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Agency collaboration	All of the survey respondents from Guyana indicated that they collaborate with academic and research organizations. The institutions that they cited are: University of Guyana and CIMH. The survey respondents indicated that they own the data that they gather but are open to sharing (private sector included) if terms are made clear.	Standardized and continuous collaboration amongst government, private, NGO, academic and other aligned agencies.	Organizations are willing to collaborate and share data, however, there are very few standards in place as of yet to support this.	Lack of multi-stakeholder projects where data is shared between them.	Sharing of data and inter-agency collaboration will have to be examined within the context of the specific problems that need to be solved. These details will need to be sorted out in Phase 2 when the protocols for the system inputs and outputs are determined.

Gaps in IT and Human Resource Capacity for Monitoring Environmental Change

Table 22: Summary of Gaps Identified in IT and HR Capacity for Monitoring Environmental Change in Guyana

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Data storage and systems backup	The data storage and back up capacity varied throughout organizations that responded to the e-survey. Guysuco had the most servers and computers (35) and (650) respectively. The other organizations that responded had fairly limited computational resources – max 70 computers and no servers reported.	Rationalization and coordination of equipment and processes. Computational power to use a web-based application that draws upon different data sources (C_READ)	Backup resources are limited and proponents use fairly basic software packages.	A number of the respondents have limited resources (Met Service and NGOs). This is likely the main factor that contributes to this.	The backup requirement will need to be assessed for the organizations depending on their role in contributing data. The storage of critical data for C-READ will need to be evaluated. It is likely that there will be a central repository of data.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Software	Computers are outfitted with Windows (7, 8, XP) and Linux Mint OS. Servers are running Windows Server 2003 / 2008, as well as Linux Red Hat 5. Apache, WebLogic, and .Net are the application server software applications.	Software packages and OS that are capable of working with the platform chosen for C-READ.	No apparent gap as of yet.	N/A	The design process for C-READ will need to address software requirements for the stakeholder groups. The software choice should be accessible and preferable have a low entry cost (nothing in terms of PHP/MySQL and GeoNode).
Internet connectivity	All four participants who responded to this question reported having DSL connectivity.	Sufficient connection that provides a continuous and relatively high volume of data transfer (for large data sets that need to be uploaded or downloaded to the C-READ servers).	Connectivity does not seem to be an issue.	N/A	The design process will need to recognize any bandwidth limitations in Guyana.
Roles	The survey respondents indicated that they had a fair proportion of programmers but not very many GIS technicians.	At a minimum each organization should have persons who can provide IT support to GIS technicians.	No training for enhanced application of statistical rigor to data. Very limited software development personnel.	Limited human and financial resources are a likely cause.	A policy that speaks to the minimum of staff and support that allows us to stay in touch with technological advances. The requirements for programming personnel will need to be examined in the sustainability and outreach component of the C-READ project.
GIS capability	Knowledge of GIS appears to be a weakness in the organizations that responded to the e-survey.	At minimum, all organizations should become familiar with simple geospatial tools.	There was no GIS capability reported in the e-survey. The Ministry of Lands did report that they collected GIS data though. So there must be some capability.	Limited human and financial resources are a likely cause.	Ascertain from consultation with stakeholders, the level of GIS competence at each organization. Based on this evaluation, an operational plan that speaks to minimum training requirements can be generated. Training can be laid out in the C-READ sustainability plan.

3.6 Gaps in Barbados

Gaps in Data Gathering, Management, and Sharing

Table 23: Summary of Gaps Identified in Data Gathering in Barbados

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 1: Meteorological and Hydrological Data and Projections					
Precipitation and general meteorological monitoring	Of the survey respondents that replied, there are currently 3 different organizations that gather time series and 1 that gather GIS meteorological data: CIMH, Barbados Meteorology Service and CARDI (Caribbean Agricultural Research and Development Institute). The Barbados Meteorology Service reported that they have three automated met stations (AWS), CARDI has one AWS, and CIMH has one manual and two automated weather stations. All of the data is stored electronically in either a database or a spreadsheet. Output from the Barbados Met Service AWS are available online. The Ministry of Agriculture also collects meteorological data but they did not respond to the e-survey. Barbados does have a national water information system for national inter-agency data sharing. Their GIS capabilities are considered to be some of most advanced in the region.	Minimum of electronic management and transfer of data from all functioning AWS and rain gauges to a centralized repository. There should be adequate coverage of the landscape (according to experts input) and proper maintenance and upkeep to ensure continuity in the supply of data. Processed averages should be easily accessible on line.	CIMH and the Met Service of Barbados indicated that they did not have a sufficient enough density of data points. They also indicated that there was no comprehensive plan for maintenance of existing AWS and there was a lack of replacement parts. The database management systems they some organizations use are outdated.	Perhaps it is a lack of investment that has led to insufficient density of data being gathered to perform accurate monitoring.	CIMH and the met service need to indicate what the idea data gathering density would be for Barbados. Based on this professional estimate of data density, suggestions for improvement of precipitation monitoring can be suggested. The C-READ should possibly include Best Practice Guidelines for data collection and sensor maintenance in order to standardize practices across the region and improve the quality of the data. This suggestion is valid for met data and water quality data as well.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Climate modeling and forecasting	The Barbados Met Service provides four-day weather forecasting. The survey respondents did not indicate that they conducted climate change scenario analysis. However, it is likely that some organizations in Barbados have. A number or the recommended data products would rely on some sort of climate change scenario output.	The future state would be such that climate models can be used with historical precipitation data and other data sets to project where impacts may be. This data should be accessible to C-READ users in a format that will be understandable and useful for stakeholders	The use of climate projections in Barbados was not reported in the e-survey. There was certainly not widespread communication of this. It could be that these projections and model output needs to become more accessible for stakeholders in Barbados. Further investigation is required.	A contributing factor could be a lack of communication on the part of the organizations that were running models to create projections.	Climate modelling and projections need to be addressed as part of C-READ, but particularly for countries that have developed little capacity for doing these activities thus far.
Hydrological monitoring	No survey respondents indicated that they gathered hydrological data. CIMH indicated that maintenance and upkeep of equipment after projects have ended is problematic. They stressed more regional planning in collaboration with local entities. There are some organizations that likely monitor water resources that did not reply to this survey. They are the Barbados Water Authority and the Governments Environment Unit – Drainage Division.	The goal is to have proper coverage of hydrological monitoring across all regions. Integrated Water Resource Management should be a goal and this would require data sharing and better means of assessing impacts on water abduction from watersheds. Accurate flood and drought risk data should be available to organizations that need it.	There was very little response to questions on hydrological monitoring in Barbados. One comment was that ongoing upkeep of equipment was problematic – especially at the end of a project.	This raises, once again, the point about whether or not we need more monitoring stations or just a better maintenance and gathering process. The factors that contributed to this could be a lack of financial resources to conduct ongoing maintenance.	The hydrological monitoring process in Barbados needs detailed analysis to determine what specific needs there are to implement a robust maintenance program for their hydrological stations. Also, a plan for quality assurance in transmitted data would be beneficial.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 2: Hazards and Risks					
Drought Risk Assessment	There was no specific indication that drought risk indices were calculated in Barbados, however many respondents did indicate that drought and fire risk were priorities. CIMH and partners have been testing drought indices such as the PDSI (Palmer Drought Severity Index) through the CDPMN (Caribbean Drought and Precipitation Monitoring Network).	The desired future state would be to have high spatial resolution analysis that can address drought risk assessment. In addition to the drought risk, there needs to specific focus on risk to key areas such as agricultural productivity and water availability. Relevant data sets should be integrated where appropriate.	It appears that drought risk indices are not being calculated widely in Barbados.	It is not clear why this capacity seems weak. It could be due to sparse hydrological monitoring.	In the design phase of C-READ, detailed analysis of exactly what drought risk analysis is done, by whom, and producing what, will be required. CIMH, the Met Service, and other relevant agencies will be contacted. C-READ could collaborate with CIMH to automate the calculation of these indices and present them in a more accessible way to users by combining with other GIS products such as land use, etc.
Flood Risk Assessment	The survey respondents did not indicate that they had a flood risk monitoring system in place. However ongoing work with CIMH's Real Time Flood Forecasting system suggests that there are procedures in development.	High-resolution flood warning data is required. Hydrological data that allows for reporting effectively on floods is necessary. This may require more sophisticated source data than is currently being gathered (stream levels).	Current real time reporting and risk analysis systems are currently in development.	N/A	C-READ should align with the work ongoing with CIMH's Real Time Flood Forecasting System. Mr. Shawn Boyce (sboyce@cimh.edu.bb) is the lead of that project. This should occur in the use case scenario development of C-READ.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Hurricane and Storm Surge Impact Analysis	The Barbados Met Service has various satellite data products such as SPIE and GOES which can help with assessing hurricane path and potential impact. Storm surge impact is a little more complicated and requires understanding of the physical impact zone.	Organizations seek to minimize the impacts and disruptions caused by storms. In order to do this each country needs to have an understanding of the critical infrastructure and populations that are at risk and then have adaptive mechanisms to achieve this. Storm tracking data must be of an adequate resolution to connect with other relevant social and economic data to produce risk products. The storm path and surge data should be in a format that can be integrated with these other data sets. Additionally, each country needs to be able to identify what other data is relevant for risk reduction in their territory.	A more clear output of storm surge risk is required.	Lack of integration of data has led to this.	Assessment of the required data and functional requirements for storm surge analysis should be conducted in the design phase.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Disease and Pest Risk and Distribution	CARDI is concerned with agricultural resilience. Risk of fire and crop tolerance and resilience to drought are stated priorities.	Risk posed to human health as a result of climate change and other environmental impacts need to be understood and consistently monitored. The risk of invasive species to agriculture and ecosystems needs attention and mechanisms to facilitate environmental management procedures.	Respondents did not indicate that data for pest risks to agriculture was gathered.	It Is not clear how this situation materialized.	Further assessment of what kind of pest risk analysis needs to be done in Barbados will be dong.
Category 3: Geographical and Biophysical Environment					
Topography	Topography GIS data was reported by the Department of Emergency Planning. It is not clear how accessible this data is for other organizations.	Topography data should be of sufficient spatial resolution and in a file format that can be integrated with other data sets, process models, and model output products.	N/A	N/A	Data accessibility and protocols for sharing will be addressed in design phase of C-READ.
Ecosystems and Biodiversity (Terrestrial)	CIMH has land cover data (GIS) but it is not clear how detailed it is with ecosystem type etc. The Lands and Survey Department did not reply to the survey.	There should be a comprehensive data set for ecosystems and biodiversity that cannot only serve as an up-to-date reference, but also be used in conjunction with other data sets. In order to understand risks posed to ecosystems and biodiversity we need to be able to integrate these data sets with hydrological, climate, and infrastructural development data sets.	There does not appear to be very detailed ecosystem and biodiversity data.	Perhaps the organizations that did not reply to the survey do have robust ecosystem and biodiversity data	Further questioning of key organizations in Barbados will be required in the design phase.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 4: Coastal Zone and Ocean					
Coastal Zone Monitoring	The Coastal Zone Management Unit does monitor the coast of Barbados. They did not provide details of the data they gather for the survey.	Coastal zone data should be accessible and usable by relevant stakeholders. Due to the integrated nature of coastal zone management a variety of data sets that come from different agencies may be required: biodiversity, inundation, tourism, etc.	It is difficult to determine gaps without the input of the Coastal Zone Management Unit.	N/A	Further examination and discussion with the Coastal Zone Management Unit will be required in the design phase.
Ocean Monitoring	The Coastal Zone Management Unit is the agency mostly responsible for monitoring the coast of Barbados. The Ministry of Environment, Water Resources and Drainage also monitors for spills and water quality. These organizations did not provide details of the data they gather for the survey and it is necessary to follow up with them.	Key physical, chemical, and biological variables need to be gathered in order to continuously monitor the health of the oceans in the Caribbean. Of particular concern are sea surface temperature, currents and activity (inundations), species data, and coral reef information.	It is difficult to determine gaps without the input of the Coastal Zone Management Unit and the Ministry of Environment, Water Resources, and Drainage.	N/A	Further examination and discussion with the Coastal Zone Management Unit and the Ministry of Environment, Water Resources, and Drainage will be required in the design phase.
Category 5: Land Cover and Land Use					
Land Cover and Land Use	CIMH does have land cover GIS data. The Lands and Survey Department presumably has more data but they did not reply. Respondents did indicate that they wanted to see data products that were able to address climate change impacts on land cover.	Land cover and land use data should be extensive, covering national and regional priorities as well as key socio-economic and biophysical phenomenon relevant to each national stakeholder. Climate change and environmental impacts should be addressed in the data sets.	It does not appear that climate projection impacts on land cover have been done in Barbados.	Perhaps lack of capacity for doing this type of analysis would explain the gap.	Functional requirements for data products that show impacts of climate change on land cover are required. This should be examined in detail in the design phase.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Protected Areas and Parks	The National Conservation Commission of Barbados and the Coastal Zone Management Unit are two key organizations associated with parks and protected areas in Barbados. There was no response from the CZMU to the e-survey and a review of the National Conservation Commission website indicated that they have delineated areas for research, recreational activity, and conservation.	Data for protected areas boundaries and health should be electronically accessible and stored. Impacts on these systems due to environmental change and climate change should be addressed.	Further information is required from the CZMU in order to ascertain exactly where the marine protected area monitoring gaps are.	N/A	Further examination and discussion with the Coastal Zone Management Unit and the National Conservation Commission will be required in the design phase.
Category 6: Agriculture and Food Security					
Agriculture: Productivity	CARDI was one of the survey respondents that had the most focus on monitoring of agricultural productivity. They monitor hydrological and meteorological influences on agriculture. Productivity of crops such as hot peppers (and others) are typically reported on by CARDI. The Ministry of Agriculture is responsible for dissemination of statistics and data pertaining to the productivity of different sectors. Unfortunately, they did not reply to the e-survey.	Data related to agricultural productivity and health as well as should be regularly gathered in a consistent and quality assured way. It is particularly important for this data to be suitable for assessing impacts of regional climate and environmental change on agriculture.	Further information is required from CARDI and the Ministry of Agriculture in order to ascertain exactly where the agricultural productivity monitoring gaps are.	N/A	Further examination and discussion with CARDI and the Ministry of Agriculture will be required in the design phase.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Soil Quality	The Soil Conservation Unit of the Ministry of Agriculture is the organization most likely to have updated soil quality data. They were not a respondent to the e-survey and will need to be consulted with directly in order to determine what their processes are for monitoring, storing, and sharing data are.	Soil quality data needs to comprehensive enough to indicate the type, productivity, and status of different regions. Spatial resolution may vary depending on the heterogeneity of the landscapes. Data should be made available to organizations concerned with food security and planning and other relevant stakeholders.	Further information from the Soil Conservation Unit is required to ascertain exactly where the data gaps are.	N/A	Further examination and discussion with the Soil Conservation Unity of the Ministry of Agriculture will be required in the design phase.
Category 7: Water: Availability, Quality, and Use					
Availability	The Barbados Water Authority is the organization primarily responsible for managing access and use of potable water in Barbados. In conjunction with the Barbados Meteorological Service, CIMH, and the Ministry of Environment, Water Resources and Drainage, they should monitor what the available water resources are. Unfortunately they did not respond to the initial electronic survey. Follow up with them will be required to determine the exact status of data collection for water availability.	Data for water available should be regularly collected and made available electronically to relevant stakeholders. Impacts of climate or environmental change should be reflected in this data.	It is difficult to ascertain where the gaps are without full knowledge of the current monitoring practices.	N/A	There will need to be specific follow with the Barbados Water Authority as well as the related agencies to determine what data is being gathered for water availability, quality, and usage.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Water Quality	See above.	Water quality data should cover all key parameters such as nitrates, phosphates, coliform, BOD, and others. The data should be made available to relevant stakeholders and electronically stored.	It is difficult to ascertain where the gaps are without full knowledge of the current monitoring practices.	N/A	There will need to be specific follow with the Barbados Water Authority as well as the related agencies to determine what data is being gathered for water availability, quality, and usage.
Water Use	See above.	Different stakeholders likely collect water use data. However the protocols for collecting this data should be consistent. Central management and integration of this data can help with getting a cohesive understanding of national water use.	It is difficult to ascertain where the gaps are without full knowledge of the current monitoring practices.	N/A	There will need to be specific follow with the Barbados Water Authority as well as the related agencies to determine what data is being gathered for water availability, quality, and usage.
Category 8: Energy: Use, Generation, Availability					
Energy Use	No survey respondents indicated they gathered data related to energy use.	Energy use data is useful for climate change mitigation processes as well as for general environmental management procedures. In nations that have energy conservation policies, gathering this data is essential.	N/A	N/A	Further consultation with relevant ministries will be required in the development of C-READ.
Renewable energy resources	N/A	N/A	N/A	N/A	N/A

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Category 9: Socio-Economic Status					
Industry Activity	No survey respondents indicated they gathered data related to industrial activity.	Data related to industrial activity should be gathered where relevant. What is particularly important is that data is acquired for industries that are exposed to risks posed by environmental and climate change. Tourism is one example.	N/A	N/A	Further consultation with relevant ministries will be required in the development of C-READ.
Socio-economic Status	The Department of Emergency Management does have GIS data of socio economic status in Barbados	An overarching goal of the C-READ is to support climate change adaptation. An essential part of understanding where vulnerabilities are is based on socio-economic data. This data should be gathered in such a way that it can reflect which communities or areas are exposed to risks from climate change.	This data needs to be reviewed to determine if it is sufficient for producing the types of analysis required of C-READ.	N/A	Further analysis of this socio-economic data will be conducted in the design phase of C-READ. It may be necessary to integrate social and economic data from other ministries.
Category 10: Critical and Emergency Infrastructure					
Disaster Response	The Department of Emergency Management is the primary organization responsible for disaster response. They manage GIS data related to storm surge risk. They have indicated they would like to have information related to vulnerable populations in C-READ.	Data related to vulnerable areas as well as disaster impact management needs to be readily accessible and available to response teams. This implies that the data should be electronic, centrally stored, and easily deployed to relevant groups.	There is not currently a dynamic database in place that can produce hazard maps and socio-economic vulnerability assessments.	It is difficult to ascertain why there is no integrated system for hazard reporting.	Development of functional requirements for C-READ will address this.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Maintenance and Security of Critical Infrastructure	The Department of Emergency Management manages data related to human settlements and infrastructure. They have GIS data for human settlements, road networks, shelters, and disaster emergency organization boundaries. This data is important for understanding where vulnerable infrastructure is and what needs to be done to protect it.	Critical infrastructure should be identified and data relating to its status should be monitored so as to ensure that it continues to function.	There may be some gaps with respect to certain types of critical infrastructure. Further exploration of which queries are required will be needed.	N/A	Further examination of the functional requirements for determining critical infrastructure is required in the design phase of C-READ.

Gaps in Data Analysis and Reporting for Environmental Change

Table 24: Summary of Gaps Identified in Data Analysis and Reporting for Environmental Change in Barbados

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Agency collaboration	75% of the survey respondents indicated that they engage in some form of research collaboration. The institutions that they collaborate with are: UWI, CIMH, and CCCCC. In terms of collaborative sharing of data, organizations indicated that they were ready and willing to collaborate and share data.	Standardized and continuous collaboration amongst government, private, NGO, academic and other aligned agencies.	There does not seem to be a significant gap here due to the willingness of organizations to share and collaborate. What is lacking is a comprehensive framework for the sharing of information.	There appears to have been no formal procedures for establishing frameworks for data sharing up to this point.	Sharing of data and inter-agency collaboration will have to be examined within the context of the specific problems that need to be solved. These details will need to be sorted out in Phase 2 when the protocols for the system inputs and outputs are determined.

Table 25: Summary of Gaps Identified in IT and HR Capacity for Monitoring Environmental Change in Barbados

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
Data storage and systems backup	The data storage and back up capacity varied throughout organizations that responded to the e-survey. CIMH had the most servers and computers (5) and (60) respectively. The other organizations that responded had fairly limited computational resources – max 20 computers and 3 servers reported.	Rationalization and coordination of equipment and processes. Computational power to use a web-based application that draws upon different data sources (C-READ)	Backup resources are fairly well established in Barbados with CIMH being the hub of hydromet data for the CARICOM nations. Further integration will be required with the added mandate that C-READ brings though.	The C-READ project is a new initiative to broaden the reach of environmental monitoring in the Caribbean.	The backup requirement will need to be assessed for the organizations depending on their role in contributing data. The storage of critical data for C-READ will need to be evaluated. It is likely that there will be a central repository of data.
Software	Computers are outfitted with Windows (7, XP). Servers are running Radar/Linux-Redhat and Windows 7 as well as Apache 2 web server software.	Software packages and OS that are capable of working with the platform chosen for C-READ.	No apparent gap as of yet.	N/A	The design process for C-READ will need to address software requirements for the stakeholder groups. The software choice should be accessible and preferable have a low entry cost (nothing in terms of PHP/MySQL and GeoNode).
Internet connectivity	The survey respondents indicated that they have either DSL or T1 connectivity.	Sufficient connection that provides a continuous and relatively high volume of data transfer (for large data sets that need to be uploaded or downloaded to the C-READ servers).	Connectivity does not seem to be an issue.	N/A	The design process will need to recognize any bandwidth limitations in Barbados.
Roles	The survey respondents indicated that they had a fair proportion of programmers but not very many GIS technicians.	At a minimum each organization should have persons who can provide IT support to GIS technicians.	Somewhat limited software development personnel. Limited GIS personnel.	Limited human and financial resources are a likely cause.	A policy that speaks to the minimum of staff and support that allows us to stay in touch with technological advances. The requirements for programming personnel will need to be examined in the sustainability and outreach component of the C-READ project.

Issue	Current State	Desired Future State	Gap	Responsible Factors for Gap	Proposed Remedial Actions
GIS capability	Knowledge of GIS appears to be a weakness in the organizations that responded to the e-survey.	At minimum, all organizations should become familiar with simple geospatial tools.	There was no GIS capability reported in the e-survey. CIMH and the Department of Emergency Management did report that they collected GIS data though. So there must be some capability.	Limited human and financial resources are a likely cause.	Ascertain from consultation with stakeholders, the level of GIS competence at each organization. Based on this evaluation, an operational plan that speaks to minimum training requirements can be generated. Training can be laid out in the C-READ sustainability plan.

3.7 Discussion of Gaps and Actions

3.8.1 Data Gathering

The first and most important observation about data gathering, management and sharing was the fact that the responses to the surveys varied significantly from country to country with respect to the attention they paid to the different issues. In some cases it was obvious that reef monitoring was a very important issue whereas in other cases landslides were more of a concern. There were some overall trends in data gathering that emerged from the evaluation of the responses to the particular issues. These issues were: quality assurance of gathered data, format of data, and frameworks for data sharing.

Data quality was cited as a concern in different situations, particularly in the gathering of hydromet data. There was a disproportionate amount of stations between the different countries. For instance, Saint Lucia and Guyana reported having (32) and (193) precipitation/meteorological stations respectively, whereas Dominica reported only (3). Although in some cases there were remarkably different numbers of precipitation monitoring stations, most organizations reported that they did not have sufficient coverage to accurately monitor precipitation. A clear distinction needs to be made here in that there is a difference between having sufficient coverage of stations and having quality data continuously collected and sent from these stations. Countries such as Saint Lucia reported that there were difficulties with having people sent to remote locations where a precipitation station is and then having them accurately record the level on a regular frequency and then transmit that information back to the meteorological service. In this case, it is not a problem of having too few stations rather it is a problem of having inadequate human resources to perform this function. Another causal factor could be that the stations are poorly maintained, thus producing low quality data, leading to inaccurate monitoring. As a general observation about data quality and gathering we need to ensure that there is: (a) adequate coverage for monitoring the given phenomenon (precipitation, stream levels, etc); (b) trained personnel to collect the data on a timely and frequent basis; and (c) stations that are well maintained and properly functioning. If any of these criteria are not met then it will be difficult to maintain adequate monitoring programs that supply data that can be trusted. This could be considered a broad, regional gap, in which data quality needs to be maintained and in some cases it currently is not. Specific analysis of data quality and gathering, per country, follows in the discussion, and is cited in the gap matrices.

Maintaining consistent data formats appears to be a challenge for connecting national monitoring systems into a system that would integrate their data together and this could be considered a generic gap amongst the stakeholder countries. For example, some countries collect and store their precipitation data in spreadsheets, others in ASCII files, and others in databases. The fact that CIMH has the responsibility to gather meteorological data from its member states and has established protocols and procedures for data sharing does set a precedent that standardization can happen. However, there may be other situations, such as with the collection of land cover and biodiversity data,

which will require protocols for ensuring that data from different partner countries for the same regional issue can be utilized together. Care should be taken to accommodate the differences between the organizations in the partner countries. In some cases groups have limited resources and may not have established protocols for data gathering and storage. The design of C-READ should acknowledge this and allow for flexibility in how stakeholder data is gathered and contributed. In terms of GIS data this may mean developing a regional standard for projections, file format, and other GIS data properties.

The survey participants generally accepted the idea of sharing data amongst their peer organizations in their country and even regionally, but they often lacked any frameworks for doing so. This could be considered a general gap in the region. Data sharing will be necessary and encouraged with C-READ, however currently many organizations will require agreements and clear frameworks in order to do so. One of the gaps that also became evident while analyzing the survey data was the fact that many of the desired data products required data from different organizations in each country and there had been little collaboration between them up to this time. The point is that there is not only a gap in data sharing protocols both within the partner countries and regionally, but there also appears to be a gap in established procedures for collaboration that could then lead to data sharing. This will need to be addressed in the operational procedures for engaging organizations with the use of C-READ.

Category 1: Meteorological and Hydrological Data and Projections

The three issues of general meteorological monitoring, climate forecasting and modeling, and hydrological monitoring comprise the base of what C-READ is attempting to build upon in terms of environmental monitoring in the Caribbean region. Upon reviewing the gap tables for the first issue: general meteorological monitoring, a clear pattern emerges which is the fact that many survey respondents indicated that they did not have enough data points to accurately reflect the landscape they were attempting to monitor. On the surface, this indicates that there may be the need for more meteorological stations. However, upon further inspection one can see that the re-occurring problems are the proper acquisition and transfer of data as well as regular maintenance of the stations. In a number of countries they clearly indicated that they did not have a sufficient amount of resources to perform ongoing maintenance for their stations. In the case of Jamaica, they had stations supplied by different vendors for different projects and problems emerged from the lack of compatibility between these systems. The point to be taken here is that having more stations does not necessarily equate to better monitoring. The primary course of action to remedy this gap is to assess the operational plans for gathering, transferring, and storing data, as well as programs for maintaining stations in each partner country. C-READ can be developed with the current understanding of data gathering and transfer, but in order to improve and expand, a good systematic analysis will be required in order to understand specifically where infrastructural improvements are required.

Climate forecasting and modeling was not extensively reported on in the e-survey responses, but some insights were gained and gaps identified for this important topic.

The results that were gathered were rather inconsistent. In the case of Jamaica it was access to the output of climate models that was the issue. Belize had been working with the CCCCC and had access to model output through the clearinghouse. Dominica reported very little in terms of modeling and climate projections. Saint Lucia as well demonstrated very little capacity in this area. Guyana has a robust climate change adaptation plan in which they appear to have used model output in order to derive their conclusions. Lastly, organizations in Barbados did not explain to any great length what work they were doing with climate projections. One thing that was consistent was the fact that all countries requested data products, such as risk maps, that rely on projections from climate model output. The overall gap here is that there is an inconsistent approach for using climate models. In some cases there is a high degree of sophistication, whereas in other cases there is nothing. The remedial action is to work with CCCCC and their clearinghouse representatives to build the work they are doing with climate models into the functionality of C-READ. This would provide a consistent platform for the use of climate models in the Caribbean. This would also help to address the functional requirements of risk maps that are dependent on projections from climate model output.

Hydrological monitoring was the least detailed in terms of the responses from stakeholders but there were some clear insights that were gleaned from the data. One of the key observations was that currently many survey respondents felt that their hydrological monitoring networks were not providing sufficient levels of detail and in some cases, poor quality data. An organization in Guyana, for instance, indicated that the hydrological network is skewed towards the coastal areas and the central part of the country is not well covered. In Saint Lucia one respondent stated that there were "inadequate monitoring stations" and poorly trained personnel for gathering data and maintaining the network. Again we have to be careful when determining the true 'gap' in hydrological monitoring in relation to the future state that is desired. It appears that in many cases the root of the problem is operational planning and maintenance for existing hydrological monitoring networks. There are countries in which more monitoring stations maybe required but the first issue is ensuring that all current systems are properly maintained and that they have properly trained human resources that can gather the data, enter it, store it, and ensure that there is continuity in the process. Projects such as CARIWIN and current activities through PPCR in countries such as Dominica are advancing hydrological monitoring and the lessons learned in terms of efficient and effective hydrological data acquisition should be gleaned from them. The first remedial action to address these gaps in each country can be achieved in the design process of C-READ. When doing the use-case scenarios for hydrological monitoring, the availability of data and process for transferring it will have to be evaluated. If there are requirements for process changes, then they will become evident here. In some countries a more detailed analysis of the hydrological monitoring system may be necessary.

Category 2: Hazards and Risks

Drought risk assessment was consistently cited as a desired function for C-READ by all of the survey respondents. The degree of capacity that each of them have for producing these data products appeared to vary between countries. Jamaica and Belize both produced drought risk data products based on SPI (Standard Precipitation Index). Dominica, Saint Lucia, and Guyana did not indicate that they produced drought risk maps or indices. Guyana is an example of a country that has plenty of hydrological data but does not seem to have integrated it into a drought assessment product. There is a gap between the different partner countries in terms of their capacity for performing drought risk analysis. A remedial action could be to examine the processes used by Jamaica and Belize for drought risk and use these findings in the design process of C-READ to be applied in other partner countries. This would then reveal what data is missing. SPI is a fairly standard means of conducting drought risk. The CARIWIN project applied this in the context of integrated water resource management in countries such as Barbados and Jamaica. This work has been operationalized through the CDPMN (Caribbean Drought and Precipitation Monitoring Network). CARIWIN and CDPMN as well as work underway as part of PPCR should be examined in conjunction with the design of use-case scenarios for C-READ. This will help to address the functional gaps for drought risk assessment that currently exist between C-READ partner countries and regionally.

Survey respondents also cited flood risk assessment as a primary function for C-READ. The partner countries demonstrated different capabilities to assess the risk of floods. Some countries such as Jamaica have accessible inland flood risk data sets whereas others have little or no data. In some countries such as Guyana and Saint Lucia there is sufficient hydrological data but a lack of integration with topographic data to enable flood risk analysis. CIMH is developing the *Real Time Flood Forecasting Project*, which will help build capacity for flood risk assessment in the Caribbean using some of the most advanced hydrogeological models available. Mr. Shawn Boyce is the project lead from CIMH and should be consulted in the functional design of flood risk analysis for C-READ. In some cases the data gap for flood risk analysis is due to a lack of adequate hydrological and topographic data. In other cases there is sufficient hydrological data but it is not integrated in such a way that can provide flood risk data products. To remedy this flood risk functionality of C-READ should utilize existing data sets in accordance with methodologies that CIMH is using. In cases where data is not available, then a hydrological data acquisition plan should be developed.

Jamaica was the only country of those sampled that indicated they had comprehensive storm surge data available. This data is for certain areas of concern along their coastline and has been developed on a project-by-project basis rather than through a systematic effort. The other countries have links to regional storm monitoring systems operated by NOAA, and appear to have access to that data. However, there does not appear to be integration of regional storm GIS data with coastal topography or maps of vulnerable infrastructure. This is a regional data gap and in order to address it, data integration for storm surge analysis should be examined as a function of C-READ.

Disease and pest risk was cited as a concern to the surveyed stakeholders for two primary reasons: (1) risk to human health, and (2) risk to agriculture. Jamaica's RADA (Rural Agriculture Development Authority) was the only agency to report gathering data relating to risk of pests. The Ministry of Health of Belize is concerned about the risk to human health from diseases that propagate as a result of environmental and climate change. Generally speaking though, there was a very significant regional data gap in relation to the desired functionality for pest and disease risk analysis and the fact that very little of this data was collected or integrated into a human or agricultural risk analysis framework. In order to realize these data products with C-READ there will need to be a specification for the required data and the risk products. In some cases, the pest or disease data may not be available. The health and agricultural ministries of partner countries will need to be consulted in order to address these gaps.

Category 3: Geographical and Biophysical Environment

Topographic data is typically stored in map or digital format such as in a DEM (digital elevation model). This data is particularly important for analytical functions that require knowledge of slope and landform – such as land slide risk or delineating flood risk zones. The resolution can vary depending on the manner in which the data was captured. Satellite-based radar digital elevation models are often 30 m resolution or coarser. Lidar-based DEMs can be made at much higher resolutions. Three of the partner countries reported that they had topographic data: Jamaica, Belize, and Barbados. In some cases, the appropriate agency in the country did not respond to the survey, hence they may actually have national topographic data. There not only needs to be topographic data present, it also needs to be in an appropriate spatial resolution and file format. The topographic data that was reported by Belize, for example is in raster format at 30-meter spatial resolution. The data gap for topography is that in some countries it is not present (at least from the survey responses we gathered) and in other cases it may not be in the ideal format for particular types of analysis. The exact topographic requirements are determined by the analytical functions that are required. In some cases, coarse spatial resolution DEMs are fine. For other functions a higher spatial resolution may be required. These will need to be determined in the design phase of C-READ.

According to the survey respondents, ecosystem and biodiversity data was not systematically collected. Rather, it was collected more on a project-by-project basis. Belize is the exception to this with their use of BERDS (Biodiversity and Environmental Resource Data System) – www.biodiversity.bz. BERDS is a web-enabled database that manages biodiversity data for Belize and serves as a clearinghouse mechanism for various government agencies to contribute and utilize data. Jamaica's Ministry of Forests collects some biodiversity data and the Institute for Sustainable Development at UWI has some data for economic valuation of ecosystem services in Jamaica. These projects are not systematically connected though. The data gap for biodiversity is that, with the exception of Belize, the partner countries do not seem to have data management systems for biodiversity that connect to agencies and organizations in their country or regionally.

It is important to have biodiversity data stored and accessible to perform impact assessments based on environmental and climate change. In order to address this issue, C-READ should be able to manage and report upon biodiversity data for the partner countries. BERDS can serve as an example of how this component of C-READ can work.

Category 4: Coastal Zone and Ocean

Coastal zone management is a concern for all of the C-READ partner countries and there is a definite need for monitoring and data management to facilitate environmental management. Stakeholders in Jamaica provided the most detailed descriptions of the data they gathered for coastal zone monitoring. Jamaica's NEPA (National Environmental Protection Agency) has 6 sites for measuring beach profiles as well as mangrove and sea grass monitoring programs. The CZMAI (Coastal Zone Management Authority and Institute) of Belize has embarked on some very innovative GIS-enabled monitoring programs to connect ecosystem health to economic valuation models. Respondents from Saint Lucia, Dominica, and Guyana did not provide many details as to data gathered for coastal zone management. The Coastal Zone Management Unit from Barbados did not respond to the electronic survey. The overall data gaps that can be gleaned from e-survey are that there is a lack of integration of the different monitoring programs that are currently underway in the partner countries. In some cases, there is very little capacity for coastal zone management to start with (Saint Lucia) and this needs to be remedied before they can meaningfully contribute to or use C-READ.

Ocean monitoring was seen as a priority for many of the survey respondents. NEPA in Jamaica has 36 live coral reef monitoring stations and 27 automated stations for monitoring ocean temperature. They also have bathymetric maps of the island shelf with the geological features delineated. Belize as well has an emphasis on monitoring of the ocean environment. In both Jamaica and Belize the specific monitoring of ocean species appeared to be a weakness. Respondents in both those countries indicated that more data was required for marine species. The other countries did not provide many details about ocean monitoring. The main priorities that can be derived from the survey are monitoring ocean temperature, acidification, reef health, and marine species biodiversity. The major data gaps occur in the countries that do not appear to have extensive monitoring programs in place. In some cases regional remote sensing platforms that estimate SST (Sea Surface Temperature) and chlorophyll may be a remedy. Another data gap is the lack of an integrated platform in countries such as Belize where there are a number of NGOs that are gathering species data that could then be evaluated with other regional data such as SST. Ideally, C-READ can be a platform for addressing this.

Category 5: Land Cover and Land Use

Land cover and land use data was collected by groups such as the Ministry of Forest in Jamaica, the Land Information Centre in Belize, and CIMH. This data was generally quite static and did not undergo regular updates. The most significant data gap identified

was that several countries indicated that they would like to be able to assess climate change impacts on land cover. Guyana has made some progress in this regard with their evaluation of ecosystem services along their coast and potential climate change impacts on them. In order to address this gap, there should be functionality in C-READ to manage land use and land cover GIS data. Secondly, there should be some functionality for coupling climate models with land cover. This should be cited in the design phase of C-READ.

Protected areas boundary data was managed and collected by an organization in each country with the exception of Saint Lucia where there was no response. If there is a gap to be identified in protected areas it is the fact that there is very little data available for the health of protected areas and biodiversity within them. There does not appear to be the capacity to assess the impacts of climate change on protected areas in the partner countries. These should be explored in the functional design of C-READ.

Category 6: Agriculture and Food Security

The majority of the partner countries had very rigorous monitoring systems in place for agricultural production. Guyana is the only country that did not provide a description of how they managed agricultural productivity data. The data gathered by these organizations is gathered and then shared on a periodic basis – often monthly. CARDI in Barbados has extensively monitoring and data sets to inform productivity planning. The data gap here is in providing an integrated framework that can take this data and enable it to be analyzed with other climatic and environmental data such as climate projections. C-READ could potentially fulfill this goal which would then lead to greater adaptive capacity for these countries.

The gathering of soil quality data was not widely reported in the survey. The Ministry of Natural Resources and Agriculture in Belize indicated that they collect soil data and share these data products but they are not integrated with any other data. The main data gap is the fact that some countries do not have data pertaining to soil quality. The other aspect of this gap is the fact that if they do gather soil quality data it is not currently integrated with any other data. In terms of addressing these gaps with C-READ, the first thing to occur should be an assessment of what soil data is available from the different countries. This has already been done and documented in this report. Secondly, in the functional design of C-READ the soil data should be able to be integrated with other data sets. For example, merging climate data with soil quality data to understand the effects of climate on soil productivity and agriculture. In the design of C-READ the use-case scenarios will be able to address this.

Category 7: Water: Availability, Quality, and Use

Water availability was fairly well monitored by survey respondents. Jamaica has an extensive monitoring system for water availability however there has been some difficulty in getting regular access to some of the monitoring stations. Belize's

Hydrology Unit has 28 stations that monitor water availability. The most significant gap in Belize is the fact that there is currently no means of assessing climate change impacts on the water supply. Dominica is undergoing a revision of its water monitoring system through the PPCR / Carib HYCOS project in which integrated models are being applied. Saint Lucia has an extensive water-monitoring network managed by the WRMA but there are challenges with distribution and sharing of this data. Guyana as well has a robust monitoring network. The overall data gap that was gleaned from the evaluation of water availability monitoring in the partner countries was that there is not sufficient data sharing and also that some of the monitoring networks need to be evaluated for the quality and continuity of the data they provide.

Water quality is generally a public health concern in the partner countries and as such, the ministries of health tend to be involved with either the sampling, analysis, or reporting of this data. In Jamaica, there are roughly 600 sampling stations, 200 of which are operated by NEPA and 400 by the NWC (National Water Commission). The challenge there is that there are problems with QA on the gathering of this data as well as integrating these data sets. This can be considered a data gap in Jamaica. In Belize, the Ministry of Health has operated boreholes for assessing water quality, however, it has been reported that this network needs examination for the quality of the stations and reporting processes. The Meteorology Service of Guyana assesses water quality in addition to Guysuco, a private sector organization. The data in Guyana is not shared at this point but there could be benefits of greater spatial coverage if this were to occur. Guysuco has expressed interest in becoming a contributor and user of C-READ which would help to foster data sharing and collaboration for environmental monitoring. The overall gaps that can be observed are the need for assessing the quality of the data collection processes and networks for water quality, as well as enhancing sharing and integration of data sets.

The only country to report on collecting water use data was Jamaica. The WRA (Water Resource Authority), the NWC, WINDALCO, and UNEP all contribute to monitoring water availability. Ground water levels of storage in aquifers as well as surface water levels are monitored through a variety of wells and point measurements. The WRA, for instance, has 3300 groundwater measurement points. The problem that was identified in Jamaica was the fact that due to insufficient funding data collection is not always possible in person. This presents a problem with continuity and consistency in data. The other challenge is coordinating these data collection programs and maintaining common standards. The overall gap that can be translated to C-READ is the need for continuous supply of quality data that is provided in a common standard format. In order to address this gap, the water availability data collection network in Jamaica should be examined to determine areas that need attention and specific remedial measures, starting with potential process changes.

Category 8: Energy: Use, Generation, Availability

Energy use was only reported on by Jamaica. The National Water Commission has a record of high-energy users. The Jamaican Bauxite Institute has data on fuel consumption, type, and quantity. Chevron undertakes monthly testing at specific sites and

reports to NEPA on a quarterly basis, and Rubis has volume data for various petroleum fuels sold. This data is interesting from a planning standpoint, but unless there is a concrete connection to environment, for example, calculating GHG emissions from energy use, then this function may be of a lesser priority than other C-READ functions.

Category 9: Socio-Economic Status

There were no survey respondents that provided adequate data for industrial activity to determine where there were gaps. This was not a priority of the initial C-READ electronic survey. In subsequent design phases we can revisit this issue. Socio-economic status was similarly under-represented in the survey responses. Only the Planning Institute of Jamaica responded with the fact that they produce poverty maps. This is a gap in data since if vulnerability maps are to be produced they need to have socio-economic status information because impoverished communities are often those that are most vulnerable when natural disasters strike.

Category 10: Critical and Emergency Infrastructure

Disaster response data was relatively sparse in the responses to the electronic survey. Risk and vulnerability maps were widely requested by different stakeholders, however. Organizations such as CDEMA, the Red Cross, and in-country organizations such as the Belize National Emergency Management Organization, Guyana's Civil Defense Commission, Barbados Department of Emergency Management, and Saint Lucia's National Emergency Management Organization, all play critical roles in response to disaster management in the Caribbean. In Barbados the Department of Emergency Management did indicate that they had GIS data for storm surge risk. The risk and vulnerability data products that were previously identified in category 2 will speak to disaster management in the Caribbean.

Critical infrastructure data was reported on by the NLA (National Land Agency), NWA (National Works Agency), and NWC (National Water Commission) of Jamaica and the Department of Emergency Management of Barbados. The data that they managed was primarily GIS files related to roads, bridges, water distribution, community assets, and emergency shelters. The main gap here is that this data is not integrated with other hazard risk data in order to assess cumulative risk. For instance, storm surge risk in conjunction with vulnerable critical infrastructure such as bridges. These queries can be investigated in the design phase of C-READ.

3.8.2 Instrumentation for Data Acquisition

Many of the issues pertaining to the data gaps that relate to instrumentation have been indirectly addressed in the previous explanations for certain issues. It is worth revisiting

this in a general sense to point out some common themes and to suggest possible solutions.

Many survey respondents indicated that they need financing for more hydrological or meteorological stations. The main argument that respondents have made is that they have insufficient coverage of the landscapes and environments they are dealing with in order to provide sufficient monitoring. The problem is that in most cases there are a very large number of stations already in place and it is not the density of the stations that is the problem, but the operational planning to gather data from remote locations and also the fact that many stations are poorly maintained and are not functioning properly. In both of these cases resources could be applied to establishing more robust data collection processes with trained, accountable personnel who are able to gather data on a continuous basis. Secondly, the stations would have a longer life and supply continuous data if proper preventive maintenance programs, including spare parts allocation, are implemented. This is the first and perhaps most important gap to address for meteorological and hydrological monitoring.

3.8.3 Data Analysis and Reporting

Gaps in issues related to data analysis and reporting were primarily related to the degree to which survey respondents collaborated with research institutions, NGO's, and other organizations. Data reporting for specific issues was addressed within each of the categories previously discussed. Research collaboration was conducted by all of the organizations the responded to the survey: Jamaica (86%), Belize (67%), Dominica, (40%), Saint Lucia (67%), Guyana (100%), and Barbados (75%). One of the gaps pertaining to collaboration was the fact that in many cases there were no data sharing agreements in place. For instance, Guysuco has a fairly extensive environmental monitoring program, the data from which could be useful for other organizations. They replied to the survey indicating that they are interested in collaboration and sharing but they would need to have some sort of framework and agreement that they could work from. C-READ has the opportunity to be endorsed as a shared platform for collaboration between different agencies and organizations.

3.8.4 IT and Human Resource Capacity

Data storage and computational capacity varied between stakeholder organizations in each of the partner countries. Some larger governmental institutions as well as private sector organizations had very robust data storage capacity and internal networks. On the other hand, smaller governmental agencies and organizations such as NGO's had less computers and servers. The gap in technology is the fact that some organizations will not be on the same level as others in terms of their access. Hence, this must be considered in the development of C-READ such that the software is not designed for the higher end of

the user spectrum. The system should be designed such that a user with access to a regular desktop computer can access the data they need and perform the analytical functions they require.

Internet connectivity was consistently high across the stakeholder groups. Most groups had access to a DSL connection. Few, if any, had a dial up connection. This level of connectivity should be considered when designing data transfer protocols for C-READ. There may be some functions that require the transfer of large amounts of data – remotely sensed images, for instance. In these cases any limitations in connectivity should be considered in how C-READ functions.

There was a gap identified in human resource capacity for IT for survey participants. There was a shortage of programmers and technical personnel who would have the capability to actively participate in advancing C-READ or performing more sophisticated functions such as programming. There was also a gap in the amount of personnel that had environmental data management training in areas such as statistics and the use of process models. Fortunately there is a significant amount of collaboration that occurs with academic institutions and this type of knowledge transfer can help address these shortages. The IT human resource gaps will need to be addressed in the development of operational plans for C-READ. This will occur in phase 3.

Technical and HR capacity for GIS was shown to be a weakness overall for most of the survey respondents. Many of the organizations that participated in the survey indicated that they did gather and manager GIS data for the purpose of environmental monitoring. However, when asked about in-house technical capacity, then one role that was most often cited as being required was that of GIS technician. The conceptual design of C-READ will be in part a database management system but it will equally be a geographic information management system (GIS). Hence it will be important to ensure that there are adequate human resources in place to allow stakeholders to actively contribute data and also use C-READ. The lack of GIS human resources is a gap that should be addressed in the development and implementation of C-READ.

4. Review of Related Regional Projects

4.1 Overview of Results

A total of 27 projects were singled out for their close relevance to the C-READ management system project. These projects were database systems, research initiatives, development funding programs, and capacity development policy frameworks. In some cases the relationship to this project was the fact that data could be shared, in other cases it was simply the fact that the objectives were shared. The results do show that there is a lot of momentum behind building resilience and reducing vulnerability in Caribbean nation states with the use of monitoring tools and database management systems. There were also some clear synergies identified.

4.2 Identified Synergies

The results of this meta-analysis can be found in Table B1 in Annex B. The synergies identified were based on the fact that in many cases the project objectives were very close between the C-READ system and these chosen projects. The review of related projects revealed projects that could possibly share data with C-READ. The possibilities for sharing of this data also provided us with an indication as to how the gaps can be addressed through data sharing agreements with existing projects. The following table summarizes the results of this analysis in relation to how existing data sets address gaps we have identified.

Table 26: Summary of Related Projects and Potential Data to Address Gaps

Project	Data	Gaps Addressed
Regional Framework for Achieving Development Resilient to Climate Change (2009- 2015)	There are a series of findings within the Regional Framework and Implementation Plan that could be useful in addressing potential vulnerabilities that partner countries may have. In some cases this may not be hard data, but these qualitative assessments will help to inform the development of C-READ.	The biggest gap that this regional framework addresses is the lack of data or capacity for estimating vulnerability of communities to environmental and climate change. The survey respondents indicated that they wanted to have information to help them assess vulnerability. Currently they are lacking data and in many cases, the cross collaboration between agencies to help them product these data products. The regional framework will encourage departments together which will in turn help address this gap. The focus of this framework on climate change adaptation will also help to address the gaps identified since many of them are related to fostering adaptive capacity and

Project	Data	Gaps Addressed
		resilience.
PPCR Pilot Program for Climate Resilience (2012-2016)	PPCR activities in C-READ partner countries have provided and are planned to provide data that will be very useful for environmental monitoring. For instance, activities in Jamaica, Saint Lucia, and Dominica could contribute data and capacity to C-READ. Dominica has already had work done on water resource analysis and quantification in conjunction with the Carib Hycos project. The systems and data that come from this project are directly related to C-READ's objectives of enhancing environmental monitoring. More data and capacity will result from other pilot projects that are part of PPCR.	A lot of the work done under the auspices of PPCR has been to set up the initial strategy and structure. However, there has been work done in Dominica already through which water monitoring has been enhanced and improved. These new monitoring approaches and data address the gap of complete hydrological data that Dominica has. Specifically, data related to hydrological function in Dominica will be useful for C-READ. There are other projects that will come online that will help to address other data gaps such as for food security and drought risk.
The CARIWIG Project (2012-2014)	The CARIWIG project has clear connections to C-READ through the use of weather generator models, which will be useful for assisting with climate change projections. This data is useful for determining areas of potential risk to drought and flood.	One of the gaps identified by the majority of the partner countries was data and projections that will show vulnerability of communities and infrastructure to environmental and climate change. The models used in CARIWIG can help to address this gap by providing the tools for decision makers to run models that will indicate where potential vulnerable areas might be. This functionality can be built into C-READ.
Australia-Caribbean Collaboration on Climate Change and Coral Reef (2012-2014)	This project is important for partner countries that expressed specific concern over the health of reefs. Belize is one such nation. In cases where reef monitoring is taking place in separate locations in the Caribbean and the data needs to be aggregated, C-READ can play a pivotal role. The monitoring 'multi tool' that is being created with this project will be useful in providing a means of gathering coral reef health data in a consistent way.	The reef health data that is being gathered as part of this project can address the data and monitoring gap that some C-READ partner countries identified. Belize was particularly emphatic about the need for high quality ocean and coral reef data sets. The development team of this project needs to be contacted to ascertain the data formats they will be using for their gathered data and also what their sharing protocols are.
CIMH - CARIWIN	CARIWIN provided capacity to its partner countries to enhance Integrated Water Resource Management. This resulted in three main tools for IRWM	One of the gaps found in the partner countries was inconsistent or sparse hydrological data. In some countries the coverage was

Project	Data	Gaps Addressed
	in Jamaica, Grenada, and Guyana: 1. National Water Information Systems 2. Precipitation and Drought Monitoring Network 3. Community Water Strategy	better than others – eg. Jamaica. The data that was gathered for Jamaica and Guyana as part of CARIWIN would be very helpful in ensuring adequate monitoring coverage in those countries. The framework for establishing national water information systems in CARIWIN countries could also be useful in C-READ countries with poorly developed hydrological monitoring systems. Hence, both these gaps could be addressed by connecting C-READ with CARIWIN. A C-READ team member was formerly with CARIWIN.
CADM (Caribbean Disaster Management) (Phase 1 and Phase 2)	CADM phase 1 and 2 was piloted in Belize, Dominica, Grenada, Guyana, and Saint Lucia. The second phase was expected to end in December 2011 with the outcomes being: (1) Flood analysis and flood hazard maps for pilot states (2) Early warning systems for flood hazards in the pilot states (3) A hydrological database at CIMH	C-READ's e-survey results showed that there was a gap in data relating to flood risk and also mapping vulnerable communities and infrastructure. The flood risk maps produced for Guyana, Dominica, and Belize can help to address this gap. Similar maps should be made for the other C-READ countries: Barbados and Jamaica. CIMH should be consulted for these flood risk maps as well as details pertaining to flood early warning systems.
CIMH – UNDP/Italy Enhance Resilience to Reduce Vulnerability (ERC Project)	The ERC project is designed to provide capacity and tools to improve disaster response in Barbados and the OECS. The key component relevant to C-READ is the DEWETRA system. Data that is used for this system such as integrating hydromet data, tsunami risk, storm risk, and fire risk together can be useful for C-READ.	One of the main gaps identified in the e-survey was the need for risk products for inundations. The ERC project and DEWETRA could potentially provide data that can address this gap (and perhaps other gaps).
CIMH - RRACC Expansion and enhancement of hydrometric networks in the OECS (USAID)	The RRACC project is intended to increase the coverage of hydromet stations and also raise awareness about climate change. The data gaps identified in the e-survey could be addressed by the addition of this data.	Where it is possible, additional data that is provided as a result of the hydromet stations could be useful for C-READ. A detailed list of these stations, their data collection format, and access protocols will be required.
CIMH - Carib-HYCOS (France & WMO)	Hydrological data is the key data product from Carib-HYCOS. This data is instrumental to address hydrological monitoring gaps that were identified in the e-survey.	This hydrological data should be integrated with C-READ. The review of Dominica's hydrological monitoring system indicated that they are already enhancing these systems via

Project	Data	Gaps Addressed
		Carib-HYCOS. Integration with these efforts and C_READ is necessary.
CIMH – GEF IWCAM (Integrating Coastal Areas and Water Resource Management)	Water quality data as well as coastal zone data is important to the function of C_READ. Barbados, Dominica, Jamaica, and Saint Lucia are C-READ partner countries also participating in this project.	Water quality data as well as other coastal zone data should be integrated into C-READ to address the gaps in monitoring that were identified in the e-survey.
CIMH – NASA - CDEMA: CSDP (Caribbean Satellite Disaster Pilot project)	MODIS, EO-1, and Radarsat-2 data has been combined to produce geospatial risk products for floods, storms, and post event assessment analysis.	These raster data sets can be used for a number of the risk products that were requested by stakeholders. They can fill current gaps in data gathering for risk analysis, which were identified through the e-survey.
Advanced Flood Forecasting System (CIMH / Japan - CARICOM / CCRIF).	Flood risk is the main issue addressed with this project. They have watershed-based data that they combine with satellite-based RS data and the radar network in the Caribbean. This data can be used for analyzing risk of floods.	The gap that was identified was the need for real time (or quasi-real time) flood risk data products that can help to inform groups in different areas about their potential risk. The data specification and accessibility will be verified with CIMH.
Caribbean Flood Risk Atlas (CIMH / World Bank / UWI – DRCC)	This project utilizes hydrological data in addition to other relevant data sets. In many cases, the data comes in GIS format.	The GIS data sets and other related data could be reviewed to see how they fit with the DE initial model.
Climate and Hydrological Data Rescue, Storage, and Dissemination (CIMH / CDB)	The data in this project is largely historical data that was originally on paper but is now being digitized to enhance access.	Gaps in the historical record for precipitation and temperature can potentially be filled with this data set.
NOAA – CORIS Geo Portal	There are a number of reef and ocean health-related data products available at this portal. The search mechanism can be geospatially executed and the results range from GIS data sets to reports. The data is shared without restriction.	Gaps in ocean and reef monitoring could be addressed with some of the data that is accessible through this portal. There is a wide array of data, much of which is focused on Puerto Rico and the US Virgin Islands however, there are also Caribbean-wide data sets. The regional data sets can be accessed and integrated into data products or queries built into C-READ.
CDERA Disaster Risk Management Framework	The data provided by this project is more in the form of guidelines and standards for disaster and hazard mapping and data collection than the raw data itself.	These guidelines can be useful in the design of use-case scenarios for hazard and risk data products. Vulnerability and risk maps were cited as gaps by stakeholders and these guidelines will help to specify how this data should be collected and represented in C-READ.

Project	Data	Gaps Addressed
CariCOOS	CariCOOS synthesizes data such as CO_2 levels in the air and seawater gathered from buoys. These are not in the areas of the C-READ partner countries but perhaps this data can be useful for ocean monitoring at the regional scale. The buoys are located around Puerto Rico and the US Virgin Islands. Data is available as .csv file downloads from their website. Winds and wave data is available as are tides and currents. Ocean colour and water quality as well as real-time CO_2 level analysis are conducted. Satellite derived products for winds and ocean colour are available via this site as well. This data maybe more relevant to C-READ due to the wider spatial coverage.	There were gaps cited for ocean acidification and water quality were by C-READ stakeholders. Belize in particular expressed interest in more robust monitoring and data sets to assist with the monitoring of their reef systems and coastal zone. The satellite-derived products, such as chlorophyll-a imagery from MODIS, can help to fill this gap. The point-sampled data from the buoys will have to be evaluated to see its value in estimating water quality regionally.
UNISDR	Prevention Web is hosted by UNISDR and it serves as a portal for disaster risk data. www.preventionweb.net/. Land cover, DEMs, and population base layers are available. Also available are specific risk related data sets such as droughts, floods, tsunamis, and landslides. The interface is not fantastic and the response time to queries is very slow. However, there may be good data sets that can be exported and integrated with C-READ.	Risk-related data that an inform vulnerability to drought, flood, landslide, and other natural hazards is a gap that has been identified by several C-READ stakeholder countries. Each country's needs in terms of risk maps need to be assessed against the data that is provided by PreventionWeb. Preliminary evaluation shows very coarse spatial resolution risk data for landslides.
CPACC (Caribbean Planning for Adaptation to Climate Change Project) / (ACCC / MACC)	The original objectives of CPACC resulted in data management programs and strategies that are useful to C-READ. A sea level / climate monitoring network and coral reef monitoring projects in Bahamas, Jamaica, and Belize are relevant to the data gaps identified in the e-survey of C-READ phase 1.	Studies such as that completed by Creary, 2006 on Coral Reef Monitoring for Climate Change Impacts in Jamaica 2001-2003 produced baseline data that is useful for C-READ. A permanent transect was not set up for this project but the format of types of data gathered can inform the coral reef monitoring data products that have been cited as current data gaps by several C-READ stakeholder countries – Belize in particular. The coastal monitoring reports and reef assessments should be used as guidelines for the use case scenarios for C-READ.
EMDAT	EMDAT provides historical data on natural and technological disasters. The data is in tabular format and can	The data from EMDAT would be a useful contextual source for C-READ but may not provide

Project	Data	Gaps Addressed
	be downloaded or exported. This data is useful for understanding historical patterns but perhaps has less utility for detailed vulnerability assessment.	analytical value.
CDEMA	CDEMA hosts a database of disaster risk related documents. Initial inspection of their site did not show that they had geospatial disaster risk data, but further exploration is required.	Anecdotal data from CDEMA would be useful in addressing some of the data gaps for risk and vulnerability in C-READ partner countries. What would be better would be GIS data that directly addresses issues such as drought, floods, landslides, etc. Further exploration in the design phase will reveal what kind of data sharing can be achieved between CDEMA and C-READ.

5. Results of Monitoring Infrastructure Electronic Survey

5.1 Overview of Caribbean Wide Results

The results of the initial electronic survey provide us with a good foundation as to what the status of environmental monitoring is in the partner countries and also what the priorities of the countries are. This survey is not a complete assessment of the state of Caribbean comprehensive environmental monitoring but the results have given us very specific results in relation to gaps in data for monitoring for environmental change. This was our objective of the first phase of this project. We did not have equal number of respondents in each country and Jamaica was the most forthcoming. One of the main reasons for this is because we were able to hold an in-person workshop in Kingston and to get key stakeholders at the table to identify data gaps in environmental monitoring as well as desired functionality for C-READ. The survey responses are also heavily weighted towards the organizations in each country responsible for meteorological monitoring and hydrological resources since these are the core groups we will work with in early stages of system development. We aim to broaden the audience as we progress.

The following graphs summarize some of the key factors we were looking to better understand: time series and GIS monitoring of meteorological / climatic, hydrological, and other environmental data; and the number of organizations that collect or manage data relating to specific national issues. The following sections explain the details of each country in relation to the key components of the electronic survey: management issues relating to monitoring and data; scientific and technical aspects of monitoring (eg. how many hydromet stations they have), and what their IT capabilities are.

Figure 1 below shows the number of survey respondents in each country that indicated they gather time series meteorological and climatic, hydrological, and other environmental data.

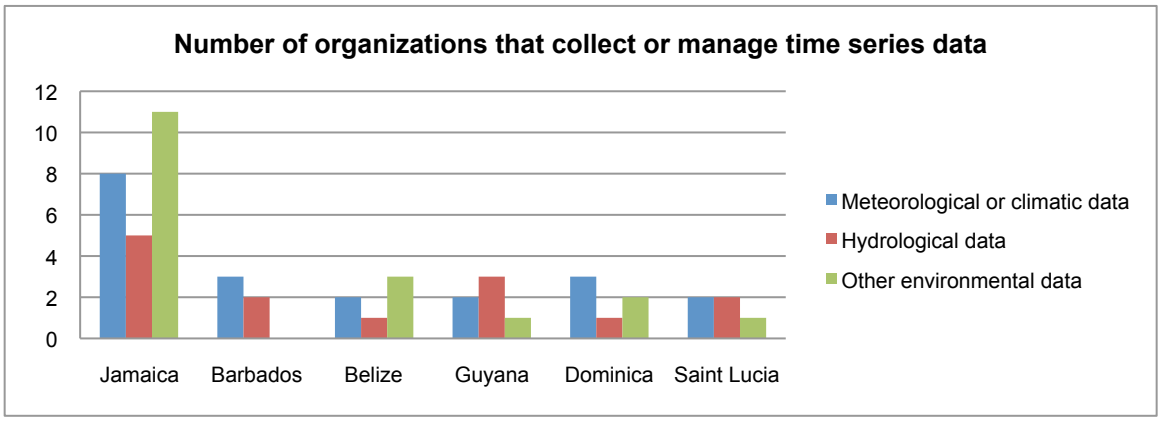

Figure 1: Number of organizations that collect or manage time series data (n=49)

Jamaica had the most survey respondents (22) and this is shown with the number of Jamaican organizations that sample meteorological and climatic (8), hydrologic (5), and environmental (11) data. At least two stakeholder organizations in each country sampled

gathered meteorological and climatic data. The spatial distribution, frequency, and means of storage of meteorological and hydromet data varies and is explained in detail in each of the country sections.

Figure 2 below shows the number of survey respondents in each country that indicated they gather GIS meteorological and climatic, hydrological, and other environmental data.

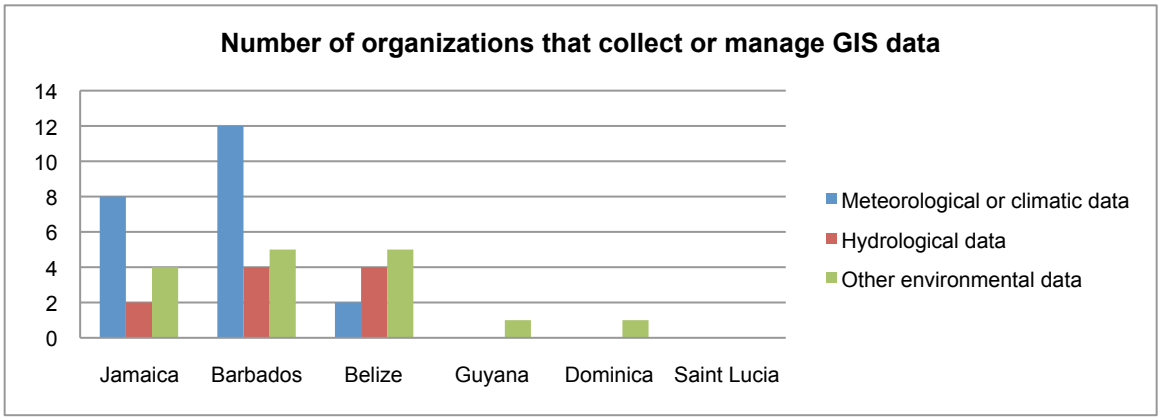

Figure 2: Number of organizations that collect or manage GIS data (n=49)

GIS data was less widely sampled throughout the countries that participated in the survey. For example, Guyana and Dominica only had one group each that reported they sampled GIS data and Saint Lucia had none. Barbados has a diverse response with several organizations reporting that they had GIS data for all three data types. The main message from Figure 2 is that there is significant GIS capability in some countries and very little in almost half of them (and perhaps more throughout the Caribbean). The initial assessment of data and functional gaps indicated that there are some data products that are required that are geospatial in nature. This indicates that a GIS component will likely be required for C-READ. There will need to be a provision for capacity development to build the in-country technical and human resource capability for GIS analysis and data management. General geospatial data standards will also need to be created to ensure that data from the different GIS-using countries can share it. Although there are international geospatial data standards and existing software platforms such as GeoNode help to reinforce them, there are still some concrete issues that will need to be addressed. For example, data from one country may be stored in a certain geographic projection. GIS data from another country could be in a different projection. In order to integrate these data sets in a GIS, there will need to be an established standard projection for C-READ and re-projection will need to be done to data sets that differ from this standard.

Figure 3 below shows the number of survey respondents in each country that indicated they gather data relating to specific national issues.

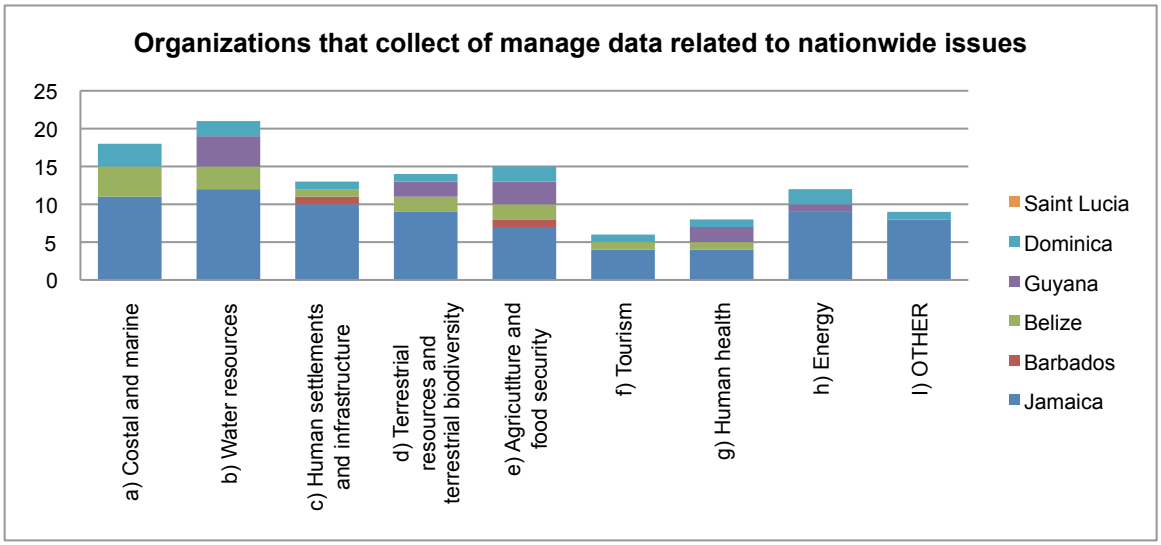

Figure 3: Number of organizations that collect or manage data related to nationwide issues (n=49)

The survey respondents provided a broad view of how data collection in the partner countries relates to different national issues. One of the key patterns to observe from Figure 3 is the importance that coastal and marine, water resources, and agricultural and food security have in monitoring and data acquisition. Agricultural and food security was the most widely considered national issue in terms of monitoring with five of the six partner countries indicating it was a priority for which data was gathered. Water resource management is the issue that has the highest number of organizations that respondent countries address with data monitoring. Human settlements and Infrastructure refers to organizations that collect data related to the status of potentially vulnerable communities and infrastructure. Terrestrial resources and terrestrial biodiversity refers to data related to agriculture, terrestrial biodiversity, and any other land-based resources for which data is gathered. These broad overview results provide us with a snapshot of where policy issues lie in terms of importance for the C-READ management system. Not surprisingly, many of the anecdotal responses to survey questions regarding desired data products indicate that risk maps for droughts and agricultural had high priority. The following sections show detailed results for each partner country.

5.2 Jamaica

5.2.1 Overview of Jamaica

Figure 4 shows the sectors/ themes from which the twenty-two participating organizations in Jamaica belong (the full listing of the organizations may be seen in Table 1). The "Environment" sector was represented by 18% (4 organizations), whilst the remaining sectors, with the exception of the "Other" group were represented by 9% or 2 organizations each. The "Other" sector shown in Figure 3 comprises the following themes: Mapping, Livelihood, Coast/ Oceans, Infrastructure, Resource and Terrestrial Biodiversity and Disaster.

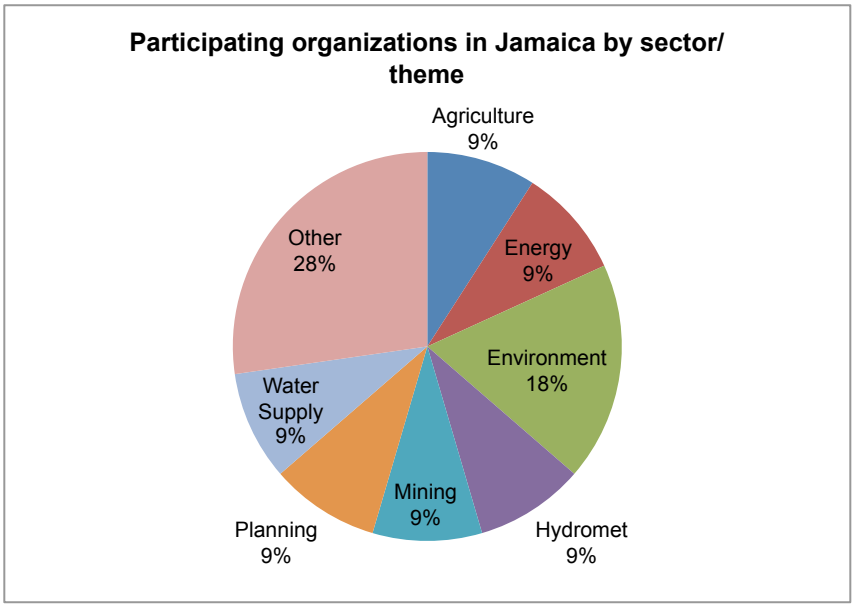

Figure 4: Participating organizations by sector/ theme (n=22)

5.2.2 Results for Jamaica

Jamaica Monitoring Overview

Q. Number of Organizations that Collect or Manage Time Series or GIS Monitoring Data

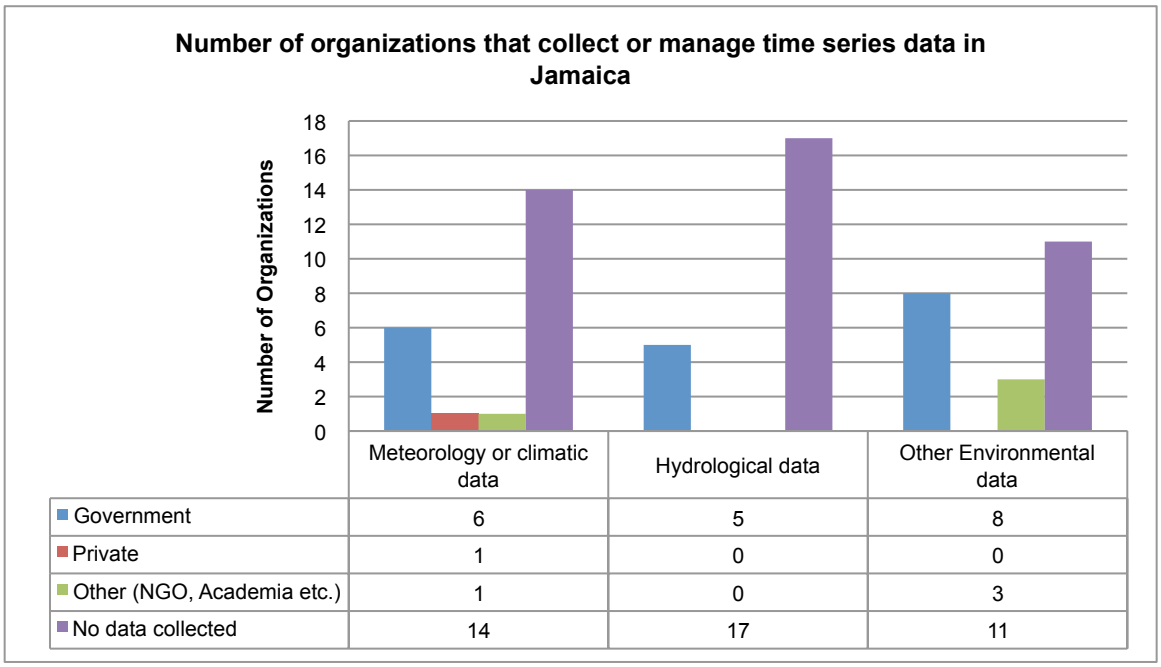

Figure 5: Number of organizations in Jamaica that collect or manage time series data (n=22)

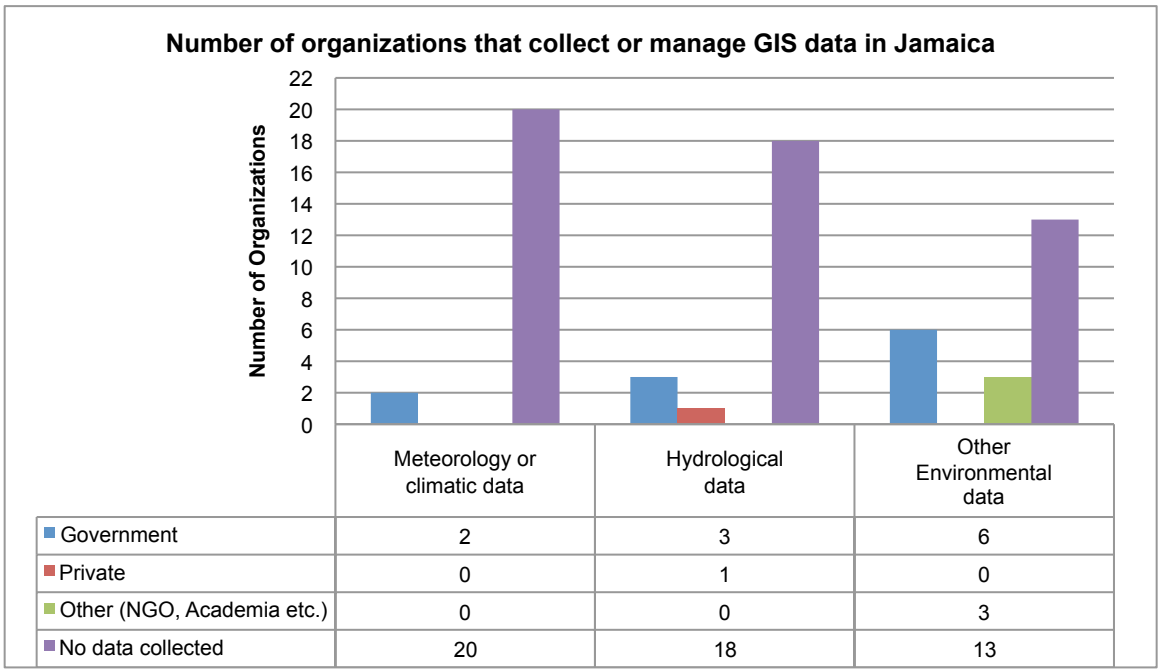

Figure 6: Number of organizations in Jamaica that collect or manage GIS data (n=22)

Observations:
Of the twenty-two organizations that returned the electronic survey, eight collected or managed time series data for meteorological and climatic monitoring (see Box 1). Of these eight, six were government agencies, one private and the other an academic group at the UWI. In contrast, only two government organizations, namely WRA and NWC stated that they managed or collected GIS data for meteorological and climatic monitoring. With regards to hydrological data, five government entities sampled time series data (Box 3) and four organizations (3 government and 1 private) collected or managed GIS hydrological data (Box 4).

Box 1: Meteorological and climatological time series data in Jamaica

1) Climate Studies Group Mona (University of the West Indies (UWI), Mona Campus)
2) Meteorological Service of Jamaica
3) Ministry of Water, Land, Environment, & Climate Change (MWLECC)
4) National Water Commission (NWC)
5) Rural Agricultural Development Authority (RADA)
6) Water Resources Authority (WRA)
7) The Jamaica Bauxite Institute (JBI)

In contrast, only two organizations, namely WRA and NWC stated that they managed or collected GIS data for meteorological and climatic monitoring.

Box 2: Meteorological and climatological GIS data in Jamaica

1) National Water Commission (NWC)
2) Water Resources Authority (WRA)

With regards to hydrological data, five entities sampled time series data:

Box 3: Hydrological time series data in Jamaica

1) Meteorological Service of Jamaica
2) Ministry of Water, Land, Environment, & Climate Change (MWLECC)
3) National Water Commission (NWC)
4) Water Resources Authority (WRA)
5) The Jamaica Bauxite Institute (JBI)

As seen in Figure 6, four organizations stated that they collected or managed GIS hydrological data, and specifically:

Box 4: Hydrological GIS data in Jamaica

1) Ministry of Water, Land, Environment, & Climate Change (MWLECC)
2) National Water Commission (NWC)
3) Water Resources Authority (WRA)
4) Chevron Caribbean

Other environmental data was collected by as many as 11 organizations as time series, and 9 as GIS data. Only two organizations specified the type of environmental data collected. NEPA stated the following parameters: air quality, water quality, sea temperatures, coral reef health and beach profile change, whilst NWC made note of water safety plans (WSP) for the Rio Cobre River, St. Catherine.

The types of meteorological, hydrological, environmental and GIS data collected by each organization are detailed in subsequent sections and Annex E.

Q. Number of Organizations Monitoring Key National Issues

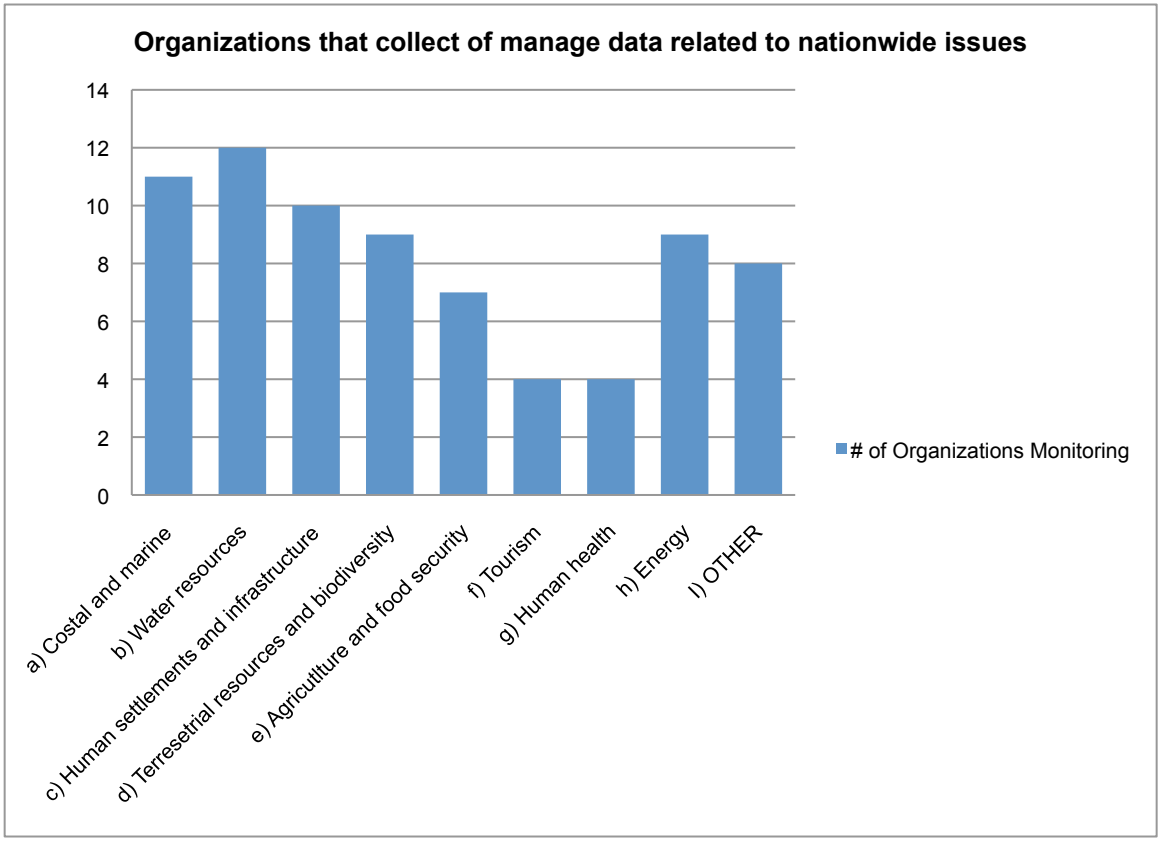

Figure 7: Number of organisations monitoring key national issues (n=22)

Observations:

As seen in Figure 7, coastal and marine and water resources are the predominant national issues that organizations in Jamaica stated to monitor (11 and 12 organizations respectively). The WRA is primarily responsible for the management, protection, and controlled allocation and use of Jamaica's water resources. This agency monitors: stream flow at over 100 stations on major rivers; groundwater levels and change of storage in aquifers; abstraction from surface and ground water sources; water quality; and rainfall (total and intensity series) in order to determine water resources balance, recharge and availability. A number of organizations that manage data related to water resources issues stated that the WRA is the data source (Chevron and MWLECC) or that data collection stations were in agreement with the WRA (JBI). Various water sources, including groundwater, surface water and rainfall, were described as important datasets being assessed. In addition, relating such sources to production (NWC), quality, availability and harvesting appeared to be important considerations.

As it relates specifically to the coastal and marine realm, fisheries (catch and effort), ecosystem extent and health (coral reef, sea grass, wetlands etc.), water quality (waste water discharge, pollutant loads, sea surface temperature), geology, geomorphology,

bathymetry and related process (beach/ coastline change, storm surge, sea level rise, saline intrusion), were all under investigation and are detailed further in subsequent sections of this report. In addition, socioeconomic aspects, such as effects on coastal livelihoods and legislative considerations (policies, laws, institutions etc.) were also stated. . Of interest are the Ministry of Agriculture and Fisheries (MOAF) and Marine Geology Unit (MGU), University of the West Indies whose mandates are directly related to coastal and marine processes and resources. Unfortunately, these agencies did not list the specific datasets collected or managed in the completed surveys.

Other prevalent nation-wide issues for which data is collected or managed by Jamaican entities include: human settlements and infrastructure (10 organizations), terrestrial resources and terrestrial biodiversity (9 organizations), energy (9 organizations), agriculture and food security (7 organizations). Tourism and human health are only addressed by 4 organizations respectively. This data is detailed in Annex E. It was discovered that though a number of organizations have specific agendas, in a number of instances these are connected to all issues listed. For example, NWC is the main institution responsible for major water and sewerage operations and data managed by NWC are dedicated to more than one issue: saline intrusion and waste water discharge (coastal and marine); water production (water resources); distribution (human settlement and infrastructure); watershed management (terrestrial resources); water usage (agriculture and tourism); water quality (human health); and high energy use (energy). Similarly, it should be noted that the Social Development Commission (SDC) is the leading community development agency in Jamaica and creates community profiles that monitor a wide range of issues.

Other nation-wide issues listed under the "other" category, included research related to disasters, such as impact assessment, emergency shelters and risk reduction, as well air quality (emissions and ambient monitoring data).

Based on the information received from the completed surveys, it can be concluded that the Met Office, WRA and NWC are important data sources for hydromet data. Pease note that all datasets collected and/ or managed by each organization are detailed in subsequent sections.

Q. Climate Change Priority Issues

Observations:

In general, climate change priorities of organizations in Jamaica pertained to various types of climate change data, modeling, as well as impacts on various facets of the environment including natural systems (water, soil, marine ecosystems etc.), industry and economy (agriculture, fisheries) and infrastructure (roads, urban areas). Disaster management, risk reduction, resilience and adaptation were also major concerns, as well as the need for public awareness. A summary of the specific issues ranked by priority may be seen in **Table E1 in Annex E**.

Jamaica General Data Procedures and Policies

Table E2 in Annex E summarizes the responses to the questions related to data management in Jamaica

Observations:
As seen in **Table E2 in Annex E**, data updates are done regularly (daily, monthly, annually etc.), as funds become available, as needed, or as driven by projects. Whilst some data is freely available at some organizations, other entities either sell or share data by means of an agreement or usage guidelines. Further, some datasets are created from projects and the data ownership and sharing limitations are specific to each.

Summary statistics, reports, maps, shapefiles, bulletins, assessments, fact sheets and brochures are some of the end user products created by organizations in Jamaica.

Specific mention was made of existing agreements, policies and legislation, such as the Access for Information Act, Health Environmental and Safety Security Management System, Land Information Council of Jamaica metadata guidelines, and Jamaica Bauxite Institute/National Resources Conservation Act, Memorandum of Understanding (2013). International standards are also used to guide data management, such as ISO metadata standards, Convention In Trade of Endangered Species (CITES), International Office of Epizootics (IOE), Sanitary and Phytosanitary Standards, Montreal Protocol, World Meteorological Organization (WMO) and Kyoto Protocol to the United Nations Framework Convention on Climate Change.

It is worth highlighting that a Climate Change Division at the MWLECC is in its embryonic stage of development and there is a plan to have this Division serve as the Clearing House Mechanism for climate change data.

Jamaica Regional DMS Recommendations

Table E3 in Annex E summarizes the responses to the questions related to data management.

Observations:
As seen by the various responses in **E3 in Annex E**, it is generally believed that the C-READ system would benefit data management in the region. Data products and queries most useful to organizations vary greatly and it is imperative that the C-READ system address the most urgent end product needs within the region. Further, a number of donor, NGO, and government organizations vital to the success of the system are listed in **Table E3 in Annex E** and should be considered in subsequent stages of the project (if not already involved).

Jamaica Outreach and Education

Q. For your organization, on a scale of 1 to 5, rate the level of need for human resources capacity building with respect to climate change and its impacts / data collection / and GIS.

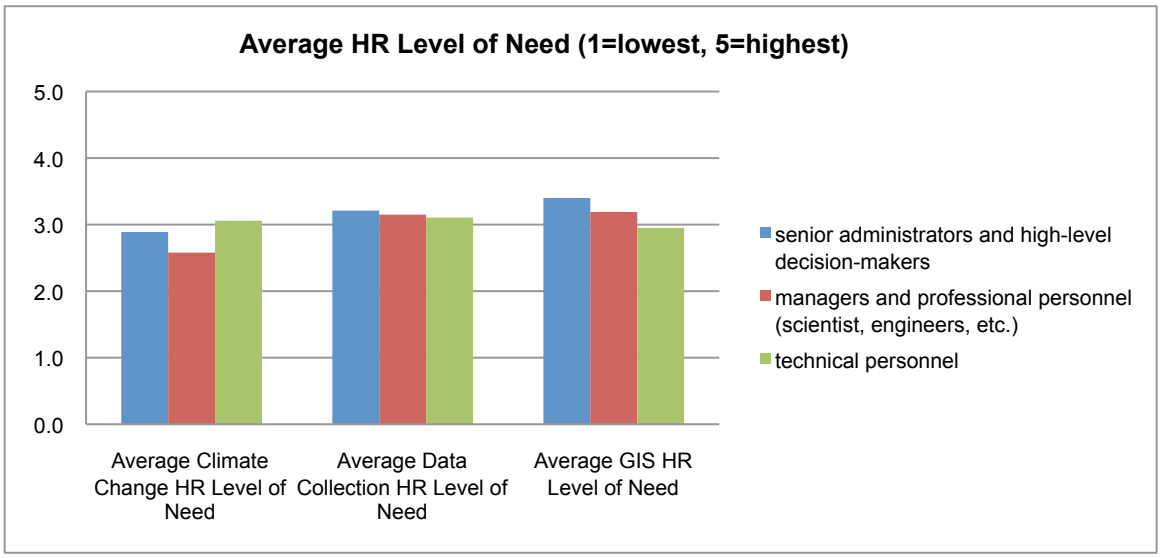

Figure 8: Average level of need for human resources capacity building (n=22)

Observations:

The highest level of need for human resources for any given area was in GIS for senior administrators and high-level decision makers (3.4). For use of geospatial products, this need decreases with managers and professionals (3.2) and technical personnel (3.0). With respect to data collection procedures, all levels of personnel required capacity building, with an average of about 3.2 for all HR levels considered. Requirement for climate change capacity building is generally less than that for data collection and GIS. The lowest level of need is seen for managers and professional personnel (2.6) whilst there is a higher requirement for technical personnel (3.1) for climate change awareness.

Q. Does your organization collaborate with research organizations and academic institutions, list them?

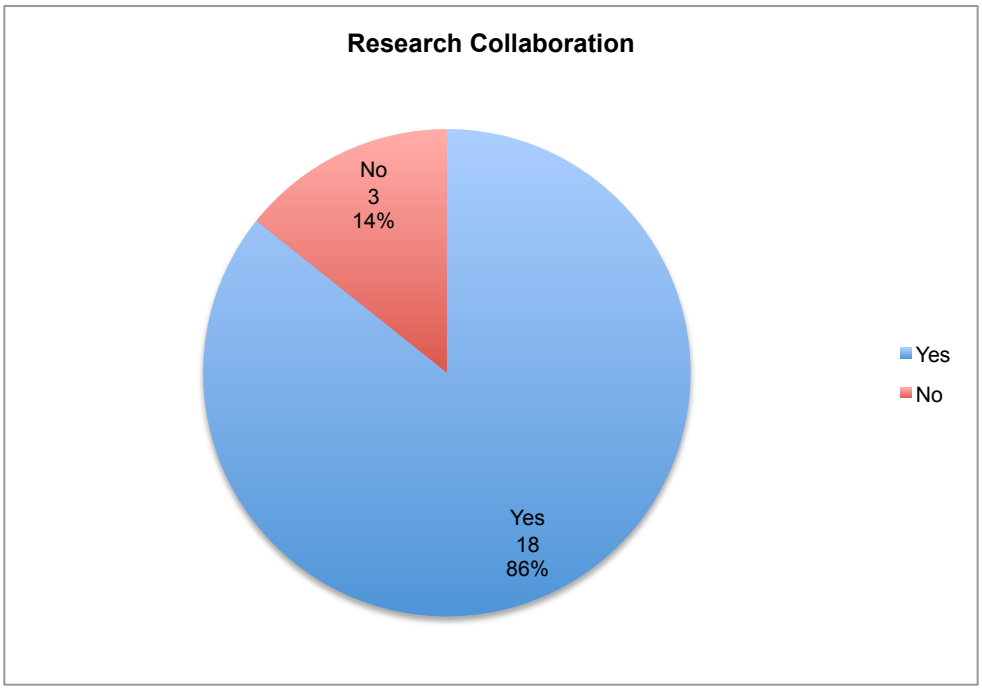

Figure 9: Organizations that collaborate with research organizations in Jamaica (n=22)

Observations:

The majority of the organizations sampled did participate in some form of research collaboration (86%). Institutions collaborated with are primarily the tertiary institutions in Jamaica, including The University of the West Indies (UWI), the University of Technology (UTECH) and Northern Caribbean University. It was stated by UNEP, that several Universities in the region have been partners on various UNEP lead projects including University of West Indies, CATIE, University of Technology, and University of Guyana. In addition, a number of organizations also collaborate with primary and secondary schools and other research groups such as the Caribbean Maritime Institute, Caribbean Institute for Meteorology and Hydrology and the Centre for Resource Management and Environmental Studies.

Table E4 in Annex E summarizes the responses to the questions related to *education about climate change* in the sampled country.

Observations:

There seems to be an overall belief that climate change is not sufficiently addressed in the education system in Jamaica. Though some organizations were knowledgeable of climate change issues being incorporated at varying education levels, it was also commented that it is insufficient as there is generally a misunderstanding of its meaning and impacts.

All organizations responded positively when asked if education can benefit the community. It was further commented that information on climate change must be presented in a form that is easily understood at all levels.

The USAID/AILEG Community energy efficiency and renewal project was mentioned as being very successful and should be examined for effective approaches for replication.

Jamaica Computing Capacity

Q. How many computers and servers does your organization have?

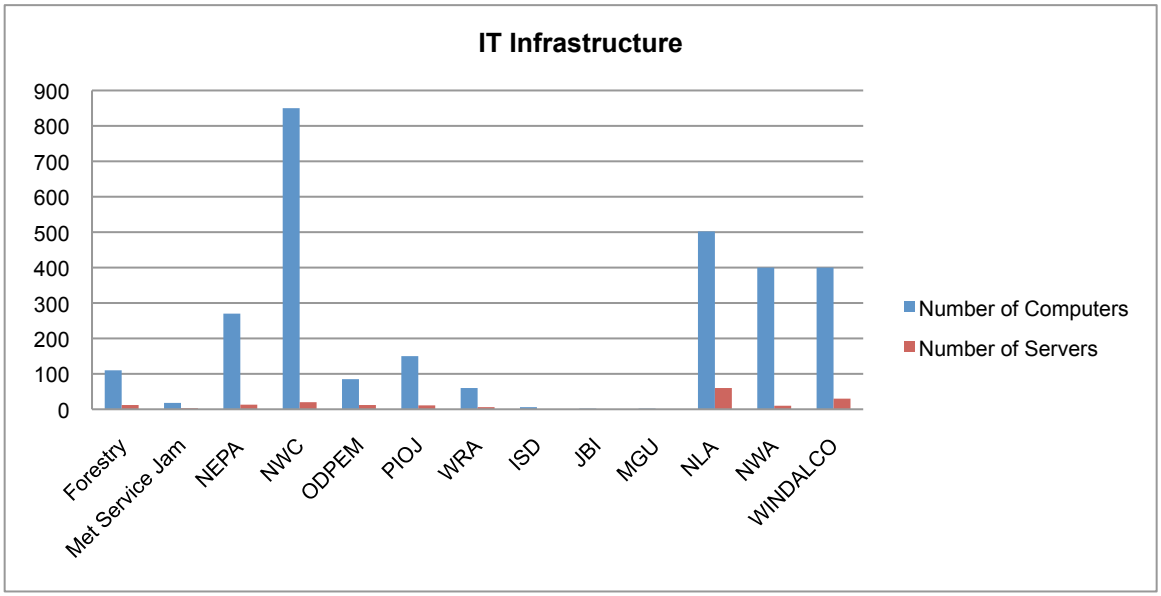

Figure 10: Number of computer and server systems existing at organizations in Jamaica (n=22)

Observations:

The technological system capacity varies dramatically between organizations and this appears to be largely influenced by the size of the organization. Large organizations such as NWC, NLA, NWA and WINDALCO have as many as 400 or more computers existing at the organization. On the other hand, smaller organizations, such as ISD, JBI and MGU have less than ten computers and did not have any servers installed (Figure 8). NLA has the greatest number of servers (60), and this is a combination of physical (30) and virtual (30) servers.

Though varied amongst organizations, the combined physical capacity of the existing computer systems in Jamaica appears adequate. In addition to existing systems numbers, it is also important to examine the architecture of the existing systems given that the C-READ system will ultimately integrate with these systems. From the e-surveys returned, it was observed that the majority of computers and servers are predominately manufactured by Dell, HP and IBM and were installed at varying times between 2005 and 2013. The predominant operating systems are Windows XP or 7 for computers and Windows Server 2003 or 2008 for servers. On computing systems, web browsers include

Internet Explorer (versions 6.0, 8.0 and 9.0), Firefox 12 and Google Chrome. On servers, the web server software included IIS (versions 5.0, 6.0, 7.0 and 7.5) and Apache Tomcat (versions 2.2.14 and 7.0), whilst the application server software were: IBM WebSphere, ArcGIS, ASP.NET, PHP 5.3.1, ACCPAC, BizPay, MS Exchange, MS Office, AutoCAD, HRMIS and AS400. Microsoft SQL Server (2000, 2005 and 2008), Clidata, Oracle, MySQL 5.1.41 and AS400/ Access were the data server software listed to be in use on servers.

Q. What type of Internet connection does your organization have?

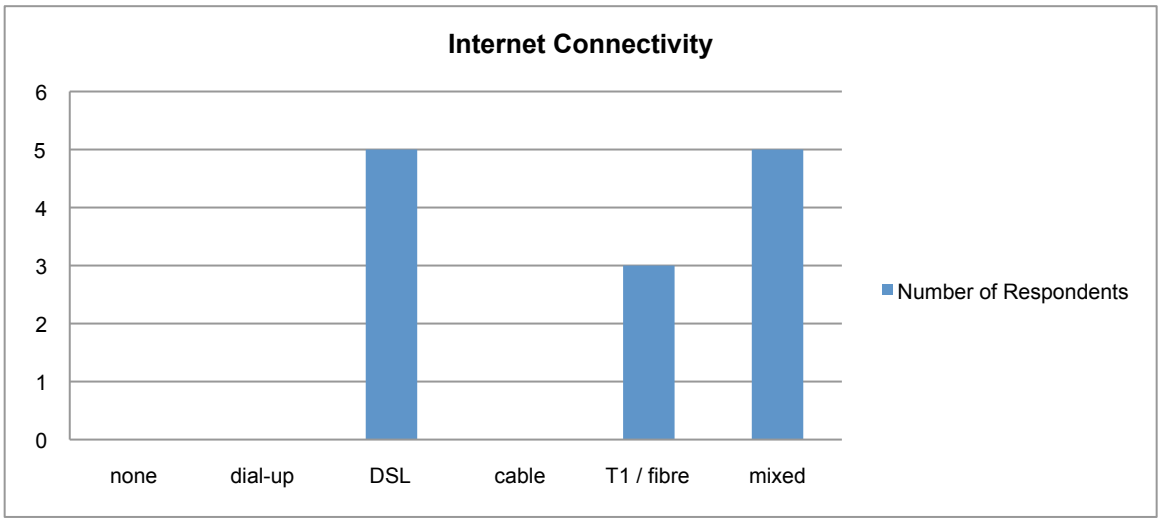

Figure 11: Internet connection types present at organizations in Jamaica (n=13)

Observations:

All organizations that responded to this question had some type of Internet connection and therefore Internet connectively is certainly not an issue in Jamaica. Of the thirteen respondents to the IT survey, 5 utilized solely DSL, 3 solely fibre/ T1 connections and the remaining 5 utilized a mixture of ADSL/ DSL, cable, fibre and T1.

Q. Describe the number and roles of staff in IT in your organization

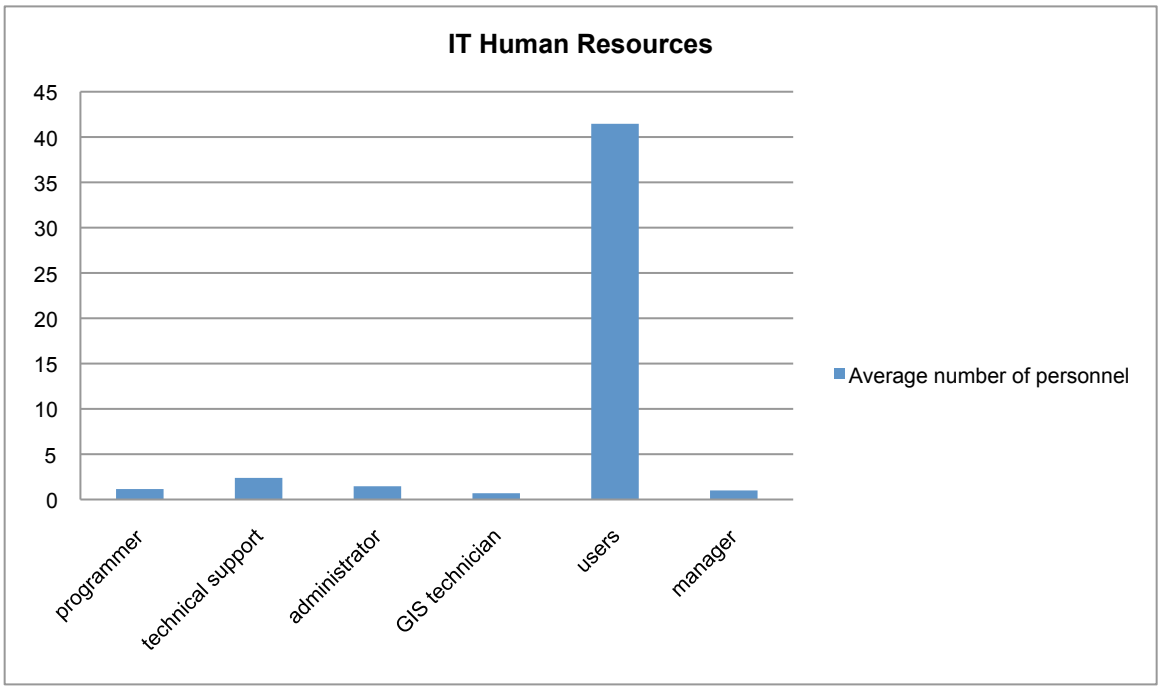

Figure 12: Number of persons in IT staff roles at organizations in Jamaica (n=13)

Observations:

It is imperative that different types of users and their capabilities are identified in order to effectively design the C-READ system. On average, the users group is by far the largest group of IT roles identified in Jamaica by the thirteen IT survey respondents, an average with 41 users per organization. Technical support roles were specified to be for networks and users and this role comprises, on average, 2 persons per entity. The role of administrator was a mixture of system, database and network administrators (1 administrator per entity). In addition, an average of 1 programmer or software developer, 1 person within management and 1 GIS technician (technicians, analysts and information officers) per entity were identified.

As it relates specifically to GIS functions, only two organizations specifically identified GIS roles. It must be borne in mind that respondents may have separated "IT" from "GIS" roles and as such did not explicitly include those having GIS functions under this question pertaining to IT staffing. Further, only three organizations possessed persons who were knowledge of GeoNode (WRA, ISD and WINDALCO); however as stated by one organization, while persons may not have working knowledge of Geonode, other geospatial tools are used.

Table E5 in Annex E summarizes the additional comments and recommendations related to IT in Jamaica.

Jamaica Meteorological and Climate Data

Table E6 in Annex E summarizes the responses to the questions related to meteorology and climate data.

Observations:
There is an obvious need for additional weather stations that measure a range of parameters in order to attain better coverage and quality of information across the island. There also seem to be gaps regarding availability and access to information both on the national and regional scale. In order to improve on data management, policy and training exercises were suggested.

Given the urgent need for access to data, the C-READ system must be designed in a way to facilitate easy access to required data.

Q. Overview of Data Acquisition for Meteorological and Climate Data

Table E7 in Annex E summarizes the stations collecting met and climate data across Jamaica

The following table outlines the types of environmental data stored, format of storage, and methods of sharing in Jamaica.

Table 27: Overview of meteorological, hydrological and environmental datasets collected or managed in Jamaica

Data Type	Org.	Measured Parameters	Storage	Share
Meteorological	Met Service of Jamaica	Precipitation, Solar radiation, Temperature, Humidity, Wind speed (10m), Atmospheric pressure (z), Wind direction, Dew point temperature	Spreadsheet	Private and public
Meteorological	NWC	Temperature	Spreadsheet	Other departments
Meteorological	WINDALCO	Precipitation, Solar radiation, Temperature, Humidity, Wind speed (10m), Wind direction		Other departments
Hydrological	NWC	Sediment - suspended, Sediment - bed load, Surface water depth - static, Ground water depth, Ground water depth - dynamic, Ground water depth - static, Discharge, Abstraction, pH, Turbidity, Dissolved Oxygen, Salinity, Phosphate, Nitrogen, Fecal coliforms, Total coliforms	ASCII/ spreadsheet /database (type) / paper	Other organizations

Data Type	Org.	Measured Parameters	Storage	Share
Hydrological	WRA	Stage, Surface water depth - static, Ground water depth, Ground water depth - dynamic, Discharge, Abstraction	Spreadsheet	Other organizations
Environmental	NEPA	Air quality: NOx, SOx, PM10, TSP	Database	Yes
Environmental	NEPA	Water quality: NO3, PO4, FC, BOD, DO	Spreadsheet	Yes
Environmental	NEPA	Sea temperature	Download	Yes
Environmental	NEPA	Live coral coverage	Spreadsheet	Yes
Environmental	NEPA	Beach profile	Spreadsheet	Yes
Environmental	NWC	Water Quality Parameters (Water Safety Plan, WSP)	Spreadsheet/ database/ paper	Other departments and other organizations

Observations:
The Meteorological Service of Jamaica currently monitors close to 200 rain gauges, 4-6 manual climate stations, 4 intensity rainfall loggers and 51 AWS's (though only one station was reported by the Meteorological Service **Table E7 in Annex E**). In addition to this organization, the NWC currently has 3 weather stations, one of which records temperature automatically, and WINDALCO, that has one manual station recording a range of parameters (station name/code was not specified by WINDALCO).

Storage of data is similar amongst agencies (spreadsheet), though transmission varies (download and paper). Further, data collected at the three agencies is currently shared with other entities.

Jamaica Hydrological Data

Table E8 in Annex E summarizes the responses to the questions related to hydrological data.

Observations:
As mentioned previously, the WRA is responsible for the management of Jamaica's water resources. WRA mentions a number gaps as described **Table E8 in Annex E**, and these primarily relate to spatial gaps in station locations, lack of resources (human resources and funding) and need for improved temporal resolution and data quality. A number of respondents also stated that additional stations are required, including upstream stations for "background" information.

Within WRA, a number of systems have been put in place in order to comply with international standards and improve data management within the organization. However, such standardization processes need to be extended to the nation and region in order to facilitate data sharing; this should certainly be addressed by the C-READ system.

Q. Overview of Data Acquisition Hydrological Data

Table E9 in Annex E summarizes the stations collecting hydrological data across Jamaica

Observations:
WRA reported to have approximately 200 stations that collect surface water data and about the same number of stations collecting groundwater information; though as seen in **Table E9 in Annex E**, only information for three station locations were completed in the returned survey but WRA has been requested to provide a full specification for their stations. In addition to WRA, NWC is the only other agency reporting to collect hydrological data. The NWC has over 400 water treatment plants island wide and these plants all monitor a total of 16 parameters as listed **Table E9**, the data from which are compiled into monthly reports.

Jamaica Environmental Data

Table E10 in Annex E summarizes the responses to the questions related to environmental data.

Observations:
On the national level, it was stated that data gaps exist for remotely sensed data, field (ground truth) data, toxic gases, species, ecosystem services, coastal zone change, tides and bathymetry. In addition, gaps relating to data management, such as lack of standardized data collection and reporting as well as archived paper records in need of conversion and data access were mentioned. It was also reported that laboratory and equipment improvements are needed.

It was expressed that similar data gaps exist on the regional level, and in addition to these, there is no central repository for data. Indeed, the main purpose of the C-READ system is to address this. Further, it was noted that more collaboration amongst stakeholders and a synchronization of efforts to avoid duplications and knowledge of existing data is needed. Standards and equipment are required in order to facilitate the coordination amongst stakeholders.

Q. Overview of Data Acquisition of Environmental Data

Table E11 in Annex E summarizes the stations collecting environmental data across Jamaica

Observations:
NEPA is the main government agency responsible for monitoring, managing and protecting the natural resource assets of the island. The agency processes and approves applications for environmental permits and licenses, planning and development, change of land use, construction and operation of prescribed industrial facilities, sewage discharge and industrial waste discharge. It has five main type of monitoring programs as listed in **Table E11 in Annex E**, three of which are manual types of data collection (water quality, coral reef health, beach profile change) and two automatic (air quality and sea temperatures). All parameters, with the exception of air quality are monitored at sites located across the island.

In addition to NEPA, NWC was the only other agency that reported to collect environmental data. NWC manually collects water quality information along the Rio Cobre as part of the Water Safety Plan. Both NWC and NEPA share information with other organizations.

Jamaica GIS Data

Q. Overview of GIS Data

Table E12 in Annex E lists all the geospatial datasets collected by organizations Jamaica.

Observations:
A total of twelve organizations collect various GIS datasets and this gives some indication of GIS capabilities at organizations in Jamaica. All datasets collected are referenced in the Jamaican coordinate system (JAD 2001) and exist as ArcGIS shapefiles. Further, it was reported that some datasets may not be collected by the organization itself, but are acquired through the Land Information Council of Jamaica (LICJ) data sharing exercises. Indeed, the LICJ is primarily responsible for coordinating and ensuring the implementation of the national land information policy and strategy and the national GIS network. The Council has begun to establish a framework to promote data sharing and to ensure compatibility among existing and proposed land information systems, in order to deliver better, and timelier, information to decision makers and users. Unquestionably, coordination with the LICJ is paramount in designing the geospatial aspects of the C-READ system. Similarly it is important to make mention of the Caribbean Risk Atlas, which was developed recently for integrated data sharing on risk and disasters in the region. Observations, limitations and recommendations resulting from this project will perhaps be useful to the C-READ system design.

Table E13 in Annex E summarizes the comments and recommendations for GIS in Jamaica.

5.3 Belize

5.3.1 Overview of Belize

Figure 13 shows the sectors/ themes from which the seven participating organizations in Belize belong (the full listing of the organizations may be seen in Table 3). The "Environment" sector was represented by 57% (4 organizations), with Hydromet having 14%, Health having 14% and Agriculture having 15%.

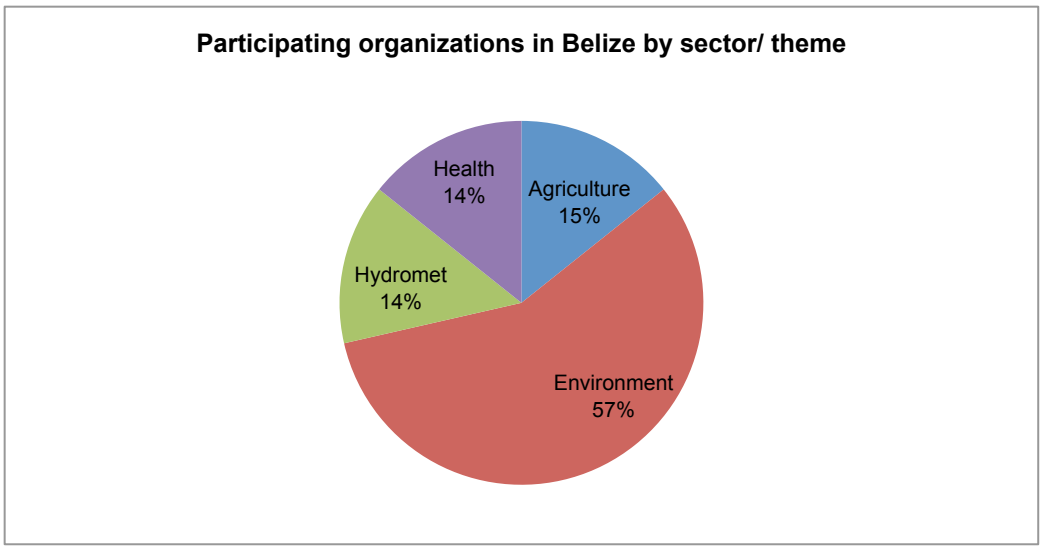

Figure 13: Participating organizations by sector/ theme (n=7)

5.3.2 Results for Belize

Belize Monitoring Overview

Q. Number of Organizations that Collect Time Series or GIS Monitoring Data

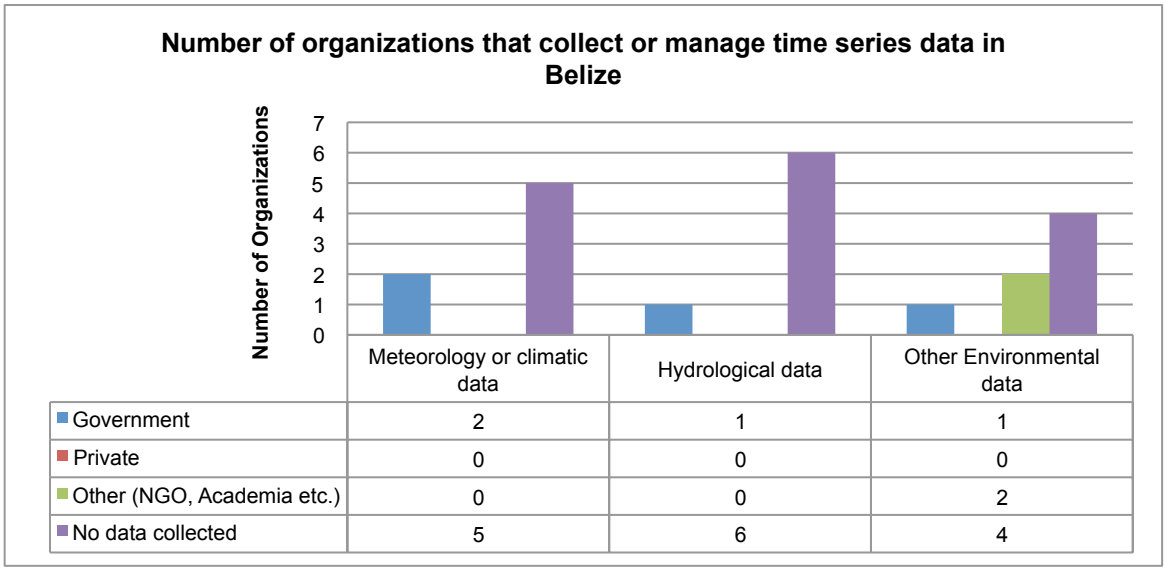

Figure 14: Number of organizations that collect or manage time series data in Belize (n=7)

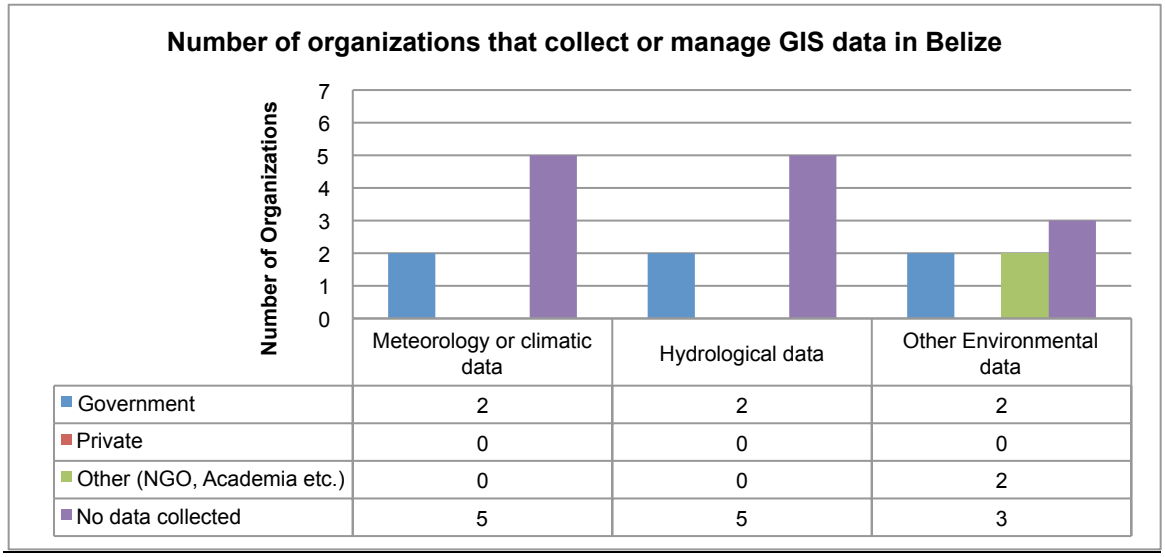

Figure 15: Number of organizations that collect or manage time series data in Belize (n=7)

Observations:
Of the six organizations that returned the management component of the electronic survey, two of them sampled time series as well as GIS data for meteorological and climatic monitoring (See Box 5 and Box 6). They are:

Box 5: Meteorological and climatological time series data in Belize

1) MNRA (Ministry of Natural Resources and Agriculture)
2) Belize National Meteorological Service

Box 6: Meteorological and climatological GIS data in Belize

1) MNRA (Ministry of Natural Resources and Agriculture)
2) Belize National Meteorological Service

In terms of hydrological monitoring, only one organization sampled time series data.

Box 7: Hydrological time series data in Belize

1) Belize National Meteorological Service

There were two organizations sampled GIS data for hydrological monitoring (Box 8)

Box 8: Hydrological GIS data in Belize

1) Belize National Meteorological Service
2) Coastal Zone Management Authority

For environmental monitoring, three organizations collect time series data (Box 9)

Box 9: Environmental time series data in Belize

1) Healthy Reefs
2) Ministry of Health
3) TIDE (Toledo Institute for Development and Environment)

Four organizations collect GIS data for environmental monitoring (Box 10):

Box 10: Environmental GIS data in Belize

1) Healthy Reefs
2) MNRA (Ministry of Natural Resources and Agriculture)
3) TIDE (Toledo Institute for Development and Environment)
4) Coastal Zone Management Authority

There is a significant amount of time series and GIS data collected by survey respondents. The data are in various formats and collection processes used by organizations in Belize are listed in Appendix F. There is further work to be done in establishing protocols for data sharing between these organizations and with C-READ. Phase 2 will address these issues in the initial stages of design and creation of use-case-scenarios.

Q. Number of Organizations Monitoring key National Issues

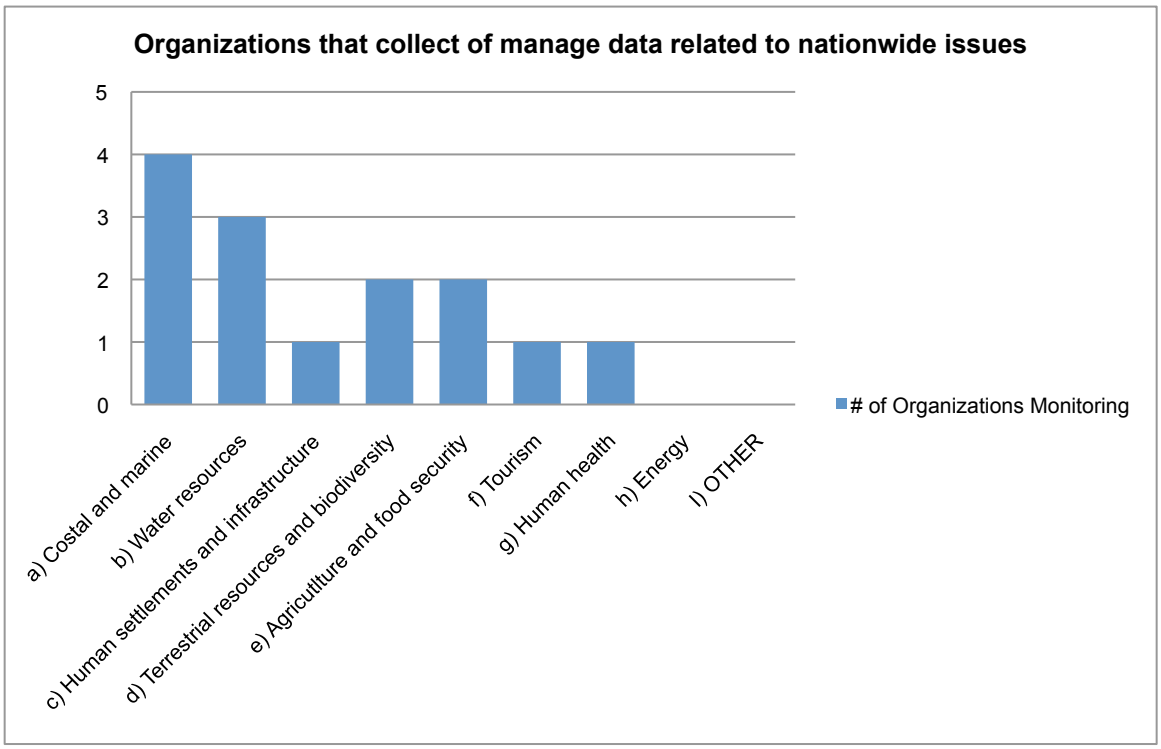

Figure 16: Number of organisations monitoring key national issues in Belize (n=7)

Observations:
Of the six organizations that responded to the management component of the electronic survey, 4 indicated they address coastal and marine issues, 3 indicated that they address water resources, 2 cover terrestrial resources and biodiversity, and 2 organizations address agriculture and food security. The following are some details pertaining to data collection pertaining to these issues:

Coastal and Marine:
Healthy Reefs provides training for biologists from Mexico, Belize, and Honduras in reef monitoring. They produce a reef health "report card" as well. TIDE has done assessments of mangroves and sea grass cover and monitor reef health. TIDE monitors the populations of lobster, conch, finfish, and sea cucumber. The Ministry of Health monitors coastal water quality as an aid to the Coastal Zone Management Authority.

Water Resources:
The Ministry of Health samples water quality at bore wells as a proxy to determine safety of public drinking water. TIDE monitors rivers in Southern Belize for dissolved oxygen, salinity, pH, turbidity, temperature, sedimentation, phosphates, and nitrates.

Terrestrial Resources and Terrestrial Biodiversity:
TIDE monitors for mammals (including bats), birds, and amphibians using 1000 metre transects.

Agriculture and Food Security:
Healthy Reefs monitors reefs for commercial fish species, an important aspect of food security. MNRA monitors crops for production, yields, and costs of production.

Tourism:
Healthy Reefs monitors reef vitality as these are considered a main contributor to tourism.

Q. Climate Change Priority Issues

Climate change priorities of organizations in Belize were very dependent on the primary mandate of each organization. **Table F1 in Annex F** summarizes climate change priorities for Belize.

Observations:
An overarching concern of organizations in Belize was the health of reefs and the coastline. The risks posed by ocean acidification and increased sea surface temperature were issues that are of high priority. Environmental impacts on the health of different species were raised as issues, as were impacts of climate change on vector borne diseases. Disaster management and risk reduction for communities are priorities. The sharing of temperature and precipitation data was identified as a national priority.

Belize General Data Procedures and Policies

Table F2 in Annex F summarizes the responses to the questions related to data management in Belize.

Observations:
Data is collected by several of the organizations sampled depending on their focal areas. For example, Healthy Reefs monitors reefs for their health and does periodic sampling of a variety of parameters. The data gathered by the respective agencies is listed in the summary of meteorological, hydrological, environmental, and GIS data results sections.

In terms of data sharing, the respondents indicated that they generally maintain all ownership of their data but are open to sharing compiled data if agreements are put in place. Data sharing protocols will need to be established as part of the design of the C-READ management system. Security concerns with respect to some data was raised as an issue. There may need to be levels of security attached to different data sets. Another interesting point raised by TIDE was the fact that community engagement in data gathering is a priority for them. This level of transparency and involvement could serve as a constructive approach for the C-READ management system.

Belize Regional DMS Recommendations

Table F3 in Annex F summarizes the responses to the questions related to data management. There are some particularly important comments with respect to how these organizations will benefit from the DMS.

Observations:
The responses were positive overall with respect to the need for a database management system that integrates national and regional data sets in the Caribbean. There is a great concern for the impact of climate change on the coastline of Belize and on the health of the reefs. The risk of sea level rise and impacts from storms were also raised as important concerns. The following are data products that were suggested by survey respondents.

- Reef health indices supported by real time data
- Coral bleaching hot-spots
- Contour maps of the country
- Agricultural production monitoring in wet season vs. dry season
- Water availability maps
- Biodiversity maps
- Flood risk vs. socioeconomic vulnerability assessments
- Monthly precipitation and relative humidity vs. solar radiation
- Agriculture potential forecast on land usage

- Projected trends in temperature and precipitation.
- Soil moisture
- Drought map in the dry season; flood maps in the wet season; runoff maps.
- What is the drought risk at given locations
- What is the average monthly precipitation, land slope, vegetative cover and soil type for Southern Belize
- What is the average monthly wind direction and speed in Southern Belize
- What is the rate of deforestation through annual forest cover change detection analysis

Belize Outreach and Education

Q. For your organization, on a scale of 1 to 5, rate the level of need for human resources capacity building with respect to climate change and its impacts / data collection / and GIS (average amount for all respondents).

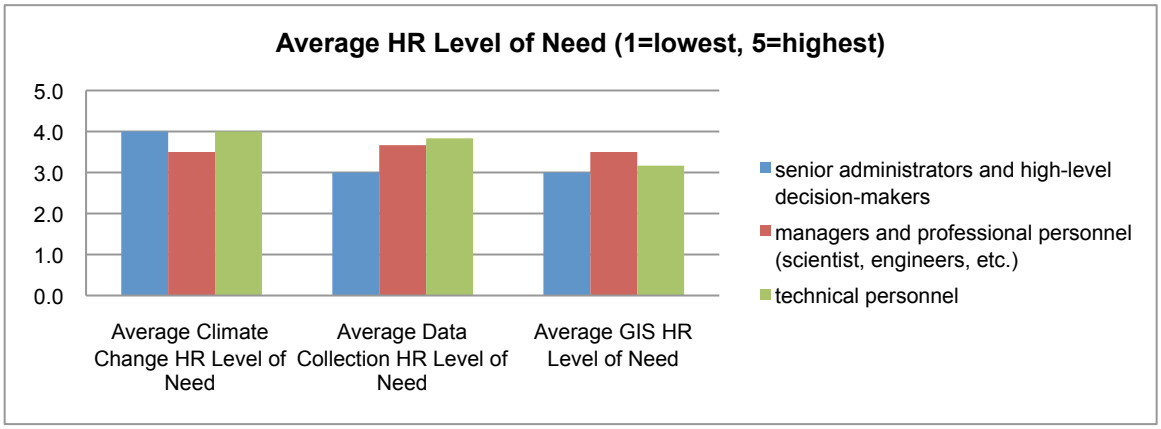

Figure 17: Average level of need for human resources capacity building in Belize (n=7)

<u>*Observations:*</u>
Figure 17 shows that the highest level of need for human resources for a given area was for climate change in Belize for senior administrators (4.0) and technical personnel (4.0). The average level for each of the categories of personnel for the three types of HR functions is: climate change (3.8), data collection (3.5), and GIS (3.2). These results show that there is a greater requirement for climate change personnel. This is in agreement with the monitoring priorities that respondents indicated previously. Close attention should be paid to specifically what skills are lacking on the part of organizations concerned with environmental and climate change in the Caribbean region.

Q. Does your organization collaborate with research organizations and academic institutions, list them?

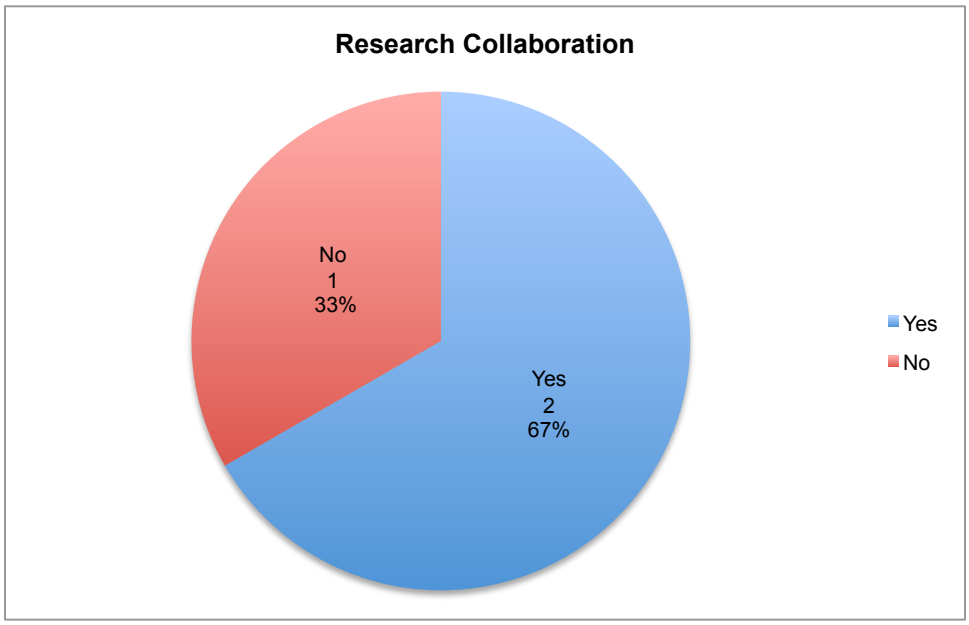

Figure 18: Organizations that collaborate with research organizations in Belize (n=3)

<u>*Observations:*</u>
The majority of the organizations sampled did participate in some form of research collaboration (67%). The institutions they collaborate with are: Smithsonian Institution, UNAM, CINVESTAV, UB, CURLA-UNAH, CIMH, and Texas A&M University.

Table F4 in Annex F summarizes the responses to the questions related to education about climate change in the sampled country.

<u>*Observations:*</u>
The survey respondents indicated that education related to climate change was not adequately addressed in schools or in the general public. One group indicated that the risks of climate change needed to be "de-mystified" for citizens. One group indicated that information and awareness should be the focus at the primary levels but responsible action should be the focus for intermediate and senior student levels. Outreach in Belize should also connect with stakeholders in the private sector who may have impacts or may be subject to impacts of these changes.

Belize Computing Capacity

Q. How many computers and servers does your organization have?

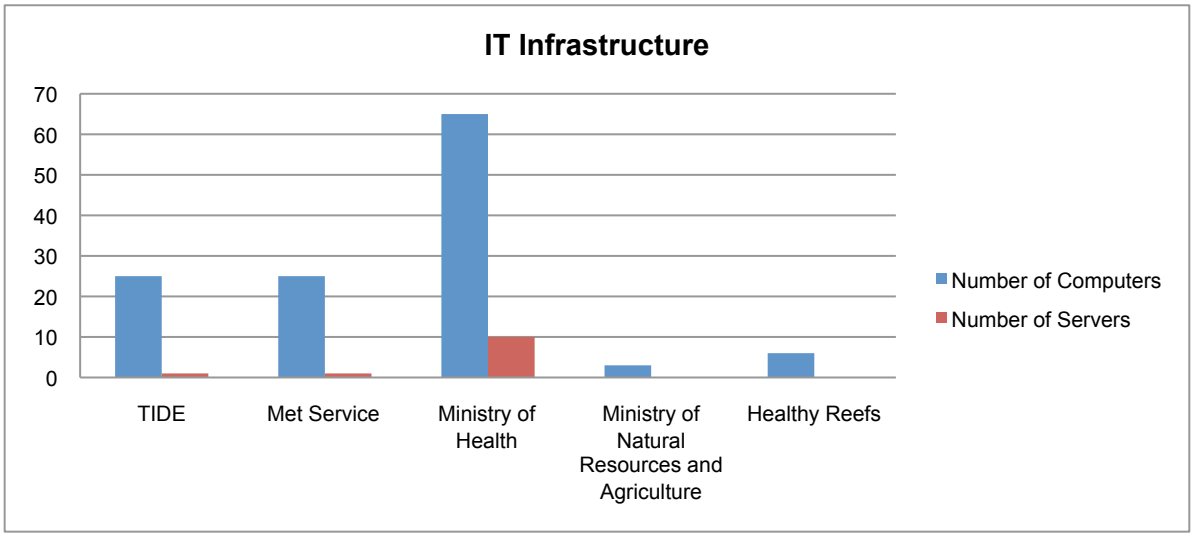

Figure 19: Number of computer and server systems existing at organizations in Belize (n=5)

Observations:
Each organization has varying degrees of technological capacity. The Ministry of Health clearly has the most servers (10) and computers (65). Some key ministries such as the Ministry of Natural Resources and Agriculture only have three computers and no servers. The Regional Plan of Action will have to address technological shortcomings of organizations that need to be able to access and benefit from the C-READ management system.

If organizations are to contribute to the C-READ management system close attention will need to be paid to the architecture of their IT infrastructure. The computers in the respondent organizations run Windows operating systems (Windows 7 and XP) and MacOS. The servers are running Linux, Centos 6.4, and Windows 2003 as well as Apache / Jetty / Tomcat web server software. Examples of software applications that are used are: Windows MS Office 2010, SQL Server, ArcGIS, MS Access, Rainbow Radar Software, Imetos, Loggernet AWS Software, and Hoboware.

Q. What type of Internet connection does your organization have?

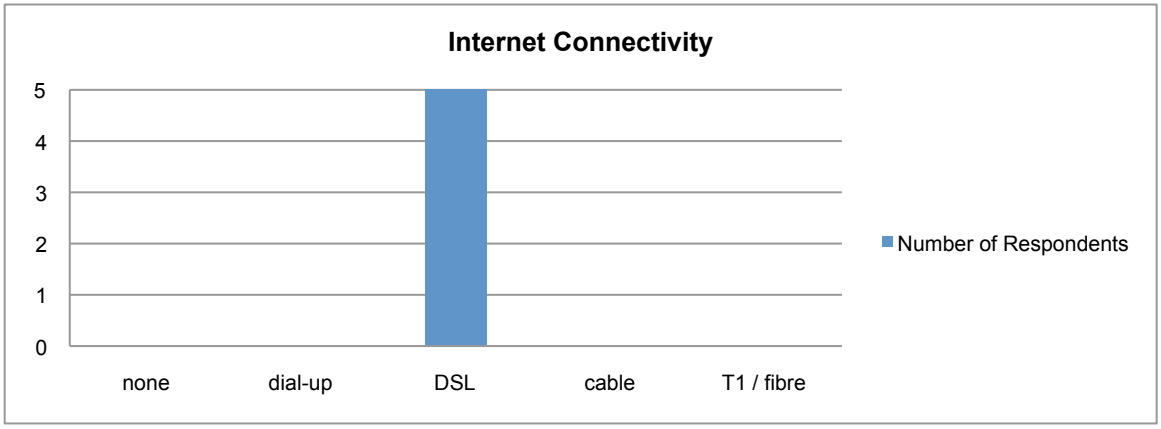

Figure 20: Internet connection types present at organizations in Belize (n=5)

Observations:
All survey respondents indicated they had a DSL (dedicated line) Internet connection, as shown in Figure 20. This indicates that data transfer will not be a significant problem in Belize.

Q. Describe the number and roles of staff in IT in your organization

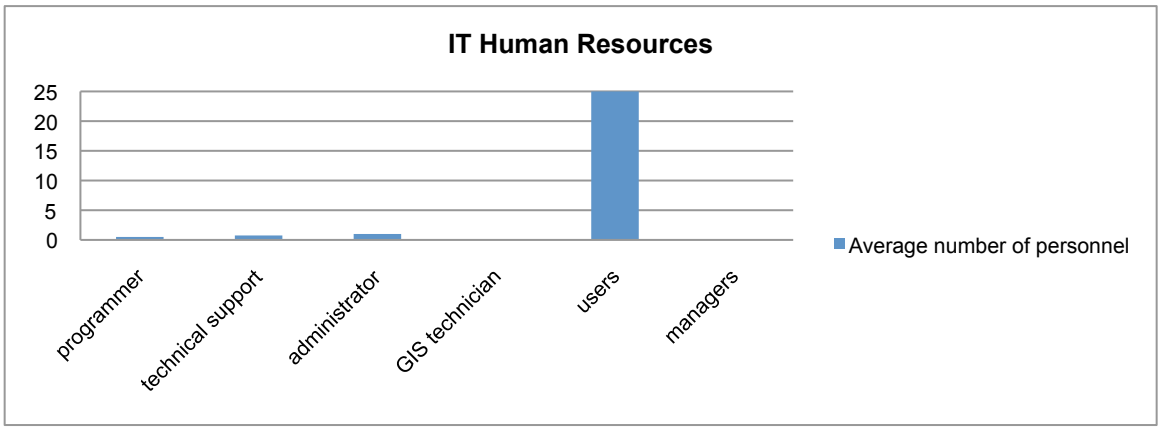

Figure 21: Number of persons in IT staff roles at organizations in Belize (n=5)

Observations:
Survey respondents indicated that they had essentially no GIS personnel. They also had very few administrative resources or programmers. This should be addressed in the Regional Plan of Action.

It is very important that we understand the in-house capabilities of the organizations that will potentially be using and contributing to the C-READ management system in the

process of its design. The user category is the largest, on average, of all that were sampled with a value of 25 from four organizations that provided IT information. There was an average of 1 administrator, 1 technical support, 1 programmer, and no GIS technicians.

Knowledge of GIS technology appears to be a weakness of the organizations sampled. Of all four organizations that responded to the IT component of the survey, there are three people that have knowledge of GeoNode. Considering that this is likely to be the GIS platform of choice for this project, capacity development and training in GIS should be a consideration in subsequent phases. In addition data collection, quality control, and regional and international archival database management should be addressed in these training sessions.

Table F5 in Annex E summarizes the additional comments and recommendations related to IT in Belize.

Observations:
There is not a tremendous amount of IT capacity in Belize, according to the electronic survey respondents. As the C-READ development process ensues our team will have to take into consideration the complexity of the system and the capability of organizations in Belize to use and update it with data. There may need to be additional capacity development for technical training, particularly in data gathering, quality control, archival and GIS.

Belize Met and Climate Data

Table F6 in Annex F summarizes the responses to the questions related to meteorology and climate data.

Observations:
There is a perceived need for more weather stations. An additional 50 meteorological stations were requested in order to provide finer spatial resolution for monitoring. Critical areas such as Belize City may require a higher density of stations. There is a need for more maintenance programs for the AWS with an inventory of spare parts (perhaps as extra stations). More data sharing across the region is required and there must be standards for these shared data sets. Digitization of archival met data is required. One respondent indicated that archiving environmental data is fine but it needs to be made into information products that are accessible to the public and general stakeholders. This will help them to prepare for changes that may occur. Real time visual analysis of large met/climate data is a desired outcome for some organizations in Belize.

Q. Overview of Data Acquisition for met and climate data

Table F7 in Annex F summarizes the stations collecting met and climate data across Belize

Table 28: Overview of datasets collected or managed in Belize

Data Type	Org.	Measured Parameters	Storage	Share
Meteorological	Met Service of Belize	Precipitation, temp, solar radiation, humidity, wind speed, clouds, sunshine, atmospheric pressure, wind direction, wind run, soil temperature, dew point, evaporation,	ASCII	Private and public
Hydrological	Met Service of Belize	Stage, Discharge	HOMS Database / Spreadsheet / Paper	Yes (with licensing)
Environmental	Healthy Reefs Initiative	Several	Paper	Yes
Environmental	TIDE	Water quality: water temp, dissolved oxygen, salinity, turbidity, nitrate, phosphate, sedimentation rate,	Spreadsheet	No
Environmental	TIDE	Lobster abundance, lobster size, lobster gender, lobster maturity	Spreadsheet	No
Environmental	TIDE	Conch abundance, conch shell length, conch lip thickness	Spreadsheet	No
Environmental	TIDE	Finfish abundance, fish tail and fork length, fish maturity	Spreadsheet	No
Environmental	TIDE	Sea cucumber length, weight, abundance	Spreadsheet	No

Observations:
There appears to be very limited meteorological / climate data for Belize. The Meteorological Service of Belize reported only one station. The Meteorological Service also collects hydrological data. The NGO's Healthy Reefs and TIDE collect a variety of species-related environmental data in marine environments of Belize. More detailed information related to monitoring can be found in Annex F.

Belize Hydrological Data

Table F8 in Annex F summarizes the responses to the questions related to hydrological data in Belize.

Observations:
There is a desire for improvements to hydrological monitoring in Belize. The respondents were not aware of the extent of hydrological monitoring that is done across the country. Hence, there is not wide public knowledge of these processes. The Meteorological Service of Belize was the only organization that reported any hydrological monitoring stations.

Q. Overview of Data Acquisition hydrological data

Table F9 in Annex F summarizes the stations collecting hydrological data across Belize.

Observations:
Hydrological monitoring in Belize is limited. There are three stations reported by the Meteorological Service and all of them are manual. This data is stored in digital form in the HOMS database. Therefore, this data could be integrated into a regional database management system. However, it will need to be transformed into the database management systems data model and uploaded. Alternatively, information on how to retrieve the data from the Meteorological Service will need to be given by the regional DMS.

Belize Environmental Data

Table F10 in Annex F summarizes the responses to the questions related to environmental data in Belize.

Observations:
The respondents indicated that hydrological and meteorological monitoring is sufficient for now but that there are some significant gaps in monitoring the effects of climate change on ecosystem productivity. Reef monitoring has been well maintained but in other areas there has been a fragmented approach. Belize has a variety of diverse biogeoclimatic zones, which makes it challenging to monitor. Higher coordination on water quality is a priority as is further collaboration between entities. Funds are limited therefore more has to be done with less financial resources. Increased efficiency, leveraging technology, and more collaboration could help with this. One group suggested an ecosystem service based model for monitoring, similar to the Millennium Assessment.

Q. Overview of Environmental monitoring data

Table F11 in Annex F summarizes the stations collecting environmental data across Belize.

Observations:
The monitoring programs in the marine environment seem very robust and are producing good results. Climate change is a regional phenomenon and often requires regional data sets for analyzing impacts.

Belize GIS Data

Q. Overview of GIS data

Table F12 in Annex F lists all the geospatial datasets collected by organizations Belize

Observations:
The GIS data that was reported by survey respondents is fairly extensive and addresses infrastructure issues as well as environmental impacts. There is some discrepancy in the projections of the different data sets and this will need to be addressed in the design of the C-READ management system. Data sets from different organizations listed in **Table F12 in Annex F** can be used to create some of the information products that have been requested. For example, risk posed by steep slopes and periods of high rains. The GIS data that is collected is collected by stakeholders is shared through structured partnerships or approved requests for information. The Coastal Zone Management Authority is the only organization that does not share its GIS data.

5.4 Dominica

5.4.1 Overview of Dominica

Figure 22 shows the sectors/ themes from which the seven participating organizations in Dominica belong (the full listing of the organizations may be seen in Table 4). The "Environment" sector was represented by 43% (4 organizations). The remaining sectors represented were Hydromet (14% - one organization), Health (14% - one organization), Water Supply (14% - one organization), and Agriculture (14% - one organization).

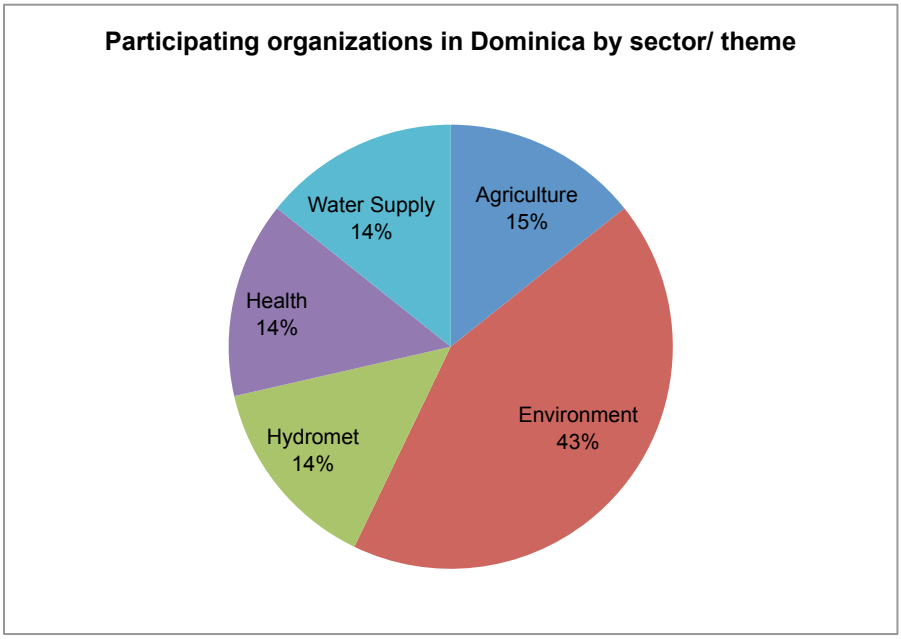

Figure 22: Participating organizations from Dominica by sector/ theme (n=7)

5.4.2 Results for Dominica

Dominica Monitoring overview

Q. Number of Organizations that Collect Time Series or GIS Monitoring Data

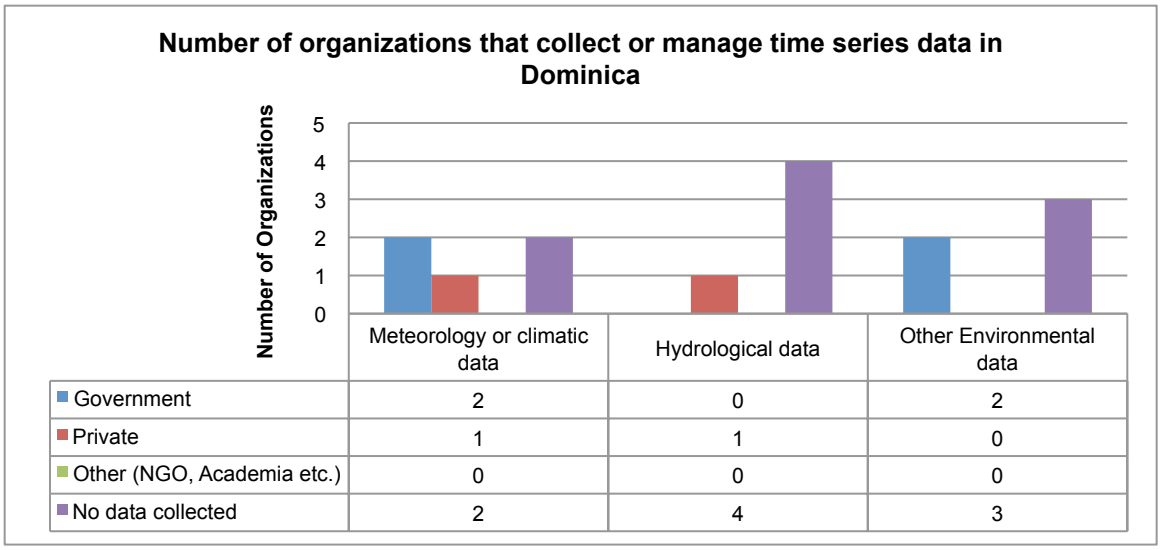

Figure 23: Number of organizations that collect or manage time series data in Dominica (n=5)

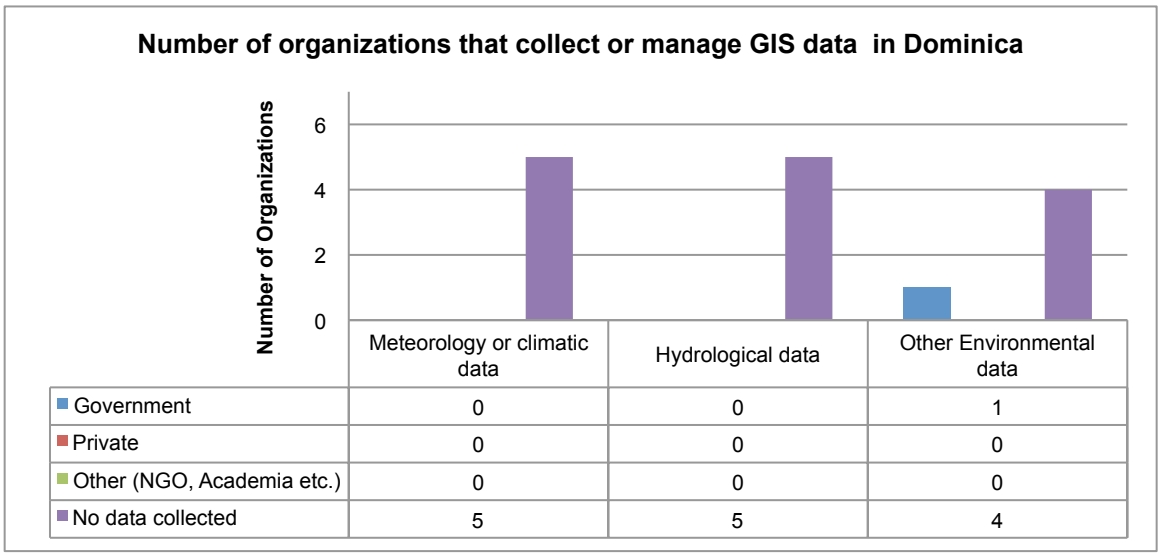

Figure 24: Number of organizations that collect or manage GIS data in Dominica (n=5)

Observations:

Of the five organizations that completed the management electronic survey three of them sampled time series data for meteorological and climatic monitoring. They are: Dominica Meteorological Service, DOWASCO, and the Ministry of Agriculture and Forestry (Box 11).

Box 11: Meteorological and climatological time series data in Dominica

1) Dominica Meteorological Service
2) DOWASCO (Dominica Water & Sewage Company)
3) Ministry of Agriculture and Forestry

One organization, namely DOWASCO, sampled time series data for hydrological monitoring but no GIS data.

Box 12: Hydrological time series data in Dominica

1) DOWASCO

Two organizations sampled time series data for other environmental monitoring

Box 13: Environmental time series data in Dominica

1) Ministry of Agriculture and Forestry
2) Ministry of Environment, Natural Resources, Physical Planning and Fisheries

One organization, Ministry of Environment, Natural Resources, Physical Planning and Fisheries, reported that they gather other environmental data in GIS format

Q. Number of Organizations Monitoring key National Issues

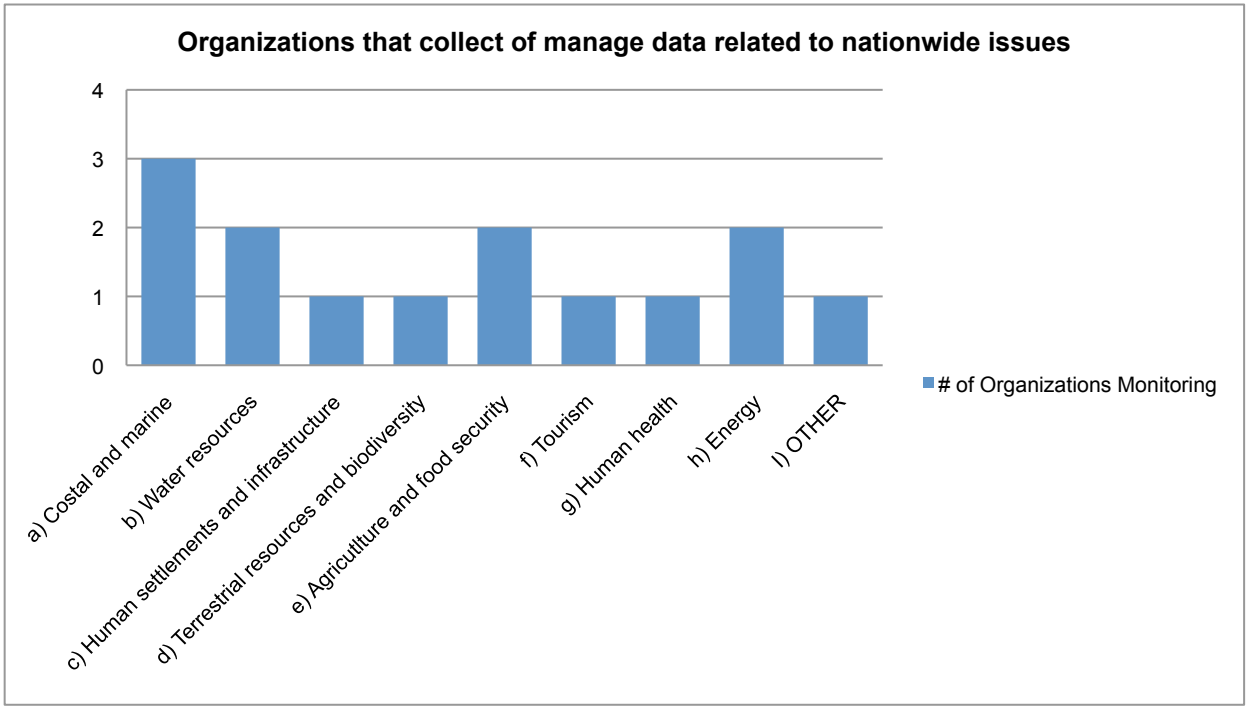

Figure 25: Number of organisations monitoring key national issues in Dominica (n=4)

Observations:

As shown in Figure 19, coastal and marine (3), followed by water resources (2), agricultural and food security (2), and energy are the predominant national issues that survey respondents identified. Organizations also identified human settlements and infrastructure (1), terrestrial resources and biodiversity (1), tourism (1), human health (1), and soil types (1) were also identified as national issues for which data was gathered.

DOWASCO indicated that for coastal and marine environments they monitor BOD near their wastewater treatment plants. For water resource management, they have automated monitoring stations on key rivers and manual stream gauging is done island wide. They monitor water quality (physical, chemical, bacteriological) regularly at all of their water intakes and at various test points throughout their distribution network. They share their hydromet data with the local power company to help them determine hydroelectric potential.

The Ministry of Environment, Natural Resources, Physical Planning and Fisheries addresses the following specific issues in relation to national policy directives: location of corals, sea grass beds, and marine reserve (coastal and marine); hydrology (water resources); settlements (human settlements and infrastructure); forest cover, forest reserves, and national parks (terrestrial resources and terrestrial biodiversity); location of most suitable lands (agriculture and food security); tourism facilities and accommodation (tourism); health centres (human health); location of geothermal resources (energy); and

soil types, utilities, and roads (other). The specific details related to data types, sharing protocols, and formats are shown in Annex G.

Q. Climate Change Priority Issues

Climate change priorities of organizations in Dominica are summarized in **Table G1 in Annex G.**

Observations:
Priority was placed upon identifying areas of vulnerability in certain locations in Dominica based on geographic features such as slope angle and land cover as well as the risk of inundations and storms. Flash floods are a concern. There is a data gap with respect to collecting hydrological, topographical, and infrastructural data required for assessing vulnerability. This gap may be overcome by integrating these data sets and providing querying functionality in C-READ to produce flood risk maps. Water is an abundant resource in Dominica; however there appear to be shortcomings in water quality assessment. Assessment of the quality and availability of water (drought index) throughout the country is a priority. Land cover assessment as well links to flood impacts and vulnerability of communities. Ideally these priority issues in Dominica can be addressed with the C-READ management system. In order to do so, there needs to be financial planning of continuous assessments of such related data and access to it must be granted by the agencies that have gathered it.

Dominica General Data Procedures and Policies

Table G2 in Annex G summarizes the responses to the questions related to data management in Dominica

Observations:
Dominica is gathering various types of data regularly. Several projects such as PPCR have helped to mobilize capacity for climate change adaptation and monitoring to support it. Specifically, water resource management has been critically analyzed and focused work has occurred in order to better understand the function of hydrological systems in Dominica. Investments have been made in analytical software packages as well as monitoring stations. It is important that C-READ be aligned with these ongoing activities.

There is regular hydrological and meteorological monitoring occurring. This is both manual and automated. This data is gathered and integrated into HYDRAS modeling software. Our team will need to examine this software as well as the general work done by PPCR and HYCOS in Dominica. The goal will be to map objectives and functionality so that these systems and monitoring processes complement each other.

There is already a loose working group established for monitoring and data sharing in Dominica. This data will have to be shared with CIMH, which is a regional institution mandated for working with meteorological/hydrological data. Standardized protocols and regular and continuous processes need to be established to guide how this data is to be shared and also the format it is to be transferred in. This may be an important step in the system design process for the sharing of hydrological data in Dominica.

Dominica Regional DMS Recommendations

Table G3 in Annex G summarizes the responses to the questions related to data management in Dominica.

Observations:

The survey responses indicate that the C-READ management system could be an effective tool in helping to inform decision making if it is effectively tied to existing and planned projects. There are a few areas of specific concern that were identified:

1) Flood risk
2) Coastal zone inundation risk due to sea level rise
3) Soil productivity and capability mapping
4) Rain fall patterns and drought risk
5) Mapping of fertilizer and pesticide mapping

Informed decision-making related to environmental quality and climate change risk reduction is the overall summation concern in the comments from stakeholders in Dominica.

Dominica Outreach and Education

Q. For your organization, on a scale of 1 to 5, rate the level of need for human resources capacity building with respect to climate change and its impacts / data collection / and GIS. (average amount for all respondents)

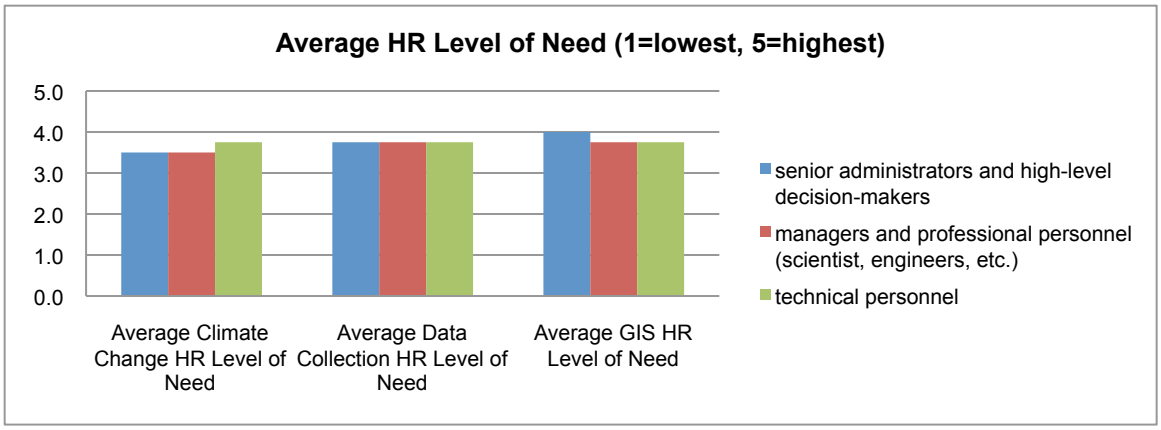

Figure 26: Average level of need for human resources capacity building in Dominica (n=4)

Observations:

The HR level of need across the three skills domains (climate change, data collection, GIS) was fairly consistent. The average level of need in data collection (3.8) and GIS (3.8) was slightly higher than the average level of need for climate change (3.6). There is a slight differentiation in terms of need for HR skill levels for climate change personnel, with technical being the highest (3.8) leading managers (3.5), and senior administrators (3.5)

Q. Does your organization collaborate with research organizations and academic institutions, list them?

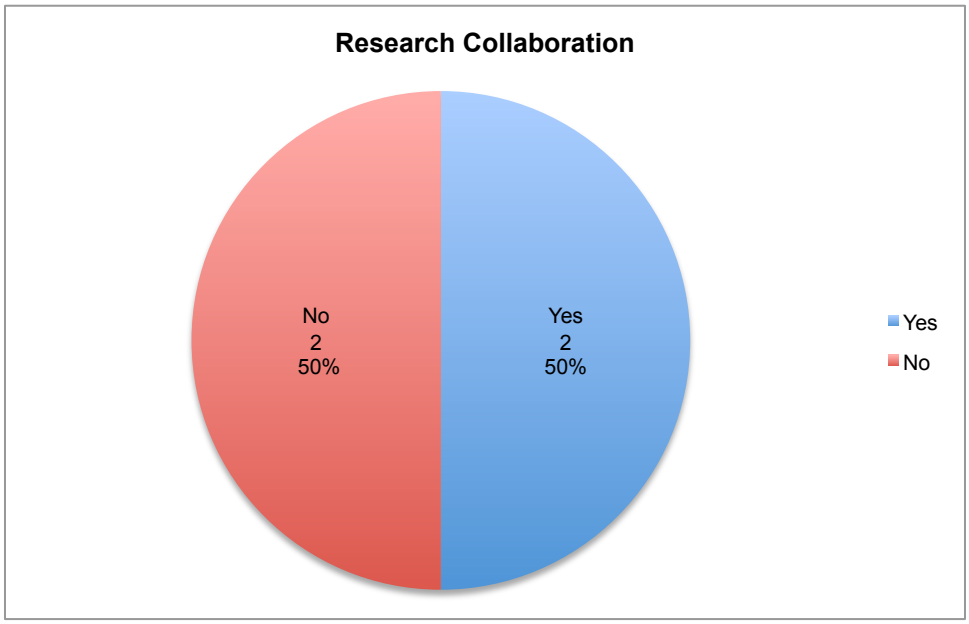

Figure 27: Organizations that collaborate with research organizations in Dominica (n=4)

Observations:
Half of the respondents indicated that they collaborated with academic institutions whereas the other half did not. The groups that were cited as key research / academic collaborators were:

1) Portsmouth University in Wales – M.Sc. student Intern in Climate Change Risk Studies.
2) Local high schools and college
3) UWI
4) CIMH

Table G4 in Annex G summarizes the responses to the questions related to education about climate change in the Dominica.

Observations:
The survey respondents from Dominica clearly stated that climate change education and environmental education as a whole needs improvement. Introduction of environmental and climate change content into the curriculum at all levels was an explicit statement by one organization. Creating a sense of ethical values connected to the environment was also mentioned in the feedback.

Dominica Computing Capacity

Q. How many computers and servers does your organization have?

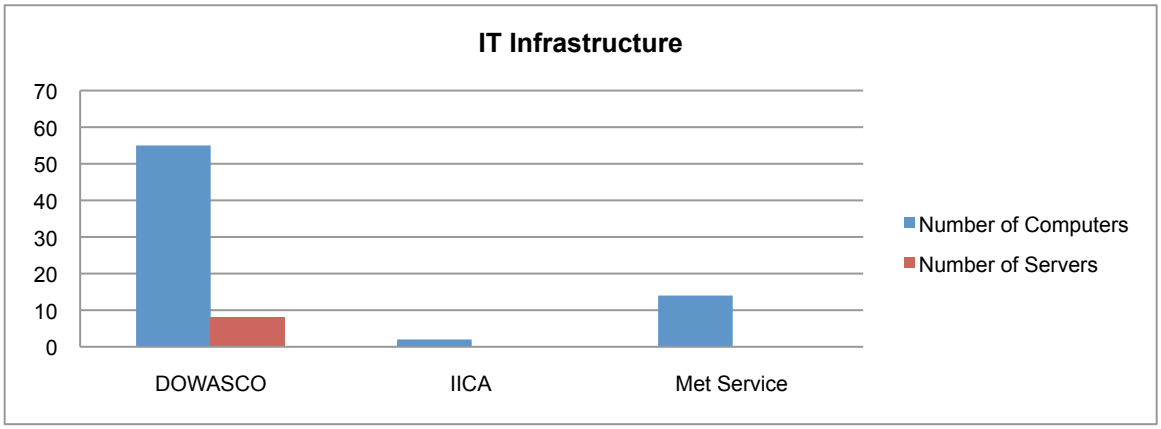

Figure 28: Number of computer and server systems existing at organizations in Dominica (n=3)

Observations:
Each organization has varying degrees of technological capacity. There was a disproportionate amount of IT capacity shown with DOWASCO having 55 computers and 8 servers. The Dominica Met Service had 14 computers and no reported servers. The IICA had 2 computers and no servers reported. There is a rather large variation in the IT capacity between these organizations and this will need to be considered when designing the C-READ management system.

Software architecture will be an element of the C-READ design and the proposed solutions need to mesh with existing configurations within stakeholder organizations. Windows XP, 7, 8, and Vista, were the operating systems reported. Examples of software applications that are used at the sampled organizations are: Microsoft Office, AutoCAD, Personnel Manager, Dynamics GP, and Bill Master.

Q. What type of Internet connection does your organization have?

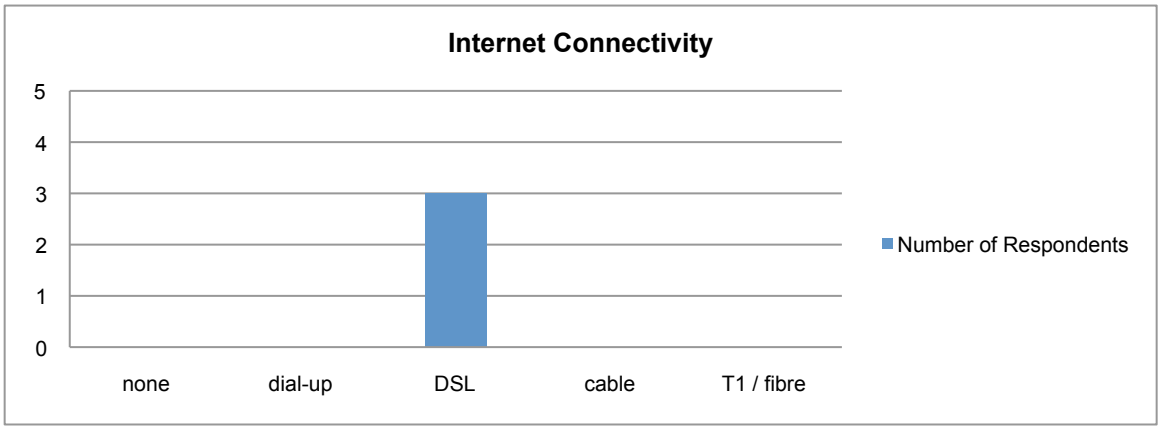

Figure 29: Internet connection types present at organizations in Dominica (n=3)

Observations:
All survey respondents that replied to this question indicated they had a DSL connection. Connectivity should not be considered a problem. However, communication of sensor devices within the country was identified as an issue in previous questions. Proposals are being generated for automated data transfer via GSM networks accessible by automated monitoring stations.

Q. Describe the number and roles of staff in IT in your organization

Observations:
No organizations responded to this question.

Table G5 in Annex G summarizes the additional relevant comments and recommendations (computing) in Dominica.

Dominica Met and Climate Data

Table G6 in Annex G summarizes the responses to the questions related to meteorology and climate data in Dominica.

Observations:
Two key themes raised by stakeholders are standardization of instrumentation and equipment as well as collaboration between national and regional entities. Additionally, maintenance processes (including spares), additional hardware, updated software, and increased training were key issues that were identified. In order to gather good, continuous data, there needs to be a continuous program of maintenance of the equipment, and quality control of acquisition, transfer, and archiving of data.

Q. Overview of Data Acquisition for met and climate data

Table G7 in Annex G summarizes the stations collecting meteorological and climatic data across Dominica.

Table 29: Overview of datasets collected or managed in Dominica

Data Type	Org.	Measured Parameters	Storage	Share
Meteorological	Met Service of Dominica	Precipitation, temperature, humidity, wind speed, solar radiation, sunshine, atmospheric pressure, wind direction, soil temperature, soil moisture, dew point, leaf wetness.	ASCII / dataview database	Yes – pay per use
Hydrological	N/A	N/A	N/A	N/A
Environmental	N/A	N/A	N/A	N/A

Observations:
There are not a large number of meteorological stations that have been reported in the surveys (3 total). The ones that have been described are very comprehensive in their

coverage of environmental variables. Two more AWS are on schedule to be installed in September 2013.

Dominica Hydrological Data

No organizations responded to this question.

Dominica Environmental Data

No organizations responded to this question.

Dominica GIS Data

No organizations responded to this question.

5.5 Saint Lucia

5.5.1 Overview of Saint Lucia

Figure 30 shows the sectors/ themes from which the seven participating organizations in Saint Lucia belong (the full listing of the organizations may be seen in Table 5). The main sectors represented were Agriculture (33% - two organizations), Other – which in this case were the Ministry of Infrastructure, Transportation, and Ports and the National Emergency Management Organization (33% - two organizations), Water Supply (17% - one organization), and Hydromet (17% - one organization).

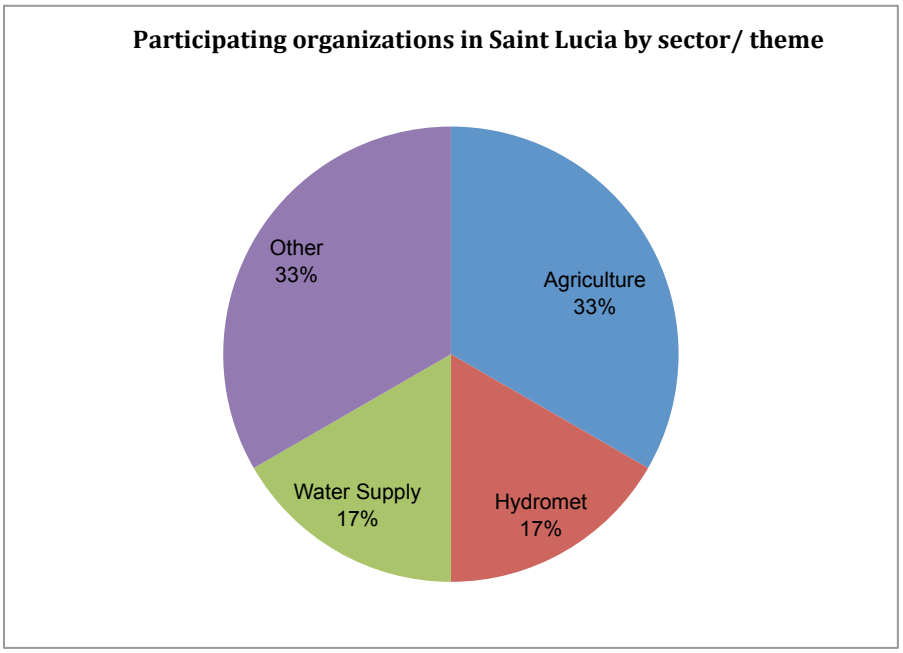

Figure 30: Participating organizations by sector/ theme (n=5)

5.5.2 Results for Saint Lucia

Saint Lucia Monitoring Overview

Q. Number of Organizations that Collect Time Series or GIS Monitoring Data

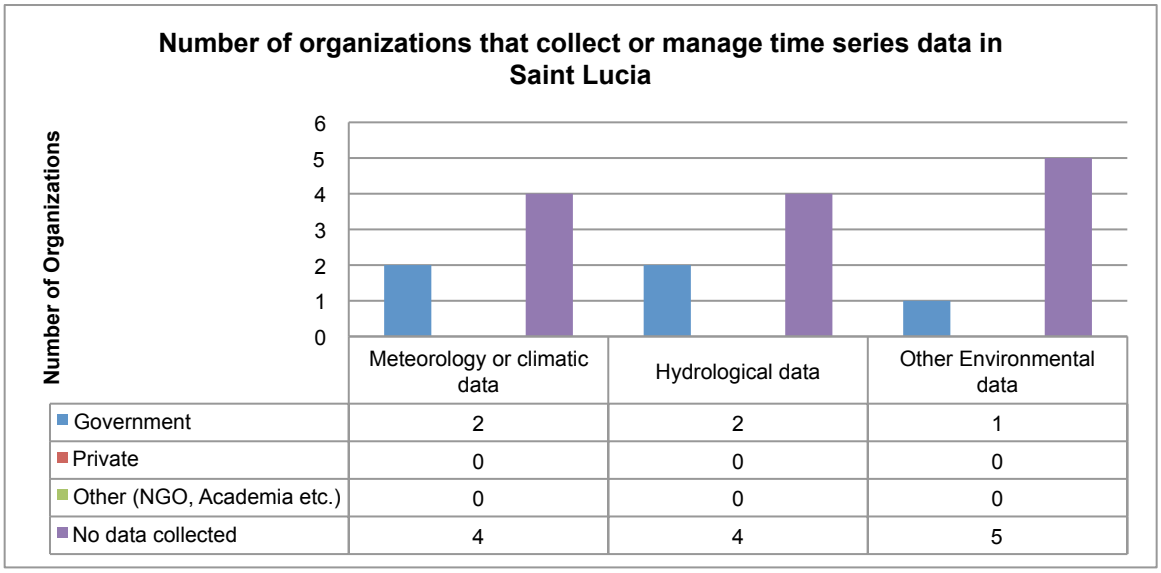

Figure 31: Number of organizations that collect or manage time series data in Saint Lucia (n=6)

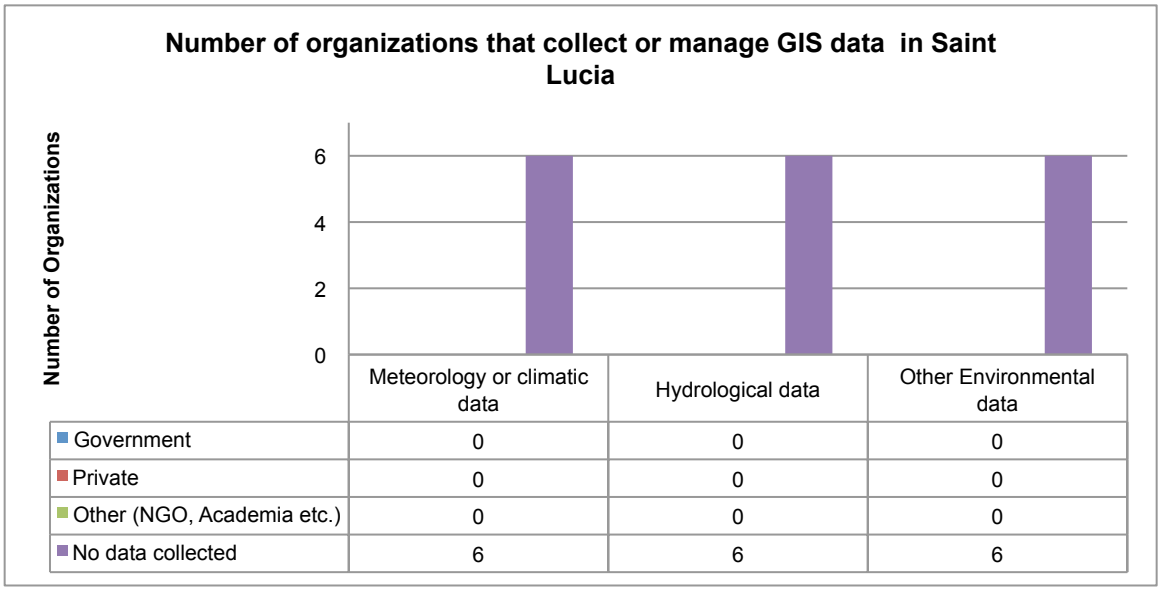

Figure 32: Number of organizations that collect or manage GIS data in Saint Lucia (n=6)

Observations:
Of the six organizations that completed the management electronic survey two of them sampled time series data for meteorological and climatic monitoring. They are:

Box 14: Meteorological and climatological time series data in Saint Lucia

1) Saint Lucia Meteorological Services, Ministry of Infrastructure, Port Services & Transport
2) Ministry of Agriculture Food Production, Fisheries & Rural Development

Two organizations sampled time series data for hydrological monitoring:

Box 15: Hydrological time series data in Saint Lucia

1) Saint Lucia Meteorological Services, Ministry of Infrastructure, Port Services & Transport
2) Ministry of Agriculture Food Production, Fisheries & Rural Development

One organization sampled time series data for other environmental monitoring

1) Ministry of Agriculture Food Production, Fisheries & Rural Development

There is not an extensive amount of time series monitoring of environmental data in Saint Lucia. There were no organizations that reported the collected GIS data, however, the WRMA did provide details of GIS data they have.

Q. Number of Organizations Monitoring key National Issues

Observations:
No organizations responded to this question.

Q. Climate Change Priority Issues

Climate change priorities of organizations in Saint Lucia focus heavily on priorities of different organizations, but there are reoccurring patterns. **Table H1 in Annex H** summarizes these priorities.

Observations:

The three organizations that responded to this question all cited that water-related issues such as sea level rise, floods, and droughts are of utmost importance. This speaks to the need to have very comprehensive hydro-meteorological monitoring as well as disaster risk response mechanisms. Key issues such as adequate monitoring system networks as well as sound climate change policy were also identified as priority issues.

Saint Lucia General Data Procedures and Policies

Table H2 in Annex H summarizes the responses to the questions related to data management in Saint Lucia.

Observations:
There is no indication that organizations in Saint Lucia are hesitant about sharing data. There are existing systems for gathering data as it currently stands and thus this is not a significant gap, they are in fact ready for collaborative data sharing. One of the challenges of the design of the C-READ system will be to find ways of integrating the different data sets that are collected in different ways: automatically and manually. The fact that there are no clear data sharing policies was mentioned more than once, indicating that there exists the possibility that the C-READ development process can help to stimulate discussion around this point. The Water Resource Management Agency currently holds the responsibility of serving as a repository for all agro meteorological and hydrological data. It was not made clear whether or not the WRMA shares data with CIMH; however, this should be addressed in the C-READ design process.

Saint Lucia Regional DMS Recommendations

Table H3 in Annex H summarizes the responses to the questions related to data management. There are some particularly important comments with respect to how these organizations will benefit from the DMS.

Observations:

There is a clear desire for the C-READ management system to assist with risk analysis in relation to water resources and agricultural production. Survey respondents indicate that enhanced agricultural practices would be desirable. Other analytical products such as such as bathymetry maps and SST maps have also been cited by survey respondents and will be considered in the development of the C-READ management system. Examples of suggested monitoring products are:

- drought maps and indices
- regional SST maps
- bathymetry maps
- climate outlooks (precipitation, temperature)
- ground water potential maps
- soil maps and land use maps
- queries that can provide accurate quantification of water resources

There were a total of 7 organizations that were recommended to participate in this project. All but two of these organizations are already participating.

Saint Lucia Outreach and Education

Q. For your organization, on a scale of 1 to 5, rate the level of need for human resources capacity building with respect to climate change and its impacts / data collection / and GIS. (average amount for all respondents)

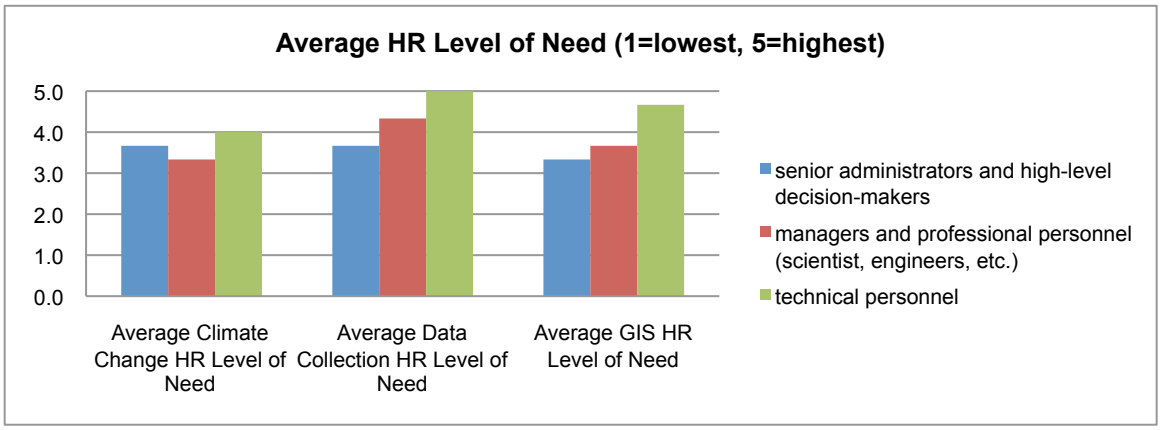

Figure 33: Average level of need for human resources capacity building in Saint Lucia

<u>*Observations:*</u>
A trend that is shown in Figure 25 with the electronic survey responses is that there is a greater need for technical personnel across all categories of HR requirements. The values for each category of technical personnel are: climate change (4.0), data collection (5.0), and GIS (4.7). The average level of need for each category of personnel for the three types of HR function is: climate change (3.7), data collection (4.3), and GIS (4.9). These values are somewhat similar indicating that there is a balanced need across the spectrum of HR categories.

This will be taken into consideration in the education and outreach aspect of the project as well as in the sustainability plan. It is evident that there is a requirement for technical personnel in Saint Lucia.

Q. Does your organization collaborate with research organizations and academic institutions, list them?

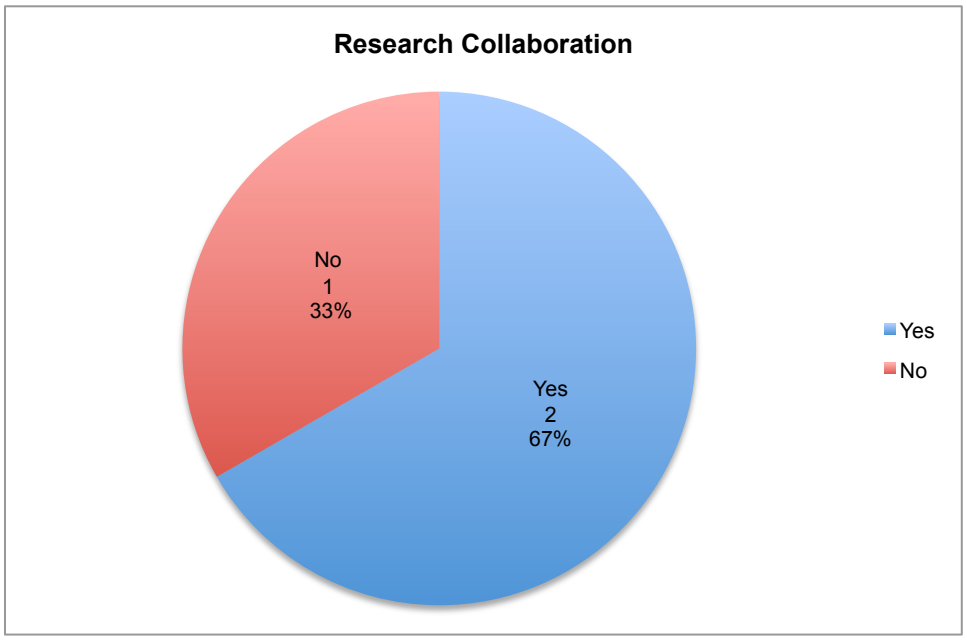

Figure 34: Organizations that collaborate with research organizations in Saint Lucia (n=3)

Observations:
Two of three respondents that replied to the management component of the electronic survey indicated they did collaborate with academic and research institutions. The institutions cited are: McGill University, CIMH, and the University of the West Indies.

Table H5 in Annex H summarizes the responses to the questions related to education about climate change in the sampled country.

Observations:
The respondents indicated there is a need for increased awareness and education about climate change. There are some good ideas cited about connecting youth and children with real projects. The overarching theme is that more can be done. Perhaps youth and children could be reached with some communications products from the C-READ project.

Saint Lucia Computing Capacity

Q. How many computers and servers does your organization have?

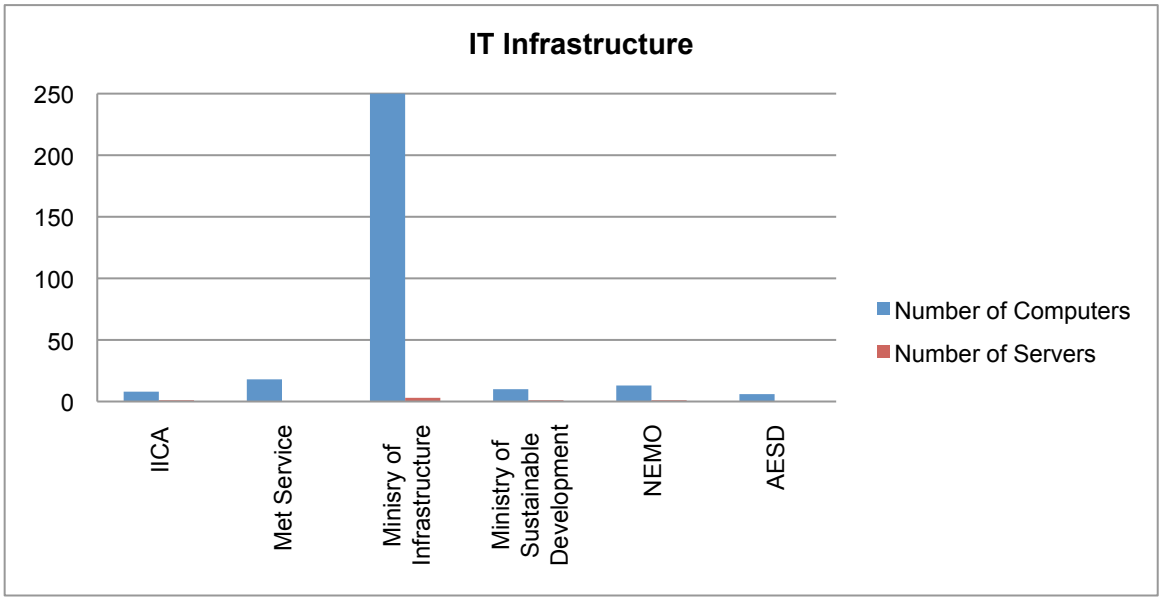

Figure 35: Number of computer and server systems existing at organizations in Saint Lucia (n=6)

Observations:
The technological capacity varies dramatically between organizations. The Ministry of Infrastructure, Port Services & Transport has the most computers (250) and servers (3) than other respondents and technological infrastructure than other survey respondents. In terms of the other organizations that responded, NEMO has 13 computers and 1 server, AESD has 6 computers and no servers, the Saint Lucia Meteorological Service has 18 computers and no servers, the Ministry of Sustainable Development has 10 computers and 1 server, and the IICA has 8 computers and 1 server.

The architecture of stakeholder IT infrastructure needs to be understood to integrate the C-READ management system with it. The computers are installed with these operating systems: Windows (XP, 7), Mac OS, Linux, and QNX4. The servers are running Windows Server 2003 / 2008, HP prolient ML 150 G6, Linux, and Smoothwall 3 (web server). The respondents to the IT component of the electronic survey indicated that their computers ran the following software: MS Office, Dropbox, ArcGIS, WebMap, Hydromet V2, Hydata 4.2, AS400, Alpha Card, AutoCAD, GEOSYSTEM, Hydrolynx Nova Star 4X, Vaisala MAWS software, and QNX4.

Q. What type of Internet connection does your organization have?

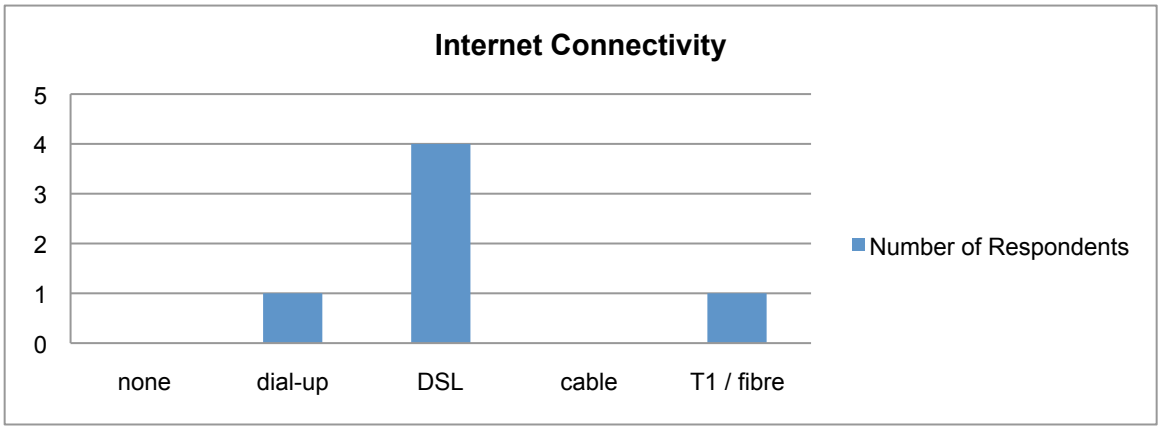

Figure 36: Internet connection types present at organizations in Saint Lucia (n=6)

Observations:
Figure 36 shows the numbers of respondents with different connection types. The large majority of the respondents have either DSL (4) or T1 (1) connections with one group indicating they have a dial up connection.

Q. Describe the number and roles of staff in IT in your organization

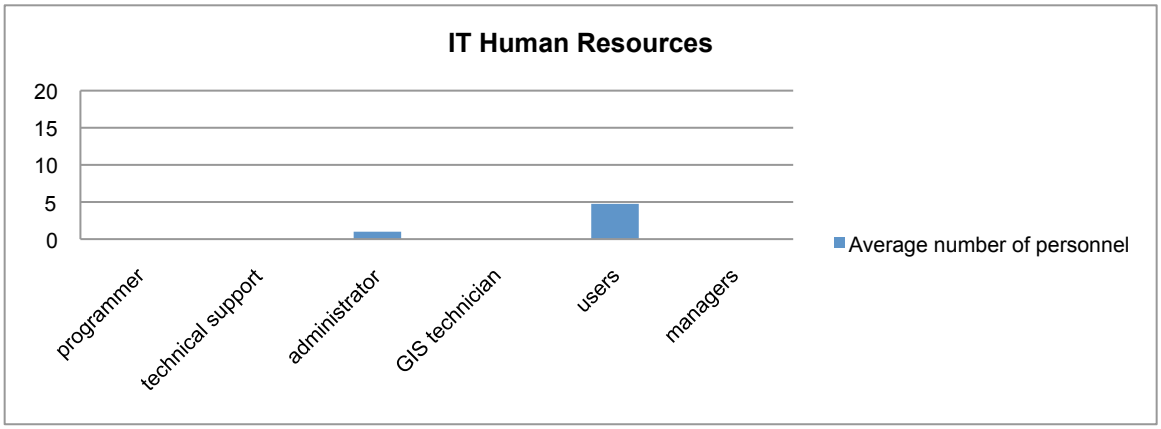

Figure 37: Number of persons in IT staff roles at organizations in Saint Lucia (n=6)

Observations:
There is a shortage of GIS technicians and programmers. The respondents indicated that they have system administrators but very few development personnel. The data for this part of the IT survey was not well populated by respondents. However, two organizations indicated they had in-house knowledge of GeoNode. Additional comments that were provided made a specific request for training for new and improved software (eg. GeoNode). This should be taken into consideration in the sustainability plan of the C-READ system.

Table H5 in Annex H summarizes the additional comments and recommendations pertaining to computing in Saint Lucia.

Saint Lucia Met and Climate Data

Table H6 in Annex H summarizes the responses to the questions related to meteorology and climate data in Saint Lucia.

Table 30: Overview of datasets collected or managed in Saint Lucia

Data Type	Org.	Measured Parameters	Storage	Share
Meteorological	Met Service of Saint Lucia	Precip, temp, humid, wind, clouds, sunshine, atm pressure, wind dir, wind run, soil temp, soil moisture, dew point, evaporation,	ASCII / climsoft / spreadsheet / paper	CIMH / WRMA
Meteorological	WRMA	Precip, temp, humidity, sunshine, atm pressure, wind run, dew point	Spreadsheet, Webmap database, Access database	Yes
Hydrological	WRMA	Surface water depth	Spreadsheet	Yes
Environmental	N/A	N/A	N/A	N/A
GIS	WRMA	River, rain gauge location, stream gauge locations, watersheds (vector / point)	Arcview	-

Observations:
There is a lack of human resource capacity for gathering and analyzing data in Saint Lucia. There seems to be a lack of consistency with the data that is gathered and also with the hardware used. A number of the observations that relate to a lack of standardization and integration are in fact objectives of the C-READ project. The goal would be for these data and instrumentation gaps to be addressed in order to supply consistent, quality assured data to C-READ. The idea of a 'clearinghouse' is somewhat similar to the initial ideas behind this project.

Q. Overview of Data Acquisition for met and climate data

Table H7 in Annex H summarizes the stations collecting meteorological and climatic data across Saint Lucia.

Observations:
Saint Lucia has a fairly extensive network of precipitation monitoring stations. There may be a need for more automated weather stations that can detect other parameters. The network and data collection processes are well established. The WRMA is the focal point for collecting all data and it is integrated in digital form in a database. This will make integration of this data into the C-READ even more fluid.

Saint Lucia Hydrological Data

Table H8 in Annex H summarizes the responses to the questions related to hydrological data.

Observations:
The survey responses indicate that there is a need for more comprehensive agro-meteorological and hydrological coverage with a full set of parameters as listed above. There needs to be an expert analysis of what the ideal hydrological monitoring station density is for Saint Lucia in order to determine that this is actually a gap. The question is, how many stations are needed to provide adequate coverage. The current met stations have good coverage for precipitation but more detailed data is required in order to analyze the status of watersheds and hydrological activity. Data sharing protocols seem to be an issue with the hydrological data. There needs to be a continuous source of good data from hydrological monitoring stations. This requires a follow up and maintenance program for the stations as well as financing to support these activities.

Q. Overview of Data Acquisition hydrological data

Table H9 in Annex H summarizes the stations collecting hydrological data across Saint Lucia.

Observations:
Hydrological monitoring in Saint Lucia is relatively sparse. There is room for enhancement here. Currently the data is gathered in such a way that can fit with the design of the C-READ management system – automated and in digital format.

Saint Lucia Environmental Data

Table H10 in Annex H summarizes the responses to the questions related to environmental data.

Observations:
There is a definite need for integration with respect to environmental monitoring in Saint Lucia. The feedback indicates that there are many organizations that have separate monitoring programs but they are not synthesized or connected. This will be a part of the Regional Plan of Action and the design process for the C-READ management system.

Saint Lucia GIS Data

Q. Overview of GIS data

Table H11 in Annex H lists all the geospatial datasets collected by organizations Saint Lucia.

Observations:
The GIS data that has been reported from the survey respondents is quite basic and is only limited to the Water Resource Management Authority. There may be other organizations that have more extensive land cover GIS data that did not respond to the electronic survey

5.6 Guyana

5.6.1 Overview of Guyana

Figure 38 shows the sectors/ themes from which the five participating organizations in Guyana belong (the full listing of the organizations may be seen in Table 6). The sectors represented were: Other (40% - two organizations), which in this case were the Guysuco and the Guyana Lands and Survey Commission; Agriculture (20% - one organization); Water Supply (20% - one organization); and Hydromet (20% - one organization).

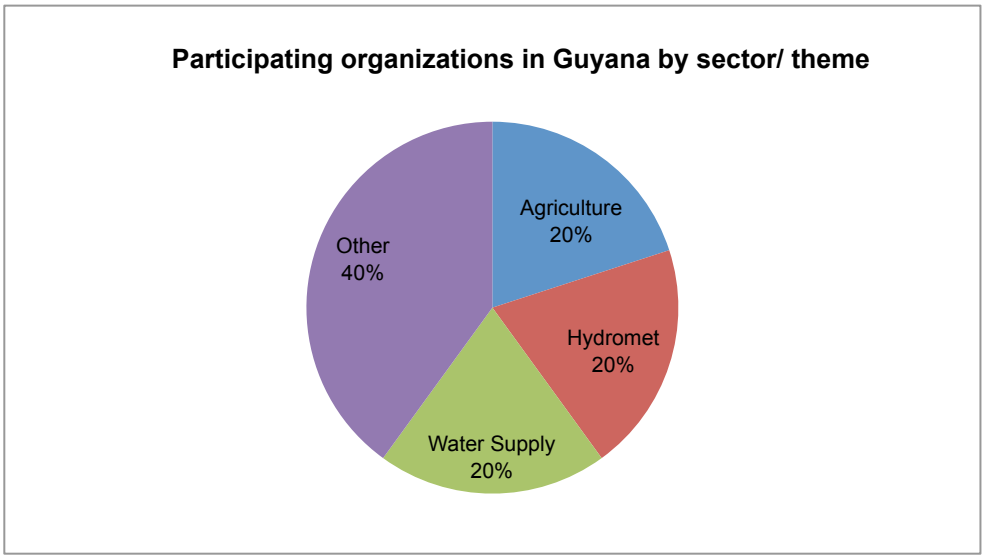

Figure 38: Participating organizations in Guyana by theme/sector (n=5)

5.6.2 Results

Guyana Monitoring overview

Q. Number of Organizations that Collect Time Series or GIS Monitoring Data

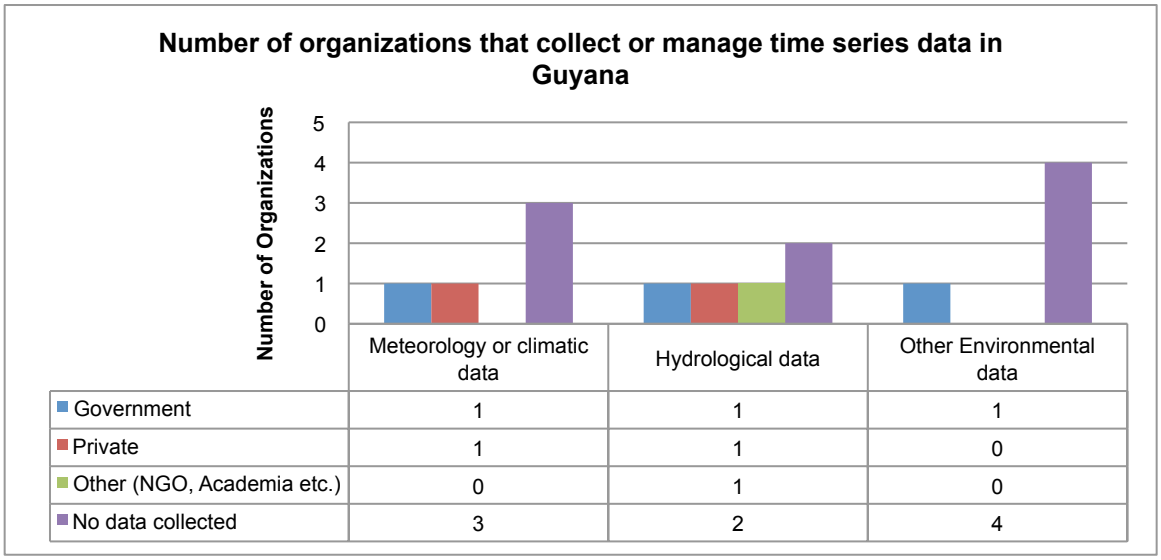

Figure 39: Number of organizations that collect or manage time series data in Guyana

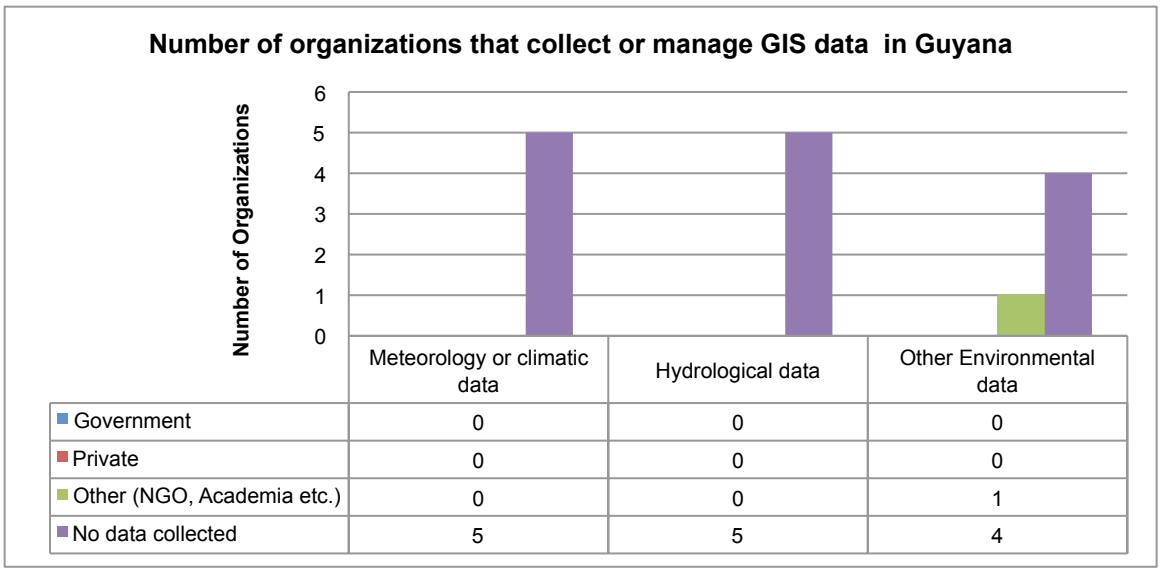

Figure 40: Number of organizations that collect or manage GIS data in Guyana (n=5)

Observations:
Of the five organizations that returned the management component of the electronic survey, two of them sampled time series data for meteorological and climatic monitoring. They are:

Box 16: Meteorological and climatological time series data in Guyana

1) Guysuco
2) Hydrometeorological Service of Guyana

In terms of hydrological monitoring, three organizations indicated they monitored time series data:

Box 17: Hydrological time series data in Guyana

1) FAO Guyana
2) Hydrometeorological Service of Guyana
3) GWI

For monitoring of other environmental data, one organization indicated it monitored time series data (Hydro meteorological service of Guyana) and one collected GIS (FAO Guyana) data.

Hydrological information was covered well. GIS data is not particularly abundant according to those groups that responded. It appears that since there is extensive hydromet time series data, these groups have an interest in very solid coverage of these parameters and thus a platform for sharing data would help them increase the spatial extent of their individual data sets.

The Guyana Sugar Company, Guysuco, has a fairly extensive monitoring program and they are very keen to participate in this project. Their monitoring program could be augmented by the data collected by other parties in the country and regionally.

Q. Number of Organizations Monitoring key National Issues

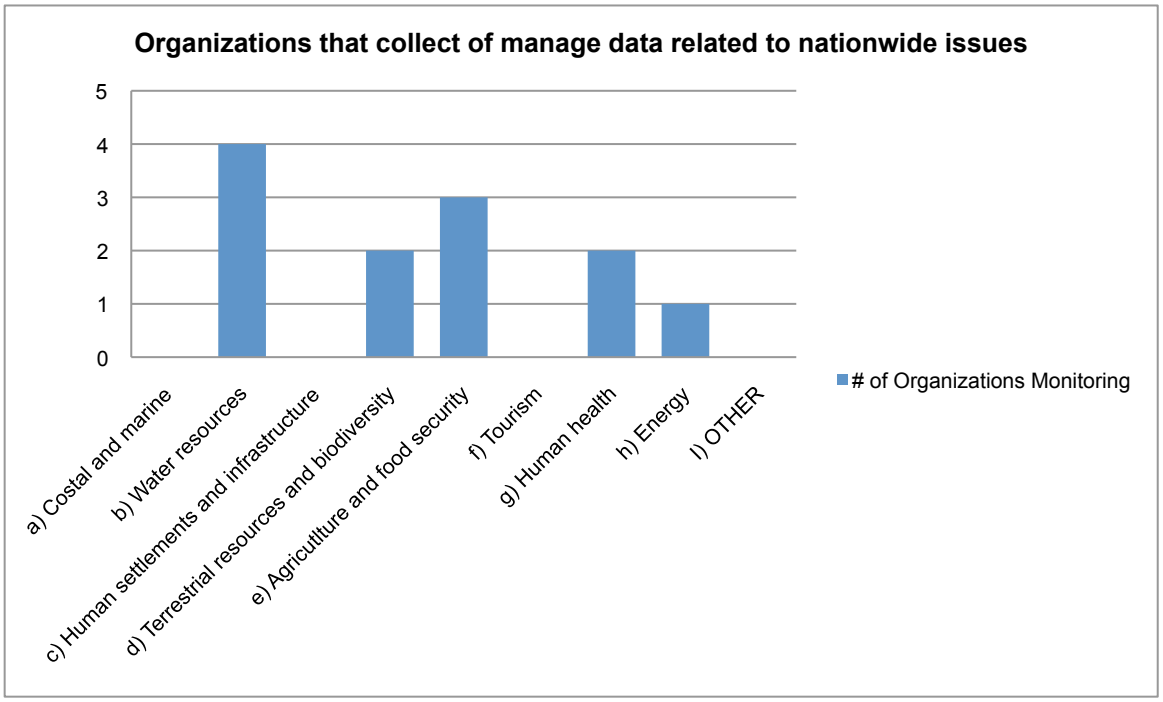

Figure 41: Number of organisations monitoring key national issues in Guyana (n=5)

<u>*Observations:*</u>
Of the five organizations that returned the management component of the electronic survey four indicated that water resources was a nationwide issue that they collected data for. These organizations are:

1) FAO Guyana (AQUASTAT is used)
2) Guysuco (water quality within cultivation area)
3) Hydro meteorological service of Guyana (water levels and discharge)
4) GWI (rate of extraction of ground water from wells)

Food security is another national priority area for monitoring as indicated by the following organizations:

1) FAO Guyana (State of global food and agriculture report)
2) Guyana Lands and Surveys Commission (land tenure for agriculture)
3) Guysuco (information on sugar cane productivity)

Additionally, other national issues such as human health terrestrial resources and biodiversity are closely monitored. One of the main conclusions that can be drawn here is that there is a strong emphasis on monitoring in relation to policy issues. This indicates that the C-READ system may have a good reception from organizations in

Guyana. This also shows that if more organizations were to be sampled it is highly likely that several national issues would be identified as priorities for monitoring.

Q. Climate Change Priority Issues

Climate change priorities of organizations in Guyana were very dependent on the primary mandate of each organization. **Table I1 in Annex I** summarizes these priorities.

Observations:
A reoccurring theme in climate change priorities in Guyana is the risk that climate change poses to water resource management. These issues are contamination, insufficient infrastructure, resulting variations in species populations, and inconsistency with weather patterns. These priorities are driven from the need for reducing the impacts of disasters as well as on economic sustainability of industry in Guyana. The C-READ management system will be a platform for data sharing that can help provide analytics and information to support decision making related to these priority areas that have been identified.

Guyana General Data Procedures and Policies

Table I2 in Annex I summarizes the responses to the questions related to data management

Observations:
Government bodies have systematic processes for gathering data. There is some degree of automated data acquisition, but there is room for improvement. Guysuco gathers hydromet data as well and has some degree of analytical capability. The private sector owns the data they capture but it seems they are open to sharing. The FAO has larger scale databases with data that can be shared. The private sector, government, and IGO's should be included in the JAD sessions to determine the processes for data sharing and the required legal agreements.

Guyana Regional DMS Recommendations

Table I3 in Annex I summarizes the responses to the questions related to data management. There are some particularly important comments with respect to how these organizations will benefit from the DMS.

Observations:

There is a clear desire for the C-READ management system to assist with risk analysis in relation to water resources and agricultural production. Drought risk and impacts on agriculture and biodiversity are concerns and these will be noted in the design of the DMS. Private and public sector organizations want to see data sharing and collaboration. This is a positive sign as this is in alignment with the goals of this project.

There is particular interest on the part of the private sector. Guysuco is very keen on this project, as it appears that they are having difficulty with risk analysis in light of the impacts of environmental change on their operations. The key products that are suggested from survey respondents are: maps of regional impacts on agriculture, land use and land cover types, maps of vulnerability for certain hazards, high resolution climate maps, flood prediction models, drought risk indices, and biodiversity mapping.

Many of the organizations that were suggested to be included have already been contacted. However, there are some respondents who have not, or did not reply. They are: Civil Defense Commission, Ministry of Works, Ministry of Housing and Water. These groups should be included in the design phase of the project.

Guyana Outreach and Education

Q. For your organization, on a scale of 1 to 5, rate the level of need for human resources capacity building with respect to climate change and its impacts / data collection / and GIS. (average amount for all respondents)

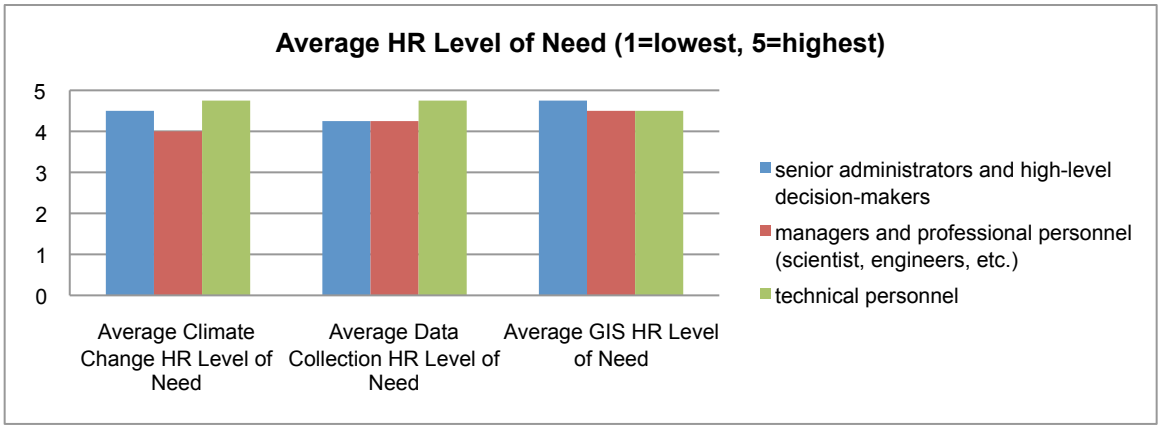

Figure 42: Average level of need for human resources capacity building in Guyana (n=5)

Observations:
Figure 32 shows that the highest level of need for human resources for a given area was for GIS in Guyana for senior administrators (4.75), managers and professionals (4.5), and technical personnel (4.5). The average level for each of the categories of personnel for the three types of HR functions is: climate change (4.4), data collection (4.4), and GIS (4.6). These results show that there is a slight differentiation between the requirements for GIS skills and climate change and data acquisition skills. Close attention should be paid to specifically what skills are lacking on the part of organizations concerned with climate change in the Caribbean region.

Q. Does your organization collaborate with research organizations and academic institutions, list them?

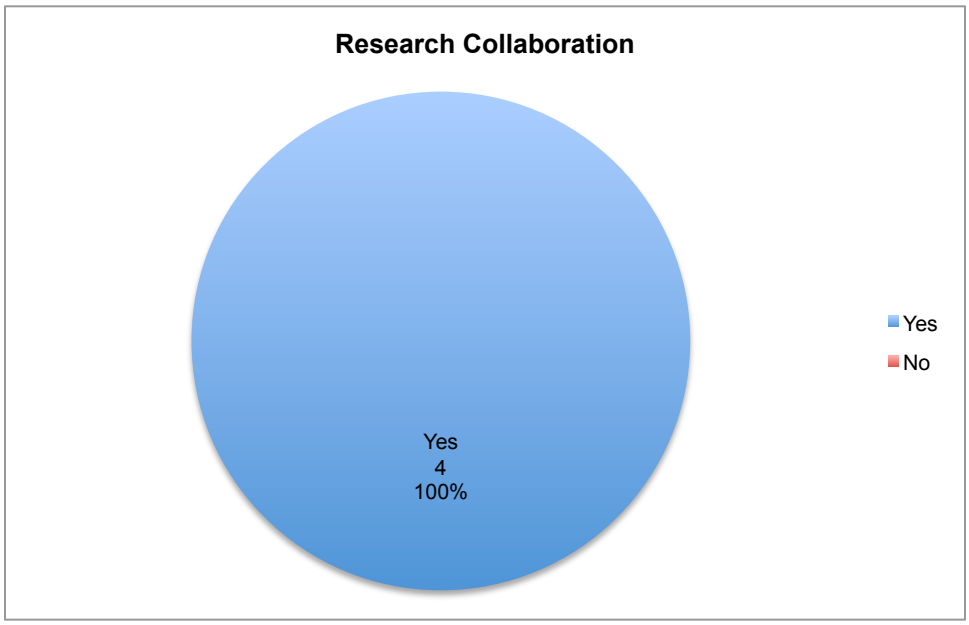

Figure 43: Organizations that collaborate with research organizations in Guyana (n=4)

Observations:
All respondents to this question engaged in collaboration with academic institutions. The two organizations cited were the University of Guyana and CIMH.

Table I4 in Annex I summarizes the responses to the questions related to education about climate change in the sampled country.

Observations:
The respondents indicated there is a need for increased awareness about the risks posed by climate change on sugar farming and to communities in general. One of the challenges with respect to data gathering for environmental and climate change is the need for properly trained personnel to gather data, maintain instrumentation, analyze data, and report on the findings. A gap exists for capacity to monitor and gather data due to the fact that there are not as many sufficiently trained individuals to fill these roles. Thus there is also a need for practical (vocational) technical training that can support industry in these monitoring challenges that lie ahead. Taking this into consideration, an outreach program focused on the private sector (agribusiness) may be advisable.

Guyana Computing Capacity

Q. How many computers and servers does your organization have?

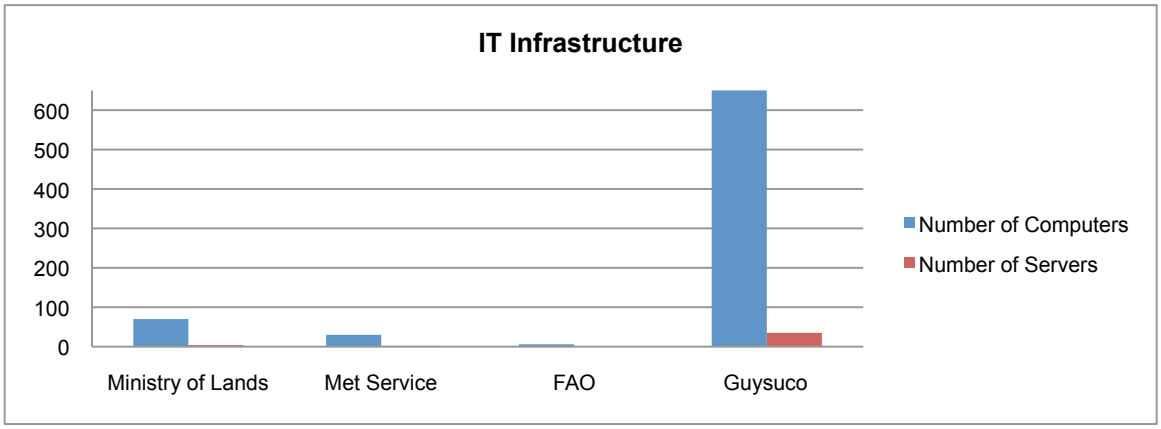

Figure 44: Number of computer and server systems existing at organizations in Guyana (n=4)

Observations:

The technological capacity varies dramatically between organizations. Figure 44 shows this variation in terms of the number of computers and servers that different organizations have. Guysuco has a larger IT infrastructure than the other respondents with a total of 650 computers and 35 servers. The Guyana Meteorological Service has 30 computers and 2 servers; the Ministry of Lands has 70 computers and 4 servers, and the FAO has 6 computers. Careful attention will need to be paid to each of the potential user groups and their technological capacity.

The IT infrastructure and software usage of each group are important parameters in the design of the C-READ system. The computers in the respondent organizations run Windows 7/8/XP and Linux Mint operating systems. Oracle Linux 5; Windows Server 2003, 2008, and Fedora; and Linux Red Hat 5 run on the servers of the organizations who responded. Apache, WebLogic, and .Net are the application server software packages.

Examples of the software licenses held by participants are: ArGIS 8.2, ArGIS 10, Erdas Imagine Pro, Messir, Rainbow, Clidata, Xconnect, and Hydata, Oracle E-Business Suite, and Microsoft Office.

Q. What type of Internet connection does your organization have?

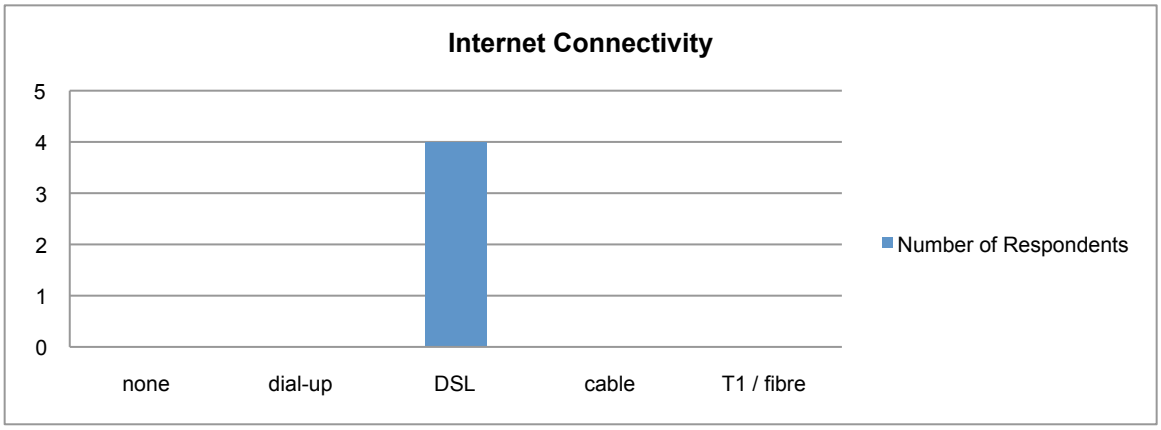

Figure 45: Internet connection types present at organizations in Guyana (n=4)

Observations:
All four organizations that responded to the IT component of the electronic survey indicated that they had a DSL connection. High-speed data transfer should not be a problem for participating organizations in Guyana.

Q. Describe the number and roles of staff in IT in your organization

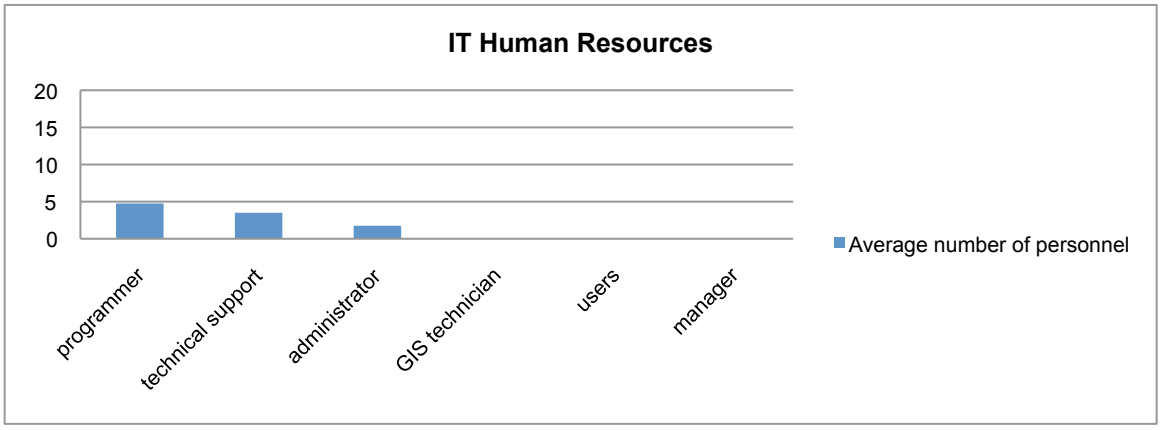

Figure 46: Number of persons in IT staff roles at organizations in Guyana (n=4)

Observations:
One of the key observations here is that there is a shortage of GIS technicians in the groups sampled. This indicates that GIS functionality in the C-READ system needs to be made accessible to a generic user. We cannot rely on users having significant training in GIS. There was also a significant amount of programming capability on the part of the respondents. Guysuco's responses skew the data since they have a disproportionately large scale of IT infrastructure. Nonetheless, GIS was shown to be an area that all groups

need attention. The average numbers of IT personnel are as follows: programmers (4), technical support (3.5), and administrators (1.75). Numbers of users were not reported.

Table I6 in Annex I summarizes the additional relevant comments and recommendations for computing in Guyana.

Observations:
Capacity development is required in IT and in monitoring instrumentation. There should be a special focus on GIS.

Guyana Met and Climate Data

Table I6 in Annex I summarizes the responses to the questions related to meteorology and climate data.

Observations:
Survey respondents indicated they seek monitoring infrastructure such as automated meteorological stations, however, data gathering processes need to ensure consistent and continuous data before new equipment is purchased. In addition, there needs to be maintenance procedures in place to ensure that the stations are continuously operational. A large proportion of the archival meteorological data is in paper format. The protocol for integrating that data into C-READ would have to include some form of digitization or data entry. A detailed assessment of what monitoring stations are required and where they are required should be conducted. The responses related to process modeling speak to the requirement for looking at what kind of modeling can or should be incorporated into the C-READ management system.

Q. Overview of Data Acquisition for met and climate data

Table I7 in Annex I summarizes the stations collecting meteorological and climatic data across Guyana.

Table 31: Overview of datasets collected or managed in Guyana

Data Type	Org.	Measured Parameters	Storage	Share
Meteorological	Met Service of Guyana	Precipitation, solar radiation, temperature, humid, wind, clouds, sunshine, atmospheric pressure, wind dir, wind run, soil temp, soil moisture, dew point, evaporation,	Spreadsheet / CLIDATA	With other govt depts
Hydrological	Met Service of Guyana	Stage, Discharge	Database / paper	Yes - CIMH
Hydrological	GWI	Surface water depth, ground water depth, discharge, abstraction, turbidity, pH, fecal coliforms, total coliforms	Excel spreadsheet	Yes
Environmental	Guysuco	pH, ECw, DO, COD, Total Suspended Solids, Chloride, Calcium, Total Kjeldhal Nitrogen, Phosphorus, Sulphate, Iron, Magnesium	Excel spreadsheet	EPA
GIS	Ministry of Lands	Administrative Boundaries, Rivers, road network, land use, land cover, watersheds, natural parks or attractions, settlements, remotely sensed products	Arcview	-

Observations:

Guyana has an extensive network of automated and manual weather stations. CLIDATA is used widely yet there is a wide variation in how data is transmitted. The data sets will need to be examined to determine the best way to integrate them together.

Guyana Hydrological Data

Table I8 in Annex I summarizes the responses to the questions related to hydrological data.

Observations:
There is good coverage on the coast in terms of water level monitoring, however, the inland area needs attention. The respondents indicated that more public awareness could help to get citizens involved with monitoring, or at least more aware of the key issues.

Q. Overview of Data Acquisition hydrological data

Guyana Water Incorporated has monitoring processes with water wells on the coastal plain of Guyana. These wells are for measuring discharge, static levels, turbidity, dissolved oxygen, fecal coliforms, and total coliforms. The Meteorological Service of Guyana has an extensive hydrological monitoring system throughout the country that covers mostly stage and discharge levels. A complete listing of stations for both GWI and the Guyana Meteorological Service can be found in **Table I9 in Annex I.**

Observations:
There is an impressive amount of data being collected by the GWI and the Meteorological Service. Guysuco also collects water quality data as part of its environmental program. It appears that the majority of this data is shared with CIMH. In order to share it more broadly there would have to be data sharing protocols and agreements put in place. Data format parameters are also going to be required in order to ensure that all the data is stored in the appropriate format. These questions can be addressed in phase 2, the DMS design phase.

Guyana Environmental Data

Q. Overview of Data Acquisition of Environmental Data

Table I10 in Annex I summarizes the responses to the questions related to environmental data.

Observations:
This data may or may not be available to share within the C-READ management system. Guysuco would need to be contacted to determine data accessibility.

Guyana GIS Data

Q. Overview of GIS data

Table I11 in Annex I lists all the geospatial datasets collected by organizations in Guyana.

Observations:
There may be more GIS data available that was not reported from the survey. There is a common trend for Arcview to be the common GIS platform. The .shp file format is very flexible and can be transferred into other formats if necessary.

5.7 Barbados

5.7.1 Overview of Barbados

Figure 47 shows the sectors/ themes from which the five participating organizations in Barbados belong (the full listing of the organizations may be seen in Table 7). The sectors represented were: Other (40% - two organizations), which in this case was the Caribbean Development Bank and the Department of Emergency Management; Agriculture (20% - one organization); and Hydromet (40% - two organizations).

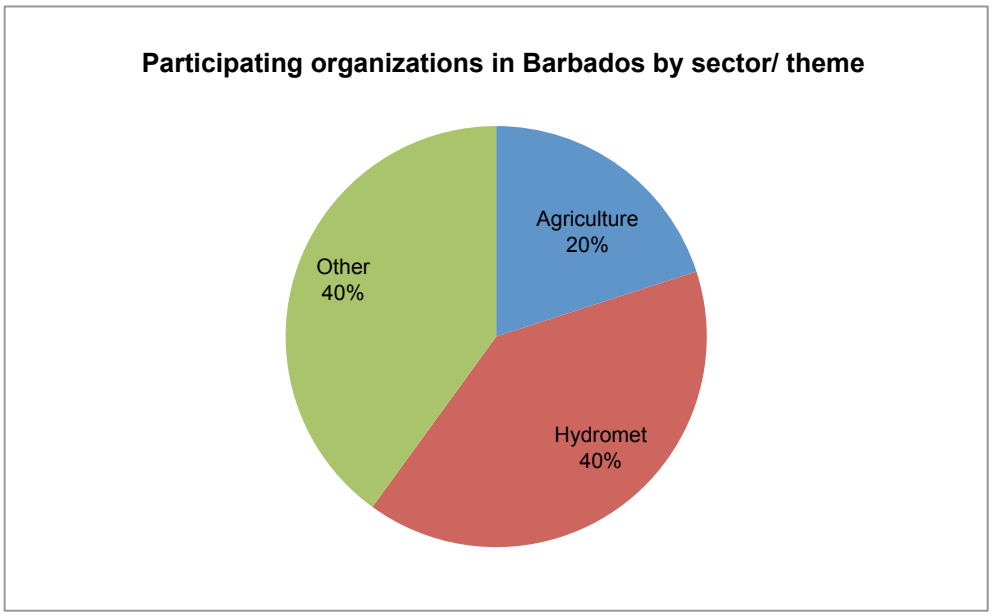

Figure 47: Number of persons in IT staff roles at organizations in Barbados (n=5)

5.7.2 Results

Barbados Monitoring overview

Q. Number of Organizations that Collect Time Series or GIS Monitoring Data

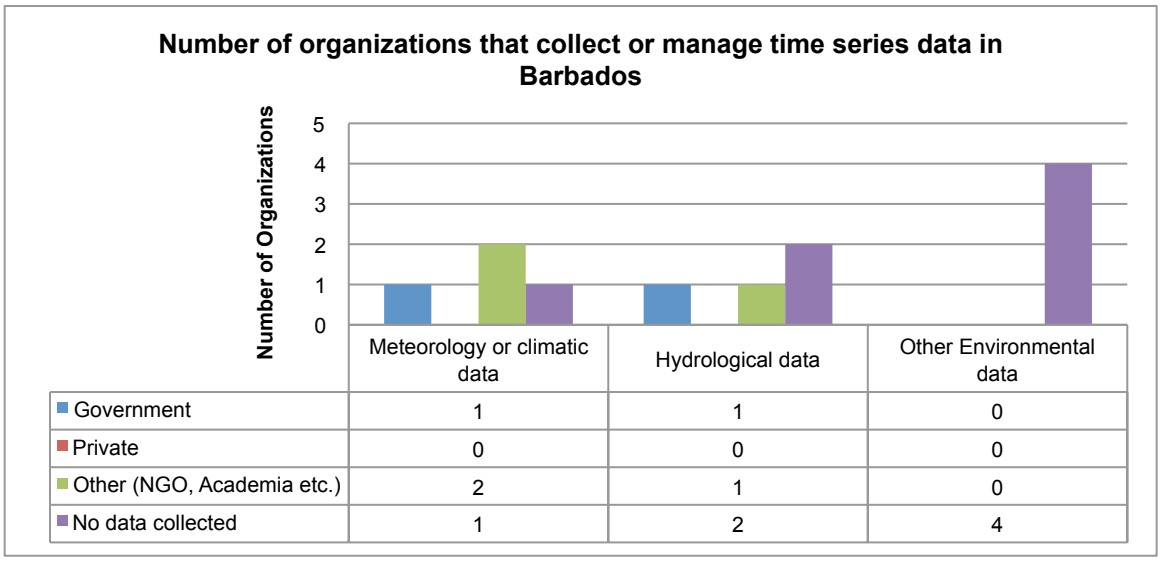

Figure 48: Number of organizations that collect or manage time series data in Barbados (n=4)

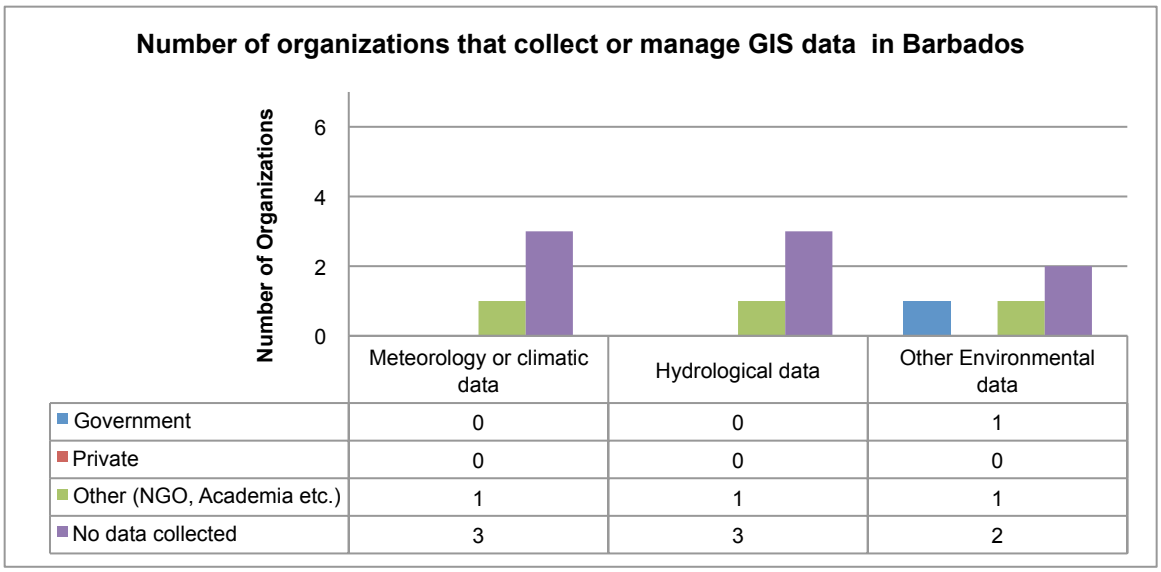

Figure 49: Number of organizations that collect or manage GIS data in Barbados (n=4)

Observations:
Of the four organizations that returned the management component of the electronic survey, three of them sampled time series data for meteorological and climatic monitoring. They are:

Box 18: Meteorological and climatological time series data in Barbados

1) CIMH (Caribbean Institute for Meteorology and Hydrology)
2) Barbados Meteorological Service
3) CARDI (Caribbean Agricultural Research and Development Institute)

Only one organization, namely CIMH, sampled GIS data for meteorological and climatic monitoring

Box 19: Meteorological and climatological GIS data in Barbados

1) CIMH (Caribbean Institute for Meteorology and Hydrology)

In terms of hydrological monitoring, two organizations sampled time series data:

Box 20: Hydrological time series data in Barbados

1) Barbados Meteorological Service
2) CARDI (Caribbean Agricultural Research and Development Institute)

One organization sampled GIS data for hydrological monitoring (CIMH).

Box 21: Hydrological GIS data in Barbados

1) CIMH (Caribbean Institute for Meteorology and Hydrology)

Two organizations sampled GIS data for other environmental monitoring:

1) CIMH
2) Department of Emergency Management

There are a limited amount of time series data sets for meteorology, hydrology, and environment with only key organizations monitoring regularly. There needs to be integration between these organizations, namely CARDI, the Meteorological Service of Barbados, CIMH, and the Department of Emergency Management.

The types of meteorological, hydrological, environmental and GIS data collected by each organization are detailed in subsequent sections and Table 32.

Q. Number of Organizations Monitoring key National Issues

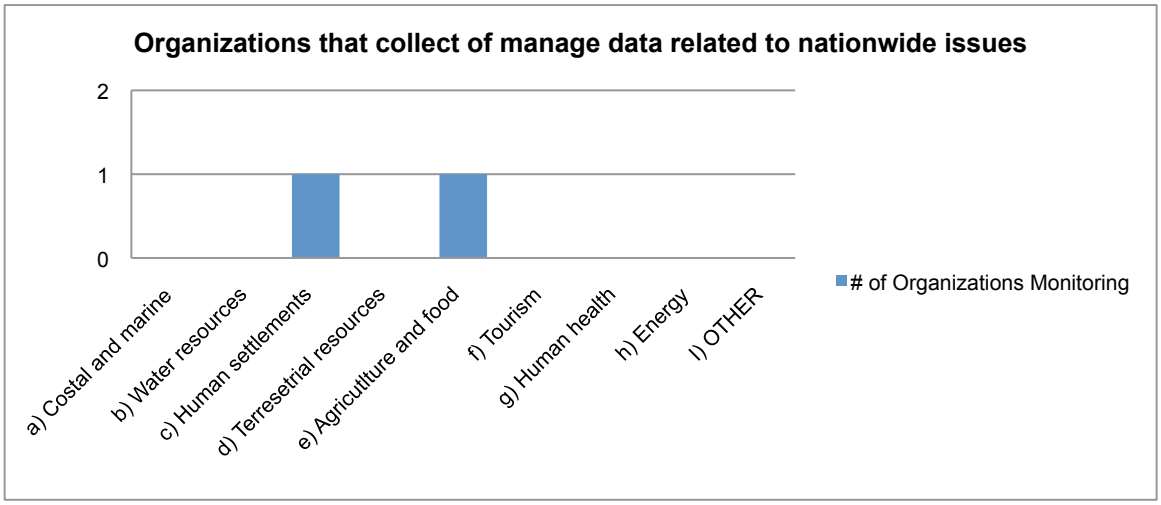

Figure 50: Number of organisations monitoring key national issues in Barbados (n=4)

Observations:

Of the four organizations that returned the management component of the electronic survey, only two identified key nation-wide issues that they collected or managed data for: Human Settlements and Infrastructure (Department of Emergency Management), and Agriculture and Food Security (CARDI). Had there been a wider range of groups that replied there would be presumably be more issues that were data was gathered for. In the next phase, more groups should be consulted in the design process. Additionally, there are some sample groups such as CIMH and the Met Service of Barbados, which are actually monitoring for water resources but did not indicate this in this part of the survey.

Q. Climate Change Priority Issues

Climate change priorities of organizations in Barbados were very dependent on the primary mandate of each organization. **Table J1 in Annex J** summarizes these priorities.

Observations:
Major concerns are risk and vulnerability to the environmental, social, and built infrastructure due to latent risks of climate change and immediate impacts of disasters. Food security was an obvious concern of organizations such as CARDI. Disaster risk reduction and increased resilience were common themes from all of the respondents. The C-READ system will need to address data that allows for the identification of areas vulnerable to risk, the reason impacts that cause this vulnerability, the data required to understand the source of these problems, and the queries that will provide useful information to help deal with climate change and disaster response issues.

In most cases the mandates of the organizations drives their data collection process. For instance the Meteorological Service of Barbados has the directive of monitoring parameters such as precipitation and temperature at sufficient spatial and temporal resolution to understand patterns and to formulate short-term forecasts. One of the desired functions that was determined through the e-survey was vulnerability assessments and drought / inundation risk maps. The analysis of e-survey responses revealed that there is a data gap that inhibits the creation of these data products - meteorological data is not adequately merged with infrastructure data. The objective of C-READ is to produce data products that regional stakeholders will be able to use in order to help them better adapt to climate and environmental change. In order to overcome the individual gaps that individual stakeholders have, C-READ will have to draw the appropriate data sets from different organizations and then act as a destination point for value-added data products that are comprised of data from these different stakeholders.

Barbados General Data Procedures and Policies

Table **J2 in Annex J** summarizes the responses to the questions related to data management in Barbados.

Observations:
Generally speaking, there do not seem to be many problems with data sharing per se. The organizations that responded indicated that they are open to sharing data (perhaps just processed data). What is lacking is a comprehensive framework for agreeing who will share data, why they share data, and how they share data. In the cases where data sources have been identified for particular applications, the terms of sharing and the agreements need to be vetted. For example, some organizations may rather be part of bidirectional agreements to retrieve data than multilateral and regional frameworks. The C-READ management system should provide design and functionality to address this problem. The first step will be in Phase 2 of this project in which the C-READ data inputs and outputs and access / sharing protocols will be identified. Survey respondents also commented on the fact that a system that will better connect the climate change and disaster risk response communities is required.

There was reference to the DEWETRA project that is underway in Barbados and the fact that the tools are being developed to implement enhanced disaster response processes but there has not been supporting human resources nor legislative and institutional frameworks implemented in conjunction with that project. Our team has already met with DEWETRA project proponents at CIMH and the C-READ project will be aligned with the technology they are using. The data that is used for DEWETRA will also be examined in phase 2 with a view to incorporating it into C-READ. Access rights and protocols will be evaluated and ideally this data will become more widely available to regional stakeholders. Additionally, as part of the sustainability and outreach phase for the C-READ management system, we will need to assess what kind of human resources will be required to maintain and sustain the system.

Barbados Regional DMS Recommendations

Table J3 in Annex J summarizes the responses to the questions related to data management. There are some particularly important comments with respect to how these organizations will benefit from the DMS.

Observations:
Climate change mitigation and adaptation and queries, maps, and data that address these issues were predominant in the responses seen in **Table J3**. Sea level rise was a major concern as well as coastal inundation. Examples of monitoring products suggested are:

- daily precipitation, temperature, humidity
- soil temperature, moisture, and type
- digital elevation models
- drought risk maps
- flood extent water levels and storm surge levels and extents (in relation to sea level rise)
- climate change informed IDF curves
- hazard event / damage and loss databases
- mapping of populations at risk / vulnerable to natural disasters

There were a total of 16 other institutions recommended as collaborators for the C-READ data management system whereas only 5 organizations responded to the electronic survey. For subsequent phases, these other organizations should be encouraged to participate in the development of this database management system.

Barbados Outreach and Education

Q. For your organization, on a scale of 1 to 5, rate the level of need for human resources capacity building with respect to climate change and its impacts / data collection / and GIS. (average amount for all respondents)

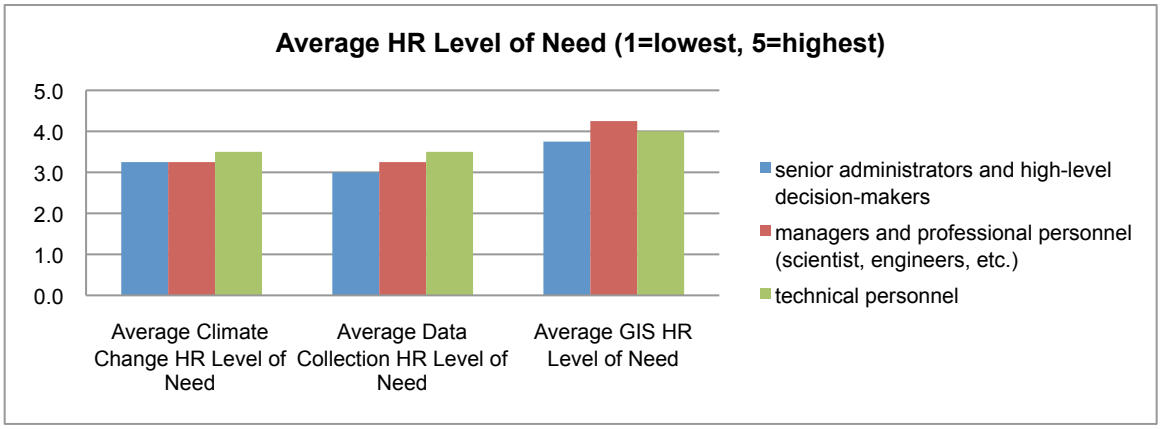

Figure 51: Average level of need for human resources capacity building in Barbados (n=4)

<u>*Observations:*</u>
Figure 51 shows that the highest level of need for human resources for a given area was for GIS in Barbados for senior administrators (3.8), managers and professionals (4.3), and technical personnel (4.0). The average level for each of the categories of personnel for the three types of HR functions is: climate change (3.3), data collection (3.3), and GIS (4.0). These results show that there is a clear differentiation between the requirements for GIS skills and climate change and data acquisition skills. Close attention should be paid to specifically what skills are lacking on the part of organizations concerned with climate change in the Caribbean region.

Q. Does your organization collaborate with research organizations and academic institutions, list them?

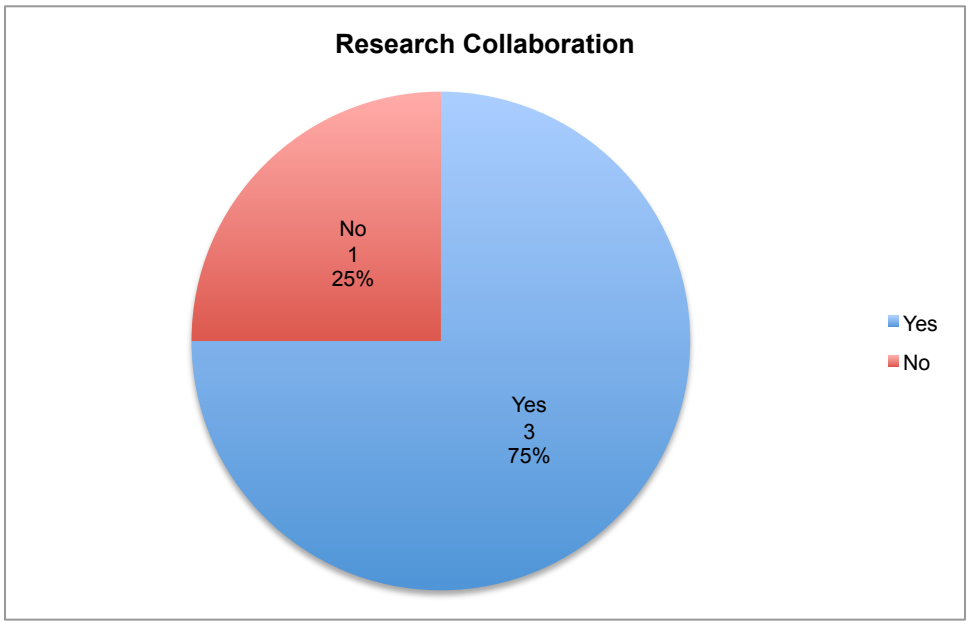

Figure 52: Organizations that collaborate with research organizations in Barbados (n= 4)

Observations:
The majority of the organizations sampled did participate in some form of research collaboration (75%). The institutions they collaborate with are: UWI, CIMH, and CCCCC. These are academic institutions and pan-Caribbean organizations that are focused on monitoring and research related to environmental quality and climate change mitigation and adaptation.

Table J4 in Annex J summarizes the responses to the questions related to education about climate change in the sampled country.

Observations:
There is an inclination and desire for outreach and education with respect to climate change and disaster response. There are already some pilot projects going but there could be an opportunity to build upon these efforts. There are some very practical benefits from having education programs that include this content – for one, a public that is more sensitized and prepared for harmful events if they should occur. An effort should be made in the outreach and sustainability phase to identify ongoing educational programs related to climate change and disaster response in each partner country with the goal of augmenting them with this project.

Barbados Computing Capacity

Q. How many computers and servers does your organization have?

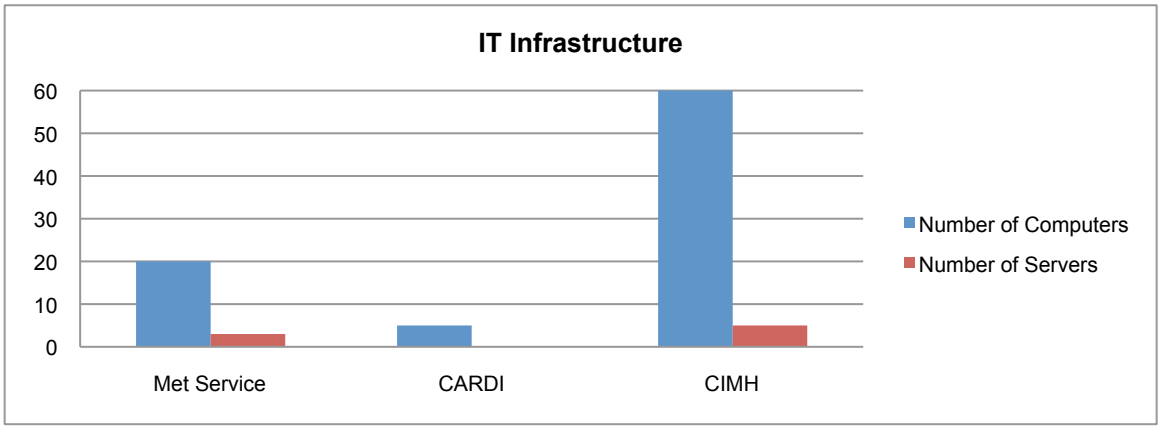

Figure 53: Number of computer and server systems existing at organizations in Barbados (n=3)

Observations:

The technological capacity varies dramatically between organizations as is shown in Figure 53. Larger organizations such as CIMH have as many as 60 computers and 5 servers, the Barbados Meteorological Service has 20 computers and 3 servers, and smaller organizations such as CARDI has 5 computers. It will be important in the design of the system to identify different types of users and their capabilities.

If organizations are to contribute to the C-READ management system close attention will need to be paid to the architecture of their IT infrastructure and how best the C-READ system can integrate with it. The computers in the respondent organizations all run Windows operating systems (Windows 7 and XP). The servers are running Radar/Linux-Redhat and Windows 7 as well as Apache 2 web server software. Examples of software applications that are used are: Windows MS Office 2010, ArcGIS, MATLAB, Genstat, PremiumSoft Navicat, Gemtronics (radar), COROBOR (communications), and Global Science and Technology Inc. (satellite).

Q. What type of Internet connection does your organization have?

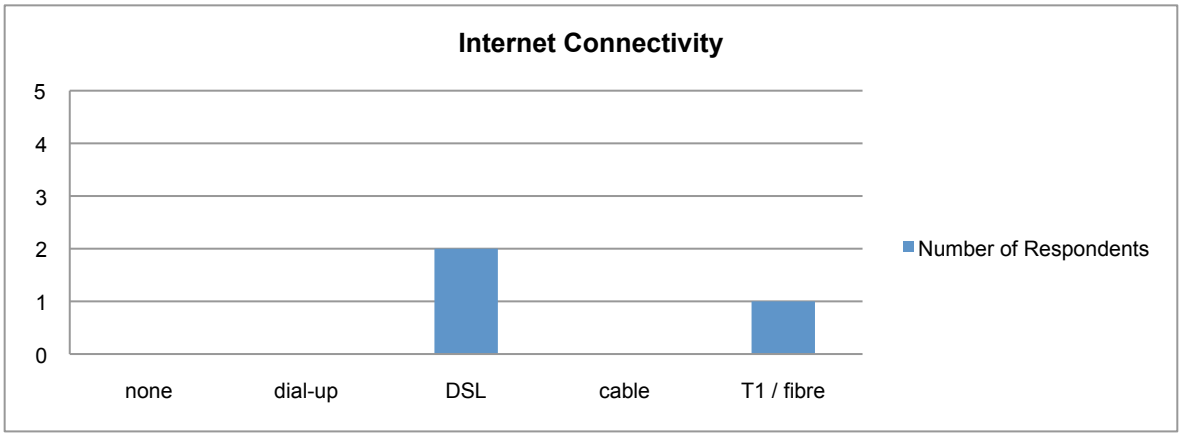

Figure 54: Internet connection types present at organizations in Barbados (n=3)

Observations:
There were not many respondents to the IT survey for Barbados, but for those that did respond, Internet connectivity was not a significant issue. Figure 54 shows that respondents had either a DSL or a T1/fibre connection.

Q. Describe the number and roles of staff in IT in your organization

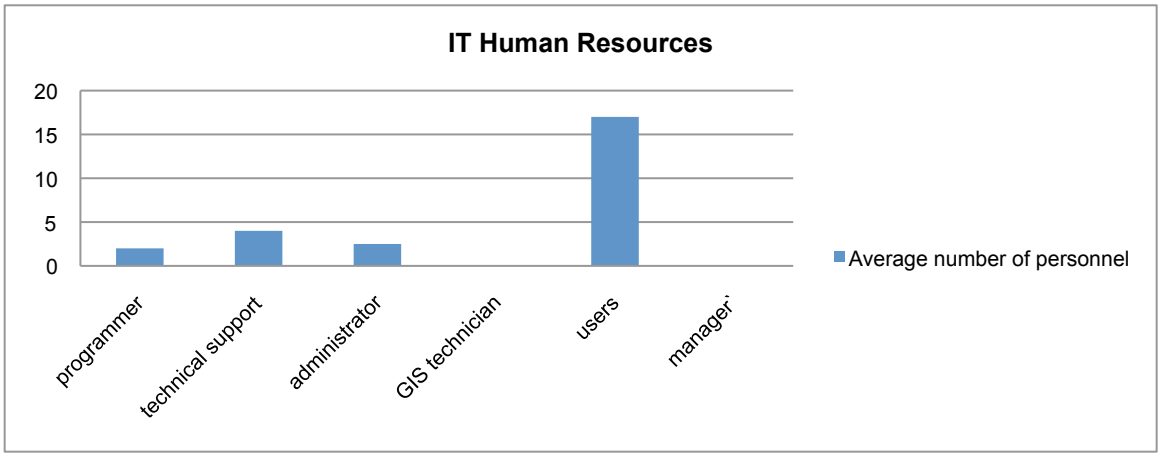

Figure 55: Number of persons in IT staff roles at organizations in Barbados (n=3)

Observations:
It is very important that we understand the in-house capabilities of the organizations that will potentially be using and contributing to the C-READ management system in the process of its design. The user category is the largest, on average, of all that were sampled with a value of 17 from three organizations that provided IT information. There was an average of 2.5 administrators, 4 technical support, 2 programmers, and no GIS technicians.

Knowledge of GIS technology appears to be a weakness of the organizations sampled. No respondents indicated that they had knowledge of GeoNode. Considering that this is the GIS platform of choice for this project, capacity development and training in GIS should be a consideration in subsequent phases.

Table J5 in Annex J summarizes additional relevant comments and recommendations pertaining to computing in Barbados.

Barbados Met and Climate Data

Table J6 in Annex J summarizes the responses to the questions related to meteorology and climate data.

Observations:
Based on the survey responses, it seems that there is a lack of density in coverage both nationally and regionally of meteorology stations. The data products need to be more accessible, meaningful, and impactful. This can be considered part of the design criteria for the C-READ management system. We need to have data products that are easy to access and have 'user impact'.

Q. Overview of Data Acquisition for met and climate data

Table J7 in Annex J summarizes the stations collecting meteorological and climatic data across Barbados.

Table 32: Overview of datasets collected or managed in Barbados

Data Type	Org.	Measured Parameters	Storage	Share
Meteorological	Met Service of Barbados	Precipitation, temperature, humidity, wind, clouds, atmospheric pressure, wind direction, wind run, dew point	Spreadsheet / digital	CIMH and other govt. departments
Meteorological	CARDI	Temperature, humidity, dew point, atmospheric pressure, wind speed, wind direction, precipitation, soil temp, soil moisture, leaf temperature, leaf wetness	Digital	Public (web)
Meteorological	CIMH	Precipitation, solar radiation, temperature, humidity, wind, clouds, sunshine, atmospheric pressure, wind direction, wind run, soil temperature, dew point, evaporation,	Digital (Dataease database – non-processed / Access database – processed)	Pay per use
Environmental	N/A	N/A	N/A	N/A

Data Type	Org.	Measured Parameters	Storage	Share
GIS	CIMH	Administrative Boundaries, Rivers, rain gauge stations, road network, land cover, watersheds, DEM, soils, numerical weather predictions (raster), drought maps	ArcGIS / GRASS	-
GIS	DEM (Department of Emergency Management)	Administrative Boundaries, road network, settlements, DTM, remotely sensed products, weather radar, physiographic maps/geology, socioeconomic maps, shelters, soils, storm surge risk (1 parish), district emergency organization boundaries.	ArcGIS	-

Observations:
There are a limited number of AWS in Barbados. Greater density will result in more cohesive coverage. The Barbados Meteorological Service has three met stations that are a part automated and part manual. CARDI has one AWS and CIMH operates two automated / manual stations and one manual rain gauge. The data that is gathered is done so in different ways – paper, through web, and via spreadsheets. There will need to be a generic strategy put in place for a consistent format of data transfer from the met stations. There may also be other met stations that are not reported here. Some survey respondents indicated that other agencies in Barbados that did not respond to this survey that operate their own met stations.

Barbados Hydrological Data

Table **J8 in Annex J** summarizes the responses to the questions related to hydrological data.

Observations:
They hydrological monitoring systems in Barbados, according to the respondents of the survey (which do not include the Barbados Water Authority), need attention. These systems are underfunded and require a systematic approach in order to meet goals related to disaster risk response and climate change adaptation. There is a lack of instrumentation and also a lack of standardization between agencies as to how hydrological monitoring should occur. This is a problem because data that could be shared between organizations is not consistent in terms of format and this then inhibits the aggregation of these data sources which otherwise would provide thorough insights into water resource management. This should be considered a priority in the C-READ design process. The three areas that need attention are: (1) creation of enhanced in-situ sensors; (2) communications transfer systems for the collected data; (3) a database platform for sharing information; (4) QA protocols for the data acquisition system.

Q. Overview of Data Acquisition hydrological data

None of the survey respondents filled out complete descriptions of specific hydrological monitoring stations. As indicated by Ms. Sueanne Clinton from CIMH, the Soil Conservation Unit, Barbados Agricultural Development Marketing Corporation, and the Coastal Zone Management Unit all may have hydrological monitoring systems but are likely limited to rain gauges.

Barbados Environmental Data

There were no respondents who completed the environmental monitoring aspect of this survey.

Barbados GIS Data

Q. Overview of GIS data

Table J9 in Annex J lists all the geospatial datasets collected by organizations in Barbados.

Observations:
Two of the survey respondents collect GIS data sets. The data sets use different projections, the National/UTM system as well as the GCS Barbados 1938 projection. It is unclear whether these are the same projections. In the event that they are different, there will need to be a means of normalizing all GIS data that is incorporated into the C-READ management system into a common projection and reference system. This has proven to be difficult in other projects in Barbados. The climate change and disaster risk response communities need to come together and one example of this is in the GIS data that is gathered by the DEM and CIMH. By combining these data sets both parties can benefit through enhanced analysis and risk reduction.

Table J10 in Annex J summarizes comments and recommendations pertaining to geospatial datasets collected by organizations in Barbados.

6. Environmental Monitoring Baselines, Gaps, and Actions

6.1 Overview

The survey responses for each country were analyzed to determine the current monitoring baselines as well as what the priorities are for environmental monitoring and data management. Using this approach, the current gaps were assessed and action items determined. The following sections explain the monitoring baselines as well as the identified gaps and suggested actions. The gaps and actions for each of the countries were then reviewed and compared to formulate regional actions.

6.2 Jamaica

6.2.1 Monitoring Baselines

Stemming from the e-survey responses, it was discovered that coastal and marine, as well as water resources are the predominant national climate change priorities in Jamaica. In general, climate change priorities at organizations were concerned with accessing climate change data, models and impacts on various facets of the environment including natural systems, industry, economy and infrastructure. Disaster management, risk reduction, resilience and adaptation were also major concerns, as well as the need for public awareness and training. In fact, there seemed to be an overall belief that climate change is not sufficiently addressed in the education system in Jamaica, thereby emphasizing the need for awareness building in the country.

The Met Service of Jamaica is the main organization concerned with the monitoring and forecasting of weather conditions for the island, and currently monitors close to 200 rain gauges, 4-6 manual climate stations, 4 intensity rainfall loggers and 51 AWS's. In addition to this organization, 4 other stations collecting met and climate data were recorded from the e-survey responses, and these are operated by NWC and WINDALCO. Additional weather stations that measure a range of parameters may be needed in order for better coverage and quality of data to be acquired. However, the first step is to ensure that the monitoring infrastructure and data collection procedures allow for continuous and quality data to be gathered. If existing stations are poorly maintained, then adding more stations will not add to the level of quality of data being gathered.

As it relates to hydrological data, the primary entity responsible for the management, protection, and use of Jamaica's water resources (WRA) reported to operate approximately 200 stations for surface water data collection, as well as the same number of stations collecting groundwater information. In addition to WRA, NWC is the only other agency that reported to collect hydrological data. Recognized gaps include insufficient station locations, lack of resources (human resources and funding), poor temporal resolution and data quality.

GIS data is currently collected by twelve organizations in Jamaica and this certainly gives some indication of the GIS capabilities. The Land Information Council of Jamaica (LICJ) oversees the national GIS network and has begun to establish a framework to promote data sharing. It currently hosts a large number of GIS datasets that are shared amongst organizations in the island. On a similar note, the ISD spearheaded the Caribbean Risk Atlas project, which sought to share data on risk and disasters by means of the GeoNode framework. Resulting from this project, a few organizations stated to be familiar with GeoNode. Indeed, it would be beneficial for the GIS aspects of C-READ system to synchronize with the efforts of the LICJ and the Caribbean Risk Atlas.

Across the board, gaps regarding availability and accessibility of data exist both on the national and regional scale. Further, standardization of data management processes is required across the island and region in order to facilitate data sharing. WRA currently has a number of systems in order to comply with international standards and perhaps could be used as an example for the C-READ system.

6.2.2 Identified Gaps and Suggested Actions

The following gaps were identified based on the electronic survey responses received for Jamaica.

GAP: No central repository of data and limited data sharing and collaboration
Data collection is currently taking place, however access (online or otherwise) to historical and current data is lacking. In many cases, data are not made freely available by agencies. Respondents suggested that access to data or pre-calculated averages, as well as to real time forecast products particularly during the hurricane season, should be facilitated online. It was further added that access should be free. On the same note, more collaboration among stakeholders and a synchronization of efforts to avoid duplications and knowledge of existing data is required. A central repository is needed.

ACTION:
The Cabinet of Jamaica database project and LICJ should be referred to for current systems and recommendations. Consult with each stakeholder who replied to the e-survey in order to determine which datasets are most needed, which can be contributed, those that should be made freely available and online, in addition to required formats. Further consultation will also be needed with entities that would provide required information and discuss any possible data usage restrictions, formats etc. A review of technological options to see what system is best for region-wide online application will need to be undertaken as well. This system should also allow for entities to share what data is being collected, even if not being shared online. These consultations will lead to specific guidelines for the data sharing framework and recommendations for a centralization database/ repository of information or sources of information.

GAP: Limited spatial coverage of stations
There seems to be a general belief that additional meteorological, climate and hydrological monitoring stations are needed across the island. Specific mention was made of stream flow/river gauges (in eastern section of island in particular), AWS,

rainfall intensity loggers (for design of early warning systems), upstream measurements (for background data) and coastal monitoring stations regionally. In addition, the WRA mentioned that different, individual well owners submit data and this often leads to spatial gaps in information. Further, there are some stations in the Blue Mountain Range that had to be abandoned due to a lack of funds to access them; these must be brought back on stream to improve the data coverage in the area, which Iis expected to be heavily impacted by climate change after 2050. Environmental data monitoring locations and supporting institutions and operational procedures are also lacking.

ACTION:
Consult with e-survey respondents and any other national stakeholder organizations that are recommended to determine where additional monitoring stations are required, where existing stations can be reactivated and/or moved, and what maintenance procedures should be implemented and sustainably financed. The outcome of this should be a list of actions and additional monitoring equipment, and preferred locations that are required. In addition, financially sustainable maintenance programs should be recommended.

GAP: Inadequate temporal data resolution
Respondents commented that it would be ideal to have all stations being loggers so that data can be recorded continuously over a 24-hour period to ensure not just improved temporal resolution for the data, but increased temporal quality. A significant amount of stations owned by the WRA are manual stations, which have to be read twice daily by someone in the field.

ACTION:
Identify, by means of consultation with respective agencies, the location of manual stations and thereby those locations requiring automated data collection. This list should be prioritized. A list of automated weather stations, with location, that need regular maintenance or retrieval of data from the the field should be generated, thus creating a focus to stations that need more attention. This list should be prioritized. What should also be considered is the feasibility of converting manual stations to AWS and whether it is necessary. All stations, manual and automated, require regular maintenance. If this is not occurring with manual stations, converting them to AWS will not solve this problem. A critical view of what the most process and cost effective solution should be undertaken. As there are gaps in data provision from discontinuous supplies, the root causes need to be determined. In many cases the solutions will be the 'low-hanging-fruit' solution of proper maintenance programs.

GAP: Inadequate parameters
It was generally believed that additional parameters need to be monitored and data made more comprehensive. For example: upper air meteorological parameters and complete annual data sets, type of attribute data attached to the hydrology datasets e.g. rivers-width, depth, water volume; watershed information; and additional data on variables other than rainfall (e.g. wind speed, temperature, humidity).

ACTION:
List, by means of further consultation with respective agencies, data parameters currently being collected and ascertain those locations at which additional information may be collected.

GAP: Lack of spatial visualization means
It was stated that spatial data representation for the Caribbean domain is needed. In addition, there is limited access to online plotting tools for local datasets.

ACTION:
Make a list of what kinds of data need to be plotted spatially online. From that, determine if the required data is currently being collected. If not, include this data in the specification for additional monitoring that is needed. Consult with stakeholders on these mapped products and include this functionality in the schematic design of the C-READ management system.

GAP: Archived hardcopy records remain to be digitized.
Large amounts of data collected by some government agencies are only available from paper records.

ACTION:
Make a list of printed data that are in need of digitization. Consult with agencies housing these archived paper records and ascertain if resources are available to convert these to electronic format. Provide recommendations for conversion process.

GAP: No complete data capture, formatting, data validation/ quality control standards.
At the national/regional level, there is a need for common standards and methods by which data is acquired and processed to help reduce the barriers in data sharing and implementing systems for regional geospatial networks and regional planning. This was noted for all types of data: meteorological, climate, hydrological and environmental. Further, it was stated that a policy that speaks to a Quality Management System for documentation and quality control of climate data was needed.

ACTION:
The WRA seeks to implement international standards (WMO and ISO standards) in its data acquisition and archival processes. The organization has also developed and implemented the use of data dictionaries for the collection of data in the field. Review such existing collection protocols, research international and regional standards for data management and suggest those that can be adopted across the region. Further, available resources will need to be reviewed in order to ascertain which standards may be complied with present systems, and if the current systems are inadequate, which resources would be needed to comply with standards. These actions will ultimately lead to data management guidelines that may be used to help guide future policies.

GAP: Need for improvement in the laboratory infrastructure and equipment.

ACTION:
Consult with e-survey respondents and any other national stakeholder organizations managing laboratories and ascertain where improvements are needed. The outcome of this action should be a list of required improvements.

GAP: Training for enhanced application of statistical rigor to data.

ACTION:

Create a training prospectus for Jamaica. These questions need to be answered: Which organizations need skills training? What training do they require? What software will they use? How will this training get delivered? Associated with this could be a move to enhance the quantity and quality of statistics education at high schools and universities.

GAP: Lack of environmental data collection
Specific mention was made of regular monitoring for type and quantity of toxic gases; more readily/easily available remote sensing and field data on species diversity and ecosystem health; species population size and distribution; identification of key or indicators species; marine species; coastal zone change tidal data and high definition bathymetry.

ACTION:
Consult with each stakeholder who replied to the e-survey in order to determine which environmental datasets are currently being monitored and which are needed. Liaise with other governmental, NGO, and private sector organizations in Jamaica that are already conducting different forms of environmental monitoring. Work with them to strengthen their methodologies and human resource capacity. Examine their data acquisition methodologies and encourage rigorous methodology, quality assurance in data gathering, and continuous monitoring. These are the key ingredients to building a robust environmental monitoring network.

GAP: Inadequate data storage capacity and systems backup.
Additionally, general workflow within organizations is adversely affected by power outages experienced at regular intervals.

ACTION:
Discuss whether data backup/ storage may be incorporated as part of data sharing guidelines and specifically as part of a central repository. Make recommendations for in-organization and national mechanisms for systems backup.

GAP: Insufficient software licenses.

ACTION:
Ascertain from consultation with stakeholders, which software are used and to prioritize these in terms of required licenses. Compare these software packages and determine if there is consistency across the island and or region and make recommendations for standardized software usage and possible open-source options. This may be included in data management standards.

6.3 Belize

6.3.1 Monitoring Baselines

Stakeholders in Belize had a significant list of priorities with respect to climate change. These points, in addition to the documentation of data being gathered have shown gaps

between what is monitored and the type of environmental data analysis that is wanted. The priorities are: data sharing for factors such as precipitation and temperature, coral bleaching linked to higher SST, deforestation, long term changes in temperature, coastal erosion, ocean acidification and its effects on coral, water quality and conservation, disaster management, changes to habitat for fish, soil conservation, increased resilience to disasters, sea level change, climate change effects on agricultural productivity, information exchange between policy makers and communities for adaptation, floods, and climate change impacts on vector borne diseases. Data is shared readily between different groups in Belize, what is lacking are formal procedures for country wide sharing. One stakeholder stressed the importance of data sharing protocols and agreements. Coral reef health is of utmost importance in Belize and in order to effectively monitor this regional and local data will be required. Hence, there is interest in the C-READ approach. Requested data products include: topographic maps, satellite imagery, models for sea level rise, time series assessment of hydromet data, flood risk maps, and maps showing climate change impacts on tourism.

The Belize Meteorological Service was the only stakeholder that indicated they gathered climatic- meteorological data (1 station reported). Survey respondents indicate that there need to be more weather stations at critical areas of the country like in Belize City and coastal communities. There is not fine enough spatial resolution for monitoring weather / climate and there needs to be at least 50 more met stations in order to assess changing weather patterns. Greater communication with neighboring countries would help to see broader variations in things such as temperature. Meteorological data needs to be transformed into information for the public – it has to be able to be understood and have meaning. The majority of met archive data is not digital, hence doing historical analysis is difficult. Better data management and real time visual analysis would be a desired outcome for some stakeholders.

The Meteorological Service gathers hydrological data in Belize (3 stations reported). Survey respondents indicated that the current number and allocation of hydrological monitoring was not sufficient, in fact, several groups did not know who actually monitored water resources. One group indicated that more monitoring of river flows, sedimentation, and water quality was required. A more updated data management system was requested but it appears that the whole hydrological monitoring network needs to be examined starting from the field through to data storage and sharing.

There are a couple of organizations that are collecting a variety of different environmental data ranging from water quality to species abundance. Healthy Reefs monitors coral reefs and produces an annual report. TIDE (Toledo Institute for Development and the Environment) does a variety of marine species abundance sampling. Climate change impacts on ecosystems are poorly understood in Belize. The impacts of climatic and hydrological changes on agricultural productivity are not very well monitored. Information pertaining to changes in nutrient levels would be useful. Any changes that climate change may pose to fisheries are also very important to know about for stakeholders in Belize. More collaboration between agencies and organizations would help to integrate findings, research, and monitoring efforts. One group suggested a

regional assessment on the health of ecosystems, similar to the Millennium Assessment, would be very helpful in understanding the impacts of climate change on the region. Priorities need to be established nationally and regionally for monitoring.

There is a fairly extensive collection of GIS data collected in Belize by the following organizations: Coastal Zone Management Authority & Institute, Healthy Reefs Initiative, TIDE, BERDS[2], Ministry of Health, Ministry of Natural Resources, and the Land Information Centre. The majority of this data is in vector format (point, line, polygon) and relates to infrastructure, administrative boundaries, settlements, coastal zones, roads, land use, land cover, watersheds, bathymetric maps, and natural parks. With this collection of data between the different organizations, some of the data products that were requested by e-survey respondents could be created. The data formats need to be reviewed to ensure that the GIS data can be formatted to one projection and re-sampled if necessary to the same spatial units. GeoNode was not widely used by the survey respondents. All of the data documented were shapefiles that are used with ArcView or ArcGIS. It is clear that there is a solid baseline of GIS data and geospatial analysis used in Belize and this can serve as a good foundation for more sophisticated analysis that is built into the C-READ management system.

Survey respondents indicated that there has not been a large amount of formal education about climate change and its impact in the school system. The stakeholder responses showed a lot of positive inclination to be more active and engaging with outreach to communities and schools. One group suggested a well-structured public awareness project through radio and TV media could benefit the community. Another respondent indicated that Universities in Belize should start to develop degrees that emphasize climate change. This would start to cultivate local expertise. There is significant interest in having the private sector closely engaged with this project; hence climate resilience could be made a priority for industry in Belize. The subsequent phases of schematic design and then outreach can aim to include the private sector in Belize.

6.3.2 Identified Gaps and Suggested Actions

The following are gaps we have identified based on the electronic survey responses received and our overall analysis of Belize.

GAP: More meteorological stations required
Survey respondents suggested that more stations were needed.

ACTION:
In the design phase of the C-READ management system, stakeholders in Belize should be consulted (along with experts from CCCCC and CIMH) about what density of AWS and other met stations are required to provide adequate coverage for Belize.

[2] Biodiversity & Environmental Resources Database System, www.biodiversity.bz

GAP: More coordination with neighboring countries for met monitoring
A more comprehensive regional perspective can be had on meteorological and climatic phenomena by combining data sets and monitoring efforts with neighboring countries.

ACTION:
Regional coordination with Central American countries can be considered as a developmental strategy for C-READ as the project progresses. The first priority is with project partners and other CARICOM countries. From there, other regional countries and entities can be consulted.

GAP: Digitization of archival data is required
A large proportion of the archival met data is in paper format. In order to do historical queries and other forms of analysis, this data will need to be digitized.

ACTION:
Consider a digitization project proposal similar to that which CIMH has been doing with the support of the CBD – refer to the EU-GCCA project as they may still be looking for suitable cases.

GAP: Real time visual analysis of weather and climatic data
Weather and climatic data could be geospatially formatted (projected geospatially) and then incorporated into a system that can allow for real time visualization – this would help with disaster management and also accessibility of the data.

ACTION:
The GIS platform of C-READ may be able to accomplish this task. First, there must be real-time digital data supplied to the database from AWS in Belize. The first step will be to determine what input data is available.

GAP: Met data needs to be converted into meaningful information
The met data that is gathered is not always useful to all stakeholders because it is stored in tabular form (spreadsheets / database). This data can be useful to other stakeholders if it is made accessible and relevant. Maps are obviously one tool. There may be others.

ACTION:
The utility of meteorological, hydrologic, and environmental data is a key priority for C-READ. The data that is gathered needs to be relevant to stakeholders. "Utility of data as information" will be considered a key operating principle in the design of C-READ management system and will be reinforced through all stages of the project – particularly the schematic design phase.

GAP: Hydrological monitoring is very weak. The whole system needs evaluation.
There were not many hydrological stations reported. The efficacy of this system in Belize is questionable.

ACTION:
In the design of C-READ there will need to be in-country expectations for the monitoring systems – if the hydrological monitoring system in Belize does not meet a minimum requirement then improvement measures can be proposed.

GAP: Ecological impacts from climate change are not studied
There is very little understanding of the effects of climate change on ecosystems in Belize.

ACTION:
Queries or tools could be built into C-READ to look at variations in ecosystem parameters (NDVI, EVI) and meteorological factors. This could be a use-case scenario that is explored. Priorities need to be established as to what ecological or agricultural phenomenon need to be assessed and then the appropriate data specified.

GAP: Changes in the environment and their effect on agriculture are currently not being monitored.
There is not much analysis being done on climatic influence on agricultural productivity.

ACTION:
This could be considered a use-case scenario for food security that we work on in phase 2. It can be built into the design process for C-READ.

GAP: Regional analysis of the ocean environment and reefs would help to better understand the risks posed from climate change
There are few integrated regional data sets for climate impacts on reefs for the region.

ACTION:
This can be a use-case scenario for C-READ that we can work on in the design phase. It is conceivable that the relevant data will be accessible; it is a matter of designing queries that can integrate this data properly.

GAP: GIS data is gathered by several organizations – it needs to be looked at from a national and regional standpoint to see how it can be integrated
There are no national standards for GIS and there is not much data sharing.

ACTION:
GIS data integration standards will have to be established for C-READ. For example, when taking in different GIS data sets into GeoNode, these sets will need to be projected to a common standard. In some cases this will require a re-projection algorithm or image re-sampling.

GAP: More education and training at post secondary institutions
Belize can start post secondary training at the Universities to help develop more local expertise in climate change.

ACTION:
This can be considered in the outreach and sustainability phase of C-READ. Perhaps a university partnership in each country to help with maintaining the system.

GAP: The private sector needs to be more involved with climate change adaptation actions
Private sector companies are already gathering data for their own management purposes. As an extension of this, they could benefit from being more closely involved with national and regional actions – especially if the data products that come from C-READ will be useful for their businesses.

ACTION:
There can be a focus area on private sector involvement in C-READ. This can start in phase 2 and lead into the outreach and sustainability phase 3.

6.4 Dominica

6.4.1 Monitoring Baselines

The organizations from Dominica that participated in the e-survey indicated that their climate change priorities were focused on droughts, flooding, sea level rise, unpredictable weather patterns, disaster risk management, improved management of water distribution systems, watershed impacts, food security, vulnerability of communities and infrastructure, sharing of data, and understanding rainfall patterns in order to optimize farming. These priority areas can be addressed with the C-READ system and the first step is to look at the outcome of the electronic survey to determine what the monitoring baseline is. From there, we can assess where the gaps are and prescribe actions.

The Meteorology Service of Dominica reported only three stations that were capturing meteorological or climatic data across Dominica. DOWASCO indicated that they do have five AWS and will increase to nine, however, they did not provide details in the Technical spreadsheet. Dr. Colin Depradine's report on the status of climate relevant data collection indicated that there were two met offices located at the two airports and also ten stations that were turned over to the Meteorology Service by Yale University. Apparently there were some difficulties with transportation logistics required to get the automatically collected data. This is a fundamentally important issue as explained in the earlier gap overview part of this document. In many cases monitoring stations are not being accessed on a regular basis either for maintenance or even to gather data. For whatever reason – lack of human resources, logistical constraints, it results in a data gap. The current reported procedures for data gathering are a mix of automated and manual and there is a plan in place to transmit the data wirelessly via GSM. There are currently no formal policies for data sharing but there are some informal networks established that would like to begin to establish data sharing protocols. Currently, the Meteorological Service of Dominica gives approval to data and it then needs to go through CIMH before it is distributed.

The responses from stakeholders indicated that there is decent hydrological monitoring however no respondents supplied station details in the technical survey. DOWASCO's five stations contribute to hydrological monitoring and according to Dr. Depradine's report the Forestry Department has ten conventional rainfall stations across the island. Dr. Depradine's report also indicated that manual stream gauging occurs regularly on the five main rivers of interest and one river has automatic gauging but it is not functioning properly. This speaks to the fact that station maintenance must be at the forefront of considerations for the sustainability planning of the monitoring network. The data from the automated stations is stored in excel format and needs to be made available to CIMH.

The climate change priorities from the e-survey indicate that hydrological monitoring is very important for Dominica. Drought risk, flood risk, and the vulnerability of infrastructure and settlements are all closely linked to hydrological monitoring. There is a PPCR project that is to take place in 2014 that will establish a baseline of hydrological monitoring data. Respondents also indicated that they would like to see a high level of analysis pertaining to island topography, soil, and land cover to complement the hydrological monitoring. The many propositions and active hydrological monitoring projects in Dominica must be aligned with the C-READ project.

No respondents indicated that they gather environmental data. There were, however, explanations of water quality sampling and proposed land cover assessments given in other parts of the survey. Respondents did indicate that they wanted to see soil capability data, fertilizer and pesticide data, and general land cover data included in the C-READ management system. These requirements will need to be assessed in light of the current status of data acquisition and also the several proposed projects that are in development.

No GIS data was detailed in the survey responses. One survey respondent indicated that they are in the process of implementing GIS for some agricultural data. There is an active GeoNode for Dominica. This indicates that there is capacity on the ground for growth and development of applications using geospatial data. The representatives from the current GeoNode project will be contacted in the design of C-READ.

The survey respondents as a whole saw climate change education and outreach as an essential activity. There are some activities with DOWASCO collaborating with several schools. There needs to be a greater level of awareness and this can be achieved by addressing these issues starting at primary and leading all the way up to secondary schools.

6.4.2 Identified Gaps and Suggested Actions

The following are gaps we have identified based on the electronic survey responses received and our overall analysis of Dominica.

GAP: The data gathered for meteorological, hydrological, and environmental monitoring was not complete
Survey respondents indicated they were doing water sampling and operating AWS, but they did not provide the full level of detail that we are seeking.

ACTION:
Stakeholders in Dominica should be consulted again during the C-READ design phase with specific questions pertaining to existing monitoring systems. Dr. Colin Depradine's report provides some detail but this needs to be re-affirmed by the stakeholder group in Dominica.

GAP: Hazard risk and vulnerability maps need to be available
Some of the desired data products are hazard risk and vulnerability maps. These are currently not available to the extent that is requested by the stakeholder group.

ACTION:
In the design of the C-READ system we need to determine what the specific queries are in order to assess vulnerability. This can be achieved through the creation of use-case scenarios. The C-READ design process will incorporate this.

GAP: Data collection AND transmission processes in general need reviewing
There was a general explanation that indicated data was being gathered both manually and automatically. A data collection and communication protocol needs to be established, at least for C-READ. Satellite communication of data would be very useful for situations in which the stations are remote. Dr. Depradine's report indicated the Met Service was experiencing difficulties accessing data due to logistical and transportation issues

ACTION:
A review of data collection and communication must be conducted for Dominica as part of the schematic design phase of C-READ and the management plan.

GAP: No procedures or policies for data sharing in Dominica
There has been informal dialogue pertaining to data sharing in Dominica but no formal procedures. There are established processes for sharing met data with CIMH.

ACTION:
In the design process of C-READ data transfer and sharing protocols should be established.

GAP: Need standardized equipment for monitoring
Respondents indicated that there was a lack of standardization in monitoring equipment.

ACTION:
CIMH, the Dominica Meteorology Service, and other relevant agencies should be consulted in regards to standards for equipment as well as for data format. The C-READ project will address the data format question, but the physical equipment standards can be addressed as well.

GAP: Effective maintenance programs need to be established
Hydromet station maintenance is a problem. There is no standard approach at this point.

ACTION:
A maintenance protocol should be established for hydromet stations in Dominica. This should include a slated amount of extra systems that can provide spare parts. This should be accompanied by a financial plan for maintaining the stations and ideally a funding organization.

GAP: Human resource development is required for data management
Survey respondents indicated there was a need for technical personnel for data management.

ACTION:
The analysis of human resource capacity that we will conduct for C-READ will address human resource requirements for each country. This is part of the sustainability of outreach phase.

GAP: Not a significant amount of environmental data being gathered
The respondents requested a number of different queries that require environmental data sets. Examples include flood maps and soil capacity maps. An inventory of environmental data to complete these queries will be required in the design process of C-READ.

ACTION:
The use-case scenarios that will be completed in the design phase of C-READ and they will need to assess what data are available to complete various queries or data products. An inventory of environmental data will need to be conducted to fulfill these queries.

GAP: Dominica GeoNode exists but can grow
Survey respondents indicated that there is a GeoNode in Dominica. This can be an element of C-READ but there needs to be some integration and coordination.

ACTION:
The GeoNode community in Dominica needs to be consulted in the design phase of C-READ.

GAP: More public education and awareness with respect to climate change
Survey respondents widely acknowledged that there is a lack of education and public awareness with respect to climate change in Dominica.

ACTION:
The outreach and education component of the C-READ management system project should address this requirement with a component dedicated to public awareness and youth education.

6.5 Saint Lucia

6.5.1 Monitoring Baselines

The climate change priorities of Saint Lucia as expressed by survey respondents are food security, flood risk, drought, inundation in coastal regions, and sufficient monitoring of rainfall patterns and floods. Some of the desired data products include drought maps, bathymetry, national soil moisture maps, land use change indices, climate outlooks, and regional sea surface temperatures. The responses from the electronic survey have provided an indication of what the current status of meteorological and climate, hydrological, and environmental monitoring is and also what their desired outcomes are for the C-READ management system. We are able to determine what the gaps and required actions are based on these findings.

The Meteorological Service of Saint Lucia and the Water Resource Management Authority are the two organizations that are responsible for meteorological and climatic monitoring in Saint Lucia. The Meteorological Service operates six met stations and the WRMA operates twenty-six weather monitoring station (weather stations as well as rain gauges). Survey respondents indicated that more stations were required and that there was a lack of standardization in the existing stations. The current systems are not integrated between departments and hence data sharing suffers. One comment indicated that they need agrometeorological stations in at least ten locations around the island. A major weakness is the lack of integration of data and therefore the inability to do analysis with data sets that come from different sources. The monitoring system needs to be re-evaluated from the standpoint of efficient and automated data acquisition with an integrated database management system implemented. Training of personnel for data analysis was also cited as a serious problem.

The WRMA is the only survey respondent that indicated they operated hydrological monitoring stations (3). Respondents indicated that the hydrological monitoring stations were inadequate and they required better training of personnel. Easier and more effective ways of gathering flow data in rivers are required. The hydrological stations are not adequately networked and there is no regional data collection format or query format. There is also a lack of critical data for calculating evapotranspiration using the Penman-Monteith method. Regional integration of hydrological monitoring systems will help to better characterize these systems. As of now, the data gathering appears somewhat spatially fragmented. In association with this is the need for personnel to maintain these stations and make site visits.

There were no survey respondents that gave details as to the environmental phenomenon they sampled. One of the key problems raised was the fact that there is no clear-cut responsibility of any one department for all aspects of environmental monitoring. One suggestion was to have these monitoring activities centralized, including having a national water quality lab. Updated technology, new data management systems, and protocols for regional integration were all priorities identified by stakeholders. The C-READ system can help to address some of these issues and build upon the monitoring baseline that currently exists in Saint Lucia.

The only respondent that indicated they collect GIS data was the WRMA and their data set is limited to locations of rivers, rain gauges, stream gauges, and watershed boundaries. Several of the data products that are requested by the stakeholders are GIS-based. For example, drought maps, bathymetry, national soil moisture maps, and land use maps. It is clear that there may need to be some capacity development in Saint Lucia with respect to GIS use as well as GeoNode.

Survey respondents were enthusiastic about the possibility of having educational outreach to primary schools, secondary schools, and communities. One group suggested that schools should be involved in the monitoring projects.

6.5.2 Identified Gaps and Suggested Actions

The following are gaps we have identified based on the electronic survey responses received and our overall analysis of Saint Lucia.

GAP: More meteorological stations required
Survey respondents suggested that more stations were needed.

ACTION:
A review of specifically how many met stations would be required should be taken.

GAP: Greater level of standardization with met stations
The met stations that exist differ in standard and this makes them difficult to integrate, maintain, and operate.

ACTION: For any new stations there should be a technical standard implemented. Additionally, there should be data standards.

GAP: Inter-departmental data sharing is weak
There is no comprehensive framework for the sharing of data. Some suggest that there be more centralization.

ACTION:
The data sharing process and protocols for C-READ can help to address this issue as they are formulated. Insights will be shared from the C-READ team as this project develops.

GAP: Need standardized equipment for hydrological monitoring
Respondents indicated that there was a lack of standardization in monitoring equipment.

ACTION:
The hydrological monitoring stations and network must have a technical standard created. This can be approached in the design phase of the C-READ by examining how source data is gathered and integrated. This discussion in the design phase can lead to recommendations for hardware standardization as well.

GAP: Not sufficient data integration
Data sets from different departments are not integrated and there is no existing platform for this to occur.

ACTION:
Data integration must serve as a key item in the design of the C-READ management system. This integration is between departments in a given country as well as between countries regionally.

GAP: Training is not sufficient for hydromet monitoring
Personnel are not adequately trained for hydromet monitoring.

ACTION:
Phase 3 of the C-READ project must address the lack of capacity for hydromet monitoring personnel in Saint Lucia with sustainable operations management accompanied with a financial plan.

GAP: Not a significant amount of environmental data being gathered
The respondents requested a number of different queries that require environmental data sets. Examples include flood maps and soil capacity maps. An inventory of environmental data to complete these queries will be required in the design process of C-READ.

ACTION:
The extent of environmental data gathering will need to be reexamined in the design phase of C-READ, particularly when we are generating use-case scenarios for various queries that require this environmental data.

GAP: The number of hydrological monitoring stations is sparse and in many cases inadequate
There were very few (3) hydrological monitoring stations reported.

ACTION:
The number of actual monitoring stations needs to be re-evaluated in the design phase. The quality of these stations and maintenance and related data gathering activities also needs evaluation.

GAP: Very little GIS data is gathered and managed
Only the WRMA indicated they gather GIS data and their collection is relatively simple. In order to realize some of the desired data products for the C-READ, there will need to be more GIS capacity in Saint Lucia.

ACTION:
A review of GIS data and capacity in Saint Lucia in the use-case scenario aspect of the design phase. The sustainability and outreach phase should consider the current gap between existing GIS skills and required skills.

GAP: More public education and awareness with respect to climate change
Survey respondents widely acknowledged that there is a lack of education and public awareness with respect to climate change in Saint Lucia. They are optimistic that there can be positive actions taken.

ACTION:
Although this is not a direct objective of this project, general education and awareness on the part of the community is a welcome outcome in light of the need for increased socio-ecological resilience in the Caribbean.

6.6 Guyana

6.6.1 Monitoring Baselines

The organizations from Guyana that participated in the e-survey indicated that their climate change priorities were focused on droughts, flooding, unpredictable weather patterns, disaster risk management, data-sharing for enhanced environmental management, pest outbreaks, and improved operational management for businesses. The responses to the electronic survey from stakeholders in Guyana provided a general understanding of the baseline of environmental monitoring. Gaps between the desired outcomes and the current situation have been evaluated with the goal of having the C-READ management system address these needs.

Currently there are forty-two meteorological and climate stations operated by the Meteorology Service that sample a number of different parameters in addition to precipitation (wind speed, humidity, etc.). There are also one hundred and fifty four rain gauges measuring precipitation. Needless to say, there is fairly decent coverage for meteorological sampling in Guyana. There could be more AWS, but the sheer coverage in this country is impressive. According to survey responses, there needs to be increased capacity for modeling (agrometeorological and entomological), a review of monitoring equipment, more human resources for archiving data and for IT and data management, and digitization of archival material. Guysuco was particularly interested in the potential of this project since their business has been dramatically affected by unpredictable weather. They feel that the integrated data sets will be very useful for themselves and other businesses in Guyana.

Hydrological monitoring is fairly well developed in Guyana. There is an extensive set of monitoring stations across the country. Of the survey respondents, it was the Meteorological Service (77 stations), Guyana Water Incorporated (3 stations), and Guysuco (5 stations) that reported that they operated hydrological monitoring stations. One comment from the respondents was the fact that the coverage of hydrological monitoring was skewed toward the coastlands and that there was not sufficient inland monitoring. The respondent indicated that the distribution of monitoring stations should be examined in order to help the country meet the WMO prescribed network density for accurate hydrological regime characterization. Additional staffing was an issue that was raised, as well as the need for training and established procedures for quality checking, updating, and backing up of data. Survey respondents also indicated that more public awareness and involvement could enhance community engagement with hydrological monitoring.

The only survey respondent that indicated they collect environmental data was Guysuco. Guysuco collects data related to water quality – biological oxygen demand, pH, chloride, phosphorous and other factors. There are likely other stakeholder groups in Guyana that gather other environmental data, but they did not reply to the e-survey. In the design phase of the C-READ system other stakeholder groups in Guyana should be included so

that a more comprehensive view of environmental monitoring is gained. Environmental data can also be further specified when creating use-case scenarios for the kinds of queries and analytics that stakeholders want as part of the C-READ design process.

Only one organization that replied to the survey indicated that they collect geospatial data (Ministry of Lands). There are other groups that did not respond who may also be gathering GIS data (NAREI, National Drainage and Irrigation Authority, MMA/ADA Development Authority). A number of the data products requested by survey respondents – drought maps, land cover, and biodiversity mapping are GIS-dependent. Hence, there needs to be a more thorough analysis of GIS data gathering and technical capacity in Guyana. The design phase of the C-READ can attempt to address these issues. The GIS data that was reported is of the same projection and managed in ArcView. This is a standard platform, which can integrate easily with other geospatial standard datasets.

The survey respondents indicated that there is some education and outreach related to climate change but there could be more. They also indicated that there should be focused technical training related to climate change and that industry groups should be included in this process.

6.6.2 Identified Gaps and Suggested Actions

The following are gaps we have identified based on the electronic survey responses received and our overall analysis of Guyana.

GAP: Archived met data is not digitized
There are different agencies that are sampling data but there is no comprehensive framework for establishing standards for the data formats and also how to share this data.

ACTION:
Assess what data needs to be digitized and the best way to go about doing it.

GAP: Increased capacity for agrometeorological monitoring
Survey respondents suggested that greater capacity for modeling in general could help to build more resilient organizations in Guyana.

ACTION:
In the design process for C-READ develop use-case scenarios for various types of modeling that groups require – agrometeorological, entomological, etc. These use case scenarios should be created in consultation with in-country stakeholders.

GAP: Data collection processes in general need reviewing
One overall comment was that the methods of data gathering and transfer were somewhat outdated and were in need of a review. A lack of financing for this was a key message.

ACTION:
Assess the data gathering processes for each relevant agency and answer the questions:

what data is gathered, when is it gathered, in what format, how is it transferred from the field, how is it stored, how is it shared (many of these questions are answered with the e-survey for those countries that responded). This information can inform the data gathering protocols for C-READ.

GAP: There needs to be vulnerability maps
Several e-survey respondents indicated that key data products would be vulnerability maps that relate to: drought, flood, crops at risk, and business infrastructure/processes affected.

ACTION:
Make a list of specifically which criteria are to be used to determine vulnerability. From that, determine if the required data is currently being collected. If not, include this data in the specification for additional monitoring that is needed. Consult with stakeholders in Guyana on these information products and include this functionality in the schematic design of the C-READ management system.

GAP: No procedures or policies for data sharing in Guyana
Survey respondents indicated that there is no comprehensive data sharing policy.

ACTION:
Produce a draft data-sharing plan as part of the schematic design of the C-READ management system. This can be for within the countries as well as regionally.

GAP: Poor distribution of hydrological stations
There are more stations towards the coast than inland. The density is not adequate to meet WMO standards.

ACTION:
Assess the distribution of hydrological stations to determine if they are skewed towards coastlands. Propose a better distribution with inland sites.

GAP: Lack of staffing and procedures for managing hydrological data
There are not enough technically skilled people for the data management aspects of hydrological monitoring. There are not sufficient data management procedures either.

ACTION:
Assess level of staffing and data management procedures for hydrological data in Guyana. This can be part of the sustainability plan and also the design process for C-READ

GAP: Not a significant amount of environmental data being gathered
Survey respondents indicate they want several vulnerability maps but the survey responses indicate they do not have enough environmental data to address this.

ACTION:
In the design process for the C-READ, conduct a re-assessment of environmental data acquisition and monitoring by contacting agencies that did not respond. Also ask the agencies that did respond which other organizations should be contacted (including private sector). In the design phase, the use-case scenarios will indicate what kind of environmental data is required in order to fulfill the analytical requirements.

GAP: GIS skills need to be enhanced
Only one group responded with a list of GIS data they gathered and they also indicated that greater technological capacity was required. GeoNode was not widely known by e-survey recipients.

ACTION:
Create a GIS training prospectus for Guyana. These questions need to be answered: Which organizations need GIS skills? What training do they require? What software will they use? How will this training get delivered?

GAP: More public education and awareness with respect to climate change
Survey respondents indicated that a more informed public could be better suited to adapt.

ACTION:
The focus of any outreach activities on this project will be related to engaging institutions or organizations that are currently gathering environmental data or would like to do so.

GAP: More technical training in environmental monitoring that will help farmers and other groups better adapt their practices to changes they are subjected to
Community stakeholders need to be more empowered to deal with the impacts of climate change on their lives and businesses.

ACTION:
Consider including business, unions, farmer associations, and any other relevant groups in a training program that is connected with the operation and creation of C-READ. The rationale behind this is that companies in Guyana such as Guysuco could be a very valuable source of data and perhaps financing to move C-READ forward. They have already expressed significant interest in being a user of C-READ, having them further engaged as a financial supporter or at least a data provider could prove beneficial.

6.7 Barbados

6.7.1 Monitoring Baselines

The organizations that participated in the e-survey indicated that their climate change priorities were focused on food security, economic security (particularly tourism) and disaster risk response. In order to achieve these goals there needs to be a robust monitoring network, an integrated data management system (C-READ), an effective GIS-based information management system (C-READ) and policies and procedures for sharing of data in Barbados and regionally.

Currently there are seven meteorological and climate stations operated by the Met Service (3), CARDI (1), and CIMH (3). These stations are either automated or a combination of manual and automated. All of the data gathered is stored digitally, transmitted by phone, paper, radio, or the web. The e-survey respondents indicated that the number of meteorological stations needs to increase and that there also needs to be a program for station maintenance, which includes extra spare parts to ensure that repairs can be made. The extent to which these numbers need to increase and their proposed locations needs to be determined.

Hydrological monitoring appears to be a weak spot in Barbados. None of the agencies indicated that they had systems in place for monitoring, however, there are agencies such as the Barbados Water Authority, the Drainage Division of the Environmental Unit, and the Coastal Zone Management Unit that did not reply to the e-survey. The e-survey respondents indicated that local agencies do not have the human and financial resources to efficiently and sustainably manage hydrological monitoring networks. There is a problem with ensuring data quality and long-term maintenance of monitoring equipment. Institutional frameworks need to be enhanced such that it is clear who is responsible for hydrological monitoring at the local level and how this then connects to regional entities. Communications systems could be implemented using GPRS/satellite systems such that rural areas become accessible for monitoring. This data-gathering network should be resilient to disasters so that disaster risk response processes can be informed with real time data.

Geospatial data is currently gathered by two of the organizations that responded to the electronic survey (CIMH, Department of Emergency Management). All of the data gathered is in ArcGIS or GRASS format. There are other groups that did not respond who may also be gathering GIS data (Lands and Surveys Department, Town and Country Planning, Ministry of Agriculture, Environmental Protection Department). Risk and vulnerability maps are requested in order to determine where vulnerable infrastructure and populations are located. This will help with disaster risk response processes. The human resource capability for GIS analysis does not appear to be very strong according to the e-survey responses. Currently there was very little GeoNode capability reported the electronic survey respondents in Barbados.

Education and outreach with respect to climate change and environmental monitoring is occurring at this time but more can be done. Education at the primary, youth, and intermediate levels will help to prepare and inform the population, particularly with sea level rise and drought.

6.7.2 Identified Gaps and Suggested Actions

The following are gaps we have identified based on the electronic survey responses received and our overall analysis of Barbados.

GAP: No data-sharing framework
There are different agencies that are sampling data but there is no comprehensive framework for establishing standards for the data formats and also how to share this data.

ACTION:
Consult with each stakeholder who replied to the e-survey and determine what the terms they wish to see in order to share data. Determine what formats work for them and for the C-READ system. This consultation will lead to a data sharing framework and standards for file formats.

GAP: More AWS and weather stations required
Survey respondents indicated that more stations were required – either AWS (automated weather stations) or manual stations. The stations that do exist need to fall into the comprehensive framework mentioned above.

ACTION:
Consult with e-survey respondents and any other national stakeholder organizations that are recommended to determine where additional AWS are required, how many, what maintenance procedures exist, and what maintenance procedures should be implemented. The outcome of this action should be a list of additional monitoring equipment that is required. This can occur in phase 2 of the project (design of C-READ management system).

GAP: Communications systems need to be enhanced
The technology for sharing of data from all monitoring systems – hydrological, meteorological, and environmental needs to be better integrated. This can be a satellite/GPRS approach that provides real-time data for purposes such as disaster risk response; however, it has to be resilient to these disturbances.

ACTION:
Ask CIMH what system they recommend. Review technological options to see what system is best for region-wide application. There are other options on the market that should be explored (using GOES satellite for communications).

GAP: There needs to be vulnerability maps
Several e-survey respondents indicated that data products they would like to see are vulnerability maps that relate to: drought, flood, sea level inundation, infrastructure at risk, and populations at risk.

ACTION:
Consult with stakeholders in Barbados to make a list of specifically which criteria are to be used to determine vulnerability. From that, determine if the required data is currently being collected. If not, include this data in the specification for additional monitoring that is needed. Consult with stakeholders in Barbados on these information products and include this functionality in the schematic design of the C-READ management system.

GAP: There is a lack of instrumentation and standardization of data for hydrological monitoring
There were no respondents that detailed hydrological monitoring instrumentation they operated, however there are respondents who did not reply but may have some field instrumentation. There is a lack of standardization and governance policy for hydrological data. Cooperation between regional and local agencies needs to be fostered. Maintenance and quality control procedures need to be established.

ACTION:
Consult with the Met Service and CIMH to determine what other agencies currently monitor hydrological systems in Barbados. Contact these other organizations and create a list of all hydrological monitoring ongoing. Consult with CIMH and other organizations to determine what the ideal would be in terms of number of stations. Document this. From this consultative process, make a list of potential software that can be used for region-wide hydrological analysis. Also assess current process to ensure that adequate quality control is in place for data gathering and that the stations are regularly maintained.

GAP: Shared data sets for flood extent maps
Flood extent and sea level rise maps need to be able to be produced.

ACTION:
Assess what currently exists in terms of bathymetry in Barbados. See what is required to create flood extent maps and risk assessment tools for sea level rise in Barbados. Provide a generic approach that can be applied to other partner countries.

GAP: Climate change informed risk maps and IDF curves need to be produced
There are currently no data sets that result in risk maps informed by climate change. IDF curves are an example.

ACTION:
Determine what is required to create climate change informed risk maps and IDF curves. This can be achieved by contacting stakeholders in Barbados, specifically the CBD and CIMH. Create a specification for climate change informed risk maps and IDF curves that

can be applied in different partner countries.

GAP: GIS data gathering needs to by standardized
E-survey respondents indicated that they currently use GIS data. The format – projection etc. is not standardized though. There is a national projection system that is unique to Barbados. If this data is to be integrated with regional data sets there needs to be a means of establishing common format (re-projection and/or or resample)

ACTION:
Assess whether there is a re-projection algorithm. Suggest a GIS data standard for Barbados and potentially the region too.

GAP: GIS skills need to be enhanced
There are GIS capabilities in Barbados, according to the e-survey respondents. They did indicate that it was not sufficient and that there needs to be more technical and human resource capacity for GIS. GeoNode was not widely known by e-survey recipients.

ACTION:
Create a GIS training prospectus for Barbados (and other partner countries). These questions need to be answered: Which organizations need GIS skills? What training do they require? What software would they use? How will this training get delivered? This can be part of phase 3 of the project – outreach and sustainability.

GAP: More public education and awareness with respect to climate change
There are educational programs in place with respect to the environment and climate change but more can be done. Risks due to drought, sea level rise, and inundations / floods need to be communicated to the public more.

ACTION:
Determine specifically how this educational outreach program will be delivered. Who is the audience? What is the curriculum? How will the course get delivered? Is it a traditional or non-traditional educational program?

7. Conclusions

The work done in phase 1 of the C-READ management system has helped to lay the foundation for its design. The e-survey was the most efficient way of having a broad and inclusive approach to stakeholder engagement. By having an initial in-person workshop in Jamaica we were able to clarify some of the potential needs of stakeholders and also refine the survey to properly address our target organizations. The overarching principles of inclusivity, applicability, and efficacy have been maintained throughout this phase in order to ensure that we are creating a system that will be of use to stakeholders in the Caribbean and used by them.

There are varying degrees of capacity in environmental monitoring throughout the partner countries but the electronic survey has provided us with enough data and insight to focus correctly on the areas that need attention. We can and will address the issues that need attention in phase 2.

There is an overwhelmingly positive response to the project thus far and although it is ambitious, the input we have received indicates that this system is needed and wanted. Outreach and education has been universally cited as a desired outcome of this project and we will keep this in mind as we proceed and formulate the approach for phase 2 and phase 3.

ANNEX A: Review of Related Projects

Below is a list of completed, ongoing, and projected projects that are related to the 5C DMS project.

Table A1: Review of Related Projects to C-READ

Project	Description	Relevance to C-READ DMS	Direct Synergies
Regional Framework for Achieving Development Resilient to Climate Change (2009- 2015)	The Regional Framework defines CARICOM's strategic approach for coping with climate change and is guided by five strategic elements and some twenty goals designed to significantly increase the resilience of the CARICOM Member States' social, economic and environmental systems. URL: http://www.caribbeanclimate.bz/ongoing-projects/2009-2021-regional-planing-for-climate-compatible-development-in-the-region.html It provides a roadmap for action by member states and regional organizations over the period 2009-2015, while building on the groundwork laid by the CCCCC and its precursor programmes and projects in climate change adaptation. The strategic elements of the framework are as follows: 1. Mainstreaming climate change adaptation strategies into the sustainable development agendas of CARICOM states. 2. Promote the implementation of specific adaptation measures to address key vulnerabilities in the	The C-READ management system will be a support tool to achieve strategic objectives for Regional Framework. Particularly: - Help with mainstreaming climate change adaptation into policy frameworks by providing integrated data and a decision-making platform - Enhanced monitoring will help to reduce the vulnerability of natural and human systems. - Forest stewardship can be enhanced with integrated hydromet, landcover, and socio-economic data managed in the C-READ DMS.	The mandates set out by the regional framework with the 5C's can be supported directly with the C-READ system. Hence, endorsement of the system will help to mobilize action for climate change adaptation.

	region 3. Promote actions to reduce GHG emissions through fossil fuel reduction and conservation, and switching to renewable and cleaner energy sources. 4. Encouraging action to reduce the vulnerability of natural and human systems in CARICOM countries to the impacts of a changing climate. 5. Promoting action to derive social, economic, and environmental benefits through the prudent management of standing forests in CARICOM countries.		

Project	Description	Relevance to C-READ DMS	Direct Synergies
Implementation Plan for Strategic Framework (2012-2021)	The CCCCC has finalized the Implementation Plan (IP) to actualize the Regional Framework document. The Implementation Plan acknowledges that transformational change is essential to deliver the strategic elements and goals of the regional framework. The IP highlights the existing and significant resource and capacity challenges that hold back the region's sustainable development and growth and a more cogent and coordinated approach to assist in resource mobilization and coordination of actions. This programme is one such initiative at a comprehensive and coordinated mechanism to addressing climate change impacts in the region. Aims and Objectives: 1. Expand knowledge and capacities through evidenced adaptation initiatives and strengthen institutions for greater climate security. 2. Scale up delivery of adaptation programmes in a range of key vulnerable sectors that are critical for sustained and expanded livelihoods. 3. Support effective national, regional, and international level climate architecture to deliver climate change adaptation financing.	Implementation measures can be supported by C-READ system: - Evidence based adaptation measures require data supplied by this system - Climate security enhanced with better integrated data sets - Regional implementation of C-READ can help with scaling up - Data from C-READ is going to be local, national, and regional. This information can help identify areas of need for climate change adaptation	The data from the C-READ system fits with the variable scales of the implementation plan. Additionally, this data informs the implementation objectives and will help to identify areas for investment to enhance climate security and resilience. The current data gaps are in relation to operationalizing adaptation. As cited in the previous sections of this report, stakeholders in C-READ partner countries want vulnerability and risk products. There is no integrated platform that can connect data such as risk of drought and agricultural productivity. C-READ aims to address this.

Project	Description	Relevance to C-READ DMS	Direct Synergies
PPCR Pilot Program for Climate Resilience (2012-2016)	PPCR is executed globally through a number of regional and national programs. In the Caribbean, the Regional SPCR is being executed for six countries. The regional SPCR is focused on: 1. Data availability and analysis 2. Data exchange, storage, and access 3. Modeling climate change and impacts 4. Identifying, up scaling and replicating adaptation measures in key sectors. Key components are: - Improving geospatial data and management for adaptation planning, sea level rise and storm surge impact analysis - Consolidating and expanding the regional climate monitoring network and global platform linkages - Downscaling and expanding climate projection models and high resolution maps - Applied adaptation initiatives	Executed for Jamaica, Haiti, Dominica, Grenada, Saint Lucia, and Saint Vincent and the Grenadines and the CCCCC for the SPCR (regional). Hence, there is overlap in some specific countries (Jamaica, Haiti, Saint Lucia) and regionally. The mandate of PPCR is in line with some of the objectives of the READ system. In particular, the sharing and exchange of data as well as modeling are encouraged as priorities.	The C-READ system supports PPCR adaptation measures such as improving geospatial data analysis, and connecting regional climate monitoring with other data sets. In general, the C-READ system is an operational aspect of PPCR.

Project	Description	Relevance to C-READ DMS	Direct Synergies
The Global Climate Change Alliance (GCCA) under the 10th EDF Intra-ACP financial framework (2011-2014)	The EU – CARIFORUM Global Climate Change Alliance (GCCA) and the Caribbean Community Climate Change Centre signed an agreement in 2011 to the tune of 8 million euro aimed at, among other things, to help strengthen Caribbean States' data-gathering and management capabilities to enable them to cope with economic uncertainty and still provide meaningful emission targets in the near term. The project aims at: 1. Enhancing the predictive powers of regional climate models and the region's ability to design and implement cost-effective adaptation activities. 2. Improving the climate monitoring, data retrieval and space-based tools for disaster risk reduction. 3. Refining the vulnerability and risk assessment methodologies that are more contextually relevant, and build local capacity to better assess the current and future vulnerabilities and risks of specific states and communities within those states. 4. Reducing the states' vulnerability to climate change through embarking on adaptation pilots	The improved data gathering from the GCCA project will help to provide more comprehensive data sets for the C-READ DMS.	The improved climate models and climate monitoring from the GCCA project can be very useful the C-READ system as inputs to the system. It would be idea to have these systems integrated and data shared between them. **These synergies will be explored in the design process of C-READ.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
Caribbean Risk Management Project (2012-2013)	The Caribbean Risk Management Project builds on the work started by the Region in 2003 in the development of Risk Management Guidelines for decision makers, but is intended to be more attuned to the needs and special circumstances of the Region given the prevailing conditions. It will also incorporate the development of new tools and risk management methodologies. The Project will be executed in a phased approach. Phase 1 will be the development of a risk management, web-based tool to guide decision-making (signed for a value of US 365,931). Phase 2 will provide in depth training for country decision makers (to be financed out of GCCA). Phase 3 will undertake detailed risk assessments in selected countries (to be financed). The overall objective is to embed risk assessment into decision-making and management systems across the region in finance and planning as well as other strategic sectors. URL http://www.caribbeanclimate.bz/ongoing-projects/2012-2013-caribbean-risk-management-project.html	At the heart of it, the C-READ system is to be used to reduce risk and vulnerability of nations in the Caribbean Region with a focus on climate change adaptation. To that end this Caribbean Risk Management project is directly relevant to the development of the C-READ system.	The goal of developing a risk management ethic in decision-making in the Caribbean can be supported by the C-READ system. **The risk management framework that has been developed by the 5C's will be consulted in the functional development of the C-READ system. This will ensure that there are cross-synergies between the function of this system and the directives laid out and established by the Caribbean Risk Management Project.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
The CARIWIG Project (2012-2014)	This project is for a total of 641,095 GP pounds. The CARIWIG project will provide locally relevant information on the weather impacts of climate change for a range of time horizons, training for stakeholder technical staff in the use o such weather information, the development of support networks within the region and development of partnerships with UK research institutes specializing in the management of a range of hazards and impacts. A web service will be developed to provide this service through the adaptation and provision of leading weather-generator models from the EARWIG and the UKCIP09 climate knowledge systems. These weather generator models will be used to provide locally relevant weather projections based on the best available observed data and climate model outputs for the region. URL: http://www.cariwig.org	Climate forecasting is definitely and weather impacts are definitely an aspect of the C-READ system and the outputs of the CARIWIG project could fit nicely as integrated data sets for the new DMS. The protocols and format for data sharing needs to be established between the two projects.	There is synergy between the two projects with respect to the type of data that is required for the C-READ system and the model output from the CARIWIG project. If these data sets can be integrated, this will certainly add value to the user's predictive and analytical capability. **These synergies will be explored in the design process of C-READ.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
Australia-Caribbean Collaboration on Climate Change and Coral Reef (2012-2014)	The project aims to link Australian, Caribbean and international expertise in climate change adaptation and coral reef management to support CARICOM member states in addressing some of the key challenges identified in Climate Change and the Caribbean: A regional framework for achieving development resilient to Climate Change (2009-2015). The project has two overarching objectives: 1. Develop a Regional Framework for addressing key challenges for the sustainability of coral reefs associated with climate change and 2. Build regional capacity through development of a climate change adaptation toolkit for coral reef managers. URL: http://climateandreefs.org/about-the-collaboration/	The monitoring of coral reefs is of utmost importance to ecosystem health and the economic well being of the Caribbean region. This is a data-intensive activity and the C-READ system will be able to provide a platform for synthesizing reef data with other factors. The development of the C-READ system requires examining a variety of different types of environmental data and coral reef data will most certainly be one aspect.	The data research and data gathered by the Australia-Caribbean Collaboration on Climate Change and Coral Reef will be very useful for the –READ system in the sense that the diverse data sets will help to connect impacts that are seen in different spheres. For example, the capability of looking at land cover change, climate forcing, and the corresponding impacts on coral reef health could be very useful. The C-READ system should be able to provide these types of insights. **These synergies will be explored in the design process of C-READ.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
CIMH - CARIWIN	The focus of the CARIWIN project is on Integrated Water Resources Management (IRWM). The Brace Centre for Water Resources Management at McGill University and the Caribbean Institute for Meteorology and Hydrology are the lead organizations for this project. The project aims to improve existing capacity in Grenada, Guyana, and Jamaica involving local community organizations, water user associations, and regional and national networks. URL: http://www.mcgill.ca/cariwin/	The gap analysis and assessment of inputs and outputs will address water resource management data and issues as well as climatology issues. The management practices for IRWM can be supported by the C-READ system due to the fact that water data will be gathered.	The outcomes of the CARIWIN can be supported with the C-READ system due to the integrated data sets that will be created. In fact, there may be even more aspects of IRWM that can be achieved with the C-READ system.

Project	Description	Relevance to C-READ DMS	Direct Synergies
CADM (Phase 1 and Phase 2)	The Caribbean Disaster Management Project is being implemented under the CARICOM/Japan Technical Cooperation Agreement through the Caribbean Disaster Emergency Management Agency (CDEMA) and with the support of the Japan International Cooperation Agency (JICA). The focus of the project is to build capacity and strengthen institutional mechanisms to mitigate damages in the CDEMA Participating States. One of the key issues addressed with the CADM project is flood impacts and risks. The project countries are: Belize, Dominica, Grenada, Guyana, and Saint Lucia. URL: http://www.cdema.org/publications/CADMPhase2Flyer.pdf	Predicting the problems that may occur from impacts and having alternative strategies is a key part of climate change adaptation. The CADM project relates to the risk mitigation character of the C-READ system. The data that will be gathered by the C-READ will help with many forms of natural disaster mitigation.	The key synergies are the data products that will be created with the CADM project and having them shared with the C-READ system. For example, flood risk maps would be very useful and helpful. **These synergies will be explored in the design process of C-READ.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
CIMH – UNDP/Italy Enhance Resilience to Reduce Vulnerability (ERC Project)	Barbados and the OECS (Organization of Eastern Caribbean States) are vulnerable to a range of hazards including earthquakes, floods, hurricanes, tsunamis and volcanic eruptions. The emergence of climate change may amplify the impacts of these natural disasters. The underlying issue is risk to the environment and societies in this region. There is a clear need for a diagnostic system that can help to facilitate disaster risk reduction. The ERC project aims to address this. URL: http://63.175.159.26/erc/home/	The technical design of the ERC system was achieved with MySQL and PHP. The objectives of the ERC system are in some ways very similar to the C-READ system and hence there should be some close synchronization between the two systems. In fact, the ERC was developed by CIMH and is now hosted by them. The development of the C-READ system should follow somewhat the path of the ERC.	The connection of these two systems is in the data they gather, the questions they are attempting to address, and the technical means by which they are implemented. Hence, there is a significant amount of overlap. **The developers of the C-READ system will consult with the developers of the ERC system. Also, ways of sharing data should be explored.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
CIMH - RRACC Expansion and enhancement of hydrometric networks in the OECS (USAID)	Reduce Risks to Human and Natural Assets Resulting from Climate Change Project (RRACC) evolved from meetings in July 2010 on Climate Variability, Change and Adaptation in the Caribbean Region. USAID was one of the main conveners of this meeting along with the OECS and the Barbados Coastal Zone Management Unit. USAID formulated a five-year plan (2011 to 2015) for climate change adaptation in the Caribbean region. The OECS Secretariat submitted a proposal to USAID for climate change financing and this was approved and initiated in 2011. The main objectives of this project are to: - Improve the enabling environment to build understanding and support for policies and laws that reduce vulnerability to climate stresses - Launch interventions in freshwater and coastal management to build resilience - Build institutional capacity and addressing information gaps through support for key practitioners in government and related sectors affected by climate change as well as support for institutions in the region such as training facilities, government departments and entities charged with developing data. URL: http://www.oecs.org/our-work/projects/rracc?showall=&start=1	There C-READ system has the mandate to fill in gaps where data is missing for environmental monitoring and climate change. This relates to the objective of the RRACC project. The delivery of a platform such as the C-READ system will help to improve action-based directives for climate change adaptation in the Caribbean region. The C-READ project can benefit from the insights that have been realized thus far with the RRACC project.	The synergy between these two projects is based primarily on the needs that have been identified by the RRACC project in climate change adaptation and awareness in the OECS. Data gaps can be filled with the C-READ project and capacity will be developed for analysis and decision-making. These synergies will be explored in the design process of C-READ.

Project	Description	Relevance to C-READ DMS	Direct Synergies
CIMH - Carib-HYCOS (France & WMO)	The project objectives are the reinforcement of national capabilities in water resources assessment and the promotion on international cooperation (exchange of data, technology and expertise). This is a joint project between the WMO and the Institut de Recherche pour le Developpement and CIMH. URL: http://www.whycos.org/whycos/projects/under-implementation/carib-hycos-cic	Hydrological and meteorological data management is central to the C-READ system and thus there is a clear relation to the Carib-Hycos project. Where there are gaps identified in the Gap Analysis there could be action items identified for the Carib-Hycos project.	The key connection and synergy is through water resource management. This is a central issue to sustainable development of the countries in the Caribbean region, hence the synergies between the Carib-Hycos and the C-READ project are very important. **These synergies will be explored in the design process of C-READ.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
CIMH – GEF IWCAM (Integrating Coastal Areas and Water Resource Management)	The IWCAM project is focused on the following main issues: - diminishing freshwater - degraded freshwater and coastal water quality - inappropriate land use - hygiene and sanitation The overall objective is to strengthen the commitment and capacity of the participating countries to implement an integrated approach to the management of watershed and coastal areas. The long-term goal is to enhance the capacity of the countries to plan and manage their aquatic resources and ecosystem on a sustainable basis. The participating countries are: Antigua & Barbuda, the Bahamas, Barbados, Cuba, Grenada, Dominica, the Dominican Republic, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent & the Grenadines, and Trinidad & Tobago. The project was approved by the GEF in 2004 and commenced in 2005. The implementing agencies are the United Nations Environment Programme (UNEP) and the United Nations Development Programme (UNDP). Executing agencies are the Secretariat of the Cartagena Convention (UNEP-CAR/RCU) and the Caribbean Environmental Health Institute CEHI. URL: http://www.iwcam.org	Improved coastal zone and water resource management is a data-intensive exercise that fits within the general mandate of the C-READ project. The integrated data sets – land cover, atmospheric, oceanic, socio-economic, etc. can all be encompassed within the data model of the C-READ system and also help to meet the objectives of the IWCAM project. The integrated data sets are the key connecting factor here.	Synergy can be achieved by connecting with responsible CEHI staff who have worked on this project to see what functional objectives for their project they have outlined and then connecting these with the C-READ system. Queries related to water resource levels, quality of freshwater and coastal waters, land use patterns in relation to water quality, and hygiene and sanitation could be addressed through analysis provided by the C-READ system. **The design of use case scenarios will take into consideration the work under this project.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
CIMH – NASA - CDEMA : CSDP (Caribbean Satellite Disaster Pilot project	The CSDP project is focused on providing satellite and value added services that can help assist countries in the Caribbean with disaster-management related tasks. One of the main outcomes of phase 1 was the establishment of regional and national partner collaboration mechanisms as well as capacity building. Under an initiative of the Canadian Space Agency, capacity building activities in phase 1 focused on satellite information for disaster management in each of the five National Partner States, Barbados, Saint Lucia, Grenada, Jamaica and the Virgin Islands. Through the Pilot, NASA has established a Caribbean-wide initiative with a satellite-based Sensor Web for flood prediction and warning at its core. As the CSDP advances in the definition of components of phase 2, institutionalization and integration of the pilot's outputs into existing disaster management programmes, plans and operations of key organizations in the region will be addressed. This will also be important to ensure the sustainability of the pilot's outputs. The new work plan for phase 2 will address additional capacity building which would be tied to service lines, as well as further risk reduction activities aimed at mitigating natural hazards and catastrophic events. User-friendly access and sharing of the CSDP products remains a priority.	The C-READ system will benefit from the integration of satellite data for environmental monitoring. In the case of the CSDP, the data being targeted is directly related to disaster risk management. This is certainly an objective of the C-READ project but there is a broader mandate of environmental monitoring as it relates to climate change adaptation. Part of this is disaster response, but also included in this are less acute problems and more chronic issues such as ecosystem degradation. Integration with CSDP could be beneficial to the C-READ system; however, this will need to be more thoroughly analyzed.	The direct point of synergy is the fact that both systems deal with reducing risk and vulnerability through providing data products to decision makers. We will clarify how much overlap there are between the specific data products that each system will use.

Project	Description	Relevance to C-READ DMS	Direct Synergies
Advanced Flood Forecasting System (CIMH / Japan -CARICOM / CCRIF).	The project, which is funded through the Japan-CARICOM Friendship and Cooperation Fund, will develop and implement a system to provide advanced warning of the potential for flooding at the country of local scale 24 to 48 hours before the onset of flooding. The system is expected to lead to better forecasting of the location and onset of flooding. Utilization of this information by disaster management community in its strategic and operational planning and advisory services is expected to reduce fatalities and property losses associated with flooding events. Although the system is being developed in concert with the disaster management community, the information that will be provided should be of significant value to the health, agricultural, transport and commercial sectors. The project is piloted in watersheds in Barbados, Guyana, and Jamaica. The methodology combines mathematical modeling in hydrology and meteorology with ground and satellite-based data collection as well as data from the Caribbean Meteorological Organization radar network. URL: http://www.cimh.edu.bb/?p=projects http://www.ccrif.org	The C-READ system can benefit from the forecasting potential of this system. It may be a separate module or perhaps the forecasting data can be imported	Several stakeholders have stated that they see flooding and inundations as risk factors. They have requested that a risk query be established in which they can see probability of drought and of flood. **Our team will look at the CCRIF project and determine how we can integrate with it.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
Caribbean Regional Climate Outlook Forum	The CRCOF is a forum that brings together experts in meteorology, hydrology, and related environmental impacts in the Caribbean related to climate change. The World Meteorological Organization (WMO), NOAA, and USAID as well as a number of national meteorological and hydrological service organizations (NMHS) support the CRCOF. The forum is a platform for sharing ideas about monitoring, assessing risk and vulnerability, and applying forecasting models to climate change in the Caribbean. The goal is to improve policy and decision-making allowing for reduced risks and better interventions to reduce vulnerability. URLs: http://63.175.159.26/~crcof/index.php http://www.gwp.org/en/GWP-Caribbean/GWP-C-IN-ACTION/News-and-Activities/Caribbean-Experts-Look-at-Establishing-a-Regional-Climate-Outlook-Forum-/	Some of the objectives of the C-READ project map directly to the topics discussed at the CRCOF forum. In particular, how Caribbean nations can deal with environmental impacts and climate change. The knowledge and discussions in this forum are in line with the C-READ project.	The stakeholder engagement process has been initiated but it is an ongoing process. **It would be good to have representation of the C-READ project at this forum to gather ideas and insights as to what the main concerns of different stakeholders are.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
Caribbean Flood Risk Atlas (CIMH / World Bank / UWI – DRCC)	The Caribbean Risk Atlas project is funded by the World Bank and housed at the Disaster Risk Reduction Centre (DRRC) at the Institute for Sustainable Development. The overall objectives of the project are to build capacity in the Caribbean Region to analyze disaster risk in terms of potential losses and to the use of this type of analysis in the development of comprehensive risk management strategies. URL: http://www.uwi.edu/isd/projects/wbdrcc.aspx	Mitigating disaster risk is a key element to the C-READ project and the lessons learned from the Caribbean Flood Risk Atlas will be useful for this project. In particular, the integration of geospatial data sets to address climate change and disaster risk will be instructive.	**The Mona Geomatics Institute team has exposure to this project and we will employ their knowledge and skills in order to see how to effectively address the vulnerability and risk issues we face on this project.**
Climate and Hydrological Data Rescue, Storage, and Dissemination (CIMH / CDB)	The Caribbean Development Bank (CDB) has provides the Caribbean Institute for Meteorology and Hydrology (CIMH) with a grant for climate change adaptation and disaster risk reduction. This project will allow CIMH to rescue and digitize historic meteorological and hydrological datasets, and to establish an electronic database to securely archive the data. This electronic hydro-meteorological database at CIMH allows it to better fulfill its mandate to its member countries. URL: http://www.caribank.org/news/news-releases/grant-for-meteorological-data	The digital form of this data could be feedstock for the C-READ project. Current measurements are collected automatically or manually and then transferred into spreadsheets or a database. However, older volumes of data are in paper form. In order to do historical trends, one would need to get the archival information in digital format. The C-READ system should be able to do this type of back casting.	It would be ideal to have access to this data and have it integrated into the C-READ system. Considering the fact that CIMH is a partner on this project, we should have no problems. **Our team will consult with CIMH on this project to see what file format they are putting the digitized archival data in**.

Project	Description	Relevance to C-READ DMS	Direct Synergies
NOAA – CORIS Geo Portal	NOAA's Coral Reef Information System (CRIS) Is a web-based information portal that provides access to NOAA coral reef information and data products with emphasis on the U.S. States. The regional data portal provides data for each geographic region, such as specific reefs in the Caribbean. URL: http://coris.noaa.gov/geoportal/	Coral reef health is an important element of environmental monitoring in the Caribbean. Several project partner organizations with sensitive reef habitats have cited the importance of monitoring reef health not only for enhancing environmental integrity but also for the health of their tourism industry. This issue is important to the economy and environmental management objectives of partner countries to the C-READ project.	The C-READ DMS is to be designed to address shortcomings in environmental monitoring and to create a common platform for climate change adaptation in the Caribbean. NOAA's CRIS provides geospatial information and a database of studies linked to reef health. The geospatial information is limited to parts of the Caribbean with American interests and does not cover the wider region. The main regions are: Florida, Navassa Island, Puerto Rico, Flower Garden Banks, and the US Virgin Islands. There are research articles from other parts of the Caribbean though. **Our team will investigate how we can link to their database of reef study articles – either through RSS feeds or some other mechanism.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
CDERA Disaster Risk Management Framework	The Caribbean Disaster Emergency Response Agency (CDERA) with the support of the Inter-American Development Bank (IDB) and in collaboration with the Caribbean Tourism Organization (CTO); CARICOM Regional Organization for Standards and Quality (CROSQ); and the University of the West Indies (UWI) implemented the Regional DRM for Sustainable Tourism in the Caribbean Project between January 2007 and June 2010. The project was designed to contribute to the reduction of the vulnerability of the Tourism sector in the Caribbean to natural hazards through the development of a Regional Public Good (RPG), which is the Regional Disaster Risk Management (DRM) Framework for Tourism in the Caribbean. Also developed was a Strategy and Plan of Action for Standards for Conducting Hazard Mapping, Vulnerability Assessment and Economic Valuation for Risk Assessment for the Tourism Sector in the Caribbean. URL: http://www.onecaribbean.org/resources/disaster-management/	All of the six stakeholder countries for this project recognize that tourism is an important part of their economy and that a healthy environment is a key ingredient to maintaining it. Additionally, there is the need to implement policies, procedures, and tools that can help reduce the risk to tourism that results from a higher frequency of natural disasters that may be connected to global climate change. The C-READ management system can potentially provide data products that can inform decision makers in the tourism industry as to what risks are posed to their operations.	The CDERA disaster risk management framework includes a variety of documents such as: (1) a manual for baseline data collection at the country level; (2) Guidance for national adaptation of the regional disaster risk management strategy and plan of action for the tourism sector in the Caribbean; and (3) Standard for conducting hazard mapping, vulnerability assessment and economic valuation for risk assessment for the tourism sector. **Our team in the development of the C-READ DMS will consult these documents and guidelines. They will give ideas as to what data should be gathered and how this data is transferred into policy actions.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
Caribbean Planning for Adaptation to Climate Change Project (CPACC) / Adapting to Climate Change in the Caribbean Project (ACCC) /	From 1997 to 2001 and 2002 to 2007 respectively the CPACC project laid the foundation for regional collaboration on climate change adaptation measures. The CPACC project consisted of four regional projects: 1. Design and implementation of a sea level / climate monitoring network 2. Establishment of databases and information systems 3. Inventory of coastal systems 4. Use and formulation of initial adaptation policy As well as five pilot projects: 1. Coral reef monitoring for climate change (Bahamas, Belize, and Jamaica); 2. Coastal vulnerability and risk assessment (Barbados, Guyana, and Grenada); 3. Economic valuation of coastal and marine resources (Dominica, Saint Lucia, and Trinidad and Tobago); 4. Formation of economic/regulatory proposals (Antigua and Barbuda, and St Kitts and Nevis); and 5. National communications (St Vincent and the Grenadines). The completion of the CPACC project led to a subsequent round of funding for the Adapting to Climate Change in the Caribbean Project (ACCC) which lasted from 2001 to 2004 with the mission of sustaining the work of CPACC and addressing issues of adaptation and capacity building that were not covered with CPACC.	The CPACC, ACCC, and MACC projects are all directed along the same lines as the C-READ management system. Perhaps one differential is the fact that the C-READ project is focused on creating a functional tool to help address the issues of climate change adaptation and environmental quality in the Caribbean. The points of synergy need to be identified.	There are several objectives between the C-READ management system and this project that have synergies. For example, the coral reef monitoring objective, the coastal vulnerability and risk assessment, public outreach and education, integration of climate change into physical planning, and building capacity in the countries to address vulnerability and increase resilience. **The development team of the C-READ project will reach out to the appropriate leads from the CPACC, ACCC, and MACC, projects to get updates to where they are with meeting their objectives so that connections can be identified.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
CariCOOS	The Caribbean Coastal Ocean Observing System was started by CaRA (Caribbean Regional Association) as a geospatial framework for integrating environmental observations such as wind direction and speed and ocean currents. This is not a completely integrated database management system, and is focused primarily on Puerto Rico and the British Virgin Islands, but it does have elements of geospatial integration that can be looked to as examples for the DMS project. URL: http://www.caricoos.org/drupal/	The data collected by the CariCOOS project is relevant to the objectives of the C-READ project. Ocean acidification and coral reef health are goals of many partner countries on this project. The data acquisition of CO_2 levels in air and seawater give an indication of the amount of acidification that is occurring. The data is from buoys around Puerto Rico, but perhaps a similar system could be explored for other parts of the Caribbean in order to broaden the coverage. Water quality is also sampled by looking at ocean colour by satellite. Globcolor, part of the ESA and NASA Ocean biology processing centre, provides Ocean colour images.	Coastal zone health – including beaches and reefs are shared priorities by both projects. The data that is being gathered by CariCOOS could be useful for C-READ countries, or at the very least the meta-data would give an indication of what should be gathered. **The C-READ team will look at the priorities of our stakeholders and map them to the CariCOOS project to see what common elements exist.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
UNISDR	UNISDR hosts PreventionWeb (http://www.preventionweb.net/english/countries/americas/brb/?) Which is a knowledge repository for disaster risk reduction. Some of the publications hosted here may be useful. And produces the Global Assessment Report (GAR 2013 - www.preventionweb.net/english/hyogo/gar/2013/en/home/index.html). They have been doing global assessment reports (two have be completed so far – country, to region to global rollups) –GAR reports. Both raw data (spreadsheets) and narrative should be available	The C-READ project is focused on disaster risk response as well as on environmental monitoring. There are clear connections between UNISDR's mandate and that of C-READ.	The country-by-country statistics and information may be interesting to be featured on the C-READ system. At least a link to this site would be useful. **The raw data that is gathered for the UNISDR GAR will be examined to see if it is useful for the C-READ management system.**

Project	Description	Relevance to C-READ DMS	Direct Synergies
EMDAT	EMDAT is a useful database which some powerful search/filtering tools. Small events tend not to be captured but significant events are.	The EMDAT (http://www.emdat.be/database) holds summary information pertaining to disasters that have occurred in different countries and regions. This may be useful for historical analysis. Also GRIP (Global Risk Information Platform) http://www.gripweb.org/gripweb/ has some interesting data and a wide view on disasters globally	There are no clear data linkages here other than records of disasters. However, more work needs to be done to investigate how EMDAT and GRIP can be connected with the C-READ project. At the very least there are case studies and reports that are relevant to C-READ. **The EMDAT and GRIP sites will be reviewed in the context of C-READ's disaster risk response objectives.**
CDEMA	CDEMA also maintains a database of regional comprehensive disaster management (CDM) interventions	CDEMA / CDERA are closely tied to this project and will be consulted with respect to system functionality and data required. http://www.cdema.org/	There are clear linkages between some of the stated objectives of the C-READ project and priorities expressed by stakeholder countries in the e-survey. CDEMA has information and processes that can support addressing DRR issues. **Our team will consult with CDEMA in terms of DRR functionality and existing data sets**

Project	Description	Relevance to C-READ DMS	Direct Synergies
ECLAC/CEPAL	ECLAC/CEPAL also maintains a database of regional disaster events and they are also a repository for DALA's – damage and loss assessments using the ECLAC methodology.	There is a broad array of statistical data available at the CEPAL site. Some of these stats may be useful for the C-READ management system.	The CEPAL database and website has data sets that may help address risk – related issues with the C-READ management system. **As this system is being developed, the CEPAL site can be consulted as needed.**

ANNEX B: E-Survey

Please refer to the .zip file:

C_READ_ESURVEY.zip that was submitted to CCCCC with this report.

The full survey responses can be found in this .zip file:

C_READ_ESURVEY_RESPONSES.zip, that was submitted with this report

ANNEX C: Stakeholder List

COUNTRY	AGENCY/COMPANY	TITLE	GIVEN NAME	FAMILY NAME	PRIORITY LEVEL (1-3)	Survey Complete (Yes/No)
Barbados	Meteorological Office	Mr.	Hampden	Lovell	1	Yes
Barbados	Meteorological Office	Ms.	Sonia	Nurse	1	-
Barbados	Ministry of Health	Mr	Winfred	Greaves	1	No
Barbados	CARDI (Caribbean Agricultural Research and Development Institute)	Dr.	Cyril	Roberts	1	Yes
Barbados	CIMH	Mr.	Adrian	Trotman	1	Yes
Barbados	CIMH	Ms.	Sueanne	Clinton	1	-
Barbados	CTO Caribbean Tourism Organization		Hugh	Riley	1	No
Barbados	Barbados Water Authority	-	-	-	2	No
Barbados	Coastal Zone Management Unit	Ms.	Lorna	Inniss	2	No
Barbados	Department of Emergency Management	Ms.	Judy	Thomas	2	Yes
Barbados	Environmental Protection Department	Mr.	Jeffrey	Headley	2	No
Barbados	Environmental Sanitation Unit	-	-	-	2	No
Barbados	Environmental Unit - Drainage Division	Mr.	Keith	Barrow	2	No
Barbados	Lands and Surveys Department	Mr.	Marcus	Brathwaite	2	No
Barbados	National Conservation Commission	-	-	-	2	No
Barbados	Town and Country Planning Department	Mr.	Mark	Cummins	2	No
Barbados	Ministry of Agriculture ...	Mr.	Ralph	Farnum	2	No
Barbados	CDEMA Caribbean Disaster and Emergency Management Agency	Ms.	Elizabeth	Riley	2	No
Barbados	Ministry of Tourism	-	-	-	2	No
Barbados	Caribbean Development Bank	Ms.	Valerie	Isaac	2	Yes
Barbados	Caribbean Development Bank	Ms.	Cheryl	Dixon	2	-
Barbados	Caribbean Development Bank	Mr.	Yuri	Isaac	2	-
Barbados	IICA	-	-	-	3	No
Belize	Agriculture Department	Mr.	Andrew	Harrison	1	Yes
Belize	Caribbean Agriculture Research and Development Institute (CARDI)	Mr.	Anil	Sinha	1	No
Belize	Coastal Zone Management Authority	Mr.	Colin	Gillett	1	Yes
Belize	Department of Environment	Mr.	Martin	Algeria	1	No
Belize	Forestry Department	Mr.	Wilbur	Sabido	1	No
Belize	Healthy Reefs	Ms.	Melanie	McField	1	Yes
Belize	Inter American Institute for Cooperation on Agriculture	Mrs.	Muhammad	Ibrahim	1	No

COUNTRY	AGENCY/COMPANY	TITLE	GIVEN NAME	FAMILY NAME	PRIORITY LEVEL (1-3)	Survey Complete (Yes/No)
	(IICA)					
Belize	Labour, Local Government, Rural Development & NEMO	Ms.	Candelaria	Saldivar Morter	1	No
Belize	Meteorological Office	Ms.	Catherine	Cumberbatch	1	Yes
Belize	Meteorological Office	Mr.	Dennis	Gonguez	1	-
Belize	Land Information Center	Ms.	Carren	Williams	1	Yes
Belize	National Emergency Management Organization (NEMO)	Ms.	Noreen	Fairweather	1	No
Belize	University of Belize	Ms.	Elma	Kay	1	No
Belize	World Wildlife Fund (WWF)	Ms.	Nadia	Bood	1	No
Belize	Association of Protected Areas Management Organizations (APAMO)	Mr.	Edilberto	Romero	2	No
Belize	Belize Audobon Society	Mrs.	Arreini	Palacio-Morgan	2	No
Belize	Fisheries Department	Ms.	Beverly	Wade	2	No
Belize	Health Department	Mr.	John	Bodden	2	Yes
Belize	Ministry of Natural Resources and Agriculture	Mr.	Paul	Flowers	2	No
Belize	Toledo Institute for Development and the Environment (TIDE)	Mr.	Joseph	Villafranco	2	Yes
Belize	Belize Red Cross	Mr.	Fred	Hunter	3	No
Dominica	Environmental Coordinating Unit	Mr.	Lloyd	Pascal	1	No
		Mr.	Collin	Juist		No
Dominica	Division of Forestry	Ms.	Jacqueline	Andre	1	No
Dominica	Meteorological Office	Mrs.	Karen	Bazil-Lawrence	1	Yes
Dominica	Meteorological Office	Mrs.	Vernie	Marceilin-Honore	1	-
Dominica	Meteorological Office	Mrs.	Marlicka	Laronde	1	-
Dominica	Inter American Institute for Cooperation on Agriculture	Mr.	Kent	Coipel	1	Yes
Dominica	Ministry of Health	Dr.	David	Johnson	1	No
Dominica	Ministry of Water Resource	Mr.	Davis	Letang	1	No
Dominica	Office of Disaster Management	Mr.	Mandela	Christian	1	No
		Mr.	Don	Corriette		No
Dominica	Physical Planning Division MOENRPPF	Ms.	Annie	Edwards	1	Yes
Dominica	Division of Agriculture	Mr.	Addissa	Trotter	2	Yes
Dominica	Fisheries Division	Mr.	Andrew	Magloire	2	No
		Ms.	Kerr	Ferrant		No
Dominica	Tourism (Discover Dominica Authority)	Mr.	Colin	Piper	2	No

COUNTRY	AGENCY/COMPANY	TITLE	GIVEN NAME	FAMILY NAME	PRIORITY LEVEL (1-3)	Survey Complete (Yes/No)
Dominica	Dominica Water and Sewerage Company (DOWASCO)	Mr.	Magnus	Williams	3	Yes
Dominica	Ministry of Community Development	Ms.	Esther	Thomas	3	No
Guyana	Ministry of Agriculture	Mr.	George	Jervis	1	Yes
Guyana	Hydro-Met Service (MoA)	Ms.	Bhaleka	Seulall	1	Yes
Guyana	Lands and Surveys Department (MoA)	Mr.	Naseem	Nasir	1	Yes
Guyana	NDIA National Drainage and Irrigation Authority	Mr.	Lionel	Wordsworth	1	No
Guyana	Civil Defence Commission	Major	Kester	Craig	1	No
Guyana	NAREI National Agricultural Research and Extension Institute	Dr.	Oudho	Homenauth	1	No
Guyana	GEA Guyana Energy Agency	Dr.	Mahender	Sharma	1	No
Guyana	FAO LAC	Dr.	Lystra	Fletcher-Paul	1	Yes
Guyana	MMA/ADA Mahaica Mahaicony Abary Development Authority	Mr.	Rudolph	Gagraj	2	No
Guyana	Guysuco Guyana Sugar Corporation	Mr.	Paul	Bhim	2	Yes
Guyana	Sea Defence	Mr.	Kevin	Samad	2	No
Guyana	GWI Guyana Water Inc	Mr.	Shaik	Baksh (Ms. Onika Holder, Ms Melissa Benjamin, Mr. Orin Browne)	2	Yes
Guyana	IICA	-	-	-	3	No
Jamaica	Climate Studies Group Mona, University of the West Indies, Mona- Physics Department	Mrs.	Roxann	Brown	1	Yes
Jamaica	Forestry Agency/Department	Ms.	Donna	Lowe	1	Yes
		Ms.	Terri Ann	Campbell		-
Jamaica	Meteorological Service of Jamaica	Mr.	Glenroy	Brown	1	Yes
		Mr.	Adrian	Shaw		-
		Mr.	Ricardo	Clarke		-
		Mrs.	Michelle	Thompson		-
Jamaica	Ministry of Agriculture and Fisheries	Mr.	Carlton	Wedderburn	1	Yes
Jamaica	Ministry of Science, Technology, Energy and Mining	Ms.	Hilary	Alexander	1	No
Jamaica	Ministry of Health	Mr.	William	Broughton	1	No
Jamaica	Ministry of Water, Land,	Lt.	Jerome	Smith	1	Yes

COUNTRY	AGENCY/COMPANY	TITLE	GIVEN NAME	FAMILY NAME	PRIORITY LEVEL (1-3)	Survey Complete (Yes/No)
	Environment and Climate Change- Climate Change Department					
Jamaica	National Environment and Planning Agency (NEPA)	Ms.	Nichelle	Oxford	1	Yes
		Mr.	Shawn	Green		-
Jamaica	National Solid Waste Management Authority (NSWMA)	Ms.	Jennifer	Edwards	1	No
Jamaica	National Water Commission (NWC)	Mr.	Ludwig Don	Streete	1	Yes
Jamaica	Office of Disaster Preparedness and Emergency Management (ODPEM)	Ms.	Leiska	Powell	1	Yes
Jamaica	Planning Institute of Jamaica (PIOJ)	Ms.	Elizabeth	Emanuel	1	Yes
		Mr.	Peterson	Hopeton		-
		Ms.	Doneika	Simms		-
Jamaica	Rubis Energy Jamaica Ltd.	Mr.	Garfield	Guy	1	Yes
Jamaica	Rural Agricultural Development Authority (RADA)	Mrs.	Marcia	Young	1	Yes
		Mr.	Basil	Fernandez		-
Jamaica	Water Resources Authority (WRA)	Ms.	Tricia-Rae	Rodriquez	1	Yes
Jamaica	Caribbean Environmental Solutions	Mr.	Jason	Allen	2	No
Jamaica	Chevron Caribbean SRL	Mr.	Dave	Grant	2	Yes
Jamaica	Jamaica Public Service Company Ltd (JPS)	Ms.	Heidi	Hanna	2	No
Jamaica	Jamalco	Ms.	Andrea	Spence	2	No
Jamaica	Marine Geology Unit (MGU)	Ms.	Deborah-Ann	Rowe	2	Yes
Jamaica	Ministry of Tourism	Mr.	Wesley	Banriel	2	No
Jamaica	National Land Agency (NLA)	Ms.	Joan	McPherson	2	Yes
Jamaica	National Works Agency (NWA)	Mr.	Varden	Dowler	2	Yes
		Ms.	Jennifer	Ferguson		-
Jamaica	Social Development Commission (SDC)	Ms.	Avril	Ranger	2	Yes
Jamaica	The Jamaica Bauxite Institute (JBI)	Mrs.	Shanti	Persaud Levy	2	Yes
		Mr.	Ian	Wilmot-Brown		-
Jamaica	The Nature Conservancy (TNC)	Mrs.	Donna	Blake	2	No
Jamaica	University of the West Indies Institute for Sustainable Development (ISD)	Dr.	David	Smith	2	Yes

COUNTRY	AGENCY/COMPANY	TITLE	GIVEN NAME	FAMILY NAME	PRIORITY LEVEL (1-3)	Survey Complete (Yes/No)
Jamaica	Windalco	Ms.	Alicia	Burnett	2	Yes
Jamaica	Caribbean Coastal Area Management Foundation (C-CAM)	Ms.	Ingrid	Parchment	3	No
Jamaica	Environmental Foundation of Jamaica (EFJ)	Mr.	Lehome	Johnson	3	Yes
		Ms.	Karen	McDonald-Gayle		-
Jamaica	Environmental Solutions	Ms	Kimberly	Bryan	3	No
		Mrs.	Rashidah	Khan-Haqq		No
Jamaica	Jamaica Civil Aviation Authority	Mr.	Donald	Shaw	3	No
Jamaica	Jamaica Conservation and Development Trust (JCDT)	Mrs.	Susan	Otokan	3	No
Jamaica	Jamaica Environment Trust (JET)	Ms.	Diana	McCaulay	3	No
Jamaica	Jamaica Hotel and Tourist Association (JHTA)	Mrs.	Evelyn	Smith - President	3	No
Jamaica	Jamaica Institute of Architects (JIA)	Ms.	Ann	Hodges	3	No
Jamaica	Jamaica Institute. of Environmental Professionals (JIEP)	Mr.	Krishna	Desai	3	No
Jamaica	Jamaica Institute of Planners (JIP)	Mrs.	Nadine	Brown	3	No
		Ms.	Donika	Simms		No
Jamaica	Jamaica Institution of Engineers (JIE)	Dr.	David	Smith	3	No
Jamaica	Ministry of Local Government and Community Development	Mr.	Philbert	Brown	3	No
Jamaica	United Nations Environment Programme, Caribbean Regional Coordinating Unit and Secretariat for the Cartagena Convention	Mr.	Chris	Corbin	3	Yes
St. Lucia	Ministry of Physical Works	Mr.	Jim	Joseph	1	No
St. Lucia	CEHI Caribbean Environmental Health Institute	Ms.	Patricia	Acquing	1	No
St. Lucia	Infrastructure, Port Services, and Transport	Ms.	Allison	Jean	1	Yes
St. Lucia	Meteorological Office	Mr.	Thomas	Auguste	1	Yes
St. Lucia	Inter-American Institute for Cooperation on Agriculture	Mr.	Kevin	Stephenson	1	Yes
St. Lucia	National Emergency Management Organization(NEMO)	Ms.	Dawn	French	1	Yes
St. Lucia	Water Resource Management Agency	Mr.	Michael	Andrew	1	Yes
		Mrs.	Farzana	Yusf-leon	1	-
St. Lucia	Ministry of Agriculture, Food	Dr.	Felix	Aria	2	Yes

COUNTRY	AGENCY/COMPANY	TITLE	GIVEN NAME	FAMILY NAME	PRIORITY LEVEL (1-3)	Survey Complete (Yes/No)
	Production, Fisheries and Rural Development					
		Mr.	Barry	Innocent		-
St. Lucia	Water & Sewerage Company (WASCO)	Mr.	John	Joseph	2	No
Trinidad	GWP-C Global Water Partnership Caribbean WACDEP Water Climate and Development Program	Mr.	Trevor	Thompson	1	No
Trinidad	CANARI Caribbean Natural Resources Institute	Ms.	Anna	Cadiz	2	No
Trinidad	CWWA Caribbean Water and Wastewater Association	-	-	-	2	No
USA	NOAA	Ms.	Anni	Hillary	1	No
USA	CDC Centers for Disease Control and Prevention	Dr.	Richard	Gelting	2	No
Panama	CATHALAC	Mr.	Emil	Cherrington	2	No

ANNEX D: Workshop Results

Please refer to the .zip file:

C_READ_WORKSHOP_JUN17_2013.zip, that was submitted to CCCCC with this report.

ANNEX E: Survey Results For Jamaica

Table E1: Summary of climate priority issues in Jamaica

Priority Rank	Climate Change Issue
1	High quality daily and monthly climate data, / Variability in rainfall patterns / Early warning system / Water harvesting and management / Sector Plans for the Reduction of Green House Gas Emissions / Building of natural (ecosystems) resilience / Water production (Drought and Storms) / Hazard and vulnerability assessment Environmental Impact Assessment / Impact of climate change on Urban Areas / Sustainable crop production and access to water/ water harvesting / Impact on water resources availability particularly groundwater / Protection of people and the environment / Effect on development / Sea-level rise / Location of all roads / Heavy rainfall / Air Pollution / Dusting (due to long periods of drought) / Disaster Risk management / Impacts on coastal and marine resources
2	Future climate change using dynamical and statistical modeling techniques / Extended dry seasons / Increase in the frequency and intensity of Tropical Cyclones / Proper land and animal husbandry / Development of national Adaptation Plan and Adaptation Plans for each Sector / Spatial planning to reduce vulnerability / Saline Intrusion / Multi-hazard Risk Assessment / Climate change on coastal and marine resources / Farmer training (natural disaster preparedness and management) / Impact on water quality in coastal aquifers with respect to sea level rise / Impacts of natural hazards / Effect on Green Economy / Coastline changes / Impact of wave action on coast and road as sea level rises. / Coastal erosion / Water Pollution / Environmental spills (due to prolonged periods of heavy rainfall) / Climate Change Adaptation / Impacts on water resources management
3	Linkages between climate change and socio-economic sectors / Increased incidents of forest fires / Changes in rainfall patterns / Appropriate research and development to include climate resilient species / Development of Micro Insurance for Small Farmers and Fishers / Public awareness / Bacteriological contamination / Training and Public Education / Impact of climate change on agriculture, food security / Crop zoning for optimal production and food security / Reduction of rainfall and impact on surface waters / Flash floods / Ways in which energy efficiency may mitigate climate change / Natural hazards / Reduction of slope failures due to increased rainfall intensity. / Flash floods / Sewage disposal / Stability of the Mud Stacking facility (due to prolonged periods of intense rainfall) / Agro-forestry / Increased pollution risks from climate change
4	Past climate extremes including hurricanes / Increased probability and intensity of hurricane / Increase in both air and sea temperature / Crop zoning / Developing Plan to deal with Slow Onset Events / Measures to support reduction in GHC emissions / Damage to infrastructure / Building disaster resilient communities/ building climate change adaptive capacity / Impact of climate change on Watersheds / Impacts on drought, floods and hurricanes on the sector / Impact on watersheds and changes in water resources regime-quantity and quality / Fires / Effect on livelihoods / Coastal development / All designs to incorporate climate change resilience. / / Non-degradable substances / Shortage of grass for cattle (due to long periods of drought) / Soil Conservation activities / Impacts on coastal Infrastructure

Priority Rank	Climate Change Issue
5	Workshops and compiling training material / Increased incidents of pests and diseases / Sea level rise / Sustainable fisheries management / Development of Disaster Risk Management Plans for each Sector / Disaster risk reduction planning / Watershed degradation / Implementation of micro-mitigation projects / / Livelihood of farming communities / Intensity of extreme events (floods and droughts) and impact on water resources-quantity and quality / Earthquake / Effect on ecosystems and ecology / Conservation / Understanding our vulnerabilities/greening of offices / / Deforestation / Deposition of sediment in ship channel (due to increased coastal sediment supply) / Reforestation / Mainstreaming of climate change into national and regional development strategies, policies, programmes, projects etc. and increasing overall awareness

Table E2: Summary of responses to questions related to data management in Jamaica

Q. Data updates and Frequencies of Data
– Data update procedures are specific to research project. – The land use/cover dataset is scheduled to be updated every 10 years. Other datasets are updated daily, weekly and monthly as the data is collected. – Available data updated monthly into database. – Quarterly reports (every 3 months). There are other ad hoc reports and reports based on project timelines etc. Daily, Change of addresses of fisher folks etc – The National Communications submitted to UNFCCC are required. However, these are highly technical and not readily used by mainstream Jamaica. Through Met Services. – Most data are primarily collected and updated on a yearly basis. – Daily, weekly, monthly, yearly monitoring through an MIS department – Inventory data - after every major event; shelter database - every 2 years; – Poverty map updated after national census data becomes available but is highly dependent on the availability of financial resources. Postal Agencies are updated as required by the Post & Telecommunications Department. – Farmer verification- on-going; crop production estimates - monthly; met data - monthly; natural disaster impact assessment- right after an event of disaster; pest surveillance- on-gong' pest surveys - from time to time (no specific period) – Technicians and professional staff collect data in field from installed stations; data processed and checked for accuracy. Complete island wide collection done per month. Stream flow -daily frequency. Groundwater monthly measurement. – Data is collected before, during and after projects. – Data is collected and updated as determined by availability of funds and project requirements – Data received monthly as specified in National Resources Conservation Act permits and licenses - air quality; some other data received quarterly or on a triennial basis (section 17 pollution control forms); database updated as data received – As funds are available - preferably monthly or at least quarterly. Following major coastal storms. – Daily data updates are done on parcels – I am not sure. The agency collects various data so there are various procedures that are used. Data can be collected on a daily, monthly, annually basis – Stations are serviced if they are suspected for underground contamination, or if they have the possibility of contaminating wells or any other ground water bodies. – Survey data is updated presently for areas where funding can be secured to undertake new surveys of each area. General policy of the organization is to update these documents (profiles) every 5 years. GPS - Asset Mapping is currently being undertaken and thus has not been updated - no set period of update has established. – Data collected daily and updated weekly – Reports from the grantees are normally received on a quarterly basis. – Project and Country Driven. Countries are required to report on the implementation of the Cartagena Convention and its Protocols every two years and the Secretariat is required under the Protocol on Pollution to produce a State of Convention Area Report on a periodic basis. The Secretariat has started to work on its first one.
Q. Data Distribution policies and restrictions
– Data that are obtained from other institutions may not be forwarded to any third party. Model data are freely provided to any institution requesting them. The institution is asked to acknowledge source. – "Prohibited Uses 1. Sale, distribution, loan or offer for sale of the Data either in whole or in part other than as prescribed herein. 2. Direct reproduction of the Data provided with the intent to sell without the prior written consent of the Department. 3. Omission, removal or alteration of the Forestry Department copyright notification. – No data distribution policies in place but restrictions are such that only limited daily or hourly data is available to users. – Most information is Public Information and data that can be had through the Access for Information Act. There are restrictions if it is a Cabinet Submission or information regarding a personal issue such

as conch quota for a named company etc.
- None.
- data collected are freely available upon request
- Freedom to information act, some information is paid for
- Data sharing agreement
- Data is shared or sold with the signing of an agreement.
- Crop production estimates- goes to the Ministry of Agriculture and Fisheries Data Bank; Farmer Registration Database (ABIS) is available on line. Personal information on farmers is restricted and retained within RADA
- Data is distributed freely but if analysis is required then a fee is charged. No restrictions on data access
- We do have policies that we implement, such as: The Health Environmental and Safety Security Management System, drugs and alcohol as well as environmental policies.
- Depends on the source of the information, some may be restricted others open. Some may not be released until after publication
- Specific reporting to National Environment and Planning Agency as per Jamaica Bauxite Institute/National Resources Conservation Act, Memorandum of Understanding (2013)
- Information and data on website is freely available to all with proper acknowledgement of the sources and credit given to the authors and respect their copyrights. The Marine Geology Unit is in no way responsible for the use of the information contained on the site. Copyright of published material remains with the authors and/or publishers. Data collected under grant-funded projects may be requested via email.
- Data sold to public with usage controlled by license agreement. Data also made available for free query by the public via web map.
- Decentralized system. So each department has own restrictions.
- Most of the data is internal and private; it has to be vetted by company management.
- Data produced by the SDC is available for use by the public however the profiles and maps are available at a set cost guided by our Cost Recovery Guidelines and this cost mainly represents a reproduction cost. Profiles are shared in PDF format. Maps and Shapefiles are also made available.
- Data reported per permit/license requirements, which are publicly available. Other available data is proprietary.
- Data is shared via internet on the EFJ website and on the EFJ Facebook page. All documents should acknowledge EFJ as the major grantor and will provide adequate visibility of the funding agency. This includes: printing the EFJ logo on all materials, publications, leaflets, brochures, promotional items, supplies and equipment.
- All data and information generated by the Programme and Projects are freely available subject. For data generated at the country level, dissemination is subject to prior approval from Governments generating the data or from Research/Academic Institutes if data is considered sensitive in nature.

Q. What are the Data products and services delivered?

- Daily, monthly, seasonal and annual model data for current and future periods, summary statistics, graphs, maps, IDF curves.
- Map design and printing, Image processing, Image georectification, Data Integration and Data Format Conversion
- Complex Spatial Analysis and Modelling, Map Digitization / Vectorization / Feature Extraction
- GPS mapping and land surveying
- Remote sensing
- Photogrammetry
- Monthly rainfall summaries, Climate Bulletins, Monthly Weather Summaries (Internally), Climate Reports, Requested Climate Statistics, Monthly Reports, Severe Weather Reports, Hurricane Reports, Seasonal Rainfall Forecast, 24 Hour Weather Forecast, Four Day Outlook, Aviation Forecast, Marine Forecast, Drought Monitoring on Station Level.
- Production data given to PIOJ and other stakeholders, cost of production data given to farmers and other stakeholders, yield data, soil data, farm gate prices, data regarding protocols for meat and fish exports and imports, data regarding import and export of plant and plant parts,
- None.
- Annual Reports, State of the Environment Reports, Work is progressing on the preparation data atlases and National Spatial Plan.

- Water Production, Water Quality, Wastewater
- Reports, shapefiles, maps
- Poverty maps, primarily. Our organization primarily uses data generated by others to conduct analysis or studies. Data obtained as a result of various projects are also managed by the PIOJ. Ad hoc GIS assignments are done by requests and this data is delivered to the client and not shared with other users.
- Farmer registration information: www.rada.gov.jm (see ABIS)
- Water resources bulletins, flood frequency analysis, flow duration curves and assessment of water availability, suitability for use and water planning (Master Plan). Water quality assessment, assessment of and recommendations for developments re impact on water resources.
- We sell gas which is our core business, we own some rental of location, and retailers operate on a contractual agreement.
- We mainly do projects with both local and international agencies such as the United Nations Development Programme or the National Environment and Planning Agency. These projects are environmentally based and involves mainly community sensitization especially during the hurricane season
- Technical reports; investigations with respect to environmental incidents; verification monitoring (sample collection and analysis)
- Mapping of the geology and physical features of coastlines
- Beach profiles
- Bathymetry of the island shelf
- Time series analysis of coastal changes using satellite imagery and aerial photography
- Environmental and hazard assessments
- Standard maps of varying scales in both hard and soft copy formats.
- Shapefiles of features such as parcels and roads.
- Customized mapping service
- Web map (iMap)
- Traffic counts and GIS data
- Any data products that we acquire are from the WRA. Rubis would be responsible for site assessments and soil borings, to determine the extent of contamination, if any.
- The SDC produced a word document/report on the Socio-economic status of a community in a document called a Community Profile. Listings of Community Based Organizations in each community also maintained and shared. Maps of each community (Line Maps generated by the community representatives and not done to scales as well as Maps generated through the use of ArcGIS. Community Boundary descriptions drawn utilizing ArcGIS.
- The organisation is a funding organisation that supports environmental NGOs and CBOs that are interested in doing environmental conservation, preservation and rehabilitation projects.
- Interactive Maps, Technical Reports, Fact Sheets, Brochures relating to the state of the coastal and marine environment of the Wider Caribbean Region

Q. What are the methods of data collection?

- Data collection methods are varied depending on variables. Abundance data for lizard and arthropod population are collected using pitfall traps and are collected for particular seasons. Meteorological data are collected using an automatic weather station mounted on the roof of the Physics Department and in the Hellshire Hills area.
- Data is collected via the use of GPS devices, surveys, survey diagrams, image analysis and digitization.
- Manual and automated.
- Data collection officers going to the fields, divers as it relate to fisheries, online surveys, other surveys
- Through Agencies. Also, MOU with UWI exists.
- Primarily field in situ collection and is based on the scientific method internationally applied.
- Manual, Automatic (sensors), Metering
- Field/primary data collection via GPS, interviews/questionnaire
- National Surveys - Survey of Living Conditions, Census. Postal Agencies etc - created from maps and tabular data submitted by the Post & Telecommunications Department.
- Farm visitations for verification purposes and manual data recording; on-line data entry for farmer database with use Tablets
- Data loggers for surface and ground water resources along with field measurement of water levels. Field mapping of extent of extreme events, which may incorporate the use of GPS Technology. Field

measurement of selected parameters using hand held meters
- Observation, reconciliation, and monitoring using special tools and equipment's.
- Post-graduate research, project sponsored data collection, onsite surveys collection of secondary data
- Electronic, paper, field collection
- "Fieldwork
- Desktop Study
- Scientific Investigation
- Aerial Photography and Satellite Imagery Interpretation
- Primary data collection method applied through gathering of data from the field using handheld GPS.
- Secondary data collection methods also applied through gathering data from source documents such as older maps etc.
- Automatic Traffic counter
- Rubis does provide basic observation; as such other agencies are referred to when needed.
- Social Research - Household Surveys, Qualitative Research utilizing Participatory Research Tools (PLA) - Focus Group Discussions and GPS Mapping of Assets present within communities
- Manual collection, real time data collected through a distributed control system (DCS)
- Data is collected through reports provided by grantees; monitoring site visits; Grantee newsletter and DVDs; participation in Expos.
- Varies depending on the programme or project. These could include all of the following: (1) Scientific field data collection ; (2) Lab monitoring and analysis; (3) Remote Sensing; (4) Modelling

Q. What are your organization's data ownership and sharing policies

- Data generated by models are freely provided on request. Institution submitting request is required to acknowledge source of the data.
- As per the national data sharing policy, persons are required to sign a data license agreement for data shared.
- We are guided by Memorandum Of Understandings that we have signed off on with our stakeholders.
- Generally data is public information but some information such as conch quota is confidential, Cabinet Submission, Draft Legislations etc.
- None that I know of. All Intellectual Property Rights as per the CBD/Institute of Jamaica - Clearing House Mechanisms would be referred to and followed.
- We are guided by government's data sharing policy.
- As per the Jamaican laws
- It is specific to the type of data
- Poverty map data is shared with the signing of a Memorandum of Understanding. Sold to private sector organizations.
- No specific policies in place except for ABIS (all requests for information not available on line to be channelled through ABIS Manager); Pest surveillance data shared with the Ministry of Agriculture & Fisheries through the work of Plant health Coordinating Committee
- Water Resource Authority owns the data and use of data must acknowledge the Authority. Data on web site in web map with free access to all.
- Private and restricted data.
- Those of the University of the West Indies
- As per regulatory requirements. Intra-governmental cooperation
- Copyright of published material remains with the authors and/or publishers. Data collected under grant-funded projects may be requested via email.
- Usage of distributed data is guided by a license agreement. The resale or redistribution of the data acquired from the organization in native format is prohibited.
- Governed by the Access to Information Act
- Private data, not shared, except for government agencies we report to.
- Data is proprietary unless reported under permit/license conditions.
- There is no problem as long as the EFJ is acknowledged and there is no breach in the Grant Recipient Agreement which is signed by the grantee and the CEO.
- Variable depending on arrangements with agenciy or country that generates the information. Any output developed by country through the work of a consultancy under contract the UN, is the property of the UN.

Q. What national, regional, or international standards are followed by your organization?

- The regulations of the University of the West Indies, Mona.
- The ISO metadata standard 2. The National Data Sharing Policy 3. Forest Act of 1996 4.Forest Policy 2001 5.FAO guideline definition for forest 6.Convention In Trade of Endangered Species (CITES)
- We abide by the guidelines set out the World Meteorological Organization Manuals.
- International law of the sea, International standards as it relate to food safety, International Office of Epizootics (IOE), Sanitary and Phytosanitary Standards
- Intellectual Property Rights, CBD - CHM.
- We have data reporting requirements under the MEA's such as CITES, Montreal Protocol, CBD, MARPOL, LDC.
- See number 13
- Metadata- as prescribed by National Spatial Data Management Division
- We are bound to follow the Land Information Council of Jamaica metadata guidelines and those established by the Geospatial Data Sharing and Access Council when sharing information with parties and agencies external to the island.
- All protocols stipulated by the Public Service system; Access to Information Act.
- As set out by the World Meteorological Organization (WMO) and national policy on data sharing
- All the relevant protocol enforced: such as the factories act, the petroleum laws.
- All national regulations that govern types of data handled (including permits and licenses)
- Rules of the University of the West Indies. Laws of Jamaica.
- The International Cartographic standards (particularly for symbolization) are applied
  2. Internationally recognized metadata standards are also applied in the creation of feature datasets
- We operate within the Total Quality Management Principles, Archives Act, ISO 215489 -1:2001, Access to Information Act, and Archival Regulation 1988
- This would be according to the standard Jamaican laws.
- Welfare Act
- Jamaican laws.
- Convention on Wetlands of International Importance especially as Waterfowl Habitats (RAMSAR) and the Kyoto Protocol to the United Nations Framework Convention on Climate Change.

Q. General comments or recommendations in relation to data issues

- The development of the Climate Change Division is not yet established and is still in its embryonic stage. There is a plan to have this Division be the Clearing House Mechanism for Climate Change Data.
- Statistical Institute of Jamaica in 2011 conducted a similar survey.
- Yes. More funds to upgrade, improve and expand the national hydrologic monitoring network and provide more reliable and accurate data is critical to better assessment of CC impacts must be allocated to Water Resource Authority.
- Need for centralized collection, monitoring and distribution of data within the Agency. Need for local body to organize and monitor document/data management

Table E3: Summary of responses to questions related to data management recommendations in Jamaica

Q. How would your organization benefit from a regional data management system tracking impacts due to climate change?
– This would reduce the challenge of accessing data from different entities and allow a quick assessment of data availability. The CSGM would also be able to point persons or institutions to this DMS for some data requests. – The data that will be obtained from this regional data management system will allow for better decision making in the Forestry Department. – It would help us to develop new and relevant products based on the needs of our stakeholders. It would help completing request and should also be a source of funding to maintain our networks of environmental monitoring stations. – Better planning and preparedness of the sector to address the climate change challenges – DEFINITELY in the area of WATER RESOURCES AND PLANNING FOR DROUGHT. Geographic information systems (GISs) have become a useful and important tool that MWLECC MUST begin to access and use so as to properly manage water resources. Climate change and greater demands on water resources require a more knowledgeable disposition of arguably one of our most vital resources for Jamaica - increasingly so in the face of DROUGHT. Because water in its occurrence varies spatially and temporally throughout the hydrologic cycle, using GIS and tracking impacts of CC on water is especially practical. While GIS systems previously were mostly static in their geospatial representation of hydrologic features at least now we have today, GIS platforms that are increasingly dynamic, narrowing the gap between historical data and current hydrologic reality. The Government NEEDS to utilize this instrument more so as to be more proactive in dealing with impacts from Climate Change. – It would support our decision making with respect to adaptation strategies – It would significantly assist us in our water production and quality, monitoring and scheduling – National profile for Jamaica. Office of Disaster Preparedness and Emergency Management is also sub-regional Caribbean Disaster Emergency Management Agency focal point for Haiti, Belize, Bahamas and Turks and Caicos. This system will provide pre-impact data on those territories. – A Regional DMS would assist the PIOJ in the monitoring of key national, regional and international development milestones relevant to the environment such as the Vision 2030 Jamaica and the Millennium Development Goals. It would also contribute to our reporting on climate change related issues in key publications of the organization such as the Economic and Social Survey Jamaica (ESSJ) – Access to regional meteorological data, which can be used for regional marketing strategies in crops trade, availability of technical expertise, information on the outcomes of regional climate change related projects and better chance for obtaining funding for climate related project. – The regional data management system would allow for a more informed and accurate assessment of the impacts of climate change; the determination of data gaps needed to be filled to assess climate change; the assessment of the strategies put in place for mitigation of CC impacts and improved forecasting of extreme weather events such as droughts and floods. – Based on the nature of our business information is always needed, and vapor is always released from our sites. This in turn would be good for our projects as informed decisions can be made. – If more data were available that would assist research and development of policy briefs – Unknown. Relationship between climate change and the bauxite alumina industry activities not clear for primary cause and effect. – Based on the mandate of the Organization this would not be applicable – Improve the planning due to experience and data garnered from other regions. – This would be more efficient and accessible. – The data can be used for priority plans for communities in order to assist with solutions. – It would greatly assist us if information/data can be accurately delivered on time. This could help in the Emergency Responses Preparations – The information would be passed on to grantees working in the area of disaster risk reduction and

climate change
- To be able to integrate climate change considerations into the design and implementation of national and regional projects

Q. Which geospatial climate and hydrographic monitoring products would be most useful for informed decision-making in your sector?

- A map that shows drought prone areas within major crop production zones/A time series assessment of regional hydro-met change in all major crop production areas/Biodiversity mapping in key agricultural production zones
- Environmental monitoring site specific products/hurricane events /ground water information would be useful
- Environmental Variables - Rainfall, soil type, topography, disaster risk /Scenario Data associated with pollution prevention interventions
- Flood modelling and projections/Topographic maps
- Flood modelling and projections
- Global Information System (GIS)/Global Positioning System (GPS)
- High resolution Drought Maps/Map showing the impact of climate change on coastal and marine resources/Map showing possible correlation between drought/intense rainfall and outbreak of diseases in humans, plants, animals
- Meteorological data/Water quality data
- Ones To adequately predict agricultural drought (duration and severity)/Ones that will predict localized flooding/Ones that will predict wind speed in localized areas
- Precipitation/Saline intrusion and coastal monitoring/Ground water flow
- Radar and sonar satellites data
- Rainfall - total and intensity data/Temperature, Evaporation/evapotranspiration/Water resources data such as stream flow, ground water levels and water quality viz. salinity.
- Rainfall data/Infrastructure maps/Drainage patterns.
- Storm surge impacts/Rainfall intensity and flooding potential/Rainfall projections
- Storm surge scenarios and impacts on communities/Hurricane monitoring and satellite data /Rainfall predictions and distributions
- Updated high resolution imagery /Island wide distribution of rainfall and temperature interval data (weekly, monthly etc.) and climatic information/Geochemical data

Q. Which other information products or mapped indices would be most useful for informed decision-making in your sector?

- Energy use by type and economic sector/Water use by sector and availability /Population density of key indicators of ecosystem health in time and space
- Flood gauge
- Future projections map on a suitability/unsuitability of specific regions for crop production with emphasis on all 10 crops targeted for ensuring food security/Data to support pest forecasting/Data to support crop forecasting
- Impact of climate change on Urban Areas/Impact of climate change on Watersheds/Impact of climate change on Agriculture, Food security
- Modeling of pollution impacts/Ecosystem change given climate change impacts/Vulnerability assessment tools
- Projected maps for risk analysis. /Satellite imagery. /Topographic maps.
- Rainfall data
- River flow/Watershed status/Sensitive and high density habitat areas
- Satellite imagery of the sites /Maps that show wells, water, sensitive areas among other receptors
- Satellite maps
- Trends in rainfall, temperature, evaporation, and stream flow and groundwater/Impact of variation in rainfall, temperature and evaporation on groundwater recharge. /Variation in water resources availability due to climate change
- Urbanization indices on bauxite lands
- What if scenarios? /Impacts of Climate Change on specific economic sector - tourism? /Impacts of

Climate Change on specific resource management issues - Fisheries, Water, Mangrove Forests, Coral Reefs
Q. Please provide a list of queries that your organization may request from the DMS - eg. What is the average monthly precipitation, land slope, land cover type, and soil type, at a particular location?
– All of the above/Precipitation, and forecasts for DROUGHT!!! – Any climate change and modelling data that DMS willing to share with Forestry Dept./A complete document of the findings of this questionnaire – Forecast of precipitation, wind speed and wind direction. – General Climate Change information/Mapping information – General meteorological data/Environmental modelling for ground water and also air dispersion modelling – Level of storm surge impact on a particular coast given an event/Extent of flooding impact on a particular ecotype/Land susceptibility – Monthly precipitation/Land cover type/Turbidity/soil erosion of watershed and sensitive areas – Rainfall data/Land type/Soil type at particular locations – Rainfall data - hourly and minutely/Landslide susceptibility/Tidal, surge height – Soil type information. /Socio-economic status of communities. /Communities that are vulnerable to Climate Change. – Trends in rainfall and other climate data over the past several years at selected localities as well as island wide. /Regional sea level rise; sea level rise in eastern Caribbean and Central Caribbean/Hydrologic changes in other islands near Jamaica in Greater Antilles for comparison with changes in Jamaica – What is the average annual rainfall for Jamaica, drought indices by parish, average annual temperature, sea level rise in mm/year, median number of hot days and hot nights/What is the impact of climate change related events (hurricanes, floods etc.) on GDP/various sectors, financing available for climate change adaptation annually, per country/Status of sea grass beds - depleted/restored in hectares, locations of protected areas, status of coral reefs, quality of surface and ground water resources – What is the average monthly max temp, min temp. rainfall, wind, cloud cover across a country or different islands of the Caribbean? /What is the average monthly soil moisture, vegetation cover? /What locations are below sea level or below a stated level? – What is the level of sediment run-off from specific location? – What is the projected monthly precipitation for May in locations with elevation of specific locations. /Hottest versus dry areas with given location/Temperature versus elevation in a given area
Q. Besides your own organization, the involvement of which national, regional and international organizations would be most essential for the success of a regional DMS?
– American Petroleum Institute – Caribbean Agricultural Research and Development Institute – Caribbean Community and Common Market – Caribbean Community Climate Change Centre – Caribbean Disaster Emergency Management Agency – Caribbean Institute for Meteorology and Hydrology – Caribbean Maritime Institute – Caribbean Natural Resources Institute (CANARI) – Caribbean Public Health Agency (CARPHA) – Caribbean Water and Wastewater Association (CWWA) – Centre for Resource Management and Environmental Studies, University of the West Indies-Cave Hill – Climate Studies Group, Mona – Disaster Risk Reduction Centre – Environmental Health Unit – Environmental Protection Agency – Food and Agriculture Organization – Global Water partnership

- Inter-American Development Bank - IDB
- Inter-American Institute for Co-operation on Agriculture
- Land Information Council of Jamaica
- Meteorological Service of Jamaica
- Mines and Geology
- Ministry of Agriculture and Fisheries
- Ministry of Health
- Ministry of Transport, Works and Housing
- Ministry of Water, Land, Environment and Climate Change
- Mona GeoInformatics Institute
- National Environment and Planning Agency (NEPA)
- National Fire Protection Agency
- National Oceanic and Atmospheric Administration - OCEANOGRAPHIC
- National Spatial Data Management Division
- National Spatial Data Management Division
- National Water and National Irrigation Commissions
- National Works Agency
- Occupational Safety and Health Administration
- Office of Disaster Preparedness and Emergency Management
- PANOS
- Parish Councils
- Petroleum Engineering Institute
- Planning Institute of Jamaica
- Port Authority/Seabed Authority
- Underground Water Authority
- UNESCO IHP
- United Nation Development Programme
- United Nations Educational, Scientific and Cultural Organization (UNESCO/IOCARIBE)
- United Nations Environment Programme - UNEP
- United Nations Framework Convention on Climate Change - UNFCCC
- United States Agency for International Development
- University of the West Indies
- Urban Development Corporation (UDC)
- USEPA
- Water Resource Authority
- World Bank
- World Health Organization
- World Meteorological Organization

Table E4: Summary of responses to the questions related to education about climate change in Jamaica

Q. Is climate change sufficiently addressed in the education system where your organization operates? Explain.
– Yes. Climate change is incorporated in the Energy and Environment major. Workshops have been organized for representatives from different sectors and members of local communities. Brochures, handouts and books have been compiled to provide information on climate information for particular sectors. A video has been compiled detailing the stories of 3 Jamaican communities adapting to climate change. – It is addressed in our organization but there is more to be done to lift the awareness level, which may be about 4 on the awareness continuum with 10 being the maximum. – We try to expose as many of our staff as possible to the different issues relating to climate change adaptation, mitigation and impacts. – No. The Ministry has agencies that work with schools, particularly at the primary and secondary levels, while there are programmes at the secondary level and some environmental courses at the primary levels this is not sufficient to drive home the issues relating to climate change and it impact. – Not sufficiently. – No. There is a need for additional infusion of information at the teacher training level. – No, there is a big misunderstanding of the concept – To some degree yes. A vulnerability ranking was done in Jamaica and some of the outputs were 1. A Community Disaster Risk Management Plan was developed and 2. Training in Disaster Risk Management, first aid, and light search and rescue. – No. There is currently no deliberate attempt to integrate climate change (CC) issues in our education system. CC is infused indirectly via subjects like geography and social studies at the secondary level and may be explored in greater detail at the tertiary level. – RADA is a key agency in Jamaica which farmer training (in Jamaica there are approx 200,000) and have direct impact on their families and quality of life in rural areas. Therefore RADA is embarking on more educational exposure for staff in addressing climate change issues. Internationally funded projects had changed the focus, with all impacts being seen now through the prism of climate change adaptation. This resulted in increasing number of farmer trainings being delivered in climate change adaptation mode. – It is a buzzword but not sure if people understand the impact on everyday life and what changes have to be made to reduce the impact. – Yes, training is done annually to inform employee and contractors of environmental impact due to climate change. – No, the impacts and causes are not well elucidated and the effects at the individual and community levels are not well communicated – Not at all. – No – No. It's only dealt with in the University and is handled as a phenomenon that's far away. – Yes, but could be more aggressively done as it relates to Climate Change. More schools should be targeted in their curriculum. – No. Presently, there is no such system in place. – Yes. In terms of funding projects and dissemination of brochures and literature. – No, still a lack of understanding about climate change, its impacts especially at the local community level and linkages with other sectors
Q. Do you see opportunities or a means by which education with respect to the environment can benefit the community where you operate? If so, at what levels: primary, secondary, tertiary, and community education?
– Yes. Graduates who have a working knowledge of climate change can assist in crafting more sustainable approaches to development, influencing policy meaningfully and working to mainstream

climate change issues across different sectors.

- Yes, through all the stated levels: primary to tertiary and including the community groups such as the Local Forest Management Committees.
- Yes, primary level because the impact will be greater and you are helping to develop good habits from an early age.
- Yes, at all levels of the community. There is the need to capture the minds of the young ones before they develop bad environmental habits. There is also the need to have specialized programmes for the adults.
- Community and Primary Education.
- Education and building awareness are key strategies in the organization at all levels of the educational system and also the public. The data and information will need to be specifically packaged.
- Yes. All levels, primary and secondary as priority and our communities
- Training, public education & awareness at the community level, internship at tertiary.
- Yes. At all levels
- Yes. At all levels, staring as early as possible (primary education as discovery learning). Community Education is key if the impact is to be sustainable. Schools should play a role in assigning students to assessing community vulnerabilities and to propose interventions.
- Yes. Through greater coordination of climate change (CC) activities and increased education programmes at all levels. Existing water education programmes should be co-opted into the national programme.
- Yes, all levels.
- Yes. At all levels.
- Across all levels but most importantly at the community level.
- No
- At all levels.
- Yes, all levels of education.
- At all levels. It should be implemented in the curriculum to stress the importance of Climate Change.
- Community education
- Yes. At all levels
- Yes at all levels.

Q. Comments and recommendations related to Outreach Activities?

- We are looking forward to the implementation of this system because a greater emphasis will be placed on the importance and use of weather and climate data.
- There is an urgent need to have climate change issues as a part of our daily existence. In schools, signage on the roadways, on public buildings, media houses ect.
- The USAID/AILEG Community energy efficiency and renewal project was VERY successful. It should be examined and used as a prototype for Climate Change community projects in Jamaica.
- Information on climate change must be presented in a form that is easily understood at all levels.
- Good project but a bit cumbersome. Hope we could help. The commission is very departmentalized and specialized so some answers may need to be directed to the specific departments
- Proposal for consideration: To put in place a system where all agricultural projects would have a component when individual stakeholders involves being asked to demonstrate at least few practices implemented on their farms to reduce impacts on natural disasters. Farmers to be trained in use agrimet information.
- There are too many bits and pieces of climate change activity taking place and the MWLECC is not aware of these. The coordination of all CC activities, projects and programmes would possible lead to costs savings, a more effective communication of the issues not just to professionals and technicians in selected areas but the entire population and a change of attitude towards CC.
- This is a good initiative; it has the potential to create a good platform in the education forum. It is good for research as information would be readily available.
- Climate change' seems to be more a catch phrase than well understood for the implications of heavy industrial activities. Jamaica does not have clearly established indices that address the relationship of

impacts of climate change.

- The Marine Geology Unit does not have any management at this time and had such no recommendations can be made.
- An integrated data base/ data warehouse should be developed. Incorporate what exists in the system already into the new data warehouse. This would include improving what is presently available.
- The region has several regional organizations with varying mandates for the collection, analysis and dissemination of data and information relating to Climate Change. There is a need to have a clear policy for information sharing in the region. There is also a need to examine the difficulties in establishing Clearing House Mechanisms. Some countries have freedom of information acts while others do not and this has hindered for example sharing and publication of sensitive information such as on recreational water quality. Finally, there is a need to look at issues such as data quality - methodology, harmonized approaches for collection to allow for improved comparison, the improved analysis and interpretation of data to inform policy and decision making, the design and dissemination of more effective information products targeted at specific target audiences. Also a need for capacity building on modelling and linking environmental data with social and economic data as well.

Table E5: Summary of additional relevant comments and recommendations (Computing) in Jamaica

Q. Do you have any comments and recommendations?
- Additional training of staff members may be required in terms of software development and programming but funding is not available for this. It is being suggested that the data and information be supplied to those who will manage and maintain the end product of this project, and those persons will in turn account for the human resources shortfalls in terms software development and programming needs. It is further being suggested that the end product be based upon software that is available to all stakeholders at very little or no cost and that is also acceptable at the international level. - University of the West Indies has centralized computing services; they are not focused on research.

Table E6: Summary of responses to the questions related to meteorology and climate data in Jamaica

Q. What gaps do you perceive in the national meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Insufficient coverage of the island and its different rainfall zones with automatic weather stations – Limited online access to meteorological data sets – Insufficient data on variables other than rainfall (e.g wind speed, temperature, humidity) 4 – Limited access to online plotting tools for local datasets – Digitization of paper records – More intensity gauges for design of early warning systems – Data accessibility and updated information. – Frequency of data capture and the availability of information island wide periodically – There are insufficient climatic stations across the island to get the best spatial resolution for data being collected. For example, there are insufficient rainfall intensity loggers owned by the WRA and the Met Office in each hydrologic basin. Additionally, not enough stations collect data hourly so that there is also a need for better temporal resolution in the data being collected. – Time series and spatial for both existing and desired – Upper air meteorological parameters and complete annual data sets as prescribed by the National Air Ambient Quality Standards (2006)
Q. What gaps do you perceive in the regional meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Limited access to online platforms for downloading data – Visualizing data temporally and spatially for the Caribbean domain – Digitizing paper records – Informality in measured parameters to enable comparisons, and time series and spatial for both existing and planned – The distribution and location of river gages needs to be increased and varied – Data accessibility and updated information.
Q. What improvements could be brought to operational data acquisition and archival processes for met and climate data?
– Access to data or pre-calculated averages should be facilitated online – Access to real time forecast products particularly during the hurricane season – Increase number and spread of functional rain stations – Increased in the number of automated stations, a sustainable maintenance programme, increased data storage capacity and manipulation capacity of the technical team – The respective agencies need to share their data – Data need to be shared and made more freely available to interested persons in the field. Archival data should be digitized and made available. – Perhaps if a general server for data storage was implemented and access was given to certain entities perhaps based on a annual fee etc.
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for met and climate data?
– A policy that speaks to the minimum of staff and support that allows us to stay in touch with technological advances and support for the implementation of a Quality Management System for documentation and quality control of climate data. – No complete data capture; systems backup, data validation exercises and training for statistical rigor, and data quality controls.

Table E7: Stations collecting met and climate data across Jamaica

Station Code	Org.	Obs. Type	Measured Parameters	Storage	QA/ QC	XMIT	Share
KA5HR029	Met Service of Jamaica	Auto	Precipitation, Solar radiation, Temperature, Humidity, Wind speed (10m), Atmospheric pressure (z), Wind direction, Dew point temperature	Spreadsheet	Yes	Download	Private and public
Mona Reservoir	NWC	Auto	Temperature	Spreadsheet	Yes	Paper	Other departments
Hope Filter Plant	NWC				Yes		
Hermitage	NWC				Yes		
	WINDALCO	Manual	Precipitation, Solar radiation, Temperature, Humidity, Wind speed (10m), Wind direction		Yes		Other departments

Table E8: Summary of responses to the questions related to hydrological data

Q. What gaps do you perceive in the national hydrological monitoring infrastructure that needs to be filled for effective observation of environmental change?
– The type of attribute data attached to the hydrology datasets e.g. rivers- width, depth, water volume; watershed information – Need for more coordinated Hydrological measuring stations – More stream flow/river gauges – The WRA has approximately 200 stations to collect surface water data and about the same amount to collect groundwater information. For groundwater, the authority maintains a constant monitoring program of wells monthly and if spatial gaps arise in the collection of this data, then new or other existing wells can be added to the monitoring program to reduce spatial gaps. Water Level data is collected monthly, which gives this kind of data at an ideal temporal resolution. However, while the WRA monitors groundwater levels, abstraction data (the amount of water being pumped from the ground) is submitted to the organization by the owners of the wells. Because the onus of gathering this data lies solely on the owners of these wells, the abstraction data may have spatial gaps where owners fail to submit data monthly as is stipulated, or where the data submitted is not of ideal quality. The ideal situation is to have the WRA monitor groundwater abstraction. However, due to a lack of human resources and sufficient funding, the organization is not always able to do this. For surface water, the organization monitors streamflow data to produce daily discharge. While most of the major rivers in the island are monitored and produce daily information, there are a few rivers of interest, especially in the eastern sections of the island, which could utilize additional stations to improve the spatial resolution of the data being gathered for such rivers. Heavy rains and storms, in particular for eastern parishes, wash many stations away. Additionally, it would be ideal to have all stations being loggers so that data can be recorded continuously over a 24 hour period to ensure not just improved temporal resolution for the data, but increased data quality. A significant amount of stations owned by the WRA are manual stations, which have to be read twice daily by someone in the field. – Background (upstream) data absent in most locations (i.e. additional monitoring points needed on ad hoc basis)
Q. What gaps do you perceive in the regional hydrological monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Need for more coastal monitoring stations – There are some manual stations that need to be replaced by recording data loggers to ensure greater accuracy and reliability of data. In addition there are some stations in the Blue Mountain Range where the rainfall is the highest in the island that had to be abandoned due to a lack of funds to access them. These must be brought back on stream to improve the data coverage in the area, which is projected to be heavily impacted by climate change after 2050.
Q. What improvements could be brought to operational data acquisition and archival processes for hydrological data?
– More coordination among agencies and data collectors with QA /QC – The WRA seeks to implement international standards (WMO and ISO standards) in its data acquisition and archival processes as much as is possible through the establishment and/or introduction of standards, systems and a suitable infrastructure for operational data acquisition and archiving which are acceptable at the national regional and international level and which all stakeholders can use. The organization has also developed and implemented the use of data dictionaries for the collection of data in the field which defines the type of data to be collected and inputted into the system and which prevents data collectors from arbitrarily using any method to collect data. Finally, the organization has implemented and continues to improve upon a centralized database with a specific method of archiving data where all data collected can be stored in a specified manner. At the national/regional level however, there is a need for common standards and methods by which data is acquired and processed to help reduce the barriers in data sharing and implementing systems for regional geospatial networks and regional planning. – Interagency collaboration for data collection and protocol for analysis sharing

Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for hydrological data?
– Rationalization and coordination of equipment and processes – The servers in operation at the WRA are not usually faced with technical difficulties and operate at a fully functional level. Where difficulties have developed in the past, those servers have been replaced with newer models. The organization is further considering the installation of fibre optics to its server system to allow for improved performance in terms of speed. However, a notable improvement to the system would be acquisition of more licenses to access the servers given there are less licenses available than actual staff members. Additionally, with the installation of solar panels, the general workflow within the organization would not be affected by power outages experienced at regular intervals. As it relates to data compilation, the WRA does have standards in place to ensure that data is compiled and processed in a specific manner and any data being added to the central databases are quality checked before they are entered into the system. The organization also ensures the quality of the data it manages through field verification. Regionally speaking, the establishment of standards which are acceptable at national and international levels could be implemented for data management as well as having a centralized platform with set methods of data gathering, processing and compilation on which data gathered and are able to be shared by various stakeholders can be hosted.

Table E9: Stations collecting hydrological data across Jamaica

Station Code	Org	Obs. Type	Measured Parameters	Storage	QA/ QC	xmit	Share
Water treatment plants	NWC	Auto/ manual	Sediment - suspended, Sediment - bed load, Surface water depth - static, Ground water depth, Ground water depth - dynamic, Ground water depth - static, Discharge, Abstraction, pH, Turbidity, Dissolved Oxygen, Salinity, Phosphate, Nitrogen, Fecal coliforms, Total coliforms	ASCII/ spreadsheet /database (type) / paper	yes	Download / paper/ internet / phone	Other organizations
Rio Cobre at Bog Walk (03CA022)	WRA	Auto	Stage, Surface water depth - static, Ground water depth, Ground water depth - dynamic, Discharge, Abstraction	spreadsheet	yes	radio and paper	Other organizations
Plantain Garden River		Auto	Surface water depth - static	spreadsheet	yes	paper	Other organizations
Bog Walk 2 (A/200/61)		Manual	Ground water depth, Abstraction	spreadsheet and shapefile	yes	manual	Other organizations

Table E10: Summary of responses to the questions related to hydrological data

Q. What gaps do you perceive in the national environmental monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Continuous, update and availability of complete data – Instruments to measure the type and quantity of toxic gases in the atmosphere – More readily/easily available remote sensing data on species diversity/change. Capacity to measure changes. Standards for the regular collection and reporting of data from the respective entities – Need for improvement in the Laboratory infrastructure and equipment – Few spatial data on species, data on species population size and distribution, currency of data, identification of key or indicators species, regular monitoring, Collection of field data (NOT remote sensing data) ground truthing. Data on Ecosystem services not collected, data on ecosystem health not collected or if collected not made available. Majority of data collected is not shared. Data collected by some government agencies is only available from paper records. In many cases data aren't shared or made freely available by government agencies – Little retrospective analysis to inform improvements to monitoring networks – Island wide, coastal zone change tidal data and high definition bathymetry of the Exclusive Economic Zone; formatting of data – Background data is lacking
Q. What gaps do you perceive in the regional environmental monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Instrumentation to quickly measure the type and quantity of toxic gases in the atmosphere – No central existing repository commonly known and available – Need for more monitoring stations island wide – Great deficit exists in data on marine species of all types, even those of economic importance – Scarce use of environmental indicators and where used, unclear if appropriate measures being used – Island wide, coastal zone change tidal data and high definition bathymetry of the Exclusive Economic Zone – Not enough collaboration
Q. What improvements could be brought to operational data acquisition and archival processes for environmental data?
– More collaboration among stakeholders and a synchronization of efforts to avoid duplications and knowledge of existing data. Also data collection can be improved through the application and implementation of national standards and equipment to ensure high quality data is collected. – Greater synergies between state agencies. For example working with the Land Information Council of Jamaica – More coordination and centralization – Address the gaps, digitize existing data and reports and make them available to public. Make Environmental Impact Assessment and SEA statements available universally – Additional resources (human and material) for deployment to monitor points; improvements needed for backing up hard and soft data – Increased frequency of data collection; uniformity of data formatting and archiving; freedom of data access – There could be improvements in regards to the island data collection, to obtain background information on the environment and collaboration throughout the region.
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for environmental data?
– The need for more capacity in the area of data analysis and quality control – Standardization – Not nearly as important as the dearth of data – Training for enhanced application of statistical rigor to data; periodic revision of sample collection protocols (feedback from existing practices)

Table E11: Stations collecting environmental data across Jamaica

Study Name	Locations	Org	Obs. Type	Measured Parameters	Storage	QA/ QC	xmit	Share
Air Quality	3 in Kingston	NEPA	Auto	NOx, SOx, PM10, TSP	Database	Yes	download	Yes
Water quality	> 200		Manual	NO3, PO4, FC, BOD, DO	Spreadsheet	Yes	paper	Yes
Sea temperatures	27		Auto	Temperature	Download	Yes	download	Yes
Coral reef health	36		Manual	Live coral coverage	Spreadsheet	Yes	paper	Yes
Beach profile change	6		Manual	Beach profile	Spreadsheet	Yes	paper	Yes
Water Safety Plan (WSP)	Rio Cobre, St. Catherine	NWC	Manual	Water Quality Parameters	Spreadsheet/ database/ paper	Yes	paper	Other departments and other organization s

Table E12: GIS datasets collated by organizations in Jamaica

Organization	Layer names	Type	Grid units	Projection	Program	File format
Forestry Department	Land cover	polygon	meters	JAD2001	ArcInfo	shapefile
	Forest Trails	line	meters	JAD2001	ArcInfo	shapefile
	Plantations	polygon	meters	JAD2001	ArcInfo	shapefile
	Forest Boundary Monuments	point	meters	JAD2001	ArcInfo	shapefile
Met Service	Rain gauge stations	point	kilometres	JAD2001	ArcView	shapefile
	Stream gauge stations	point	kilometres	JAD2001	ArcView	shapefile
MOAH	Land use	polygon		WGS1984	ArcView, ArcMap	shapefile
NEPA	Administrative boundaries	polygon		JAD2001	ArcView	shapefile
	River	line		JAD2001	ArcView	shapefile
	Road network	line		JAD2001	ArcView	shapefile
	Land use	polygon		JAD2001	ArcView	shapefile
	Land cover	polygon		JAD2001	ArcView	shape file
	Watersheds	polygon		JAD2001	ArcView	shape file
	Coastal zones			JAD2001	ArcView	shape file
	Tourism infrastructure			JAD2001	ArcView	shape file
	Natural parks or attractions			JAD2001	ArcView	shapefile
	Inundation boundary	polygon				
	Settlements	polygon		JAD2001	ArcView	shape file
	DEM	raster	30m	JAD2001	ArcView	shape file
	Weather radar	raster				
	Physiographic maps	raster		JAD2001	ArcView	shape file
	Socio-economic maps			JAD2001	ArcView	shape file
	Bathymetric maps			JAD2001	ArcView	shape file

Organization	Layer names	Type	Grid units	Projection	Program	File format
NWC	Plant layout for potable and waste water	line	meters	JAD2001	ArcView/ Editor/ Info	shapefile
	Fire hydrants	point	meters	JAD2001	ArcView/ Editor/ Info	shapefile
	Pipe Networks	polygon / line	meters	JAD2001	ArcView/ Editor/ Info	shapefile
	Valves	point	meters	JAD2001	ArcView/ Editor/ Info	shapefile
	Maintenance points	point	meters	JAD2001	ArcView/ Editor/ Info	shapefile
	Utility poles	point	meters	JAD2001	ArcView/ Editor/ Info	shapefile
	Man hole	point	meters	JAD2001	ArcView/ Editor/ Info	shapefile
	Underground enclosure	polygon	meters	JAD2001	ArcView/ Editor/ Info	shapefile
	Water sub-structure	polygon	meters	JAD2001	ArcView/ Editor/ Info	shapefile
	Water system	polygon	meters	JAD2001	ArcView/ Editor/ Info	shapefile
	Water structure	polygon	meters	JAD2001	ArcView/ Editor/ Info	shapefile
	Administrative boundaries	polygon	meters	JAD2001	ArcView	shapefile
ODPEM	Emergency Shelters	point		JAD2001	ArcGIS 10.0	shapefile
	Storm surge	polygon		JAD2001	ArcGIS 10.0	shapefile
	Building Inventory	point		JAD2001	ArcGIS 10.1	shapefile
PIOJ	Socio-economic maps	polygon		JAD2001	ArcGIS	shapefile
	Post Office Postal Agencies	points		JAD2001	ArcGIS	shapefile
WRA	River	line	metres	JAD2001	ArcView	shapefile
	Rain gauge stations	point	metres	JAD2001	ArcView	shapefile
	Stream gauge stations	point	metres	JAD2001	ArcView	shapefile
	Ground water gauge stations	point	metres	JAD2001	ArcView	shapefile
	Watersheds	polygon	metres	JAD2001	ArcView	shapefile
	Inundation boundary	polygon	metres	JAD2001	ArcView	shapefile
JBI	Administrative boundaries	polygon	kilometres	JAD2001	ArcView	shapefile
	Point source pollution			JAD2001	Aermod	shapefile
NLA	River	line	all island	JAD2001	ArcView	Shapefile
	Road network	line	all island	JAD2001	ArcView	Shapefile
	Land parcels	polygon	all island	JAD2001	ArcView	Shapefile
NWA	Administrative boundaries	polygon	meters	JAD2001	ArcGIS advanced	Shapefile
	River	line	meters	JAD2002	ArcGIS advanced	Shapefile

Organization	Layer names	Type	Grid units	Projection	Program	File format
	Road network	line	meters	JAD2001	ArcGIS advanced	feature class
	Flood prone areas	point	meters	JAD2001	ArcGIS advanced	Shapefile
	Landslides	point	meters	JAD2002	ArcGIS advanced	Shapefile
	Breakaways	point	meters	JAD2003	ArcGIS advanced	Shapefile
SDC	Administrative boundaries	polygon	metres	JAD2001	ArcView	*.shp
	River	line	metres	JAD2001	ArcView	*.shp
	Road network	line	metres	JAD2001	ArcView	*.shp
	Land use	polygon	metres	JAD2001	ArcView	*.shp
	Land cover	polygon	metres	JAD2001	ArcView	*.shp
	Watersheds	polygon	metres	JAD2001	ArcView	*.shp
	Settlements	points	metres	JAD2001	ArcView	*.shp
	SDC Community Boundaries	polygon	metres	JAD2001	ArcView	*.shp
	SDC Development Area Boundaries	polygon	metres	JAD2002	ArcView	*.shp
	Enumeration Districts	polygon	metres	JAD2001	ArView	*.shp
	Community Asset	points	metres	JAD2001	ArcView	*.shp
	IKONOS Imagery	raster	metres	JAD2002	ArcView	*.shp

Table E13: Summary of comments and recommendations for GIS data

Q. Do you have any comments and recommendations?
– Other data types used to enhance analysis etc. Not collected by Meteorological Office but acquired through agreements with the Land Information Council of Jamaica – The Caribbean Risk Atlas was developed with the same concept in line: Geonode and geonetwork.

ANNEX F: Survey Results For Belize

Table F1: Summary of climate priority issues in Belize

Priority Rank	Climate Change Issue
1	– Not enough data sharing eg. Temperature – Accelerating Coral bleaching and coral disease linked to higher SST – Deforestation – We are interesting in studying the change in Temperature and Precipitation trend over the last 60 years across weather stations for Belize. – Transmission of infectious diseases – Coastal erosion that could possibly be tied to climate change. For the past 8 years coastal erosion has increased exponentially resulting in over 80 feet being eroded from some communities such as Monkey River in Southern Belize. Other communities like Punta Negra also in the South loss about 10 ft over the past 5 years. Many families had to abandon their homes, which are now literally in the sea.
2	– Ocean acidification effects on coral, coralline alga, and other calcifying organisms – Water conservation – The impacts of Climate Change on Belize Barrier Reef. Coral Bleaching. – Food Quality Control – Possible changes in spawning seasons for key commercial fish species such as lobster, conch and sea cucumber which have designated open and closed seasons based on research done more than 20 years ago. If climate change affects the spawning seasons for these species, current open and closed seasons may not be as effective in protecting the species as they ought to be.
3	– Increased strength and or frequency of hurricanes - impacting reefs with reduced resiliency – Soil conservation – The impacts of Climate Change on Belize Coast Line. – Water Quality – Changes in weather patterns that result in increased drought or flooding leading to loss of crops, livestock etc. The loss of such livelihoods can result in increased pressures on Protected Areas.
4	– Sea level rise affecting coastal lagoons, mangroves, and deeper reefs – Flood prone areas – The impacts of Climate Change on Agriculture productivity. – Disaster Management – Increased exchange of information between policy makers and local communities for climate change adaptation. Many community members are ignorant when it comes to understanding the possible impacts of climate change on their lives.
5	– Increased fluvial run-off following increased storm events, possibly combined with increased nutrient run-off following increased fires – Production under covered structures – The impacts of Climate Change on Vector Borne Disease.

	– Air Pollution Control – Installation of additional hurricane shelters in communities. Southern Belize is considered to be the highest in poverty rate in Belize. Most of the households in the rural communities are made of sticks and leaves that cannot even withstand a tropical depression. Many of these communities do not have adequate hurricane shelters to withstand a category II and above hurricane.

Table F2: Summary of responses to questions related to data management in Belize

Q. Data updates and Frequencies of Data
– We collect reef health data every two years (odd numbered years) and publish these in report cards in even years. – Data are collected by Extension Officers in a monthly basis. – Data is updated based upon the International Civil Aviation organization and the protocol we have established. Generally speaking, environmental data (precipitation and temp), we have high frequency gathering and analysis. In some cases we may flag data during validation that has questionable quality and issue a change order process to update the data if necessary. – We have clearly delineated categories of data - some of which is for office use only. We also have data sets the have been cleared for public use, they are made available on our web-access server for the public (www.hydromet.gov.bz). – Data updating is only conducted by the Water Quality Laboratory and it is done monthly. – Human Health data is done real time by practitioners. – Our data collection procedures and frequencies vary according to what we are monitoring. Conch, lobster, and sea cucumber have defined open and closed seasons annually so these are monitored before the open and before the close season dates annually. Other parameters such as water quality, sedimentation, and terrestrial biodiversity are monitored on a monthly basis. All monitoring events have defined protocols established as per international methodologies.
Q. Data Distribution policies and restrictions
– We share with partners (48 partner groups in HRI). We also share with other groups upon request and signing of an agreement. – Data distribution is the whole country. Restrictions are the small islands. – We deliver flood and forest fire information on a regularly bases - especially in seasons where there are higher risks. Precipitation seasonal forecast and drought monitoring. – Distribution of Information has different levels. First to the generators, secondly to agreed institution and thirdly to the public. Restriction of information is based on confidentiality principles for patients (health Data) and only shared in aggregate form to protect privacy with other agency. In-house use by Ministry of Health staff contains restriction based on scope of work or responsibility. Information in regards to water results is accessible to the general public. – Data are kept for in-house use mainly. Before data are shared a data-sharing agreement must be signed. The agreement stipulates the conditions for the use to data and specifies restrictions if applied.
Q. What are the Data products and services delivered?
– Report Card on ecosystem health, published in even years eg. 2008, 2010, 2012. Eco-Audit of management responses published in odd years, eg. 2011. All available on www.healthyreefs.org.

- Monthly production, weekly market prices, annual production report
- We deliver flood and forest fire information on a regularly bases - especially in seasons where there are higher risks. Precipitation seasonal forecast and drought monitoring.
- We use satellite-based data gathered from Landsat, MODIS, and Radarsat. We have field-based data that is gathered by different teams (agriculture sector). This data follows pre-defined data format specifications.
- Health Care, Water Analysis, inspection and monitoring services.
- Reports on the population dynamics, distribution, health and trends are generated on an annual basis. Reports on the condition of the water quality in Rivers and Seas are generated on an annual basis. These reports are public and are shared on our website or directly with other institutions as requested. Data analysis is used to make management decisions for fisheries management.

Q. What are the methods of data collection?

- We train and collect using the Atlantic and Gulf Rapid Reef Assessment Protocol (www.agrra.org).
- Field visits
- We assume 100% ownership of the data gathered. We offer a variety of products (processed data) to the public on our web server download page. We also receive requests for data (unprocessed) from partner agencies (Researchers).
- Registration, Questionnaires, Interviews, Direct observation and Reporting.
- Data collection methods vary according to the type of data being collected. Fisheries assessments for conch, lobster, sea cucumber and finfish are done as landing sites as well as under water surveys. Other data are collected during field visits on a monthly basis or as it is required by the approved methodology.

Q. What are your organization's data ownership and sharing policies
Summarize responses

- We make our data available on request. We encourage data sharing among our partners. We are building a new online database to facilitate this now.
- Sharing of compiled data not raw data.
- We assume 100% ownership of the data gathered. User must acknowledge its origin and cannot alter the data without the consent of the National Meteorological Service.
- The data produced by the Water Quality Laboratory is the property of the Ministry of Health. In formation is can be shared with other institutions however only general components would be shared to protect confidentiality.
- TIDE owns 100% of the data generated from the monitoring events. As indicated above, data can be shared using a data-sharing agreement signed by both parties.

Q. What national, regional, or international standards are followed by your organization?
Summarize responses

- The AGRRA protocol is Caribbean-wide.
- FAO
- We use International Civil Aviation Organization (ICAO) standards for data gathering and storage. We have established our own internal protocols for data gathering.
- WHO Standards
- For monitoring of biodiversity we use methods establish protocols such as those established for the region through MBRS (Mesoamerican Barrier Reef Systems). CITIES, for conch monitoring and others established by the Belize Fisheries Department for lobster and sea cucumber. Aside from

monitoring obligations, TIDE is also responsible for obtaining a 'Certificate of good standing' with the Government of Belize on an annual basis. We also operate through international grants where each grant making organization/institution has its own binding agreements for the use of grant funds.
Q. General comments or recommendations in relation to data issues *Summarize responses*
– It is very important for us to see clear data sharing protocols and agreements in place with other users. We are open to sharing data but we need to know that there are security protocols in place on the regional DMS side as there are some data sets that we consider to be sensitive. We would also like to see an emphasis on regional data pertaining to coral reef (bleaching) health and coastal zone management. This is so important in the case of the Belize Barrier Reef and the Meso American Reef. This is a problem we are trying to address, however, we do not have regional data for Central America and the Caribbean to analyze this problem. A regional DMS could be a very significant in helping us in this regard. We have already established a DMS in our case the Central American Data Base. – Although TIDE does Protected Area Management, it cannot be done in isolation from the communities that are affected by the protected areas. TIDE can be considered one of the few Non-Governmental Organizations in Belize who involves community participation in protected areas management. This approach puts us in the forefront of the many issues faced by communities, both related and non-related to protected areas. TIDE is therefore in some ways obligated to seek ways to address developmental issues faced by these communities including the many issues climate change brings.

Table F3: Summary of responses to questions related to data management recommendations in Belize

Q. How would your organization benefit from a regional data management system tracking impacts due to climate change?
– Data is always important. We could use this data for communicating with the general public so that they can make informed decisions – We would benefit from a tracking system that could help make linkages to the reef health data we are collecting, if such linkages exist – The Ministry would benefit by being more informed of vulnerabilities, to establish an early warning system and have a better perspective of climate change developments in the region. – We see immense benefit to participating in a regional program such that we contribute data and are permitted access to large-scale, regional, value added data products. We also recognize that climate change is a global phenomenon with regional implications that cross the region and involve our neighbors. In order for us to achieve our climate change adaptation goals nationally, we need to have regional data to inform our decisions and make us aware of the risks that are posed to our country. - - The regional DMS is an integrated platform that can help tremendously, particularly by integrating data sets at different scales both temporally and spatially. – This can assist us in better determining the expected magnitude of health impact and put in place the appropriate interventions that correspond to the effects induced by climate change. – Such tool would allow us to share vital information with the communities we work with to help them better understand the impacts of climate change and empowering them to make the best decisions for their communities. This tool would also allow us to make more informed decisions for fisheries management; such as correlate climate change and species behavior and recruitment to establish open and closed seasons.

Q. Which geospatial climate and hydrographic monitoring products would be most useful for informed decision-making in your sector?

- Satellite imagery
- Topographic maps
- SeaWIFS or other ocean color monitoring of fluvial runoff and phytoplankton blooms following climatic events
- Models of sea level rise projected on key habitats and ecosystems
- Models and calibration data of projected and current levels of ocean acidification
- A time series assessment of regional hydro-met change and land cover change
- High spatial resolution drought map
- Flooded prone areas with contour map
- A map that shows the regional impact of climate change on Belize coastline.
- A time series assessment of regional hydro-met change and land cover change
- A time-series map showing forecasted changes in weather patterns (Droughts or increased rains etc)
- A map that shows the regional impact of climate change on tourism
- A map forecasting wind patterns that can affect sea currents (which cause erosion of beaches as well as affect recruitment of key commercial fish species through the distribution of eggs and larvae from one site to the next)

Q. Which other information products or mapped indices would be most useful for informed decision-making in your sector?

- Our reef Health Index is useful - and your data could widen the net of users of such data
- NOAAs coral bleach watch - "hot spots" is a useful product to share
- Contour maps of the country
- Production vs. dry spells vs. wet season
- Water availability
- We would like to see a focus on biodiversity mapping
- We would like to see a drought vs. fire vs. groundwater vs. flooding vs. rainfall vs. climate change - future projected map for risk analysis
- We would like to see a map of infrastructure vs. present and future climate forcing
- We think that communities can benefit from guidelines for decision making related to the adaptation of climate change. This guideline can be handed down from one local government to the next. We noticed that many time when local governance changes, decisions made by previous governments are discarded resulting in the community being negatively affected.
- The use of new technology such as applications for mobile devices (tablets, smart phones etc) to educate young children and youths on climate change effects. This could be in the form of educational games etc.
- The development of innovative educational programs for women and children on climate change. For example, for the past 10 years TIDE has been implementing an innovative way of getting communities involved in conservation through an annual football competition. Everyone loves football so merging these two things actually promotes them both effectively.

Q. Please provide a list of queries that your organization may request from the DMS - eg. What are the average monthly precipitation, land slope, landcover type, and soil type, at a particular location?

- What communities are most vulnerable to flood vs. socioeconomic status
- Monthly precipitation and relative humidity vs. solar radiation

– Agriculture potential forecast on land usage – What are the projected trends in temperature and precipitation. Soil moisture, Drought map in the Dry season, flood maps in the wet season, runoff maps. – What is the drought risk at given locations and how is it partitioned - eg. Lack of surface water, extreme temperature forcing, lack of groundwater - what is the relative contribution of each factor? – What communities are most vulnerable to climate change based on strength of environmental threats vs. socio economic status – What is the average monthly precipitation, land slope, vegetative cover and soil type for Southern Belize. – What is the average monthly wind direction and speed in Southern Belize. – What is the rate of deforestation through annual wildfires and other means in Southern Belize
Q. Besides your own organization, the involvement of which national, regional and international organizations would be most essential for the success of a regional DMS?
– CATHALAC – National Oceanic and Atmospheric Administration- NOAA – Food and Agriculture Organization – FAO – Gulf & Caribbean Fisheries Institute – GCFI – Minority Biomedical Research Support- MBRS – United Nations Convention on Biological Diversity – UNCBD – CREDIA – AGRRA – CONABIO – CCCCC – BNMS – Mexico – CSA – Central American and Caribbean – CEC – World Bank – Inter American Development Bank

Table F4: Summary of responses to the questions related to education about climate change in Belize

Q. Is climate change sufficiently addressed in the education system where your organization operates? Explain.
– No it is not. But there is a need to address the impacts of Climate Change in the educational system. – Doubtful, but our outreach is focused on stakeholders not the formal education system. Thus we have not formally reviewed all the curricula, etc. – No or partially. We do not have a clear climate change adaptation or mitigation policy we address water management during dry spells and promote covered structures during the wet season. However, an education awareness to demystify climate change to stakeholders in the agriculture sector. – No - we have no adequate attention paid to it, at least not in any sophisticated way. It is essential that we get young generations informed - it is important not only for the sustainability of the planet but also for the professional futures of these children. – No. There isn't a mandatory curriculum for teaching climate change in schools. Budgets are not

allocated for climate change education or adaptation by central government.
Q. Do you see opportunities or a means by which education with respect to the environment can benefit the community where you operate? If so, at what levels: primary, secondary, tertiary, and community education?
– Yes. It is needed and helpful at ALL levels. – I think a well-structured public awareness through radio and TV media can benefit the community. – I would like to see more active and engaging environmental education at all levels. At the primary levels it is more about information, engagement, and excitement. At the secondary and tertiary level it is about cultivating responsible actions – Yes. At all levels of education available in Belize. Universities need to develop degrees in climate change so that it can produce its own experts; this could be the only sustainable way of addressing climate change issues at a local level.
Q. Comments and recommendations related to Outreach Activities?
– We would like to see this project connected with the private sector as well. The major industries in our region are interested in participating in projects that foster environmental responsibility and they want tools to work with. This could be one. We are looking forward to ongoing participation in this project! – Climate change education cannot be limited to the formal education system. It has to go beyond the classroom and into the lives of uneducated people and those who are not interested in obtaining formal education.

Table F5: Summary of comments and recommendations related to IT in Belize

Q. Do you have any comments and recommendations?
– Not at this time. – Most of our licenses for our computers are from cracked versions of software, eg, XP Office 2007 and 2010, Windows 7. Only actual computers that come from abroad have valid licenses.

Table F6: Summary of responses to the questions related to meteorology and climate data in Belize

Q. What gaps do you perceive in the national meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
– I think that there needs to be more weather stations at critical areas of the country like in Belize City and the other coastal communities. Other types of data equipment (wave data, temperature and others) are also needed in these critical areas as well as on the outside islands of the country. – Maintaining all weather stations is important. The stations of the outer cays are also very important for assessing marine conditions. – We currently do not have fine enough spatial resolution for monitoring weather / climate across our large landmass across our country. We need at least 50 more met stations in order to get a reasonable assessment of changes in weather patterns. Many of our stations are not automated and should be upgraded. So, spatial resolution is one issue.
Q. What gaps do you perceive in the regional meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
– There is a need for greater communication and collaboration with our neighboring countries in accessing regional data and the sharing of temperature data especially with wide variations of temperature. – Oceanographic parameters and equipment should be standardized and allocated in a meaningful spatial distribution, related to threats. – We cooperate with organizations such as NOAA, WMO, etc. for regional analysis in region (4). . A gap is the lack of regional standards for data and also a comprehensive data acquisition strategy for larger scale climate impact assessments. This kind of cooperation will be needed increasingly in the future.
Q. What improvements could be brought to operational data acquisition and archival processes for met and climate data?
– I believe that the main improvement apart from those mentioned above is turning this data into information for the public. Archiving the data doesn't help anyone. Convert the data into information that the public can use in their language to prepare themselves for the changes that are occurring. – I am not familiar with their current processes. – Currently we do not have digital archive of our climatic data . We need to undergo an archival retrieval process to digitize this data, which is mostly on hardcopy maps. Our met data retrieval is fine for the newer automated stations, however, the majority of our stations are manual and require human intervention to ensure good quality data is gathered. We need to seriously assess how we plan to go forward with data gathering because in many rural stations, the data may not be 100% accurate due to maintenance issues and improper gathering.
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for met and climate data?
– I don't know what is in place now. – I have requested meteorological data in Belize (years ago) and it was not digital in a timely timeframe. One improvement that could be done is to get real time data and have a large amount of Meteorological data. – One of the biggest improvements we want to see is the integration of our large met/ climate data with real time visual analysis.

Table F7: Summary of responses to the questions related to meteorology and climate data in Belize

Station Code	Org	Obs. Type	Measured Parameters	Storage	QA/QC	xmit	Share
PWSGIA01	Met Service	Auto	Precip, temp, solar rad, humidity, wind speed, clouds, sunshine, atm pressure, wind dir, wind run, soil temp, dew point, evaporation,	ASCII	Yes	Radio/ Internet	Yes

Table F8: Summary of responses to the questions related to hydrological data in Belize

Q. What gaps do you perceive in the national hydrological monitoring infrastructure that needs to be filled for effective observation of environmental change?
– I don't think much hydrological data is being collected at this time, so any work done on it would be great. The CZMAI used to collect water quality data, but has not done so in many years. – We need more hydrological monitoring of river flows, sedimentation and water quality. Also for coastal and marine waters. Weather stations need to be maintained and more data on Cays and at sea are needed. – We definitely need a more extensive network of hydrological monitoring sites and stations.
Q. What gaps do you perceive in the regional hydrological monitoring infrastructure that needs to be filled for effective observation of environmental change?
– I believe that the Belize Port Authority does some monitoring of hydrological data, but not sure if they work with anyone in the region. – I have less knowledge on this level but the needs are similar to Belize national needs.
Q. What improvements could be brought to operational data acquisition and archival processes for hydrological data?
– More institutions need to begin collecting quality data. This costs money that they don't have. More grant funding should be pointed in this direction.
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for hydrological data?
– Any work done on these matters would be a step in the right direction. – A more updated Computer database.

Table F9: Stations collecting hydrological data across Belize

Station Code	Org	Obs. Type	Measured Parameters	Storage	QA/QC	xmit	Share
Double Run	Met Service	Manual	Stage, discharge	HOMS database / paper	n/a	Paper	Yes (licensing)

Benque		Manual	Stage, discharge	HOMS database / spreadsheet	n/a	Paper	Yes (licensing)
Blue Creek		Manual	Stage	HOMS database	n/a	Paper	Yes (licensing)

Table F10: Summary of responses to the questions related to environmental data in Belize

Q. What gaps do you perceive in the national environmental monitoring infrastructure that needs to be filled for effective observation of environmental change?
– There are so many gaps because of lack of funding. We have many environmental organizations that do work, but they are all fighting for the same money out there. This limits their scope of what they can do. If more funds were available to fill the gaps in environmental monitoring (water quality, coral reef monitoring, temperature changes, coral bleaching, ocean acidification, wave action, coastal erosion, etc) these organizations would begin looking at them. – We have a fairly comprehensive reef condition monitoring effort. We need more coordination and effort for water quality. – We have a very poor understanding of the impacts of climate change in ecosystem function nationally. One of the key problems is the fact that we have a very large land mass and very diverse ecosystems and biogeoclimatic zones within this large land mass. It is logistically very challenging for us to efficiently and effectively analyze ecosystem function nationally, never mind connecting it with impacts of climate change. This is a gap now and will be particularly significant in the future. On the agriculture side, we need better integration of climatic and hydrological data with agricultural productivity. We need to optimize our agricultural activities based on sound science and hence need to know how changes in environmental factors - water, temperature, soil structure, and nutrient availability will affect output. – Deforestation – As a manager of marine fisheries we need to know if and how climate change will affect the important marine commercial species, and if it does how do people adapt or make management decisions to address those effects.
Q. What gaps do you perceive in the regional environmental monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Although there is some collaboration on certain environmental issues (environmental protection in Ports) there can still be a lot more. This could be bridged with the use of teleconferencing, which would reduce the costs of travelling, and the sharing of data with each other would be even better. – We have a fairly comprehensive reef condition monitoring effort. We need more coordination and effort for water quality. HRI effort could be expanded to wider Caribbean. – There are very big gaps in different aspects of environmental monitoring regionally. Hydrological and meteorological assessment is fine. However, a broad ecosystem service based method is not being employed right now regionally. The Millennium Ecosystem Assessment could be a good model for a North American regional assessment of ecosystem-based environmental monitoring. The emphasis of governments in these areas on having 'natural capital stocks' accounted for could be a good motivation. At this point, it is somewhat regionally fragmented and done on a project per project basis such as with the CEC or various NGOs (IUCN, TNC, etc.). This is a gap that could be addressed regionally. – We need to know whether commercial fish species are being recruited from regional habitats; for example, are the conch caught in Belize being transported as eggs or larvae from other areas in the

Caribbean or Florida, and how will climate change affect this recruitment.
Q. What improvements could be brought to operational data acquisition and archival processes for environmental data?
– Convert data to information that we can use. – HRI system is under development. – First we need a definition of what environmental data has priority for regional and national analysis. – Various Clearing-House Mechanisms have worked to a certain extent for Belize; however this data is not readily accessible by local communities because they don't have access to the technology such as Internet needed to access the information. We believe that there needs to be physical structures such as resources libraries in local communities with both digital and hard copies of information.
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for environmental data?
– Creating an agreed set of data quality parameters and have everyone use that one guideline for gathering, compiling and processing of data. – HRI system is under development. – Better integration in certain area - eg. Connecting climatic data with environmental data for impact assessment - both present and in the future (modeled). – Building capacities of locally established organizations such as TIDE to play a more active role in data management at the regional level.

Table F11: Stations collecting environmental data across Belize

Station Code	Org	Obs. Type	Measured Parameters	Storage	QA/QC	xmit	Share
Report Card for MesoAmerican Reef	Healthy Reefs Initiative	Manual	- Several	Paper	N/A	-	Yes
Port Honduras Marine Reserve – water quality	TIDE	Auto / Manual	Water quality: water temp, dissolved oxygen, salinity, turbidity, nitrate, phosphate, sedimentation rate,	Spreadsheet	Yes	Paper	No
Port Honduras Marine Reserve – Caribbean spiny lobster assessment		Manual	Lobster abundance, lobster size, lobster gender, lobster maturity	Spreadsheet	Yes	Paper	No
Port Honduras Marine Reserve – queen conch assessment		Manual	Conch abundance, conch shell length, conch lip thickness	Spreadsheet	Yes	Paper	No
Port Honduras Marine Reserve – finfish assessment		Manual	Finfish abundance, fish tail and fork length, fish maturity	Spreadsheet	Yes	Paper	No

Port Honduras Marine Reserve – sea cucumber assessment		Manual	Sea cucumber length, weight, abundance	Spreadsheet	Yes	Paper	No

Table F12: GIS datasets collated by organizations in Belize

Organization	Layer Name	Type	Grid Units	Projection	Program	File Format	Share
Coastal Zone Management Authority & Institute	Administrative Boundaries	polygon	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
	River	line	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
	Road Network	line	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
	Land use	polygon	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
	Land cover	polygon	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
	Watersheds	polygon	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
	Coastal zones	polygon	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
	Tourism infrastructure	polygon	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
	National parks or attractions	polygon	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
	Settlements	polygon	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
	DEM	raster	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
	Socio-economic maps	polygon	-	WGS 1984 UTM Zone 16N	Arcview	.shp	No
Healthy Reefs Initiative	Administrative Boundaries	polygon	-	-	Arcview	.shp	With partners
	Land use	polygon	-	-	Arcview	.shp	With partners
	Land cover	polygon	-	-	Arcview	.shp	With partners
	Watersheds	polygon	-	-	Arcview	.shp	With partne

							rs
	Coastal Zones	polygon	-	-	Arcview	.shp	With partners
	Tourism infrastructure	polygon	-	-	Arcview	.shp	With partners
	Natural parks or attractions	polygon	-	-	Arcview	.shp	With partners
	Settlements	polygon	-	-	Arcview	.shp	With partners
	Socio-economic maps	polygon	-	-	Arcview	.shp	With partners
	Bathymetric maps	polygon	-	-	Arcview	.shp	With partners
TIDE	Administrative Boundaries	polygon	km	UTM 16	Arcview	.shp	With partners
	River	line	km	UTM 16	Arcview	.shp	With partners
	Road Network	line	km	UTM 16	Arcview	.shp	With partners
	Land cover	raster	km	UTM 16	Arcview	.tif	With partners
	Watersheds	polygon	km	UTM 16	Arcview	.shp	With partners
	Point source pollution	Point / polygon	km	UTM 16	Arcview	.shp	With partners
	Settlements	polygon	km	UTM 16	Arcview	.shp	With partners
	Remotely sensed products	raster	km	UTM 16	Arcview	.shp	With partners
	Marine biodiversity monitoring sites	point	km	UTM 16	Arcview	.shp	With partners
Ministry of Health	Administrative Boundaries	polygon	-	UTM	Arcview	.shp	No
	River	line	-	UTM	Arcview	.shp	No
	Road Network	line	-	UTM	Arcview	.shp	No
Ministry of Natural Resources	Administrative Boundaries	polygon	km	NAD27	Arcview	.shp	Yes
	River	line	km	NAD27	Arcview	.shp	Yes
	Road Network	line	km	NAD27	Arcview	.shp	Yes
	Settlements	polygon	km	NAD27	Arcview	.shp	Yes
Land Information Centre	Administrative Boundaries	polygon	m	NAD 1927	ArcGIS 10.1	.shp	Yes
	River	line	m	NAD 1927	ArcGIS 10.1	shp	Yes
	Road Network	line	m	NAD 1927	ArcGIS 10.1	shp	Yes

	Land Use	polygon	m	NAD 1927	ArcGIS 10.1	shp	Yes
	Land Cover	polygon	m	NAD 1927	ArcGIS 10.2	shp	Yes
	Natural Parks or attractions	polygon	m	NAD 1927	ArcGIS 10.2	shp	Yes
	Watersheds	polygon	m	NAD 1927	ArcGIS 10.2	shp	Yes
	Settlements	polygon	m	NAD 1927	ArcGIS 10.2	shp	Yes
	DEM	raster	m	NAD 1927	ArcGIS 10.2	shp	Yes

ANNEX G: Survey Results For Dominica

Table G1: Summary of climate priority issues in Dominica

Priority Rank	Climate Change Issue
1	- Food security - Human Settlements: Vulnerability of settlements in: coastal areas susceptible to the effects of Sea Level Rise; steep mountainous areas vulnerable to flash floods and landslides. - Increase in rainfall intensity will lead to higher levels of surface runoff resulting in contamination of water sources and heightened turbidity levels. This will result in more frequent service interruptions and a requirement for more advanced water treatment processes, which will require high capital expenditure and O&M costs. - Water resource management distribution. Given our abundant fresh water supply we are of the belief that insufficient monitoring of this resource is being done.
2	- Pest and disease - Watershed Management: Type of activities permitted in watersheds; % of tree cover; minimum lot sizes; tree buffer along rivers. - Increase in the frequency of extreme weather events such as tropical storms/hurricanes will have similar impacts as listed above, but additionally cause damage to a lot of our vulnerable "non-climate proofed" infrastructure. Due to our local mountainous terrain and remote location of our intakes, much of our supply pipelines are on riverbanks and steep slopes and vulnerable to rock falls and landslides. Debris and boulders transported by swollen rivers also can cause damage to intake structures and pipelines. The high levels of silt cause complete blockage of intakes and service interruptions. The cost for cleaning of intakes and restoration of service is very high. - We are interested in collecting met and hydro data island wide due microclimates. Given the type of terrain that we have on island this would be an interesting area of research.
3	- Livestock and veterinary services - Food Security: Land reserved for agricultural production; land suitability mapping. - More frequent occurrences of drought will lead to water shortages and possible rationing in some communities, which rely on small water sources. If these sources become unsustainable, large investments will be required to link these water systems to larger ones with sources that are more resistant to the effects of drought. - Rainfall distribution as it relates to farming and farming practices.
4	- Weather and climate info - Squatting: Squatter settlements in vulnerable along watercourses and on steep slopes. - Sea level rise will result in higher coastal flooding due to storm surge and put pipelines and other infrastructure located near the coast at greater risk. - Climate change impact on our natural resources/feature in relation to tourism industry.
5	- Environmental sustainability - Compliance with codes regulations and standards: All applications are reviewed against the Dominica Building Code, regulations and standards. EIAs are requested for specific developments and appropriate mitigation methods recommended. - Hydro meteorological events and how they impact the coastal communities. In addition how the impacts can be mitigated.

Table G2: Summary of responses related to data management in Dominica

Q. Data updates and Frequencies of Data
– For agriculture – monthly, for weather – bimonthly – Data update takes place when needed or requested. – Water quality data is collected by Laboratory Staff in the Operations & Maintenance Department based on an established schedule, and stored within their database in Excel format. Manually collected stream flow data is collected by a team of 2 technician using a wading current meter and the data is then inserted into a standard Excel spreadsheet for calculation of flow rates. These spreadsheets are stored in a database on the Engineering network. – We presently have installed 5 automatic hydromet stations and are in the process of increasing this number to 9. The stations are of radar and pressure type and take regular river level measurements which are stored in a data logger. A technician from the Engineering Department downloads the data to a laptop at regular intervals and the data is input into a database at our main office and is processed using HYDRAS software. We are in the process of upgrading the stations to transmit the data wirelessly via GSM and have also started installing rain gauges on each station to collect and transmit rainfall data as well. – At present the only data that we have jurisdiction over is our meteorological data.
Q. Data Distribution policies and restrictions
– Policies are not yet established – Informal policies exist for data sharing among department of government and the private sector. – No formal policy has been developed as yet, however, a small informal committee of stakeholder institutions including DOWASCO, Domlec, Forestry, Agriculture, and Met Services has been formed and there are plans for developing a network for data sharing. All data collected would be transferred to the Met Office for processing, for eventual distribution to the parties, which require the information. It is intended that this network will be set up as part of the World Bank's PPCR (Pilot Programme for Climate Resilience) and the Office of Disaster Management, Public Works Ministry, and IRC will also be included within the network. – The data has to go through the CIMH before it is distributed. Final approval of data needs to go through the Meteorological Service of Dominica.
Q. What are the Data products and services delivered?
– Agriculture and weather data – Maps. Dominica Geonode now exists. – Most of the data we collect are for internal use and sharing with the stakeholder institutions mentioned above. Other institutions or individuals may make request for certain data and these requests are considered on a case-by-case basis. We are also sometimes requested to perform manual stream gauging measurements or water quality testing for private individuals or businesses. – Climatological data (daily, weekly monthly and yearly summaries) a monthly agro meteorological bulletin.
Q. What are the methods of data collection?
– Manual and automated – GPS, onscreen digitizing. – We have various instruments and trained personnel for collection of water quality and stream flow data. -- -- Hydromet data is collected automatically, and simply require downloading.

- Manual data collection and automatic weather station sensors.

Q. What are your organization's data ownership and sharing policies
Summarize responses

- Policies are not yet established
- Data is held by the Department and shared when requisites. No formal policies exist.
- We presently don't have a data policy in place. We have signed MOUs with the agencies that have funded our hydromet equipment, which mandates sharing of data with specified parties.
- We assume 100% ownership of all the data collected by our institution.

Q. What national, regional, or international standards are followed by your organization?
Summarize responses

- Meteorology standards
- None.
- We follow WHO guidelines with respect to water quality testing. We have our own guidelines for other data collection, and use WMO for reference, but look to adopt relevant international standards when the hydromet committee is formalized.
- We are a member of the World Meteorological Organization and hence are guided by its standards and guidelines. All our staff are trained and certified by the Caribbean Institute for Meteorology and Hydrology, which is a regional training and research institution. At present we are pursuing ISO certification as mandated by the International Civil Aviation Organization and the World Meteorological Organization.

Q. General comments or recommendations in relation to data issues
Summarize responses

- We are in the process of implementing GIS for some agriculture data. There are other agencies that collect environmental data. Policies for data management are not yet established.
- Not at this time.
- It is very important that this project does not duplicate other similar planned initiatives, but rather complements them. On a local level, the World Bank / Climate Investment Funds funded PPCR will include a project to gather water resource baseline data and develop a hydromet network for data sharing among local agencies. The project will be put forward to the Board of the World Bank for final approval in November 2013, with funding expected to become available by March 2014.
- The technical expert Mr. Jerry Meier has suggested that once information on topography, soils, land use/land cover, and rainfall are accurately known for the entire island, then river flows can be determined via the use of hydromet modeling software such as CAUHSI and HEC-RAS. The installation of hydromet stations on strategic rivers on a temporary basis can then be used for proper calibration of the models.
- As such, it is proposed for an ultra-specific, aerial LIDAR topographic survey to be done for the entire island (including aerial photography). This will give a very accurate elevation reading (tree-top and ground level) for every square metre of the island's surface.
- The deployment of strategic rainfall stations is also proposed to provide real-time gridded rainfall data.
- A repeater network is proposed for data transfer from remote areas.
- Purchase of portable stream gauges, acoustic Doppler profilers, and piezometers will be done.
- A new soil survey will be undertaken.
- Provision will also be made for the upgrade of data networks for all agencies who will share hydromet, GIS, mapping, and related data (fiber optic, 30 MBps minimum), procurement of technical equipment to support project (e.g. portable stream gauge, acoustic Doppler profiler, piezometers), software (ArcGIS, AutoCAD, hydromet modeling software), and hardware upgrades (high spec PCs, servers,

etc, to run software). WB Project personnel Nick Calendar and Jerry Meier can be contacted for further details at the following contacts: ncallender@worldbank.org, gemintpan@aol.com. The hydromet equipment presently used by DOWASCO was made available by CREDP-GTZ and the Carib HYCOS Project. Under the Carib HYCOS Project, there were plans for development of a regional network for data sharing among the participant countries as well. The project director Jean-Pierre Briquet can be contacted for more information: jean-pierre.briquet@ird.fr.

Table G3: Summary of responses related to data management in Dominica

Q. How would your organization benefit from a regional data management system tracking impacts due to climate change?
– Improved planning and decision making for the agriculture sector. – This would provide important data to aid in decision-making. – There are sure to be benefits from observation of trends on a region wide basis and how various phenomena impact on water resources and water supply in similar islands. However, the greatest benefit specific to my organization would be the increased availability of reliable data on a national level that would be available due to upgrades in hydromet and data transmission systems, which may materialize as a result of this project, or related projects. – Better decision-making, long term planning, comparison of trends in weather/climate patterns.
Q. Which geospatial climate and hydrographic monitoring products would be most useful for informed decision-making in your sector?
– Rainfall – Temperature – Land – Information on the impact of sea level rise on the coastline: To identify coastal communities that should be relocated or appropriate methods of adaptation. – Flood risk data: To identify areas susceptible to flooding. – Soil capability data: To assist in land use planning. – High spatial resolution map with topography, soils, land use / land cover, and precipitation – Vulnerability maps as it relates hydro meteorological occurrences. – Water and rainfall distribution – Impacts of climate change on our coastlines and water distribution
Q. Which other information products or mapped indices would be most useful for informed decision-making in your sector?
– Fertilizer and pesticide geospatial data – Soil type – Vulnerability and hazard mapping – Sea level rise: Models of the future likely impacts. – Soil capability mapping: Detailed information on soil types to guide land use zoning and watershed management. – Flood risk mapping: To educate and guide police-makers on future development. – Robust hydrological modelling system integrated with GIS.

Q. Please provide a list of queries that your organization may request from the DMS - eg. What are the average monthly precipitation, land slope, landcover type, and soil type, at a particular location?
– Average monthly precipitation – Pest and disease – Soil and land cover type – SLR: What is the likely impact on the coastline if 1m SLR is experienced. – Land Use Planning: Given information of soil type, elevation, slope and rainfall, what is the most appropriate type of land use for a particular area and what standards should apply. – Hazard risk - What hazard risks are faced by a particular community and what changes should be made in its pattern of development. – Rainfall patterns and distribution – Land use vis a vis a water distribution and location and underground water availability
Q. Besides your own organization, the involvement of which national, regional and international organizations would be most essential for the success of a regional DMS?
– Information Communication Technology (ICT) Unit – Central Statistics Office (CSO) – The Caribbean Institute for Meteorology and Hydrology (CIMH) – University of the West Indies (UWI) – Food and Agriculture Organization (FAO) – Caribbean Community and Common Market (CARICOM) – Water Company, forestry, agriculture, utility companies, and public works. – Tourism organizations; agricultural research institutions. – Local government. – Local, regional and international education institutions involved in research in climate change and disaster risk reduction research. – Local, regional and international meteorological organizations. – Local regional and international disaster risk management organizations. – Dominica Meteorological Services – Environmental Coordinating Unit – Caribbean Environmental Health Institute – OECS – ESDU – World Bank / Climate Investments Fund – World Meteorological Organization – USAID Organization of Eastern Caribbean States (OECS)- Reduce Risk to Human & Natural Assets Resulting from Climate Change (RRACC Project)

Table G4: Summary of responses to the questions related to education about climate change in Dominica

Q. Is climate change sufficiently addressed in the education system where your organization operates? Explain.
– There is need for improvement – No it is not sufficiently addressed. More programs need to be initiated and effectively managed. – I do not believe so, however, I do not have details on the educational curriculum for full justification of this belief. DOWASCO has collaborated with a number of schools and imparted knowledge to students on a number of water-related topics and climate change themes. We have also increased our public education drive and are alerting our customers on the expected impacts of climate change, particularly droughts and the need to conserve water and manage the environment sustainably. Nevertheless, we still believe that more can be done with respect to addressing climate change in the education system.
Q. Do you see opportunities or a means by which education with respect to the environment can benefit the community where you operate? If so, at what levels: primary, secondary, tertiary, and community education?
– Yes, at all levels – Yes. This should be integrated into the curriculum at all levels. The level of awareness is still very limited. – At all levels. But it is particularly important to start promoting a culture of environmental awareness at the primary level with the hope that those values will grow with the children. Formation of environmental clubs should be beneficial. Environmental awareness and knowledge will impact on behaviour leading to improved land use and management, leading to healthier watersheds and coastal areas.
Q. Comments and recommendations related to Outreach Activities?
– Data collectors or personnel dedicated to specific data utilizing GIS system. Training and capacity building. Policies for data management

Table G5: Summary of additional relevant comments and recommendations (Computing)

Q. Do you have any comments and recommendations?
– We do not have plans to hire staff with specialization in software development to devote to this project. We have current in-house staff that can assist an outside development team with tasks related to this project. – This Office comprises of one (1) Technical Specialist, and one (1) Administrator. There is no IT Specialist. – Our present department structure does for allow for us to employ staff with specialization in Information technology. Most IT related the Government Information and Communications Technology Unit (ICT) address issues. However, we have staff that can collaborate with outside development teams. We are willing to engage in capacity development of these staff members to meet the required standards of this project assignment. At present, we do not utilize any database management system but we are willing to

work alongside your team in developing a system suitable to meet the needs of our organization and end users. Based on development plans for the DMS outreach, user-friendly database analysis and communication for current and climate change adaptation are among the list of priorities.

Table G6: Summary of responses to the questions related to meteorology and climate data in Dominica

Q. What gaps do you perceive in the national meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Standardized Instrumentation/ Equipment , Human Resource, collaboration between national stake holders, Effective maintenance - Spares and transportation
Q. What gaps do you perceive in the regional meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Collaboration amount regional entities, Standardized instrumentation/equipment
Q. What improvements could be brought to operational data acquisition and archival processes for met and climate data?
– Centralized repository, Space availability, Hardware and Software Equipment, Additional Staffing and Training
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for met and climate data?
– Human Resource and Training,

Table G7: Stations collecting met and climate data across Dominica

Station Code	Org	Obs. Type	Measured Parameters	Storage	QA/QC	xmit	Share
Canefield (Sutron)	Met Service	Auto	Precip, temp, solar rad, humidity, wind speed, atm pressure, wind dir, dew point	ASCII / Xconnect dataview database	Yes	Radio/	Yes (pay per use)
Canefield (Sutron)		Auto	Precip, temp, humidity, wind speed, sunshine, atm pressure, wind dir, dew point	ASCII text file	Yes	Radio	Yes (pay per use)
Melville Hall		Auto	Precip, temp, humidity, wind speed, solar rad, sunshine, atm pressure, wind dir, soil temp, soil moisture, dew point, leaf wetness.	ASCII	Yes	Radio	Yes (pay per use)

ANNEX H: Survey Results For Saint Lucia

Table H1: Summary of climate priority issues in Saint Lucia

Priority Rank	Climate Change Issue
1	– Impact on hydro-meteorological hazards. – Flood – Food security for small island states
2	– Human resources/Institutional capacity to provide related services. – Drought – Inundation of coastal regions
3	– Adequacy of observation network – Increased number & strength of hurricanes – Rainfall patterns and flooding
4	– Adequacy of role in CC policy development. – Increased medical issues – Encroachment of the sea and its impact on agricultural lands
5	– Sea level rise

Table H2: Summary of responses to questions related to data management in Saint Lucia

Q. Data updates and Frequencies of Data
– Manual observations data updated every hour, less in social circumstances. Data from Automatic Weather Stations (AWS) updated every few minutes. – Front line agencies collect.
Q. Data Distribution policies and restrictions
– Currently no clear policy; left to discretion of management.
Q. What are the Data products and services delivered?
– Raw data, processed data and reports, time series, short and mid-range forecasts, seasonal forecasts and outlooks, periodicals.
Q. What are the methods of data collection?
– Manual reading of instruments & sensory observations, automatic data acquisition from AWS. – Data equipment, questionnaire
Q. What are your organization's data ownership and sharing policies *Summarize responses*
– No clear policy; left to discretion of management. World Meteorological Organization (WMO) provides guidance on International sharing.
Q. What national, regional, or international standards are followed by your organization? *Summarize responses*

– World Meteorological Organization (WMO) & International Civil Aviation Organization (ICAO) standards. – Disaster Management Act, Comprehensive Disaster Management (CDM) Strategy, Hyogo Framework for Action (HFA), St Georges Principles
Q. General comments or recommendations in relation to data issues *Summarize responses*
– The AESD was once the repository for the collection of all agrometeorological and hydrological data. However, this responsibility was transferred to the Water Resource Management Agency, which is housed in the Ministry of Sustainable Development, Energy, Science and Technology.

Table H3: Summary of responses to questions related to data management recommendations in Saint Lucia

Q. How would your organization benefit from a regional data management system tracking impacts due to climate change?
– It would be a useful resource, for local product development and climate service provision. – Mitigation programmes and response to disasters are predicated on data. The study of data and the extrapolation of trends by subject matter, allows for disaster managers to facilitate mitigation response, if needed. – It would assist in guiding a policy to enhance the agricultural sector – It would provide an opportunity to improve our present data collection program, sharing data and experiences, which can benefit the member states.
Q. Which geospatial climate and hydrographic monitoring products would be most useful for informed decision-making in your sector?
– Drought maps and indices. – Regional SSTs – Bathymetry – National soil moisture maps over both the dry and wet season, which can provide a guide for irrigation use – Land use maps over time, which can be used to finalize the national land use policy – Rainfall, stream flow
Q. Which other information products or mapped indices would be most useful for informed decision-making in your sector?
– Climate outlooks and forecasts (Precipitation, Temp, etc.) – Drought index – Zones of potential ground water for irrigated agriculture – Intervention measures for sustainable agriculture based on projection of climate change analysis
Q. Please provide a list of queries that your organization may request from the DMS - eg. What are the average monthly precipitation, land slope, landcover type, and soil type, at a particular location?
– Statistics on various meteorological parameters. – Potential for alternative sources of water other than surface water. – Interventions for watershed rehabilitation

– Accurate quantification of available water resources.
Q. Besides your own organization, the involvement of which national, regional and international organizations would be most essential for the success of a regional DMS?
– Saint Lucia Water Resource Management Agency (WRMA) – Caribbean Institute for Meteorology & Hydrology (CIMH) – World Meteorological Organization (WMO) – Food and Agriculture Organization of the United Nations (FAO) – The Canadian International Development Agency (CIDA) – University of the West Indies (UWI) – Local water resources agency

Table H4: Summary of responses to the questions related to education about climate change in Saint Lucia

Q. Is climate change sufficiently addressed in the education system where your organization operates? Explain.
– No - Inadequate Primary School curriculum. – There does not seem to be an active thrust. It is a passive process, i.e. left to enterprising teachers to make the linkages to their lesson plans. – No. It is not perceived as an immediate threat.
Q. Do you see opportunities or a means by which education with respect to the environment can benefit the community where you operate? If so, at what levels: primary, secondary, tertiary, and community education?
– Yes - At primary, secondary and community based levels. – Yes always for example - I have yet been able to mainstream http://www.createspace.com/4183759 into the Education System. – Yes. At all levels. It should, however, be given priority at the primary level. If it can be effectively articulated at the primary level, in essence we are preparing the nation.
Q. Comments and recommendations related to Outreach Activities?
– Schools should be encouraged to be involved in the projects. There is need for capacity building at the technical level and for proper instrumentation. Sufficient allocation for operation and maintenance should be incorporated into the project, since most of the small island states generally do not have, or do not allocate funds for operation and maintenance.

Table H5: Summary of additional relevant comments and recommendations (Computing) in Saint Lucia

Q. Do you have any comments and recommendations?
- Training in new and improved tools and software (e.g. Geonode), would assist technical officers in their area of work. This would assist the Ministry of Infrastructure, Port Services & Transport in regards to its need for further assistance and support. - The department is ill equipped with the number of available IT officer(s) and services must be outsourced.

Not only does this result in financial burden with the number of unexpected breakdowns, but it also hinders department productivity when services are not readily available. The recommendation is that NEMO should have a GIS/IT Officer. - There is a need for new and more updated computers.

Table H6: Summary of responses to the questions related to meteorology and climate data in Saint Lucia

Q. What gaps do you perceive in the national meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Inadequate monitoring stations, inadequate and poorly trained personnel. Need for fully equipped monitoring stations and a properly staffed hydrological unit. – Lack of integration of databases (inter & intra agency). Difficulty in acquiring copies of historical records for Saint Lucia stored overseas. – Capabilities for data analysis are collected. However, due to human resource capacity constraints, the analysis is often neglected on a national level. – Water quality, soil moisture, stream flow, stage and rainfall (including intensity data), solar radiation, sunshine hours, wind run, evapotranspiration, field capacity, permanent wilting point data and soil moisture data. Water abstraction for agriculture, domestic, tourism, etc. Proper control and measuring structures for monitoring stage and discharges. Software, hardware and training for real-time data collection of climatic parameters. Agromet stations with the potential to measure continuous data in real time should be installed in at least 10 locations around the island.
Q. What gaps do you perceive in the regional meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Insufficient networking, information gathering and sharing. Also, there is an insufficient number of staff. – Variability of instrument manufacturers & calibration schemes and schedules between countries. – Sharing of results is lacking. Often when equipment is installed, it is difficult to retrieve information on the outputs and outcomes of the studies. Perhaps a clearing house mechanism for reports would assist countries in the process of procuring equipment, in order to inform specific types of equipment ordered – Lack of regional data collection format. Absence of a protocol for requesting data. Absence of critical data for computing evapotranspriation using Penman-Monteith method. There is a need to collect rainfall intensity data, solar radiation
Q. What improvements could be brought to operational data acquisition and archival processes for met and climate data?
– Newly equipped centralized systems. – Integration of databases and rigorous standardized quality control. – Data acquisition is currently time consuming due to manual collection, therefore, a cost-efficient method (perhaps satellite transmission) of transmitting data to headquarters. Or data could be transferred to a specific database used by the relevant agencies (in specified format), which would reduce man-hours in the field and assist in database management and archiving. – A need for a common protocol. Trained personnel and commensurate remuneration to avoid quick staff turnover. Proper equipment
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for met and climate data?

– Updated servers. – Upgrading quality check program. – Specifically designated personnel to verify data being transmitted. – Better integration necessary, the use of robust and versatile software, and collection of data in real time, production of monthly, quarterly and annual bulletins.

Table H7: Stations collecting met and climate data across Saint Lucia

Station Code	Org	Obs. Type	Measured Parameters	Storage	QA/QC	xmit	Share
Hewanorra Airport, Vieux Fort	Met Service	Manual	Precip, temp, humid, wind, clouds, sunshine, atm pressure, wind dir, wind run, soil temp, soil moisture, dew point, evaporation,	ASCII, climsoft & paper	Yes	paper	CIMH, WRMA
George F.L. Charles Airport, Castries		Manual	Precip, temp, humid, wind, clouds, atm pressure, dew point	ASCII, climsoft & paper	Yes	paper	CIMH, WRMA
Anse La Raye		Auto	Precip	Database-QNX4	No	Radio	WRMA
Desraches, Soufriere		Auto	Precip, temp, humid, wind, atm pressure, wind dir	Spreadsheet	No	Radio	WRMA
Millet, Anse la Raye		Auto	Precip, temp, humid, wind dir	Spreadsheet	No	Radio	WRMA
Errard Estate, Dennery		Auto	Precip, temp, humid, wind	Spreadsheet	No	Radio	WRMA
Barthe Nursery	WRMA	Manual	Precip	Spreadsheet, Webmap database, Access database	Yes	paper	Yes
Anse la Raye		Auto	Precip	Spreadsheet, Webmap database, Access database	Yes	Downl oad	Yes
Barre de L'Isle		"	"	"	"	"	"
Bexon		"	"	"	"	"	"
Blanchard		"	"	"	"	"	"
Cap Estate		"	"	"	"	"	"
CARDI, La Resource		Auto	Precip, temp, humidity, sunshine, atm pressure, wind run, dew point	Spreadsheet, Webmap database, Access database	Yes	Downl oad	Yes
Delcer		Auto	Precip	Spreadsheet, Webmap database, Access database	Yes	Downl oad	Yes

Edmund Forest		“	“	“	“	“	“
Errard Estate		“	“	“	“	“	“
George V Park		“	“	“	“	“	“
Grace, Vieux Fort		“	“	“	“	“	“
Hewanorra		“	“	“	“	“	“
Marquis Babonneau		“	“	“	“	“	“
Millet		“	“	“	“	“	“
Patience		“	“	“	“	“	“
Saltibus		“	“	“	“	“	“
Soucis		“	“	“	“	“	“
Soufriere		“	“	“	“	“	“
Troumasse Estate		“	“	“	“	“	“
Trouya		“	“	“	“	“	“
Union Agricultural Station		“	“	“	“	“	“
Union Vale Station		“	“	“	“	“	“
Deglos		“	“	“	“	“	“
Mabouya		“	“	“	“	“	“
Canelles		“	“	“	“	“	“

Table H8: Summary of responses to the questions related to hydrological data in Saint Lucia

Q. What gaps do you perceive in the national hydrological monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Inadequate monitoring stations, inadequate and poorly trained personnel. Need for fully equipped monitoring stations and a properly staffed hydrological unit. – Methods/training to employ easier (less time consuming) retrieval of flow data, especially in rivers with rapidly changing channel sections, due to high sedimentation rates and/or high rates of erosion. Spot measurements are human resource and time intensive. – Water quality, soil moisture, stream flow, stage and rainfall (including intensity data), solar radiation, sunshine hours, wind run, evapotranspiration, field capacity, permanent wilting point data and soil moisture data. Water abstraction for agriculture, domestic, tourism, etc. Proper control and measuring structures for monitoring stage and discharges. Software, hardware and training for real-time data collection of climatic parameters. Agromet stations with the potential to measure continuous data in real-time should be installed in at least 10 locations around the island.
Q. What gaps do you perceive in the regional hydrological monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Insufficient networking, information gathering and sharing. Also, there is an insufficient number of staff. – Lessons learnt from other counties in new technologies employed, especially for rivers with rapidly changing channel sections. – Lack of regional data collection format. Absence of a protocol for requesting data. Absence of critical data for computing evapotranspriation using Penman-Monteith method. There is a need to collect rainfall intensity data, solar radiation
Q. What improvements could be brought to operational data acquisition and archival processes for hydrological data?

– Newly equipped centralized systems. – Remote systems with data transmission technologies that require little maintenance, i.e. tried and trusted systems. – A need for a common protocol. Trained personnel and commensurate remuneration to avoid quick staff turnover. Also a need for improved/proper equipment
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for hydrological data?
– Updated servers. – Regional training in the handling of data may assist in streamlining quality control methods for data compilation and processing. – Better integration necessary, the use of robust and versatile software's, collection of data in real-time, production of monthly, quarterly and annual bulletins.

Table H9: Stations collecting hydrological data across Saint Lucia

Station Code	Org	Obs. Type	Measured Parameters	Storage	QA/QC	xmit	Share
Deglos	WRMA	Auto	Surface water depth	Excel spreadsheet	Yes	Downl oad	Yes
Mabouya		Auto	Surface water depth	Excel spreadsheet	Yes	Downl oad	Yes
Canelles		Auto	Surface water depth	Excel spreadsheet	Yes	Downl oad	Yes

Table H10: Summary of responses to the questions related to environmental data in Saint Lucia

Q. What gaps do you perceive in the national environmental monitoring infrastructure that needs to be filled for effective observation of environmental change?
– No clear-cut responsibility of any one department for all aspects of environmental monitoring. There is a need for centralization of activities, the strengthening of human resource capacities and an improved monitoring system, especially where intervention has a direct impact on livelihoods. – A national water quality lab is necessary for all water quality monitoring agencies, to submit samples at lower costs than private companies; human resource capacity is lacking to conduct comprehensive WQ sampling and testing.
Q. What gaps do you perceive in the regional environmental monitoring infrastructure that needs to be filled for effective observation of environmental change?
– Disjointed approaches. Need for centralization and information sharing. – Sharing of experiences and data regionally is lacking, especially in regards to types of equipment that are useful/sturdy for in-field monitoring.
Q. What improvements could be brought to operational data acquisition and archival processes for environmental data?
– Improved systems. – Adequate database management systems, which might increase human resource capacity.
Q. What improvements could be brought to the servers, data compilation, data processing and quality

control of data generated for environmental data?
– Updated servers – N/A

Table H11: GIS datasets collated by organizations in Saint Lucia

Organization	Layer Name	Type	Grid Units	Projection	Program	File Format
WRMA	River	line	Decimal degrees	WGS1984	Arcview	.shp
	Rain gauge stations	point	Decimal degrees	WGS1984	Arcview	.shp
	Stream gauge stations	point	Decimal degrees	WGS1984	Arcview	.shp
	Watersheds	polygon	Decimal degrees	St. Lucia 1955	Arview	.shp

ANNEX I: Survey Results For Guyana

Table I1: Summary of climate priority issues in Guyana

Priority Rank	Climate Change Issue
1	– Prolonged drought – Unpredictable weather patterns, which prevent field operations from being accomplished in specified schedules (eg. harvesting). As such production target is not materializing. – Accurate and timely observations. – Flooding – Water
2	– The changing climate is resulting in serious setbacks on the company move to mechanize its operations particular field. – Contamination of ground water wells due to extreme flooding – Sharing and exchange of data – Disaster risk management
3	– Current field infrastructure is not built to accommodate rainfall in the extended wet season, particularly drainage, which cannot provide fast enough drainage during extensive rainfall. On the other hand, during extended periods of the dry season not enough water is available for irrigation. – Processing of user friendly information – Air and Climate Change
4	– Frequency at which pest outbreaks occur is worrying since insects are better able to quickly adapt to Climate Change. – Bioenergy indicators
5	– In the case of weeds, more rain favor its growth, at the same time preventing efficient management of weeds which is critical to control because of the competition it poses with Sugarcane growth. The corporation is in the process of enhancing its Integrated Weeds Management Strategies but there is little we can do to stop the excessive rainfall.

Table I2: Summary of responses to questions related to data management in Guyana

Q. Data updates and Frequencies of Data
– Collection of met data is carried out daily, which follows internal established procedures and standards on the various climate measurements that are of importance to the sugar industry. – Met data collected is primarily for internal use to guide management when developing their work plan. However, met data is also provided to the Ministry of Agriculture - Hydro Metrological Service. – Depends on the data set. For many of the databases, the countries are requested to provide the data annually. For Aquastat, consultants are hired to collect the data every 5 years or so, following strict – Guidelines to ensure that the data are reliable. – Varies from 1hr, 3 hrs, 6 hrs, daily, monthly and every 3 months. In most cases data is collected manually, also we have some automatic weather station
Q. Data Distribution policies and restrictions

– Met data gather across the Sugar industry is tabulated and circulated within the company for internal uses – We are guided by the Water and Sewerage Act of 2002 – Generally available to Government institutions, most available to public. Cost recovery implemented.
Q. What are the Data products and services delivered?
– Upon requests, data on abstraction rate and water quality are provided – Weather data provided is limited to our ability to collect met data. Each Estate has designated teams that collect met data conventionally, which is analyzed manually. – Databases and publications – Surveying, mapping and GIS.
Q. What are the methods of data collection?
– Mostly manual collection but also a moderate level of automated collection – Collection of data is done through instruments that required to be read manually and physically very little automatic met data reading. The data collected is owned by the Industry. – For Aquastat, national consultants are hired to collect and collate data from national agencies – Various Manual and Automatic networks are in place for data collection – Surveying, remote sensing.
Q. What are your organization's data ownership and sharing policies *Summarize responses*
– No established policy exists. – We take full ownership of gathered data. Data sharing with the Agriculture Ministry is open and based on request from others, data may be provided depending on the nature of request. – We own the data in our databases but we share widely – We are guided by the Guyana Water and Sewerage Act of 2002 – Data has to be acknowledged when used.
Q. What national, regional, or international standards are followed by your organization? *Summarize responses*
– The data collected is in keeping with the standards of the Ministry of Agriculture - Hydrological Metrological Service. – World Meteorological Organization
Q. General comments or recommendations in relation to data issues *Summarize responses*
– Our medium of data collection needs updating and upgrading, however, it is not possible due to our ability to fund such a venture. – The level of details required in this survey would require someone with lots of time, regrettably demands of other assignments will not permit us to provide all the information. Annex 1 provides details of our entire monitoring network. The Hydrometeorological Service mandate is clearly outlined in Water and Sewerage Act of 2002. A lot of goals under this mandate is still its in infancy stages. Hence, any system(s) that are proposed by this consultancy should ensure that any database should captured everything (for example, all parameters listed in Hydrology and Met and Climate survey , GIS - the Hydromet Service is expected to capture it, it is envisage that in the near future that this can be achieved.)

Table I3: Summary of responses to questions related to data management recommendations in Guyana

Q. How would your organization benefit from a regional data management system tracking impacts due to climate change?
– GuySuCo see enormous benefit to participating in a regional program such that we contribute data and are allowed access to large-scale, regional, value added data products. We also recognize that climate change is a global phenomenon with regional implications that cross over our Estates. In order for us to achieve our climate change adaptation goals, we need to have regional data to inform our decisions and make us aware of the risks that are posed to our cultivation. The regional DMS is an integrated platform that can help tremendously. – It would help us in our role in information sharing and providing our stakeholders with reliable data for decision making – It will improve the efficiency and effectiveness of our data retrieval for analysis and utilization. – From activities related to mapping of flooding related to disaster preparation and response.
Q. Which geospatial climate and hydrographic monitoring products would be most useful for informed decision-making in your sector?
– A map that shows the regional impact of climate change on Agriculture – Specific real time monitoring of the climate over our cultivation. – Precipitation maps – Agro-Climatic monitoring for food security – Contamination tracking – A map that shows the regional impact of climate change on Agriculture and Water Resources
Q. Which other information products or mapped indices would be most useful for informed decision-making in your sector?
– We would like to see a focus on biodiversity mapping – Accurate weather forecasting – Land use – Land cover – Areas which are vulnerable to floods and other natural hazards – Drought and Flood Indices – Higher resolution climate forecast products – We would like to see a focus on biodiversity mapping
Q. Please provide a list of queries that your organization may request from the DMS - eg. What are the average monthly precipitation, land slope, landcover type, and soil type, at a particular location?
– Drought risk across the industry especially during the dry seasons of the year. – Average monthly precipitation of a particular location – Land use and land cover types, soil types elevation, topography etc – Vulnerability indices for specific hazards – Drought risk across the Country especially during the dry seasons of the year. – Highest 5 day rainfall or comparison of rainfall totals against a particular year – Need good rainfall data and development of flooding models for predictive purposes.
Q. Besides your own organization, the involvement of which national, regional and international organizations would be most essential for the success of a regional DMS?
– FAO

– IICA – Ministry of Agriculture – CCCCC – CEHI – CIMH – WMO – UWI – CMO – Guyana Water Inc – Ministry of Housing and Water – Civil Defense Commission – Ministry of Works

Table I4: Summary of responses to the questions related to education about climate change in Guyana

Q. Is climate change sufficiently addressed in the education system where your organization operates? Explain.
– No, lack of updated equipment and technically trained personals is causing a voided in GuySuCo. – At the university level, yes but with secondary school students there is need for more information
Q. Do you see opportunities or a means by which education with respect to the environment can benefit the community where you operate? If so, at what levels: primary, secondary, tertiary, and community education?
– All and any form of training would be a great starting point to educate members of the communities about the threat Climate change is having and will continue to be. – Yes, at all levels
Q. Comments and recommendations related to Outreach Activities?
– We would like to have cane farmer on-board and be more conscious of the impacts of Climate Change on Sugarcane farming.

Table I5: Summary of additional relevant comments and recommendations (Computing) in Guyana

Q. Do you have any comments and recommendations?
- The Hydrometeorological Service is aware of the importance of such skills and has begun to take steps to ensure such skill is recruited by end of 2013

Table I6: Summary of responses to the questions related to meteorology and climate data in Barbados

Q. What gaps do you perceive in the national meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
- There is need for capacity building in aspects of modeling including agrometeorological and

Entomological modeling so as to aid Agriculture Ventures - More monitoring equipment in order to have statistically valid sampling for model building.
Q. What gaps do you perceive in the regional meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
- Need a functioning agromet unit - Exchange of personnel to work on common grounds
Q. What improvements could be brought to operational data acquisition and archival processes for met and climate data?
- Air conditioned office, Full time staff to for archiving data, computers and personnel - Raising the awareness of the use and importance of IT in data management. - Currently we do not have a digital archive of our climatic data We need to undergo an archival retrieval process to digitize this data, which is mostly on hardcopy maps (precip maps, etc). Our met data retrieval is fine for the newer automated stations that we possess, however, the majority of our stations are manual and require human intervention to ensure good quality data is gathered.
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for met and climate data?
- There is need for digitization of historical data from all sources instead of having them in hard copies - Funding for more equipment.

Table I7: Stations collecting met and climate data across Guyana

Station Code	Org	Obs. Type	Measured Parameters	Storage	QA/ QC	XMIT	Share
Georgetown Botanic Gardens	Met Service	Manual	Precip, solar rad, temp, humid, wind, clouds, sunshine, atm pressure, wind dir, wind run, soil temp, soil moisture, dew point, evaporation,	spreadsheet	Yes	phone	With other govt depts
Timehri Airport	Met Service	Manual	Precip, solar rad, temp, humid, wind, clouds, sunshine, atm pressure, wind dir, wind run, soil temp, soil moisture, dew point, evaporation,	Spreadsheet / CLIDATA	Yes	Phone	With other govt depts
Mabaruma	Met Service	Manual	Precip, temp, humid, clouds, sunshine, wind dir, wind run, dew point, evaporation,	Spreadsheet / CLIDATA	Yes	Phone / internet	With other govt depts
Kamarang	Met Service	Manual	Precip, temp, humid, wind, clouds, sunshine, wind dir, wind run, dew point, evaporation,	Spreadsheet / CLIDATA	Yes	Phone	With other govt depts
Kaieteur	Met Service	Manual / Auto	Precip, solar rad, temp, humid, wind, clouds, sunshine, atm pressure, wind dir, wind run, soil temp, soil moisture, dew point, evaporation,	Spreadsheet / CLIDATA	Yes	Phone	With other govt depts
New	Met	Manual	Precip, temp, humid,	Spreadsheet /	Yes	Phone	With

Amsterdam	Service		wind, clouds, sunshine, wind dir, wind run, soil temp, soil moisture, dew point, evaporation,	CLIDATA		/ Paper / Satellite	other govt depts
Lethem	Met Service	Manual	Precip, temp, humid, wind, clouds, sunshine, atm pressure, wind dir, wind run, soil temp, soil moisture, dew point, evaporation,	Spreadsheet / CLIDATA	Yes	Phone	With other govt depts
Ebini	Met Service	Manual	Precip, solar rad, temp, humid, wind, clouds, sunshine, atm pressure, wind dir, wind run, soil temp, soil moisture, dew point, evaporation,	Spreadsheet / CLIDATA	Yes	Phone	With other govt depts
OGLE AERODROME		Aeronautic/ Synoptic	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature				
DAWA		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration				
LEONORA CORNER W.C.D		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration				
LA BONNE INTENTION FRONT		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration				
WAUNA N.W.D.		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours				
ENMORE FRONT E.C.D		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours				
MON REPOS CENT. AGR. STA.		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours				
BLAIRMONT FRONT		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration				
M/CONY. ABARY RICE DEV. S(MARDS)		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration				
ROSE HALL FRONT		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative				

			Humidity,Evapouration				
SKELETON FRONT		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration				
MAZARUNI PRISON		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration				
ALBION FRONT		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Leonora Corner		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Parika		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Anna Regina		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Dawa		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Little Baiboo		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Maduni		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil				

			Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
St.Cuthbert's Mission RG		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
St.Cuthbert's Mission WL		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Copeman Conservancy		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Kuruduni		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
St.Francis Mission		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Orealla		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Apaikwa		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
kaieteur		Automatic	Precipitation,				

		Weather Station	Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Tumatumarie Falls		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
St. Ignatius		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
Eclipse Falls		Automatic Weather Station	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation				
CHARITY POMEROON		Rainfall	Precipitation				
MC NABB BACK		Rainfall	Precipitation				
ONDERNEEMING ESSEQUIBO		Rainfall	Precipitation				
PICKERSGILL POMEROON		Rainfall	Precipitation				
WAKAPOA POMEROON RIVER		Rainfall	Precipitation				
WARAPOKA		Rainfall	Precipitation				
WOREBUCCO		Rainfall	Precipitation				
LA BAGATELLE LEGUAN		Rainfall	Precipitation				
BELLE VUE BACK W.C.D.		Rainfall	Precipitation				
BELLE VUE FRONT W.B.D.		Rainfall	Precipitation				
BOERASIRIE W.C.D		Rainfall	Precipitation				
DE KINDEREN BACK W.C.D.		Rainfall	Precipitation				
DE KINDEREN FRONT		Rainfall	Precipitation				

W.B.D.							
FORT ISLAND ESSEQ RIVER		Rainfall	Precipitation				
HOG ISLAND ESSEQ RIVER		Rainfall	Precipitation				
LA RESOURCE W.B.D.		Rainfall	Precipitation				
LEONORA BACK W.B.D.		Rainfall	Precipitation				
LEONORA FRONT W.C.D		Rainfall	Precipitation				
MELVILLE WAKENAAM		Rainfall	Precipitation				
POTOSI W.B.D		Rainfall	Precipitation				
REYNESTEIN FRONT W.B.D		Rainfall	Precipitation				
REYNESTEIN BACK W.B.D		Rainfall	Precipitation				
TUSCHEN FRONT W.C.D		Rainfall	Precipitation				
UITVLUGT BACK W.C.D		Rainfall	Precipitation				
UITVLUGT FRONT W.C.D		Rainfall	Precipitation				
VERSAILLES BACK W.B.D		Rainfall	Precipitation				
VERSAILLES FRONT W.B.D		Rainfall	Precipitation				
VRIESLAND FRONT W.B.D		Rainfall	Precipitation				
VRIESLAND BACK W.B.D		Rainfall	Precipitation				
SANS SOUCI WAKENAAM ESEQ		Rainfall	Precipitation				
WALES FRONT W.B.D		Rainfall	Precipitation				
YOUNG RACHAEL W.B.D		Rainfall	Precipitation				
CANE GROVE BACK E.C.D		Rainfall	Precipitation				
CANE GROVE FRONT E.C.D		Rainfall	Precipitation				
COVE & JOHN POLICE STN		Rainfall	Precipitation				
DIAMOND FRONT E.B.D		Rainfall	Precipitation				
ENMORE BACK E.C.D		Rainfall	Precipitation				
Enterprise Front E.C.D		Rainfall	Precipitation				
Enterprise Back E.C. D		Rainfall	Precipitation				
GEORGETOW		Rainfall	Precipitation				

N PROMENADE GDN							
KAIRUNI LINDEN HIGHWAY		Rainfall	Precipitation				
LALUNI		Rainfall	Precipitation				
LA BONNE INTENTION BACK		Rainfall	Precipitation				
LUSIGNAN BACK E.C.D		Rainfall	Precipitation				
LUSIGNAN FRONT E.C.D		Rainfall	Precipitation				
NON PARIEL BACK E.C.D		Rainfall	Precipitation				
NON PARIEL FRONT E.C.D		Rainfall	Precipitation				
OGLE BACK E.C.D		Rainfall	Precipitation				
OGLE FRONT E.C.D		Rainfall	Precipitation				
VRYHEID'S LUST BACK		Rainfall	Precipitation				
VRYHEID'S LUST FRONT		Rainfall	Precipitation				
BATH BACK W.C.B		Rainfall	Precipitation				
BATH FRONT W.C.B		Rainfall	Precipitation				
BLAIRMONT #7 W.C.B		Rainfall	Precipitation				
Blairmont Pomping Station		Rainfall	Precipitation				
BLAIRMONT MIDLANDS W.C.B		Rainfall	Precipitation				
MAHAICONY Railway station		Rainfall	Precipitation				
ST FRANCIS MISSION		Rainfall	Precipitation				
ADELPHI BERBICE		Rainfall	Precipitation				
ALBION69\ NIGG92		Rainfall	Precipitation				
ANKERVILLE . E. 82		Rainfall	Precipitation				
ENTERPRISE BACK BERBICE		Rainfall	Precipitation				
ENTERPRISE FRONT BERBICE		Rainfall	Precipitation				
FRIENDSHIP CANJE BCE		Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration				
IKURUWA LAKE		Rainfall	Precipitation				

JUBILEE3 \NIGG72		Rainfall	Precipitation				
JUBLILEE 1-9		Rainfall	Precipitation				
LESBEHOLD EN SEED PADDY B		Rainfall	Precipitation				
LETTER KENNY BERBICE		Rainfall	Precipitation				
LOCHABER BERBICE		Rainfall	Precipitation				
MIBIKURI		Rainfall	Precipitation				
MARA LAND DEV. SCHEME		Rainfall	Precipitation				
NEW SPRING GARDEN 12		Rainfall	Precipitation				
NIGG 58 C\TYNE		Rainfall	Precipitation				
NO 54 VILLAGE BERBICE		Rainfall	Precipitation				
NO 63 BENAB		Rainfall	Precipitation				
NO 73 VILLAGE		Rainfall	Precipitation				
PORT MORANT FRONT		Rainfall	Precipitation				
PROVIDENCE BACK BERBICE		Rainfall	Precipitation				
PROVIDENCE FRONT BERBICE		Rainfall	Precipitation				
RELIANCE BERBICE		Rainfall	Precipitation				
RESOURCE .E. 13\17		Rainfall	Precipitation				
RESOURCE .E. 33\34		Rainfall	Precipitation				
RESOURCE O.G.16		Rainfall	Precipitation				
SKELETON 82/B1 BERBICE		Rainfall	Precipitation				
WHIM		Rainfall	Precipitation				
APAIKWA MAZARUNI		Hydromet	Precipitation				
BARTICA DEM STATION		Rainfall	Precipitation				
CHINOWEIN G		Rainfall	Precipitation				
JAWALLA MAZARUNI		Rainfall	Precipitation				
KAKO		Rainfall	Precipitation				
KURUPUNG POLICE STATION		Rainfall	Precipitation				
PARIMA		Rainfall	Precipitation				

PIPLLIPAI KAMARANG RIV.		Rainfall	Precipitation				
TIBOKU MAZARUNI RIVER		Rainfall	Precipitation				
WARAMADO NG		Rainfall	Precipitation				
Crab Wood Creek Corentyne		Rainfall	Precipitation				
# 44 Village Corentyne		Rainfall	Precipitation				
Johanna South B.B.Polder		Rainfall	Precipitation				
Onverwagt		Rainfall	Precipitation				
#5 Village WCB		Rainfall	Precipitation				
North Yakusari B.B.Polder		Rainfall	Precipitation				
Lesbeholden South B.B.Polder		Rainfall	Precipitation				
Light Town E.B. Berbice		Rainfall	Precipitation				
MAHADIA		Rainfall	Precipitation				
ACHAWIB RUPUNUNI		Rainfall	Precipitation				
ANNAI RUPUNUNI		Rainfall	Precipitation				
APOTERI		Rainfall	Precipitation				
AISHALTON RUPUNUNI		Rainfall	Precipitation				
Mackenzie		Rainfall	Precipitation				
Moco Moco Settlement		Rainfall	Precipitation				
Kairuni		Rainfall	Precipitation				
Great Falls		Rainfall	Precipitation				
St. Ignatius		Climatolog y	Precipitation, Temperature,Wind Run, Sunshine Hours,Atmospheric Temperature,Soil Temperature, Relative Humidity,Evapouration				
AWAREWAU NAU RUPUNUNI		Rainfall	Precipitation				
SHEA		Rainfall	Precipitation				
SURAMA		Rainfall	Precipitation				
Sand Creek		Rainfall	Precipitation				
Orealla		Rainfall	Precipitation				
Wismar		Rainfall	Precipitation				
Dadanawa		Rainfall	Precipitation				
Parishara		Rainfall	Precipitation				
Sawariwau		Rainfall	Precipitation				
ARAPIACO FORESTRY STATION		Rainfall	Precipitation				

BETTER HOPE ESSEQUIBO		Rainfall	Precipitation				
CAPOEY LAKE		Rainfall	Precipitation				
SAXACALLI		Rainfall	Precipitation				
ST.DENNY'S MISSION		Rainfall	Precipitation				
NAAMkYCK		Rainfall	Precipitation				
BEEHIVE		Rainfall	Precipitation				
ENTERPRISE E.C.D		Rainfall	Precipitation				
FRIENDSHIP E.C.D		Rainfall	Precipitation				
LAND OF CANAAN		Rainfall	Precipitation				
SAM ATTA POINT		Rainfall	Precipitation				
SOESDYKE FORESTRY		Rainfall	Precipitation				
STRATHAVON		Rainfall	Precipitation				
ABARY IR		Rainfall	Precipitation				
BARA BARA		Rainfall	Precipitation				
BUSH LOT		Rainfall	Precipitation				
COPEMAN SITE		Rainfall	Precipitation				
DE EDWARDS		Rainfall	Precipitation				
FOULIS		Rainfall	Precipitation				
GRASS HOOK		Rainfall	Precipitation				
HELENA #2		Rainfall	Precipitation				
LITTLE BIABOO		Rainfall	Precipitation				
MARAKABI		Rainfall	Precipitation				
NOVAR MAHAICONY		Rainfall	Precipitation				
PINE GROUND MAICHONY		Rainfall	Precipitation				
ST.CUTHBERT		Rainfall	Precipitation				
WASH CLOTHES		Rainfall	Precipitation				
SPRINGLANDS FORESTRY		Rainfall	Precipitation				
CHINOWEING		Rainfall	Precipitation				
KAKO		Rainfall	Precipitation				
GUNN STRIP		Rainfall	Precipitation				
WEST WATOOKA		Rainfall	Precipitation				

Table I8: Summary of responses to the questions related to hydrological data in Guyana

Q. What gaps do you perceive in the national hydrological monitoring infrastructure that needs to be filled for effective observation of environmental change?
– The coverage is skewered toward the coastlands. Much work is needed in adding monitoring infrastructure throughout the middle to southern sections of the country to achieve the WMO prescribed network density and for realizing accurate hydrological regime data for each catchment area.
Q. What gaps do you perceive in the regional hydrological monitoring infrastructure that needs to be filled for effective observation of environmental change?
– More public awareness, this will get everyone involved and make it not only an agency responsibility but also a community and a nation responsibility. Proper and accurate data collection.
Q. What improvements could be brought to operational data acquisition and archival processes for hydrological data?
– Additional staff along with relevant training.
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for hydrological data?
– Have standard operating procedures, have data quality checked, frequent updating of data, back up data regularly

Table I9: Stations collecting hydrological data across Guyana

Station Code	Org	Obs. Type	Measured Parameters	Storage	QA/ QC	xmit	Share
Coastal	GWI	Auto	Surface water depth, ground water depth, discharge, abstraction, turbidity, pH, fecal coliforms, total coliforms	Excel spreadsheet	Yes	Download	Yes
Mabouya		Auto	Surface water depth, ground water depth, discharge, abstraction, turbidity, pH, fecal coliforms, total coliforms	Excel spreadsheet	Yes	Download	Yes
Canelles		Auto	Surface water depth, ground water depth, discharge, abstraction, turbidity, pH, fecal coliforms, total coliforms	Excel spreadsheet	Yes	Download	Yes
Mahaica River at St.Cuthbert's Mission	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
East Demerara Water Conservancy at Flagstaff	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH

Kairuni River at Kairuni bridge	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Loo River at Lin/Soes. H/way Bridge	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Lamaha Canal at Shelter Belt	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
St.Francis Mission	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Berbice River at Itabru Falls	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Canje River at Digitima Creek	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Canje River at Reynold's Bridge	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Canje River at Karia Kuri nr 3 Sisters	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Ikuruwa River At Belcum	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Mazaruni River at Kamarang	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Mazaruni River nr. Apaikwa Falls	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Ikuribisi R at Ikuribisi Falls	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Potaro River at Tumatumari Falls	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Siparuni River at Pakatau Falls	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Burro-Burro River at Sandstone	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Potaro River at Kaieteur Falls	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Takatu River at St. Ignatius	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Demerara River at Great Falls	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Essequibo River at Plantain Is.	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Perimeter Channel - North West	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Kofi Channel - US of Road Sluice	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Land of Canaan Channel - Head Regulator	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH

Cunha Channel - Head Regulator US of Conservancy Sluice	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Cunha Channel - Head Regulator DS of Conservancy Sluice	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Lamaha Creek - Confluence with Eastern Cross-Conservancy Drain	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Lama - DS of Lama Big Sluice	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Loo River	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Timehri and St Cuthberts(Raingauge)	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Conservancy NE(Raingauge)	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Montrose North	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Martyr's Ville	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Dawa	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
West Demerara Conservancy at Leonora Corner	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Perimeter Channel - North Centre	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Perimeter Channel - NE at Flagstaff	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Kofi Channel - Head Regulator US of Conservancy Sluice	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Kofi Channel - Head Regulator DS of Conservancy Sluice	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Kofi Channel -	Met	Auto	Stage, discharge	Paper/databa	-	Paper/typ	Yes -

DS of Road Sluice (Gauge Board Only)	Service			se		e	CIMH
Land of Canaan Channel - US of Road Sluice	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Lamaha Creek - Confluence with Western Cross-Conservancy Drain	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Kofi Waterway - Confluence with Eastern Cross-Conseservancy Drain	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Conservancy Eastern Section Storage Cell	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Maduni - US of Conservancy Sluice	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Maduni - DS of Conservancy Sluice	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Lama - US of Lama Big Sluice	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Mahaica River - St Cuthberts	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Mahaica River - At Little Baiboo	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Mahaica River - At Bellmont	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Loo & Kairuni upper catchment (GT&T antenna)	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Laluni	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Lama Stop-off	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Land of Canaan	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Conservancy W	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Buxton South	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Buxton North	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Enterprise	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH

Bee Hive	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Mosquito Hall	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Cane Grove	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Belmont	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Wash Clothes Mahaicony	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
St.Cuthbert's Mission	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Maduni	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Little Biaboo	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Kairuni River	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Demerara River - Gafoors	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Lama Little Sluice - DS of Conservancy Sluice	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Conservancy - Western Section Storage Cell	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Laluni Creek	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Land of Canaan Channel - DS of Road Sluice (Gauge Board Only)	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Mahaica River - Mosquito Hall (Now gauge board only due to security)	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Mahaicony River at St.Francis Mission	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Abary River at Coopeman	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Corentyne River at Orealla	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Berbice River at Kuruduni	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH

Table I10: Stations collecting environmental data across Guyana

Station Code	Org	Obs. Type	Measured Parameters	Storage	QA/QC	xmit	Share
Aircraft Sample	Guysuco	Manual	pH, ECw, DO, COD, Total Suspended Solids, Chloride, Calcium, Total Kjeldhal Nitrogen, Phosphorus, Sulphate, Iron	spreadsheet	Yes	paper	EPA
Well Water Testing		Manual	pH, ECw, DO, Total Suspended Solids, Chloride, Lead, Iron	spreadsheet	Yes	paper	EPA
Tailing Pond		Manual	pH, ECw, DO, COD, Total Suspended Solids, Phosphorus	spreadsheet	Yes	paper	EPA
Factory Sampling		Manual	pH, ECw, DO, COD, Total Suspended Solids, Phosphorus	spreadsheet	Yes	paper	EPA
Estates Sampling		Manual	pH, ECw, DO, COD, Total Suspended Solids, Magnesium, Calcium, Total Kjeldhal Nitrogen, Phosphorus, Sulphate, Iron	spreadsheet	Yes	paper	EPA

Table I11: GIS datasets collated by organizations in Guyana

Organization	Layer Name	Type	Grid Units	Projection	Program	File Format
Ministry of Lands	Administrative boundaries	polygon		PSAD '56	Arcview	.shp
	River	line		PSAD '56	Arcview	.shp
	Road network	line		PSAD '56	Arcview	.shp
	Land use	polygon		PSAD '56		
	Land cover	polygon		PSAD '56	Arcview	.shp
	Watersheds	polygon		PSAD '56	Arcview	.shp
	Natural Parks or Attractions	points / polygon		PSAD '56	Arcview	.shp
	Settlements	points / polygon		PSAD '56	Arcview	.shp
	Remotely sensed products	raster		PSAD '56	Arcview	.shp

ANNEX J: Survey Results For Barbados

Table J1: Summary of climate priority issues in Barbados

Priority Rank	Climate Change Issue
1	Germplasm availability in climate change / Appropriate disaster management framework / Mobilization of adequate climate finance / Human health
2	Resilience of crops to drought stress / water resource management / Wider development of citizen engagement and community disaster management programs / sector resilience building and mainstreaming climate change adaptation
3	Resilience of crops to higher temperatures / agriculture and food security / connecting climate change adaptation and disaster risk response
4	Management of floods / tourism impacts of climate change / climate change risk assessment / education and awareness about climate change adaptation and disaster risk response
5	Risk of crops due to salinity / enhance community response through training / vulnerability of energy sector / develop climate change and disaster risk response instruments

Table J2: Summary of responses to questions related to data management in Barbados

Q. Data updates and Frequencies of Data
– Data is downloaded monthly / Data is quality checked daily and updated on a monthly basis
Q. Data Distribution policies and restrictions
– Data is available on request and is available online / Data is provided on request at no cost, monthly statistical averages are made available to the public via the website / no policy
Q. What are the Data products and services delivered?
– Temperature, rainfall, wind, humidity, etc. – Monthly statistics on all meteorological parameters are freely available to the public. – Data with respect to specific meteorological events are provided on request to Insurance Agencies, Loss Adjusters, and Law Firms etc. Aeronautical Meteorological Services and Public Weather Services are also provided. – Compiling of emergency data for internal purposes as needed
Q. What are the methods of data collection?
– Received after being saved to data storage disk / manual and electronic data collection / Source from data collecting agencies
Q. What are your organization's data ownership and sharing policies *Summarize responses*
– Shared upon request – All data belongs to the Barbados Government and is freely shared with other government agencies and the public in general. – Emergency Management Act (2006) clause 5 (c) the Department of Emergency Management "in collaboration with other agencies, gather timely and authoritative information concerning the

conditions and trends in the quality of the environment, both current and prospective as these relate to the likelihood of disaster in Barbados"; clause 5 (j) "in conjunction with other agencies, identify, prepare and maintain a national database and a geographical information system that includes information on areas, structures, institutions and those persons who are particularly vulnerable to the consequences of natural disasters"
Q. What national, regional, or international standards are followed by your organization? Summarize responses
– WMO / ICAO standards / Emergency Management Act (2006)
Q. General comments or recommendations in relation to data issues Summarize responses
– There is need for a systematic approach for the purchase of spare parts for AWS's etc, update of outdated database software. – A clearing house should be established which services both disaster management and climate change adaptation – Presently there are plans to establish a greenhouse inventory in Barbados. A management framework has been presented for the greenhouse inventory, which provides a useful framework that could be set-up for climate change adaptation and disaster management. Important aspects of the framework should include establishing MOU's and standards for data supply. – Particular attention should be paid to providing the institutional and technological framework necessary to support the sustainable collection of data. For example significant investment has been made in the DEWETRA system for disaster management, however the supporting human resources, legislative and institutional framework is not in place to ensure emergency managers and decision makers use the system.

Table J3: Summary of responses to questions related to data management recommendations in Barbados

Q. How would your organization benefit from a regional data management system tracking impacts due to climate change?
– The organization would be able to make comparative assessments of climatic impacts. Will also help in mitigation of future impacts. – This system would provide easy access to specific information impacts on Barbados, which could be readily translated into risk reduction planning and decision-making. – CARDI would be better positioned to advise and develop strategies to counter the impacts of climate change in its member states – Would be useful in decision-making on how and where to allocate project resources and programming efforts as well as for project appraisal.
Q. Which geospatial climate and hydrographic monitoring products would be most useful for informed decision-making in your sector?
– Coastal inundation from sea level rise and storm surge analysis inclusive of SLR (sea level rise) considerations.

- CC informed IDF curves
- Downscaled temperate and precipitation maps based on CC projections.
- Expected flooding, sea level rise, drought hazards and risk information mapped and incorporated in regular briefings to decision makers and supported by regular monitoring and up dating of the information.
- All climate change hazard impacts

Q. Which other information products or mapped indices would be most useful for informed decision-making in your sector?

- Digital elevation maps
- Flood water extent and levels, sea level rise levels and expected storm surge levels and extent. Storm frequencies and expected intensities and periods.
- Drought indices, expected fire risk and water shortages.
- Vulnerable and at risk populations and critical infrastructure and keys sectors such as tourism and agriculture.
- Sector specific climate variability/climate change/disaster risk assessments
- Hazard event/damage and loss databases

Q. Please provide a list of queries that your organization may request from the DMS - eg. What are the average monthly precipitation, land slope, landcover type, and soil type, at a particular location?

- daily precipitation
- daily temperatures
- daily humidity
- soil type
- soil temperature

Q. Besides your own organization, the involvement of which national, regional and international organizations would be most essential for the success of a regional DMS?

- CIMH
- Ministries of Works
- Ministries of Finance & Economic Planning
- CCCCC
- UWI
- Ministries of Physical Planning, Environment & National Disaster Offices
- Ministry of Agriculture
- Local Department of Emergency Management (DEM)
- Coastal Zone Management Unit
- Drainage Department
- CDEMA
- Barbados Water Authority
- Statistics Department
- Ministry of the Environment and Ministry of Health
- Lands and Surveys
- Town and Country Planning

Table J4: Summary of responses to the questions related to education about climate change in Barbados

Q. Is climate change sufficiently addressed in the education system where your organization operates? Explain.
– There are a number of ongoing projects related to climate change. Also, significant education awareness campaigns are prevalent – There has been recent development of material for communities. – More can be done. CARDI within the last few months has sponsored a public lecture presented by Mr. Carlos Fuller of the CCCCC that was attended by a wide cross-section of the public. – It needs to be more strongly enforced in our social sector programming as well as for the training and/orientation of new officers.
Q. Do you see opportunities or a means by which education with respect to the environment can benefit the community where you operate? If so, at what levels: primary, secondary, tertiary, and community education?
– Climate change education especially with respect to rising sea levels, temperature and drought need to be taught to school and college students so that they are sensitized and prepared to respond appropriately to these changes. – The society as a whole can benefit from any available opportunities where education on the environment is concerned. – All levels. The DEM has programs presently targeting the primary and secondary schools. These programs could be could be enhanced with climate change educational material.
Q. Comments and recommendations related to Outreach Activities?
– There must be regular briefings to decision makers and this should be supported by regular monitoring and up dating of the information. This must be undertaken within a coordinated framework.

Table J5: Summary of additional relevant comments and recommendations (Computing)

Q. Do you have any comments and recommendations?
– Please note that there is no official IT department but we do have a number of personnel with some of these skills. There is need for an established post of IT Specialist/Systems Analyst in the Department.

Table J6: Summary of responses to the questions related to meteorology and climate data in Barbados

Q. What gaps do you perceive in the national meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
– More weather stations are needed to be part of a more complete/representative network so that more accurate data is collected and reported – Lack of systematic network of AWS; quite a few around but are maintained by individual ministries and are of different makes, hence the need for standardization.

Q. What gaps do you perceive in the regional meteorological and climatic monitoring infrastructure that needs to be filled for effective observation of environmental change?
– More weather stations are needed to be part of a more complete/representative network so that more accurate data is collected and reported – A need for greater collaboration and sharing of data. – There is density issue that can only be solved by increased observation stations, more specifically Automatic Weather Stations, some more remote ones with the option for telemetering/transmitting of data.
Q. What improvements could be brought to operational data acquisition and archival processes for met and climate data?
– Human resources be made accessible so that data collected in interpreted and reported to stakeholders in more impactful manner – Need for continued upgrade of existing stations and placement of AWS's in more strategic locations. – Upgrade of archival facilities at the CIMH. – Automatic production of hourly and daily data from 10 min data and automatic importation into database
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for met and climate data?
– Need for IT training and improved software to bring data processing software up to date. – Developing more products and signing products with security certificates

Table J7: Stations collecting met and climate data across Barbados

Station Code	Org	Obs. Type	Measured Parameters	Storage	QA/ QC	XMIT	Share
Grantley Adams International Airport	Met Service	Auto / manual	Precip, temp, humid, wind, clouds, atm pressure, wind direction, wind run, dew point,	Spreadsheet / digital	Yes	paper / radio	CIMH and other depts.
Rawinsonde (airport)		Auto / manual	Precip, temp, humid, wind, clouds, sun duration, atm pressure, wind direction, dew point,	Spreadsheet / digital	Yes / no	paper / radio	CIMH and other depts.
St. George		Auto	Precip, temp, solar radiation, humid, wind, clouds, sun duration, atm pressure, wind direction, soil temp, dew point,	Spreadsheet / digital	Yes / no	phone	CIMH and other depts.
CARDI Barbados http://www.weatherlink.com/u	CARDI	Auto	Temp, humidity, dew point, atm pressure, wind speed, wind	Digital	Yes	Web	Public (web)

ser/cardibarbados/			direction, precip, soil temp, soil moisture, leaf temp, leaf wetness				
13159642	CIMH	Auto/ manual	Precip, solar rad, temp, humid, wind, clouds, sunshine, atm pressure, wind dir, wind run, soil temp, dew point, evaporation,	Digital (Dataease database – non processed / Access - processed)	Yes	Paper / radio / cable	Pay-per-use
Orange Hill		Manual	Precip	ASCII/ database	No	Download	Pay-per-use
Apes Hill		Auto / manual	Precip	ASCII / database	No	Web	Pay-per-use

Table J8: Summary of responses to the questions related to hydrological data in Barbados

Q. What gaps do you perceive in the national hydrological monitoring infrastructure that needs to be filled for effective observation of environmental change?
– My observations are that (i) the local agencies do not have the resources (human and financial) to efficiently and sustainably manage hydrological monitoring networks (ii) very little attention is paid to ensuring data quality and (iii) very little attention paid to adequate data storage. In addition, institutional arrangements need to be strengthened so that it is clear who is responsible for hydrological monitoring at the local level.
Q. What gaps do you perceive in the regional hydrological monitoring infrastructure that needs to be filled for effective observation of environmental change?
– One thing that has been noticed is the difficulty that some entities have regarding the general maintenance and upkeep of the equipment after the project has ended. Also, getting access to the data can be challenging. The installation of common equipment with common standards across the region would reduce some maintenance issues. Regional agencies need to work more closely with the local agencies to ensure that common standards are applied. It may be useful for regional agencies to procure, install and manage networks across the region as they may more likely have the resources to do such. The regional agencies should work together to establish a set of specifications for monitoring, storage, QA etc in order to ensure consistency.
Q. What improvements could be brought to operational data acquisition and archival processes for hydrological data?
– Resources required to ensure (i) an efficient hydrological monitoring program is established locally (ii) the use of satellite/GPRS communications for data transfer (iii) the acceptance of a common regional platform or database for managing data and (iv) quality control procedures are followed.
Q. What improvements could be brought to the servers, data compilation, data processing and quality control of data generated for hydrological data?
– We need to focus on systems capable of transmitting data remotely to a pre-defined database for storage preferably through a dedicated communication method that is not compromised during

disasters. For real-time applications a preferred method of dissemination needs to be identified. This may require a public private partnership with telecommunications providers. QA procedures need to be articulated, standardized and applied throughout the region.

Table J9: GIS datasets collated by organizations in Barbados

Organization	Layer Name	Type	Grid Unit	Projection	Program	File Format
CIMH	Administrative boundaries	polygon		National / UTM	ArcGIS / GRASS	varies
	River	line		National / UTM	ArcGIS / GRASS	varies
	Rain gauge stations	point		National / UTM	ArcGIS / GRASS	varies
	Road network	line		National / UTM	ArcGIS / GRASS	varies
	Land cover	polygon /raster		National / UTM	ArcGIS / GRASS	varies
	Watersheds	polygon		National / UTM	ArcGIS / GRASS	varies
	DEM	raster		National / UTM	ArcGIS / GRASS	varies
	Soils	raster		National / UTM	ArcGIS / GRASS	varies
	Numerical weather predictions	raster	mm	lat / long	WRF	netCDF
	Drought maps	raster		lat / long		varies
Department of Emergency Management (DEM)	Administrative boundaries	polygon	m	GCS Barbados 1938	ArcGIS	shp
	Road network	line	m	GCS Barbados 1938	ArcGIS	shp
	Settlements	polygon	m	GCS Barbados 1938	ArcGIS	shp
	DTM	points	m	GCS Barbados 1938	ArcGIS	shp
	Remotely sensed products	raster		GCS Barbados 1938	ArcGIS	shp
	Weather radar	raster		GCS Barbados 1938	ArcGIS	shp
	Physiographic maps / geology	polygon	m	GCS Barbados 1938	ArcGIS	shp
	Socio-economic maps	points	m	GCS Barbados 1938	ArcGIS	shp
	Shelters		m	GCS Barbados 1938	ArcGIS	shp
	Soils		m	GCS Barbados 1938	ArcGIS	shp
	Storm surge risk (1 parish)		m	GCS Barbados 1938	ArcGIS	shp
	District emergency organization boundaries		m	GCS Barbados 1938	ArcGIS	shp

Table J10: Summary of comments and recommendations for GIS data

Q. Do you have any comments and recommendations?
– The database should include vulnerable persons (disabled and other compromised persons (for

example the elderly, single mothers) who are unable to take care of themselves/ dependents in times of disaster/ emergency) however the capacity will need to be built within the social care and community organizations to collate this information and ensure that it is kept up to date within the clearing house. This is a critical area where external assistance is needed.

- Consideration may be given to including key hazard maps- static and dynamic in the database. Note however where this information does not exist there could be some scope to produce the data.
- The DEM presently does not collect its own data.
- The Department does not have a GIS technician as part of its current structure. However from time to time this expertise is available to the Department. The Department is currently in the process of an institutional assessment, which is expected to provide recommendations for the Department in advancing its role in information management interalia.