DESIGN + ENVIRONMENT

PHASE 2: C-READ SYSTEM DESIGN

CONCEPTUAL DESIGN DOCUMENT

FINAL VERSION

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

IDB project: ATN/OC-12554-RG

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For the 5C DMS project DE has brought on the MONA Geoinfomatics Institute. MONA Geoinfomatics 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

ASCII	American Standard Code for Information Interchange
AWS	Automated Weather Station
BERDS	Biodiversity and Environmental Resource Data System (Belize)
BWA	Barbados Water Authority
CARDI	Caribbean Agriculture Research and Development Institute
CARIBHYCOS	Caribbean Hydrological Cycle Observation System
CariCOOS	Caribbean Coastal Ocean Observing System
CARIWIN	Caribbean Water Initiative
CCCCC	Caribbean Community Climate Change Centre
CDEMA	Caribbean Disaster and Emergency Management Agency
CIMH	Caribbean Institute for Meteorology and Hydrology
C-READ	Caribbean Regional Environmental and Atmospheric Data Management System
CSW	Catalogue Service on Web
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
DEM	Department of Emergency Management (Barbados)
DEWETRA	Real time data and information system for hydrometeorological risk forecasting, environmental monitoring, and disaster risk management
DOWASCO	Dominica Water and Sewerage Company Limited
EFJ	Environmental Foundation of Jamaica
ESRI	GIS Software company
FTP	File Transfer Protocol
GEF IWCAM	Global Environmental Facility Integrated Watershed and Coastal Area Management Project
GIS	Geographic Information System
GPS	Global Positioning System
GUI	Graphical User Interface
GWI	Guyana Water Incorporated
IADB	Inter-American Development Bank
IT	Information Technology
JAD Session	Joint Application Development Session
JBI	Jamaican Bauxite Institute
JSON	JavaScript Object Notation
LIC	Land Information Centre (Belize)
MGI	Mona Geoinformatics Institute
MGU	Marine Geology Unit – University of West Indies, Jamaica
MOAF	Ministry of Agriculture and Forestry (Dominica)
MOH	Ministry of Health (Belize)
MVC	Model-View-Controller
NAREI	National Agricultural Research Extension Institute (Guyana)
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)
NWIS	National Water Information System (Barbados)
ODPEM	Office of Disaster Preparedness and Emergency Management (Jamaica)

OGC	Open Geospatial Consortium
ORM	Object Relational Mapping
PAHO	Pan American Health Organization
PIOJ	Planning Institute of Jamaica
PM10	Particulate Matter (10 micron diameter)
PPCR	Pilot Project for Climate Resilience
RADA	Rural Agricultural Development Authority (Jamaica)
RSS	Rich Site Summary
RUBIS	Exclusive Distributor of Shell Energy Products in Jamaica
SDC	Social Development Commission of Jamaica
SOx,	Sulphur Oxides
SQL	Structured Query Language
TIDE	Toledo Institute for Development and the Environment
TSP	Total Suspended Particles
UNEP	United Nations Environment Program
UNISDR	United Nations International Strategy for Disaster Reduction
USGS	United States Geological Service
UWI	University of the West Indies
WASA	Water and Sewage Authority (Belize)
WCS	Web Coverage Service
WFS	Web Feature Service
WINDALCO	West Indies Alumina Company (Jamaica)
WMO	World Meteorological Organization
WMS	Web Map Service
WMTS	Web Map Tile Service
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 conceptual design of C-READ (Caribbean Regional Environmental and Atmospheric Data) management system of the project awarded to DE Design + Environment Inc. by the Caribbean Community Climate Change Centre. The Conceptual Design was the main activity outlined in the terms of reference for the second 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 Conceptual Design is to build upon the Gap Analysis from phase 1 and provide an overview of the general structure and function of C-READ. The key elements to this Conceptual Design are the architecture of the system, the design of the user interface, the specification of data inputs and outputs, the determination of functional requirements, and delineation of use case scenarios, as per the project terms of reference. This document is to provide a blueprint for how the system can be constructed but does not constitute a complete technical specification including source code.

1.2 Objectives of Conceptual Design Document

The Conceptual Design was generated from the electronic survey responses gleaned from the six partner countries for this project: Jamaica, Belize, Dominica, Saint Lucia, Guyana, and Barbados. These survey responses were the basis for determining what the functional objectives of this system ought to be. The e-survey broadly addressed management, technical, and information technology aspects that relate to environmental monitoring in the wider Caribbean region. These survey responses helped to identify specific areas of need for different stakeholders. As an example, these are three questions that recipients responded to which helped to gauge where priorities for C-READ should be and what functionality it should have:

Q. Which geospatial climate and hydrographic monitoring products would be most useful for informed decision-making in your sector?

Q. Which other information products or mapped indices would be most useful for informed decision-making in your sector

Q. Please provide a list of queries that your organization may request from the DMS - eg. What are the average monthly precipitation, land slope, land cover type, and soil type, at a particular location?

The answers to these questions are summarized respectively in Annex H, Annex I, and Annex J.

The responses to these questions provided our team with an understanding of the specific types of queries and data products that C-READ should produce. The same overall structure of Categories and Issues that was used in the Gap Analysis is employed with the conceptual design. Hence, the analysis of data inputs and outputs and functionality follows this breakdown:

- Category 1: Meteorological and Hydrological Data and Projections
- Category 2: Hazards and Risks
- Category 3: Geographical and Biophysical Risk
- Category 4: Coastal Zone and Ocean
- Category 5: Land Cover and Land Use
- Category 6: Agriculture and Food Security
- Category 7: Water: Availability, Quality, and Use
- Category 8: Energy: Use, Generation, and Availability
- Category 9: Socio-Economic Status
- Category 10: Critical Emergency Infrastructure

This high-level structure will guide the user interface of C-READ as well as server as the organizational hierarchy for the catalogue.

The Conceptual Design is organized as follows: *System Architecture*, *User Interface*, *Data Inputs and Outputs by Category*, *Functional Requirements*, and *Use Cases*.

2. System Architecture

2.1 Overview of System

The C-READ System will be a web-based application that will be accessed by standard and current web browsers such as Internet Explorer, Chrome and Safari.

It will leverage the well-established technologies including:

- Web 2.0 technologies such as AJAX, JSON and jQuery for responsiveness and an interactive web experience
- Standard HTTP/HTTPS transport protocols
- Model-View-Controller (MVC) architecture, which facilitates separation of concerns; that is, the rendering and the display of data in the View, is independent of how that data is stored and represented within the C-READ system itself, the Model. The Controller typically a lightweight framework that simply acts as a mediator between the View (user input and output) and the data. This architecture allows for greater flexibility in terms of data usage and representation.
- Service Oriented Architecture (SOA) is an industry standard design pattern that provides discrete pieces of application functionality as services. Applications built with this pattern are highly scalable, distributable, and reusable. Web service interfaces are accessed via standard HTTP/HTTPS requests and typically act as the Controller piece of the MVC architecture.
- A web server and platform that is capable of handling the anticipated volume, security requirements and architecture of the C-READ system.
- A core GIS server and data store that will manage all GIS-related functionality
- GeoNode as an implementation tool for GIS-oriented analysis – particularly when considering integrating with already existing GeoNodes in the Caribbean region.

2.2 C-READ Services

There will be five primary C-READ web services:

- GIS Service
    - All GIS-related requests by the C-READ GUI web interface
    - A Cataloguing Service for spatial data that supports the CSW protocol of the Open Geospatial Consortium
    - GeoNode will most likely be the implementation platform for C-READ GIS functionality
    - A FileStore rest within the GIS Service component and will store timeseries and statistical data
- C-READ Web Application Service
    - Handles navigational and other non-GIS related requests
    - The ORM (Object Relational Mapping) Service will take the object-oriented representation of data (eg. JSON representation, Java entity, etc) and map it to a relational database. It will be used to map things such as user data and session data to facilitate basic website functionality.
- Authentication Service
    - User registration
    - User management
    - User authentication (login) and authorization
    - Users can submit an application to access (licensed) data
    - Licensing info can be part of the metadata (multi-level): public, educational, commercial
- Catalogue Service
- Provide a (metadata) catalogue that is able to register, point to, store and make available time series and other data.
    - A queryable service that will provide info/instructions on where and how to retrieve and import data (including the providing organization, the type and scope of data, the method and protocol to access it)
    - licensing information may also be queryable
    - provide actual links to external sites/servers where possible
    - include the geonodes in the region
    - catalogue can be updated/maintained online
- Data Services
    - Users can define a layer preset that details input format requirements (e.g. columns/attributes required, units, etc…)
    - Allows users to import / upload different data types

        - shapefiles and raster data sets
        - metadata information for layers
        - timeseries data and statistics (e.g. in Excel, ASCII Format)
        - Feed integration via RSS, FTP/SFTP, Dropbox or other protocol
        - non-spatial documents that supplement spatial data (e.g. in PDF, Word Format)
    - Allows users to upload data via HTTP/HTTPS for integration with the C-READ GIS Services
    - Allows users to export data
        - GIS data in the form of shapefiles, KML, PDF or image formats (GIF, JPG, PNG, TIFF) to local GIS systems
        - timeseries data and statistics in the form of datafiles and tables in various suitable formats (e.g. ASCII, Excel)Possible integration with national GeoNodes and other standardized spatial data infrastructures
        - download metadata for layers
        - OpenLayer to support embeddable previews of layers.
        - Support OGC protocols for automated retrieval of metadata, data and cataloguing in order to allow other platforms to connect to the system
    - Allows logical grouping of datasets using folders, tags or categories.
    - Workflows
        - Users can define a workflow for a dataset and indicate the stage the dataset is at in the flow. Users can indicate that a dataset is for example « raw » or « under review » or « published ».
        - Example workflows for standard cases of processing data should be provided and illustrated
        - Users can add datasets to different stages in a flow.
        - Users can define relationships between datasets (e.g derivates or aggregate) within a flow. This is explained in the use case scenarios section of this report (section 6).
        - Users can duplicate workflow structures.
        - Users can define license and access requirements on the entire workflow or stages of the workflow.
        - Allows users to download all the datasets within a workflow.
    - Users can apply advanced functions on defined data types within the system. Examples are being given below in section 2.2.4.2. Data

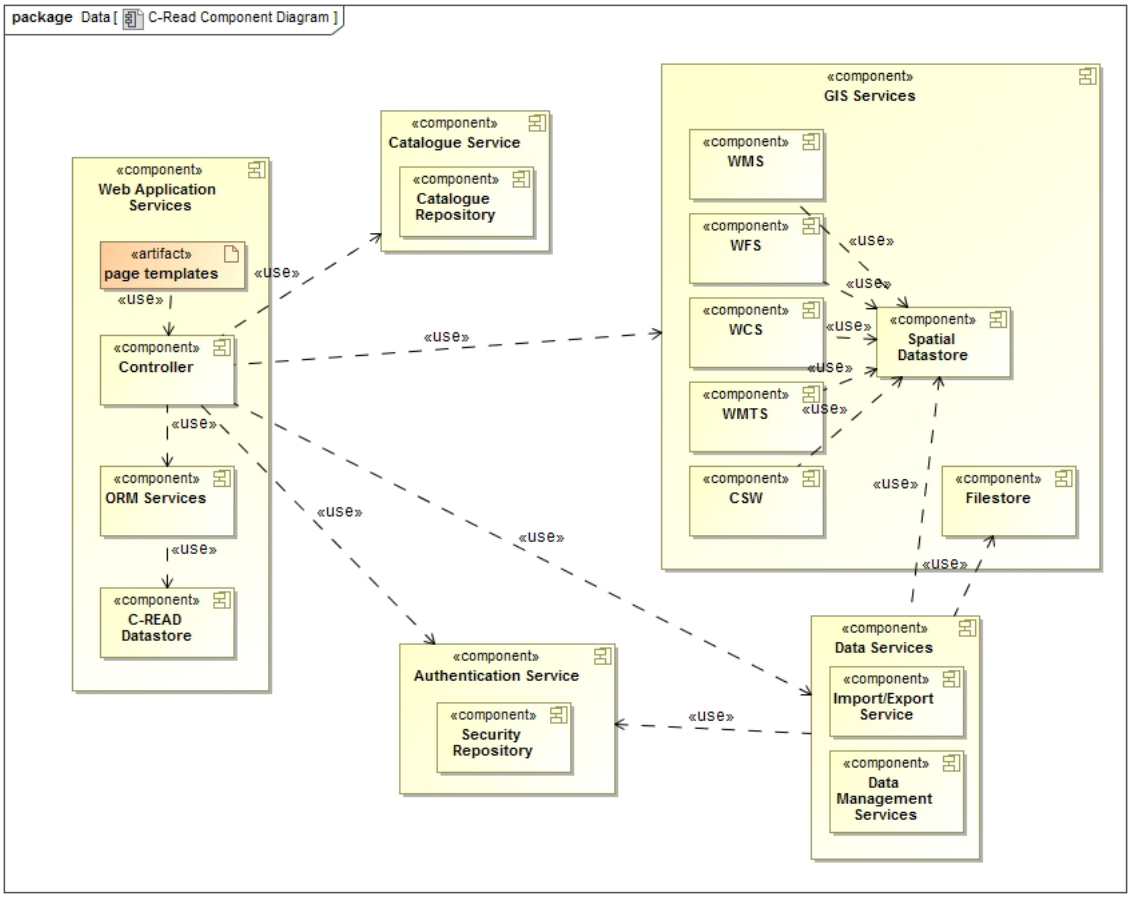
Management Services

- Creating Maps
  - Users can combine several datasets to create a map via attaching geospatial information (coordinates, projection, etc) to point data.
  - Users can define default extents for the map.
  - Users can apply access restrictions to the viewing of the map.
  - Users can define « category map » that require a list of data types.
  - Users can apply styles to the different layers on the map.
- Harvesting functionality to integrate data from existing national GeoNodes and from other GIS catalogues

Separating the C-READ application into these five distinct services allows for greater implementation flexibility. So long as all of the interfaces are well-defined and established, it should be relatively straightforward to build each of these pieces independently.

Figure 1 shows an overview of the C-READ system components.

Figure 1: C-READ Component Diagram



2.2.1 GIS Service

As the C-READ system will be a web-based application that will be accessible via any current web browser, the system should adhere to established standards to support this, specifically, those set out by the Open Geospatial Consortium (OGC) and OpenGIS.

Following standards has the following advantages:

- interoperability: C-READ will be able to easily integrate with other systems following the same standards
- longevity: the C-READ system will be able to evolve gracefully with the standards making the application more future-proof than proprietary implementations
- familiarity: individuals who have worked with other systems using the same standards will be able to ramp up quickly with the C-READ system
- productivity: C-READ will be able to leverage any existing tooling or platforms that already exist to support these standards
- flexibility: As the C-READ system will be based on an SOA approach, it should be possible to simply plug in any OpenGIS-compliant GIS server

The following are a list of standards that have been identified as being particularly relevant to the C-READ system:

1. OpenGIS Web Map Service (WMS)
    - HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases. A WMS request defines the geographical layer(s) and area of interest to be processed. The response to the request is one or more geo-registered map images that can be displayed in a web browser. The interface also supports the ability to specify whether the returned images should be transparent so that the layers from multiple servers can be combined or not.
2. OpenGIS Web Feature Service (WFS-T)
    - This standard defines operations to create, modify, delete and query instances from an underlying data store that are invoked via HTTP requests.
3. OpenGIS Web Coverage Service (WCS)
    - This standard supports electronic retrieval of geospatial data as “coverages”; that is, digital geospatial information representing space/time-varying phenomena.
4. OpenGIS Catalogue Services (CSW)
    - This standard specifies the interfaces, bindings and a framework for defining application profiles required to publish and access digital catalogues of

metadata for geospatial data, services and related resource information.

5. OpenGIS Web Map Tile Service (WMTS)
    - This standard provides a solution to serve digital maps using predefined image tiles to achieve scalable, high performance services for web based distribution of cartographic maps.

2.2.2 C-READ Web Application Service

This service will implement the MVC design pattern mentioned earlier. It will handle all navigation requests from the user and will define the various views or templates that define each web page. It will have its own datastore to manage session data and web-specific content.

2.2.3 Authentication and Licensing Service

Users will seamlessly be able to access public or educational data without having to first register or log in. Authentication will only be required in the following circumstances:

- The user wishes to access data that is either non-public or a paid license is required
- The user wishes to access import/upload data to the C-READ GIS system
- The user wishes to add or modify Catalogue Service entries
- The user wishes to modify workflow states, permissions, logical groupings, presets or any other configurations

The following roles have been identified at this point (user can have multiple roles):

- User: members with this role will have access to all public and educational data, along with any licenses that they are associated with
- Data Manager: this is an administrator role who will review and manage imported data into the C-READ system
- Catalogue Manager: this is an administrator role who will manage the Catalogue Service
- Administrator: this is a general administrator who will manage all of the users and licenses within the system

The registration process will include an option to apply for access to licensed data. Upon submitting the registration and application, an Administrator will be notified by e-mail of the pending application at which point the Administrator can either grant or deny the application.

Users will be required to request for authorization to download specific, licensed data sets. Upon approval from the appropriate licensing body (for example, a meteorological service) the user will be able to download the data set.

There will be a User Administration interface not accessible to the public allowing Administrators to manage users and applications.

All user management functionality (including login, registration and administration) will be done over an encrypted communication protocol (i.e., HTTPS) and as a result, the hosting domain for C-READ must have a valid SSL certificate.

Authentication and authorization services will be provided by a sub-component of the C-READ system and backed by a secure repository.

Passwords and password-related data will remain encrypted throughout the system.

There will be a facility to recover forgotten userid's and passwords (users must register with a valid email to recover their userid).

2.2.4 Data Services

2.2.4.1 Data Import and Export Services

The C-READ system will be collecting data from a wide variety of sources in various formats, including raster, vector, timeseries, statistical, and topography data. It is assumed that all input data will be digital in nature. Converting hardcopy data (e.g., maps and reports) is beyond the scope of this system, however, PDF files that have resulted from digitized maps and other hardcopy documents are likely and their upload and linking should be possible.

Specific data types that will be supported by C-READ include:

- ADRG/CADRG/ECRG (ARC Digitized Raster Graphics/Compressed/Enhanced)
- ESRI Shapefile
- GeoTIFF
- MapInfo MIF/MID
- USGS DEM (Digital Elevation Model)
- Timeseries/statistical data in Excel, CSV, PDF files etc

The Data Import Service will integrate with both the Authentication Service (to ensure the user is appropriately authenticated and authorized to import data) as well as the Core GIS Service where the data will be managed and stored.

The Data Import Service can be extended to also allow for data to be imported from feeds, via (S)FTP or other file transfer protocols as well as from platforms that use the GeoNode suite.

Likewise, the Data Export Service will let authenticated, authorized and appropriately licensed users export data in various formats (which ever is appropriate, e.g., shapefiles, Excel spreadsheets, etc) and may also be integrated with external GeoNodes.

2.2.4.2 Data Management Services

The Data Services allows users to manage data and maps that are created within the system. The service will also provide means for users to create presets for layers and maps. A preset layer allows the user to describe a type of layer and provide requirements for the attribute table and units of measurement used in the layer. For example, a user could create a population density data preset for a given year that requires the attribute table to contain values for male and females.

Users are also allowed to define map presets that combine data presets. For example, a user could create an Eco-System map preset that requires topographic, administrative boundaries and land use data presets. The use of map and data presets will help to:

- Promote consistency in the data that is uploaded and the maps that are created from map presets.
- Share knowledge as it relates to minimum data requirements for layers and maps.

The Data Services also provide workflows so users can highlight linkages between datasets and also indicate the stage in the process of data preparation that a dataset is in. For example, workflows can be used to track and guide through the process of data quality checking and subsequent map preparation.

A stage in this workflow could indicate that a time series dataset was converted into a shapefile. The time series dataset may have been marked with a raw status and the resulting shapefile would could have a status of « map generated » and subsequently « published ». For datasets that are within a workflow, the user can opt to use advanced functions defined in C-READ to perform advanced operations. The following are examples of sample operations that may be supported:

- Conversion of a vector to a raster
- Aggregation of time series data

Additionally, the data services will allow grouping of layers into folders and tagging of presets, layers, maps and work flows. This will allow for advanced filtering and searching of the data. These suite of services will work in tandem with the Authentication and Licensing services to ensure that there is regulated access to work flows, presets and each of the layers and maps that are created.

To ease the understanding of the benefits of the preset, workflow and grouping functionalities for the users, it is important that they are being explained as part of the user experience and illustrated with good examples and a useful preconfiguration. This applies to both geospatial data and to time series or statistical data.

2.2.5 Catalogue Service

This is a publicly accessible, queryable service that allows users to find external resources that may possess the data that they are looking for (particularly if it is not part of C-READ yet). The results of the queries should provide the user with information on the providing organization, the type and scope of data, a link to the resource (if applicable) along with the appropriate instructions on the protocols required to access it

The users overseen by a moderator can dynamically maintain the catalogue. It should be presented in the form of a table and it must be searchable.

3. C-READ User Interface

3.1 Overview of User Interface

The user interface was designed based on the analysis of functional requirements for C-READ. The system development process has been very demand-driven on the part of potential C-READ users and as such these interfaces came from the functional assessment and data inputs and outputs that we specified for each category and issue.

We have studied a number of different monitoring systems and have taken into consideration the fact that C-READ will have a two-pronged development platform: MySQL/PHP (or similar) and Geonode. The following sites are examples of references we used to design the interface and some characteristics from each that are laudable.

Geonode
http://demo.geonode.org/
The Geonode demonstration site gives a very good depiction of what a complete interface can look like. This site shows an online platform that is built to enable people to share spatial data easily and openly. This interface also shows how users, map making, adding labels, categorizing data, and sharing data can be managed. The C-READ interface compositions that have been created emulate this functionality.

Cariska
http://cariska.mona.uwi.edu/
Cariska is a site made in Geonode and it clearly shows how data uploading is featured. Layer management is also clearly shown with all of the associated detail information for each layer easily accessible. Download functionality is also featured prominently. Controls are built into this Geonode application to change the base map. Similar upload and download functionality and map manipulation is required of C-READ.

Servir
http://Servir.net/
Servir is a good demonstration of multi-layer functionality for the purpose of visualizing environmental data. C-READ will likely only have one base map layer rather than the different options as they have it. Nonetheless, clearly showing how precipitation radar can overlay a base map layer demonstrates how aspects of C-READ will function.

CrimeMapping
http://www.crimemapping.com/
Crimemapping.com shows how data filtering can be done dynamically. Much of the data gathered by C-READ will be for the purpose of looking at change over time of different

monitored environmental parameters. By using fixed time periods or slider bars, changes of different parameters can easily be queried.

Jampro
http://projects.monagis.com/jampro_test/#
The Jampro site shows common controls that allow the user to see what layers are active at any given time. Layers can be turned off or on by the controls in the top left panel box. C-READ could have similar functionality with environmental data layers being turned off or on.

The C-READ interface has incorporated aspects of the above sites into its design. The goal is to have an uncluttered interface and achieve the functionality desired. Layering geospatial data and combining these data sets is clearly one of the key functions that is required for C-READ.

The following user interface designs highlight some of the categories of functionality:

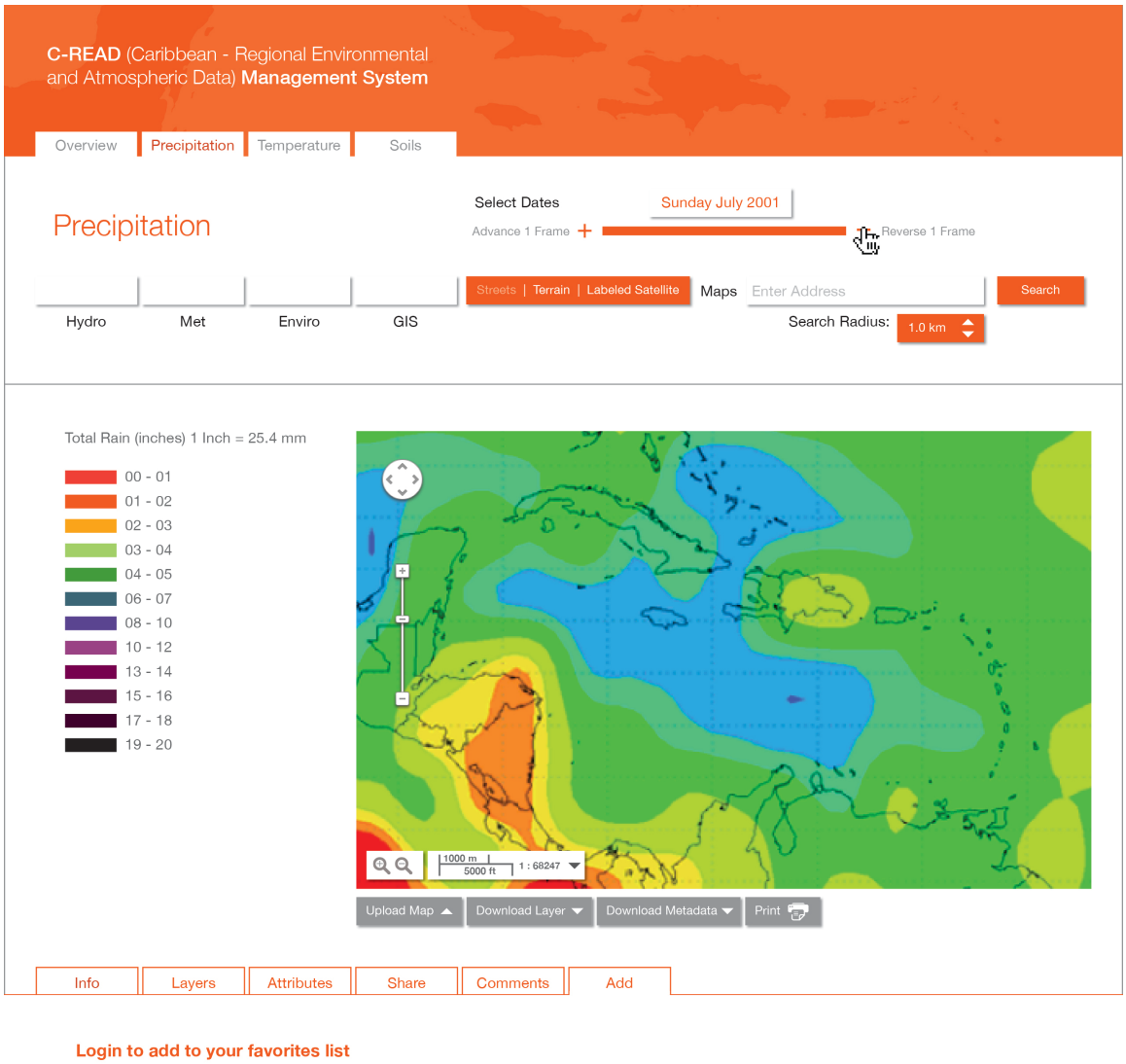
- Precipitation monitoring
- Drought risk assessment
- Topography assessment
- Ecosystem and biodiversity evaluation

The full size interfaces can be found in the file referenced in *Annex A: User Interface Document* on page 93.

3.2 Precipitation

Precipitation monitoring is a central component of C-READ. In this interface the level of precipitation is shown for a given time period (July 2001). Zoom functionality will allow for a finer resolution analysis where data is available.

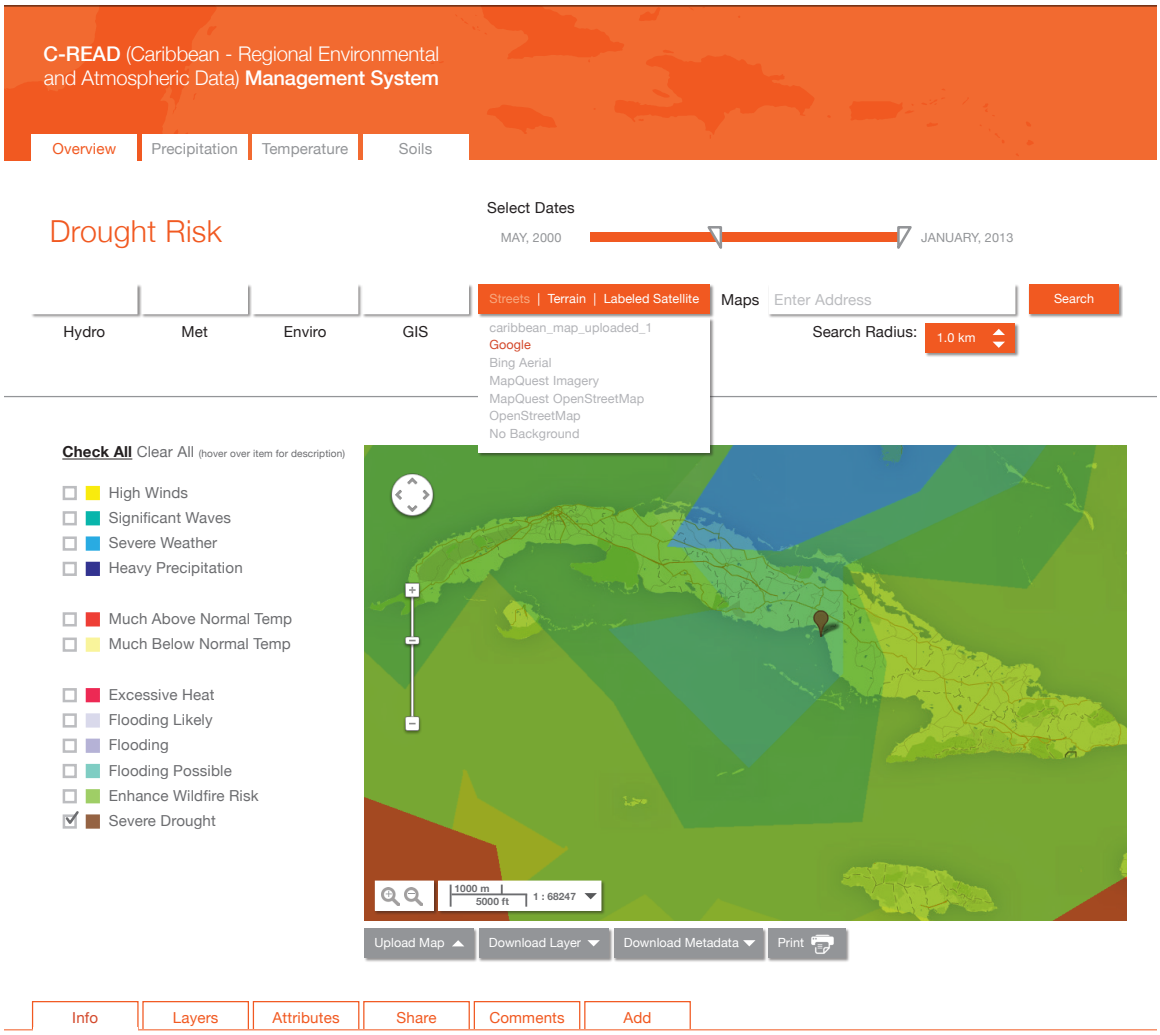
Figure 2: Precipitation monitoring interface for C-READ



3.3 Drought Risk

Several stakeholders identified drought risk as a key issue to be addressed with C-READ. The following interface diagram shows how a drought layer can be selected for a specific region. This layer is derived from the SPI (Standard Precipitation Index).

Figure 3: Drought risk map for C-READ



Title: caribbean_map_uploaded_1

Abstract: No abstract provided

Publication Date: Oct. 24, 2013, 1:15 a.m.

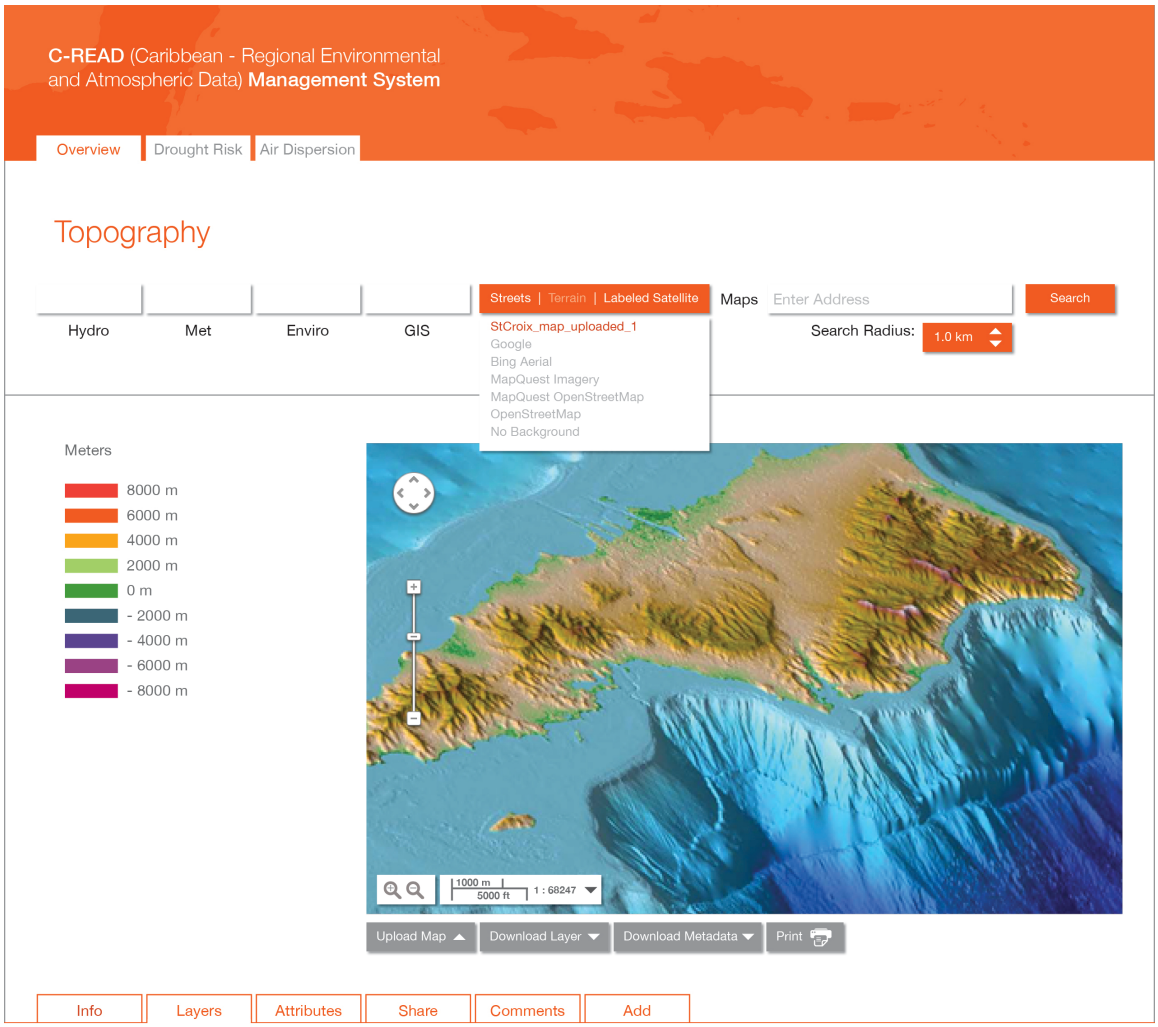
Type: Vector Data

Category: Location

3.4 Topography

C-Read must be able to show Topography (including bathymetry). This data will also be combined with other data for data outputs such as flood risk.

Figure 4: Topography interface for C-READ



This map uses the following layers:

on off Lorem Ipsum

on off Doloriosant

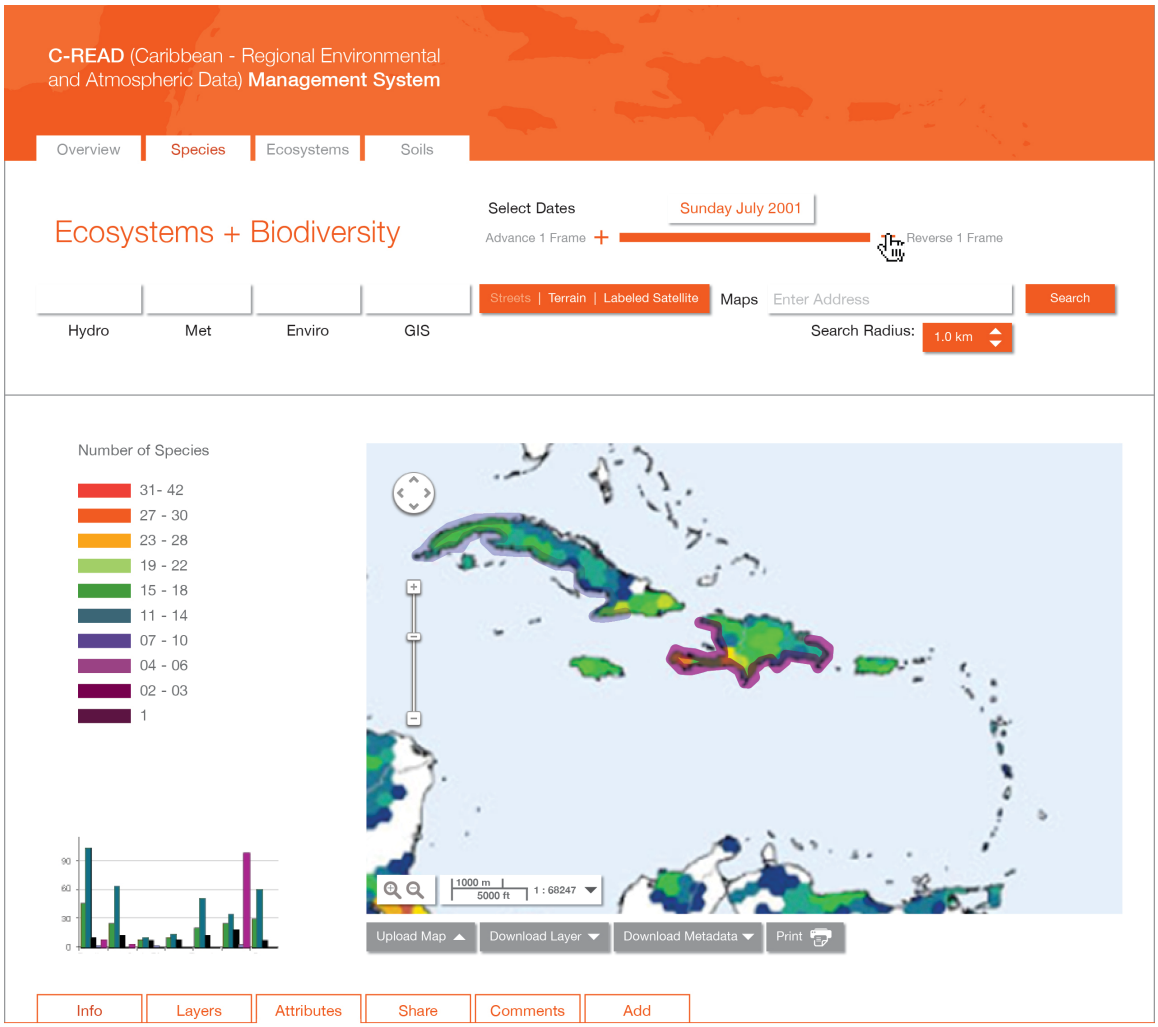
Uploaded by: satmaram on Aug. 6 2012

Description: Doloriosant est, quiat et lici berum aliquis reptati onserit voloreperum repella natum dolorectat earum eos perovit landam faccatur, conet que et quamus ni vereper iatius solupta tiatem de sum lam fuga. Abore eum facerum num erspel ipicide sincipsa doloreperio eatiorrorro excepre et aut quam enimenectati is et min con corepti dolorru ntotatur alicto veles sam conesseque quaeper epratur, ulpa nus et ullit facipsa voluptaturem saectium resti deliquas rest, expliqui bea dolorporem solupti busaectaque aute exerae ea doluptat.

3.5 Ecosystems and Biodiversity

This interface must show Land cover and land use data as well as ecosystem type and levels of biodiversity.

Figure 5: Ecosystems and Biodiversity interface for C-READ



Species Data:

Natural Boundaries
Administrative Boundaries
Classification
Number of Species per Administrative Boundaries
Spatial Data (tables & graphs)

4. Data Inputs and Outputs

4.1 Overview of Data Inputs and Outputs

The inputs and outputs of data to C-READ were derived from the initial assessment that occurred through the first phase of which involved the Gap Analysis. The survey of monitoring data that was gathered, as well as desired functionality, allowed us to breakdown the data inputs and outputs into the ten key categories that were established in the Gap Analysis.

A detailed assessment of data requirements was performed for the issues that were identified within each category. Some survey respondents did not indicate that the required data were gathered. In these cases, further inspection and inquiry is required. Data formats and access protocols were cited for each country in relation to the environmental monitoring issues.

The e-survey responses were the primary source of information for the data inputs and outputs. Raw data from the surveys can be found in the following Annexes:

- Annex B: Jamaica – Monitoring Data Reported from E-Survey
- Annex C: Belize – Monitoring Data Reported from E-Survey
- Annex D: Dominica – Monitoring Data Reported from E-Survey
- Annex E: Saint Lucia – Monitoring Data Reported from E-Survey
- Annex F: Guyana – Monitoring Data Reported from E-Survey
- Annex G: Barbados – Monitoring Data Reported from E-Survey

The following data input and output descriptions are the basis for the database structure. The use case scenarios draw upon them to explain functionality.

4.2 Data Inputs and Outputs by Category

4.2.1 Category 1: Meteorological and Hydrological Data and Projections

Issue:	Precipitation and general meteorological monitoring			
User need:	Consistent representation of rainfall vs. historical normal			
Purpose:	To provide a geographically referenced visual metric of recent changes in rainfall			
Data requirements (inputs)	**Hydro:**	**Met:** precipitation, temperature	**Enviro:**	**GIS:** map
Data sources:		Jamaica - Met Service, WINDALCO Belize - Met Service Barbados - Met Service, CARDI, CIMH Dominica - Met Service St. Lucia - Met Service, WRMA Guyana - Met Service		
Database spec:	Follow protocols established by CIMH.			
GIS spec:	Precipitation radar data may be used as well. This data is in raster format and needs to adhere to a common projection and spatial resolution.			
Information product (output)	Map overlaid with option of charts for last 30 days, 90 days, 365 days showing daily rainfall and a chart of accumulated observed vs. normal observed. As the Regional Climate Centre for the Caribbean in Demonstration phase, these products will form part of the repertoire of CIMH.			
Of note:	See also http://www.cpc.ncep.noaa.gov/products/global_monitoring/precipitation/sn72202_30.gif for the example of last 30 days of precipitation in Miami.			

Protocol for accessing data:
Through its primary function to collect, analyze and publish meteorological and hydrological data, CIMH has agreements in place and established protocols to accomplish this with the 16 member countries of the CMO. CIMH has existing relationships with each of the Met Services. These relationships should be leveraged in the implementation of C-READ, and combined with a verification process that ensures that each country is following the protocols.

- Jamaica – The Met Service and WINDALCO gather precipitation and temperature data. The NWC gathers temperature data. All three organizations store their data electronically and do share with other departments. The Met Service also has GIS point files with the locations of rain gauge stations. This may be useful in C-READ. NEPA collects rain radar data as well. NEPA collects rain radar data as well.
- Belize – The Met Service collects precipitation, temperature, and general meteorological data. They only reported one met station. This data is stored in ASCII format and they do share this data.

- Dominica – The Met Service gathers precipitation, temperature and general meteorological data. This data is stored in ASCII format. The Met Service indicated it shares this data on a pay per use basis.
- Saint Lucia – The Met Service gathers precipitation, temperature and general meteorological data from 6 stations. WRMA gathers general met data from 27 stations. The data from these stations is stored electronically in ASCII files, spreadsheets, climsoft database, or access database. WRMA also has GIS point files of rain gauge stations.
- Guyana – The Met Service collect precipitation, temperature, and other parameters from several stations and also has a series of rain gauges throughout the country. All data is stored in Spreadsheets or CLIDATA and is shared with other government departments.
- Barbados – The Met Service gathers precipitation, temperature, and other meteorological parameters as does CARDI and CIMH. All data is stored digitally.

  NOTE: CIMH has existing relationships with these Met Services and data products are generated through the exchange of data. These relationships should be leveraged in the implementation of C-READ.

Issue:	Weather forecasting			
User need:	Consistent representation of short term precipitation forecast			
Purpose:	To provide a geographically referenced visual metric of probable short-term rainfall.			
Data requirements (inputs)	**Hydro:**	**Met:** Parameters for forecasts	**Enviro:**	**GIS:**
Data sources:		Jamaica – Met Service, UWI Climate Studies Group Belize – Belize Met Service Dominica – Met Service St. Lucia – Met Service Guyana – Met Service Barbados –		
Database spec:	Follow protocols established by CIMH			
GIS spec:	Raster data of precipitation forecasts at relevant spatial resolution and in the geographic projection that matches with other C-READ GIS data			
Information product (output)	Incorporate the product generated by the Caribbean Regional Climate Outlook Forum into C-READ			
Of note:	http://cimh.edu.bb/?p=precipoutlook presents a precipitation outlook map for the region.			

Protocol for accessing data:

- Jamaica – Forecast data available from the Jamaican Met Service.
- Belize – Precipitation outlooks conducted by Met Service. Data should be available.
- Dominica – Any required data should be accessible from the Dominica Met Service
- Saint Lucia – Any required data should be accessible from the Saint Lucia Met Service
- Guyana - Any required data should be accessible from the Guyana Met Service
- Barbados – Any required data should be accessible from the Barbados Met Service or CIMH

NOTE: Compilation of data will remain the responsibility of C-READ contributors. See use cases for more explanation of how this process will work. The role of Data Analyst / Manager has been established for each C-READ participant country. This person will need to coordinate with the relevant agencies in each country for different data sets. They will work with ministry and agency representatives to ensure that data is transmitted to C-READ in the proper format. This type of data-intermediary will be very important, especially for environmental phenomenon that is sampled in a variety of different ways and stored in different formats throughout the Caribbean. This role will help to enforce consistency in data within the C-READ framework.

Issue:	Climate projections			
User need:	Consistent approach for using short term forecasts as well as longer term climate projections models			
Purpose:	To use climate model projections as the basis for delineation of risk maps and the development of climate change adaptation plans. To provide geographically referenced visible metrics of projected changes in climatic variables, notably precipitation and temperature.			
Data requirements (inputs)	**Hydro:**	**Met:** Parameters for climate projections	**Enviro:**	**GIS:**
Data sources:		Jamaica – Met Service, UWI Climate Studies Group Belize – Belize Met Service, CCCCC Dominica – Met Service St. Lucia – Met Service Guyana – Met Service Barbados – CIMH, Met Service		
Database spec:	Follow protocols established by CIMH and CCCCC			
GIS spec:	Raster data of climatic parameter output from model (usually temperature). Data to be at appropriate projection to be used with other GIS data in C-READ.			
Information product (output)	Map of projected climatic conditions at selected time intervals in the future – likely to 2050 and 2100 to start, as these are the most commonly used GCM temporal projections.			
Of note:	CCCCC is working on building capacity for more of this kind of analysis throughout the Caribbean. The CCCCC Clearinghouse has an online platform with some of the modelling data available online in the form of interactive maps and in ASCII and NETCDF formats. This data is available to everyone and should be incorporated into or linked to C-READ. Analysis on other countries should be examined through existing work with CCCCC.			

Protocol for accessing data:

- Jamaica – Met Service of Jamaica and the UWI Climate Studies Groups can provide data and model output. Some projections are available online through the CCCCC Clearinghouse.
- Belize – Model output is available online through the CCCCC Clearinghouse and can be incorporated in to C-READ.
- Dominica – Any required data for models should be available from Met Service. Some projections are available online through the CCCCC Clearinghouse.
- Saint Lucia - Any required data for models should be available from Met Service. Some projections are available online through the CCCCC Clearinghouse.
- Guyana - Any required data for models should be available from Met Service. The Guyana Climate Change Action Plan may have relevant data.
- Barbados – Any required data for models should be available from Met Service or CIMH

Issue:	Hydrological monitoring			
User need:	Consistent representation of water level vs. historical normal			
Purpose:	To provide a geographically referenced visual metric of recent changes in surface water level			
Data requirements (inputs)	**Hydro:** water level and associated meta data	**Met:**	**Enviro:**	**GIS:** map with watershed layer, river layer
Data sources:	Jamaica - NWC, WRA, Met Service, MWLECC, JBI, NWA Belize - Met Service, Coastal Zone Management Authority Dominica - DOWASCO St. Lucia - WRMA Guyana - GWI, Met Service Barbados – CIMH, Barbados Water Authority, Environment Unit – Drainage Division			
Database spec:	Text data to be appended to location data. If necessary, conversion from hard copy text to electronic prior to this.			
GIS spec:	Vector data of station location – in relevant geographic projection.			
Information product (output)	Map overlaid with option of chart for last 30 days showing daily water level for each station or of a chart of last 365 days plotted against historical min and max. 2D graphs showing water levels at particular stations (when selected) over the designated time periods.			
Of note:	http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=02OE012&report=daily&year=2011 has an example for a station in Canada.			

Protocol for accessing data:

- Jamaica – The NWC and WRA gather hydrological data and store it in spreadsheet / ASCII format. They share this data with other organizations hence sharing with C-READ, given appropriate agreements, could be possible. GIS hydrological data such as station location, are collected by the Met Service (point files), WRA has watershed (polygons) and stream gauge station locations (points), NLA has rivers (line), NWA has rivers (line) and flood prone areas (point), and SDC has watersheds and rivers. The projections are generally JAD2001 to 2003 format.
- Belize – The Met Service gathers hydrological data and stores in the HOMS database. They license their data out, so there will have to be some sort of data sharing agreement with C-READ. The Coastal Zone Management Authority & Institute has GIS hydrological data such as watersheds (polygon), rivers (lines), and coastal zones (polygon). They do not share this data so there would have to be a discussion about them about collaborating with C-READ.
- Dominica – DOWASCO reported that they gather hydrological data however they did not report specifics. Further inquiry with them will be required in regards to data sharing. Carib-HYCOS under PPCR is implementing new monitoring equipment and data sharing technology. Jean-Pierre Briquet (project lead) can be contacted for more information (jean-pierre.briquet@ird.fr)

- Saint Lucia – The WRMA collects hydrological surface water depth and stores this data in excel spreadsheets. They do share this data, so an agreement with C-READ could likely be established.
- Guyana – GWI and the Met Service collect hydrological data. This data is stored in excel spreadsheets or in a database. They share this data with CIMH or other departments, so sharing with C-READ is likely possible.
- Barbados – Although no respondents responded with the specific specifications for the hydrological data they gathered, some groups indicated that CIMH, the Barbados Water Authority, and the Environment Unit – Drainage Division, were those the ones responsible for gathering hydrological data. Further inquiry with these organizations is required.

NOTE: Compilation of data will remain the responsibility of C-READ contributors. See use cases for more explanation of how this process will work. The role of Data Analyst / Manager has been established for each C-READ participant country. This person will need to coordinate with the relevant agencies in each country for different data sets. They will work with ministry and agency representatives to ensure that data is transmitted to C-READ in the proper format. This type of data-intermediary will be very important, especially for environmental phenomenon that is sampled in a variety of different ways and stored in different formats throughout the Caribbean. This role will help to enforce consistency in data within the C-READ framework.

4.2.2 Category 2: Hazards and Risks

In general, NOAA has an excellent GIS-based hazard-warning tool (at http://www.cpc.ncep.noaa.gov/products/predictions/threats/threats.php**)** for the US. This example was used in developing the C-READ interface. Much of this functionality is being developed within the DEWETRA platform being developed by CIMH/CDEMA and hence the potential integration of C-READ with this system should be a considered a priority. Rather than re-developing the same functionality, these two systems could potentially be coupled. Additionally, the Caribbean Drought and Precipitation Monitoring Network functionality should be examined in terms of being coupled with C-READ so as to reduce redundancy.

Issue:	Drought Risk Assessment			
User need:	High spatial resolution assessment of drought risk			
Purpose:	Mitigation and emergency planning for drought conditions			
Data requirements (inputs)	**Hydro:**	**Met:** precipitation	**Enviro:**	**GIS:** land use map
Data sources:		Jamaica - Met Service, WINDALCO, Belize - Met Service Barbados - Met Service, CARDI, CIMH Dominica - Met Service St. Lucia - Met Service, WRMA Guyana - Met Service		
Database spec:	Automated calculation of SPI for determined period (one month, 3 months or six months) using cumulative precipitation compared to historical record of comparable time period.			
GIS spec:	Raster data sets at spatial resolution established from CIMH drought monitor. Maps should be in a common projection to be able to be used with other GIS data in C-READ.			
Information product (output)	National and regional scale maps indicating drought risk colour-coded severity using scale of +2 to -2.			
Of note:	Development of the C-READ Drought Risk Assessment will be coordinated with the existing CIMH Drought Monitor (results currently displayed at http://63.175.159.26/~cdpmn/bbspi.html). See also www.cpc.ncep.noaa.gov for an additional example. This should be accomplished in the creation of C-READ such that system interoperability and data exchange is verified.			

Protocol for accessing data:

- Jamaica – Jamaica Met Service can provide data for SPI. CIMH can provide insights on algorithm.
- Belize – Met Service can provide data.
- Dominica – Met Service can provide data – perhaps Ministry of Agriculture as well. Ongoing Carib-HYCOS project (under PPCR) can be a source of data too.
- Saint Lucia – Met Service and WRMA may provide data.
- Guyana – Met Service of Guyana can provide data as well as GWI

- Barbados – CIMH and Barbados Met Service can provide data. CARDI may provide relevant data too.

Issue:	Flood Risk Assessment			
User need:	Assess regions where flood vulnerability exists			
Purpose:	Mitigation and emergency planning for flood conditions			
Data requirements (inputs)	**Hydro:** stage; tide; sea level; storm surge; ground water depth	**Met:** precipitation	**Enviro:**	**GIS:** topography, geology, land use, infrastructure, population, surface water, watershed borders
Data sources:	Jamaica - WRA, NWC Belize - Met Service Dominica - N/A St. Lucia - WRMA Guyana - Hydromet Service, GWI Barbados - CIMH	Jamaica - Met Service, WINDALCO Belize - Met Service Dominica - Met Service St. Lucia - Met Service, WRMA Guyana - Hydromet Service Barbados - Met Service, CIMH, CARDI		Jamaica - WRA St. Lucia - WRMA Guyana - Ministry of Lands Barbados - DEM
Database spec:	Text data to be appended to location data.			
GIS spec:	Raster data sets at spatial resolution established from CIMH drought monitor. Maps should be in a common projection to be able to be used with other GIS data in C-READ.			
Information product (output)	National scale maps showing flood prone areas and nature of flood risk (storm surge, high surface water, high groundwater, excess urban runoff, etc.). In countries where more detail exists, such as Jamaica, links to local floodplain maps (for 10 yr, 25 yr, 50 yr and 100 yr floods) can be included.			
Of note:	C-READ will coordinate with CIMH to incorporate their work on Real-time Flood Forecasting using HydroGeoSphere numerical model in combination with the Weather Research Model. NOAA generates a global precipitation analysis over land map. A zoom-in of this would be useful for the Caribbean region.			

Protocol for accessing data:

- Jamaica – Data sharing agreements with WRA, NWC, Met Service, WINDALCO will be required.
- Belize - Data sharing agreements with Met Service, will be required.
- Dominica - Data sharing agreements with Met Service will be required.
- Saint Lucia - Data sharing agreements with Met Service, and WRMA will be required
- Guyana - Data sharing agreements with Met Service, GWI, Ministry of Lands will be required.
- Barbados – Data sharing agreements with Met Service, CARDI, CIMH, and DEM will be required

Issue:	Hurricane and Storm Surge Impact Analysis			
User need:	Integration of regional storm data with coastal topography and maps of vulnerable infrastructure			
Purpose:	Mitigation and emergency planning for storm conditions			
Data requirements (inputs)	**Hydro:** Water levels	**Met:** Storm strength / precipitation levels	**Enviro:**	**GIS:** topography, infrastructure, population, coastal zone
Data sources:	Jamaica - NWC, WRA, Met Service, MWLECC, JBI, NWA Belize - Met Service, Coastal Zone Management Authority Dominica - DOWASCO St. Lucia - WRMA Guyana - GWI, Met Service Barbados – CIMH, Barbados Water Authority, Environment Unit – Drainage Division	CDEMA – Tropical weather radar outlook NOAA – regional storm tracker Jamaica - Met Service, WINDALCO Belize - Met Service Barbados - Met Service, CARDI, CIMH Dominica - Met Service St. Lucia - Met Service, WRMA Guyana - Met Service		Jamaica – NEPA Belize - LIC Dominica – N/A St. Lucia – N/A Guyana - CZMU Barbados - CZMIA
Database spec:	Text data to be appended to location data.			
GIS spec:	Raster data sets at spatial resolution that allows for adequate decision-making. Maps should be in a common projection to be able to be used with other GIS data in C-READ.			
Information product (output)	Map showing infrastructure and communities exposed to hurricanes and storm surges, including historical locations of storm landfall.			
Of note:				

Protocol for accessing data:

- Jamaica – Data sharing agreements with WRA, NWC, Met Service, WINDALCO will be required. Data is stored electronically in all cases.
- Belize - Data sharing agreements with Met Service, Coastal Zone Management Authority & Institute. Data is electronically stored.
- Dominica - Data sharing agreements with Met Service, DOWASCO will be required.
- Saint Lucia - Data sharing agreements with Met Service, and WRMA will be required. Data is electronically stored.
- Guyana - Data sharing agreements with Met Service, GWI, Ministry of Lands will be required. Data is electronically stored.
- Barbados – Data sharing agreements with Met Service, CARDI, CIMH, DEM, and Environment Unit – Drainage Division will be required. Data is electronically stored.

Issue:	Disease and Pest Risk Assessment			
User need:	Geographic distribution of risks to human health and to agriculture as influenced by climate change			
Purpose:	Mitigation and planning for epidemics			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:** Pest Presence	**GIS:**
Data sources:			Jamaica - RADA Belize – MOH, Ministry of Natural Resources and Agriculture Dominica – Ministry of Agriculture and Forestry St. Lucia – N/A Guyana – Guysuco, NAREI, Guyana Forests Commission Barbados - CARDI	
Database spec:	Text data to be appended to location data.			
GIS spec:	GIS data should be in a common projection to be able to be used with other GIS data in C-READ.			
Information product (output)	Vector map with a list of disease and pest risks per region. The survey did not reveal any significant data available to produce such a map. Output could be point or vector format.			
Of note:	Further inquiry with key stakeholders is required, as sufficient data was not provided from e-survey.			

Protocol for accessing data:

- Jamaica – RADA has information on pest surveillance, pest damage / infestation. Further inquiry is required in order to determine the format and sharing protocols.
- Belize – The Ministry of Health and Ministry of Natural Resources and Agriculture are the most likely organizations to manage this type of data in Belize. Neither provided specifications for this data though. Further follow up is required.
- Dominica – The Ministry of Agriculture and Forestry set pest control as a high priority, but they did not indicate what data they gather to monitor this issues. Further inquiry with them is required.
- Saint Lucia – No survey respondents indicated that they gather data related to this issue. Further inquiry with the Ministry of Agriculture, Food Production, Fisheries, and Rural Development is required.
- Guyana – Guysuco indicated they had monitoring programs for pest infestations but they did not provide specific details as to what data they gathered and the format in which they gathered it. Further inquiry with Guysuco, NAREI, and the Guyana Forest Commission is recommended.
- Barbados – CARDI, the Ministry of Agriculture, and the Ministry of Health are the three organizations that are most concerned with disease and pest risks in Barbados. CARDI did not provide specific explanations of data they gathered for this purpose. Further consultation with these three organizations is recommended.
- Regional - A consultation with the Pan-American Health Organization PAHO is recommended.

Issue:	Saline Intrusion Assessment			
User need:	Assess saline intrusion risk to groundwater (freshwater aquifers)			
Purpose:	Mitigation and planning for water availability and supply			
Data requirements (inputs)	**Hydro:** ground water depth	**Met:**	**Enviro:** TSS, EC, T, solubility	**GIS:** topography
Data sources:	Jamaica - NWC, WRA Belize - N/A Dominica - N/A St. Lucia - N/A Guyana - GWI Barbados - BWA		Jamaica - NWC Belize - TIDE Dominica - N/A St. Lucia - N/A Guyana - GWI Barbados - BWA	
Database spec:	Text data to be appended to location data.			
GIS spec:	GIS data should be in a common projection to be able to be used with other GIS data in C-READ. Data will likely be in vector format.			
Information product (output)	Yearly maps indicating areas affected by saline intrusion and TSS level compared to baseline freshwater aquifer and to freshwater quality.			
Of note:	This could be combined with numerical models taking into account hydrogeological aspects and the effect of sea level rise in order to predict acceleration of intrusion due to climate change			

Protocol for accessing data:

- Jamaica – The NWC manages saline intrusion data, however they did not provide specifications for this data in the survey response. Further discussion with them will be required in order to determine access protocols.
- Belize – The Ministry of Health indicated they operate boreholes to assess water quality in the coastal zone. Additionally, the Coastal Zone Management Authority would be a responsible agency for this issue. Further discussion about access protocols for existing data is recommended.
- Dominica – No survey respondents indicated they collected data related to this issue. DOWASCO would be one organization that would be concerned about this issue. Further discussion with DOWASCO is recommended.
- Saint Lucia – No survey respondents indicated they collected data related to this issue. WRMA would be one organization that would be concerned about this issue. Further discussion with WRMA is recommended.
- Guyana – No survey respondents indicated they collected data related to this issue. There is, however, an extensive amount of hydrological data being gathered in Guyana. GWI, the Guyana Met Service, and Guysuco have extensive water monitoring programs and this specific issue should be further discussed with them. NAREI, the Guyana Mangrove Project, and the Guyana Environmental Protection Agency as well as the Civil Defence Commission would have interest in saline intrusions.
- Barbados – BWA, CIMH, Barbados Environment Unit – Drainage Division, and the Coastal Zone Management Unit all would have interest in this issue. None of the stakeholders provided specifications of data they gathered for saline intrusions, however, further discussions with them are recommended.

Issue:	Oil Spill Assessment			
User need:	Comprehensive understanding of extent and environmental impact of oil spills			
Purpose:	To mitigate the negative effects of oil spills by gathering data and implementing environmental management plans accordingly.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:** Impacts of spills	**GIS:** Spatial extent of spills
Data sources:			Jamaica - Chevron Belize – N/A Dominica - N/A St. Lucia - N/A Guyana – N/A Barbados – N/A	Jamaica - Chevron Belize – N/A Dominica - N/A St. Lucia - N/A Guyana – N/A Barbados – N/A
Database spec:	Text data to be appended to location data.			
GIS spec:	GIS data should be in a common projection to be able to be used with other GIS data in C-READ. Data will likely be in vector format however it may be in raster format depending on the manner in which it was gathered.			
Information product (output)	Maps depicting the spatial extent of oil spills as well as anecdotal description of their severity.			
Of note:	Jamaica was the only country that responded to this issue. However, considering its importance, it is worth examining how data gathering for oil spills can be integrated into C-READ for regional analysis.			

Protocol for accessing data:

- Jamaica – Chevron gathers data for oil spills but detailed specifications for this data were not provided. Further discussion with them is recommended.
- Belize – No stakeholders indicated that they gather data for this issue.
- Dominica - No stakeholders indicated that they gather data for this issue.
- Saint Lucia - No stakeholders indicated that they gather data for this issue.
- Guyana - No stakeholders indicated that they gather data for this issue.
- Barbados – No stakeholders indicated that they gather data for this issue.

4.2.3 Category 3: Geographical and Biophysical Environment

Issue:	**Topography**			
User need:	Topographical data (Digital Elevation Model, DEM)			
Purpose:	Input data to various models (e.g. drought risk, air dispersion), easy integration with other datasets and as background data.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:**	**GIS:** Elevation data (text with coordinates, vector contour data, raster models, hardcopy maps.
Data sources:				Jamaica – DEM (NEPA) Belize – DEM (LIC) Barbados – DEM (CARDI) Regional Projects – DEM (UNISDR)
Database spec:				
GIS spec:	Conversion from hardcopy to digital format. If input is text, automated plotting to create point vector dataset. Automated interpolation required to convert vector to raster. All final raster models should be created with common spatial resolution.			
Information product (output)	National and regional maps depicting elevation (DEM). Classified, colour-coded heights.			
Of note:	Regional DEMs exist that are accessible online; however minimum specifications for use need to be established in order to decide if such regional models are acceptable, or if national datasets of better resolution are required. Further investigation perhaps needed in some countries to ascertain if hardcopy information or derived elevation information from topographic maps may be used as input (e.g. Dominica and Saint Lucia, see below). All data require QC and conversion to common coordinate system and other standards (e.g. metric/imperial system) to ensure data is accurate and standardized for input into subsequent models. The DEWETRA platform will cover some aspects of Geographical and Biophysical Environmental monitoring and therefore potential integration of these two systems should be considered a priority.			

Protocol for accessing data:

- Jamaica - NEPA currently has a DEM for the island and data is freely available upon request. Integration to the system is therefore fairly straightforward given that required data freely available in an electronic format.
- Belize - The LIC (Land Information Centre) currently have a raster data set that is shared with other ministries and organizations (CIMH included). Integration to the system is straightforward given that required data is currently shared with CIMH and in an electronic format.
- Dominica - Topography data not available digitally (as per survey responses). Further consultation with stakeholders is required to determine if any topographical data exists in hardcopy or digital format and protocol for accessing this data.
- Saint Lucia - Topography data not available digitally (as per survey responses). Further consultation with stakeholders required to determine if any topographical data exists in hardcopy or digital format and protocol for accessing this data.
- Guyana - Topography data not available digitally (as per survey responses) however such data should be available through the Guyana Lands and Survey Commission, at which data (with acknowledgement) is generally available to government institutions, most available to public.
- Barbados – DEM model exists at CARDI and data is shared upon request. Topography GIS data also reported by the Department of Emergency Planning; however not clear how accessible this data is for other organizations.

Issue:	Ecosystems and Biodiversity (Terrestrial)			
User need:	Comprehensive terrestrial species and ecosystem distribution indicating population size (flora and fauna) and ecosystem health.			
Purpose:	To serve as an up-to-date reference in order assess biological resources in terms of population size, health and services. To be used in conjunction with other data sets such as hydrological, climate, and infrastructural development to better understand potential risks to biological diversity. Once data for different time periods is acquired, this will allow for change detection.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:** Species (flora and fauna) population size, health and other related information (e.g. indicator species, economic value, and protection status). appended to GIS data or presented in tables, reports etc. (hard copy and digital)	**GIS:** Location species and ecosystem data in the form of species distribution and ecosystem maps, text, vector or raster data (hard copy and digital).
Data sources:			Jamaica - NEPA, UWI Mona, Forestry and EFJ Belize – BERDS Saint Lucia - Ministry of Agriculture, Food Production, Fisheries, and Rural Development Barbados - CIMH	Jamaica - NEPA, UWI Mona, Forestry and EFJ Belize - BERDS Saint Lucia - Ministry of Agriculture, Food Production, Fisheries, and Rural Development Barbados - CIMH
Database spec:	Text data to be appended to location data. If necessary, conversion from hard copy text to electronic prior to this.			
GIS spec:	If hardcopy maps exist, conversion to electronic vector data will be necessary. All location data to be merged to create overall polygon and point datasets as appropriate. Point data analyzed in order to calculate diversity index raster maps.			
Information product (output)	National and regional scale maps as follows: • Vector (point and polygon) maps showcasing detailed data, including location of species and ecosystems along with attribute data appended (population size, health, protection status etc.). • Raster or polygon vector diversity indices maps with color-coded scale. • Summarized species data by natural or administrative boundaries, classified and colour-coded, e.g. number of species per administrative boundary. Information from spatial data summarized and presented as tables and graphs.			
Of note:	Further consultation required to ascertain additional sources of information for the region. Standardization of ecosystem types for region is required in order to allow for comparison between islands. Both scientific and common names should be sought for species. Decision regarding if data to be represented as point or polygon data, as well as type of diversity indices needs to be made based on input data acquired. All GIS data require QC and conversion to common coordinate system.			

Protocol for accessing data:

- Jamaica – Various types of species data (attribute and GIS) exist at NEPA, UWI Mona, Forestry and EFJ. Data is freely available from EFF, with acknowledgement and once there is no breach in the Grant Recipient Agreement. Government agencies (NEPA, Forestry) freely share data on request, and are guided by the national data sharing policy, which ultimately allows for intra-governmental cooperation. Data modelled and owned by UWI is freely available upon request;

however some data may not be released prior to publication. Overall, once correct mechanisms are put in place to request the sharing of necessary data, access should be granted.

- Belize - Various groups monitor ecosystems and biodiversity; BERDS, an online data warehouse and research tool set is considered a good starting point for access data for the country.
- Dominica - Survey respondents did not indicate that ecosystems and biodiversity data was gathered. The Ministry of Agriculture and Forests and Environment, Natural Resources, Physical Planning and Fisheries would be obvious groups to follow up with on this. No formal data sharing policies exist at present.
- Saint Lucia - The Ministry of Agriculture, Food Production, Fisheries, and Rural Development appears to be responsible for this data; however survey responses did not provide any data sharing policy information.
- Guyana - There was no report of biodiversity data being gathered.
- Barbados - CIMH has land cover data (GIS) but it is not clear how detailed it is with ecosystem type etc.

Issue:	Air Quality			
User need:	Regional coverage of ambient air quality and emissions data.			
Purpose:	Air pollution mitigation and inputs to air dispersion modelling			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro**: Ambient air quality measurements and emissions	**GIS:** Location of air quality monitoring stations (maps, text with coordinates or point vector)
Data sources:			Jamaica - ambient and emissions monitoring stations (JBI and NEPA)	Jamaica - JBI and NEPA Regional Projects – CariCOOS (CO_2 levels)
Database spec:	Automated calculation of average values (daily/monthly/yearly etc.) and other statistical parameters.			
GIS spec:	If input is text, automated plotting required creating point vector of monitoring stations with relevant air quality attribute data. Vector is converted to raster by automated interpolation.			
Information product (output)	National and regional scale maps indicating air quality (colour-coded). Information from maps summarized and presented as tables and graphs.			
Of note:	Further consultation is certainly required in most countries in order ascertain any existing air quality data and monitoring efforts. Where coverage data is lacking, it may be necessary to confine models to those areas rather than creating island wide or regional models, until additional stations improve coverage across islands and in the region. Standardization of air quality parameters (e.g .NOx, SOx, PM10, TSP) to be collated and the types of statistical measures to be calculated needs to done in order to allow for comparison between islands. All GIS data require QC and conversion to common coordinate system			

Protocol for accessing data:

- Jamaica – NEPA (National Environmental Projection Agency) freely share data on request. A Memorandum of Understanding exists between NEPA and JBI (Jamaican Bauxite Institute regarding distribution policies and restrictions. Further investigation is required to ascertain if all air quality data may be shared for the purpose of the system.
- Belize – no information gathered from survey for this issue.
- Dominica - no information gathered from survey for this issue.
- Saint Lucia - no information gathered from survey for this issue.
- Guyana - no information gathered from survey for this issue.
- Barbados - no information gathered from survey for this issue.

4.2.4 Category 4: Coastal Zone and Ocean

Issue:	Coastal Zone Monitoring – Beach profile / coastal change			
User need:	Spatial and numerical information pertaining to changes in coastline position and profile.			
Purpose:	For input to coastal risk and vulnerability assessments, to inform mitigation measures, adaptation strategies and coastal planning, and as input to modelling future scenarios.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:** Coastline type (sandy beach, cliff etc.), Beach profile information.	**GIS:** Coastline position and beach profile information presented as vector (point, polyline or polygon).
Data sources:			Jamaica – beach profile, *.xls (NEPA, MGU); geology and physical features of coastlines (MGU)); Belize – coastal zone (CZMA, Toledo Institute); Belize Integrated Coastal Zone Management Plan 2013 Barbados - Coastal Zone Management Unit Regional projects - CIMH – GEF IWCAM (Integrating Coastal Areas and Water Resource Management) (coastal zone data)	Jamaica – beach profile, station locations (NEPA, MGU); mapped coastal zones (NEPA, MGU); geology and physical features of coastlines (MGU) Belize –coastal zone (Healthy Reefs); GIS-supported ecosystem service models (CZMA); Belize Integrated Coastal Zone Management Plan 2013 Barbados - Coastal Zone Management Unit
Database spec:	Descriptive text such as physical geography and geomorphology to be categorized to create coastline type field. All descriptive information will need to be appended to location GIS data (coastline position). Automated plotting of beach profiles.			
GIS spec:	Coastline position vector data converted to polyline and joined with any descriptive information regarding coastline type (similar to database information, descriptive text will be categorized according to coastline type). Coastal zone physical data collated, converted to common vector type (polygon) and comprehensive datasets created. Where information is collated for different time periods, input data to be converted to raster and automatic raster change analysis undertaken.			
Information product (output)	Colour-coded beach profiles showcasing profiles for different time periods. National and regional scale maps indicating coastline type and position and coastal zones. Where possible, coastline change maps showcasing areas of 1 - shoreline movement and 2 – changes in coastline type. Information from maps summarized and presented as tables and graphs.			

Of note:	Descriptions of coastlines vary (biological, geomorphological, geological, built/human etc.) and agreement of coastline categories is essential to efficiently compile all information. Coastal information will also need to be arranged according to date in order to allow for coastal change detection. Beach profiles will need to be plotted in standardized format for easy comparison between stations and as such data formatting is a necessary step to consider. Further consultation is required in some countries in order ascertain coastal zone monitoring efforts and data.

Protocol for accessing data:

- Jamaica – NEPA freely shares data on request, and are guided by the national data sharing. Information and data on MGU's website is freely available to all with proper acknowledgement and credit given, whilst data collected under grant-funded projects may be requested via email. Existing data from both entities are in electronic format, allowing for easy integration
- Belize - Individual coastal projects were reported by the CZMA, but this data does not seem integrated or overly accessible. However, Belize Integrated Coastal Zone Management Plan 2013 is available online and both descriptive and GIS data may be gathered form this document, though this would require additional formatting than if the electronic data is received directly. With regards to data residing at Health Reefs and Toledo Institute, data is shared upon request and signing of an agreement.
- Dominica - The Met Service has indicated a deep interest in assessing the impacts of climate change on coastlines; however respondents did not indicate that they are gathering data at this stage.
- Saint Lucia - An official coastal zone management department does not exist and 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.
- Guyana - 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.
- Barbados - The Coastal Zone Management Unit did not provide details regarding data collection or sharing. Further consultation with stakeholders required.

Issue:	Coastal zone monitoring – Coastal Ecosystems (mangroves, seagrasses and coral reefs)			
User need:	Comprehensive coastal ecosystem mapping, including mangroves, seagrasses and coral reefs, which will record health, as well as species identification and population estimates.			
Purpose:	To serve as an up-to-date reference in order assess biological resources in terms of population size, health and services. To be used in conjunction with other data sets such as hydrological, climate, and infrastructural development to better understand potential risks to biological diversity. Once data for different time periods is acquired, this will allow for change detection.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:** Mangrove, seagrass and coral reef species, health, services and other related descriptive information.	**GIS:** Mangrove, seagrass and coral reef extent (electronically as vector polyline or polygon or raster, or hardcopy maps)
Data sources:			Jamaica - coral cover, *.xls (NEPA); replanting of mangroves (EFJ); impacts on coastal ecosystems, status of coastal ecosystems (UNEP). Belize – coastal zone (CZMA); Belize Integrated Coastal Zone Management Plan 2013 Regional projects - CIMH – GEF IWCAM (Integrating Coastal Areas and Water Resource Management) (coastal zone data); Australia-Caribbean Collaboration on Climate Change and Coral Reef (coral reefs); CPACC (Caribbean Planning for Adaptation to Climate Change Project) / (ACCC / MACC) (coral reef monitoring projects)	Jamaica – mangrove, seagrass extent and coral cover (NEPA); mapped coastal zones (NEPA, MGU) Belize –coastal zone (Healthy Reefs, CZMA), marine biodiversity monitoring sites (Toledo Institute); GIS-supported ecosystem service models (CZMA); Belize Integrated Coastal Zone Management Plan 2013 Regional projects - NOAA – CORIS Geo Portal (reef and ocean health-related data products)
Database spec:	Text data to be appended to location data. If necessary, conversion from hard copy text to electronic prior to this.			
GIS spec:	If hardcopy maps exist, conversion to electronic vector data will be necessary. All location data to be merged to create overall polygon dataset.			
Information product (output)	National and regional scale maps showcasing the extent and associated attributes (species, health, protection status etc.) of the following ecosystem types: • Mangroves • Seagrasses • Coral Reef Information from spatial data summarized and presented as tables and graphs.			
Of note:	Further consultation required to ascertain additional sources of information for the region. Both scientific and common names should be sought for species. Further discussion should be had to ascertain if additional coastal habitats should be included in system. All GIS data require QC and conversion to common coordinate system.			

Protocol for accessing data:

- Jamaica – NEPA freely shares data on request, and are guided by the national data sharing. Information and data on MGU's website is freely available to all with proper acknowledgement and credit given, whilst data collected under grant-funded projects may be requested via email.

Existing data from both entities are in electronic format, allowing for easy integration. Data is freely available from EFF, with acknowledgement and once there is no breach in the Grant Recipient Agreement. All UNEP data generated by the Programme and Projects are freely available subject. For UNEP 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.

- Belize - Individual coastal projects were reported by the CZMA, but this data does not seem integrated or overly accessible. However, Belize Integrated Coastal Zone Management Plan 2013 is available online and both descriptive and GIS data may be gathered form this document, though this would require additional formatting than if the electronic data is received directly. With regards to data residing at Health Reefs and Toledo Institute, data is shared upon request and signing of an agreement.
- Dominica - The Met Service has indicated a deep interest in assessing the impacts of climate change on coastlines; however respondents did not indicate that they are gathering data at this stage.
- Saint Lucia - An official coastal zone management department does not exist and 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.
- Guyana - 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.
- Barbados - The Coastal Zone Management Unit did not provide details regarding data collection or sharing.

Issue:	Ocean Monitoring – sea temperature			
User need:	Regional coverage of sea temperatures			
Purpose:	To serve as an up-to-date reference and be used in conjunction with other data in ocean modelling.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro**: Sea temperature measurements	**GIS:** Location of sea temperature monitoring stations (maps, text with coordinates or point vector)
Data sources:			Jamaica – sea temperature monitoring stations (NEPA) Belize – sea temperature (Toledo Institute); coastal water quality (CZMAI) Dominica – water quality near outfall from the wastewater treatment plant (DOWASCO) Regional projects - CPACC (Caribbean Planning for Adaptation to Climate Change Project) / (ACCC / MACC) (sea level / climate monitoring network)	Jamaica - NEPA Regional Projects – CariCOOS (seawater gathered from buoys)
Database spec:	Automated calculation of average values (daily/monthly/yearly etc.) and other statistical parameters.			
GIS spec:	If input is text, automated plotting required creating point vector of monitoring stations with relevant temperature data. Vector is converted to raster by automated interpolation.			
Information product (output)	National and regional scale maps indicating sea temperature (colour-coded). Information from maps summarized and presented as tables and graphs.			
Of note:	Further consultation is required in most countries in order ascertain any existing sea temperature monitoring efforts. Where coverage data is lacking, it may be necessary to confine models to those areas rather than creating island wide or regional models, until additional stations improve coverage across islands and in the region. All GIS data require QC and conversion to common coordinate system			

Protocol for accessing data:

- Jamaica – NEPA freely shares data on request, and are guided by the national data sharing.
- Belize - With regards to data residing at Toledo Institute, data is shared upon request and signing of an agreement. Individual coastal projects were reported by the CZMA, but this data does not seem integrated or overly accessible. However, Belize Integrated Coastal Zone Management Plan 2013 is available online and both descriptive and GIS data may be gathered form this document, though this would require additional formatting than if the electronic data is received directly.
- Dominica – At DOWASCO, no formal policy regarding data distribution has been developed as yet, however, a small informal committee of stakeholder institutions 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. The Ministry of Environment, Natural Resources, Physical Planning and Fisheries would an obvious group that would gather sea temperature data; unfortunately, they did not respond to the survey.
- Saint Lucia - No reported data monitoring of the ocean environment on the part of survey respondents.

- Guyana - The Environmental Protection Agency as well as the Ministry of Agriculture (Fisheries Department) are the organizations that have primary concerns of the ocean environment; however no survey response regarding sea temperatures.
- Barbados - 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.

Issue:	Ocean Monitoring – Tides			
User need:	Tidal charts and tables			
Purpose:	To serve as an up-to-date reference and be used in oceanographic analyses.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:** Tide measurements	**GIS:** Locations of tide stations (maps, text with coordinates or point vector)
Data sources:			Jamaica – sea level data (Met Service)	Jamaica – Met Service
Database spec:	Automated plotting of tidal/ seal level information.			
GIS spec:	Plotting of tide stations as points, if coordinates received. Collation of all point locations with attribute tide data.			
Information product (output)	National and regional scale maps indicating tide stations with appended sea level charts, with ability to retrieve historical information as well as look at current conditions. Information should also be presented in tables as well.			
Of note:	Further consultation is required in most countries in order ascertain if tide monitoring efforts are in place. All GIS data require QC and conversion to common coordinate system			

Protocol for accessing data:

- Jamaica – No data distribution policies are in place at the Met Service, but restrictions are such that only limited daily or hourly data is available to users.
- Belize – no tide information gathered from survey for this issue. Further consultation with stakeholders required to ascertain if any sea level data exists and protocol for accessing this data.
- Dominica - no tide information gathered from survey for this issue. Further consultation with stakeholders required to ascertain if any sea level data exists and protocol for accessing this data.
- Saint Lucia - no tide information gathered from survey for this issue. Further consultation with stakeholders required to ascertain if any sea level data exists and protocol for accessing this data.
- Guyana - no tide information gathered from survey for this issue. Further consultation with stakeholders required to ascertain if any sea level data exists and protocol for accessing this data.
- Barbados - no tide information gathered from survey for this issue. Further consultation with stakeholders required to ascertain if any sea level data exists and protocol for accessing this data.

Issue:	Ocean Monitoring – bathymetry			
User need:	Digital model of bathymetry			
Purpose:	Input data to various models (e.g. storm surge, current modelling), easy integration with other datasets and as background data.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:**	**GIS:** Sea depth data (text with coordinates, vector contour data, raster models, hardcopy maps.
Data sources:				Jamaica –MGU, NEPA
Database spec:				
GIS spec:	Conversion from hardcopy to digital format. If input is text, automated plotting to create point vector dataset. Automated interpolation required to convert vector to raster. All final raster models should be created with common spatial resolution.			
Information product (output)	National and regional maps depicting bathymetry model. Classified, colour-coded depths.			
Of note:	Regional bathymetry models exist that are accessible online; however minimum specifications for use need to be established in order to decide if such regional models are acceptable, or if national datasets of better resolution are required. Further investigation perhaps needed in some countries to ascertain if hardcopy information or derived sea depth information from admiralty charts may be used as input. All data require QC and conversion to common coordinate system and other standards (e.g. metric/imperial system) to ensure data is accurate and standardized for input into subsequent models.			

Protocol for accessing data:

- Jamaica – Data from NEPA is freely available upon request. Integration to the system is therefore fairly straightforward given that required data freely available in an electronic format. Information and data on MGU's website is freely available to all with proper acknowledgement and credit given, whilst data collected under grant-funded projects may be requested via email. Existing data from both entities are in electronic format, allowing for easy integration.
- Belize - no bathymetry information gathered from survey for this issue. Further consultation with stakeholders required to ascertain if any bathymetry data exists and protocol for accessing this data.
- Dominica – no bathymetry information gathered from survey for this issue. Further consultation with stakeholders required to ascertain if any bathymetry data exists and protocol for accessing this data.
- Saint Lucia - no bathymetry information gathered from survey for this issue. Further consultation with stakeholders required to ascertain if any bathymetry data exists and protocol for accessing this data.
- Guyana - no bathymetry information gathered from survey for this issue. Further consultation with stakeholders required to ascertain if any bathymetry data exists and protocol for accessing this data.
- Barbados - The Coastal Zone Management Unit is the agency mostly responsible for monitoring the coast of Barbados; however did not provide details of the data gathered. Further consultation with stakeholders required.

4.2.5 Category 5: Land Cover and Land Use

Issue:	Land cover and land use			
User need:	Up-to-date land cover and land use dataset for the region, covering national and regional priorities as well as key socio-economic and biophysical phenomenon relevant to stakeholders.			
Purpose:	To serve as an up-to-date reference and be used in conjunction with other data in analyses and climate change impact assessment. If information for different time periods exists, land use change analysis may be undertaken.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:**	**GIS:** Land use and cover (hardcopy maps, vector or raster electronic data)
Data sources:				Jamaica – Forestry Department Belize - Land Information Centre of the Ministry of Natural Resources and Agriculture, CZMAI, Healthy Reefs, TIDE Dominica- Ministry of Environment, Natural Resources, Physical Planning and Fisheries, Ministry of Agriculture and Forestry Guyana - Lands and Survey Commission of Guyana Barbados – CIMH Regional projects - UNISDR
Database spec:				
GIS spec:	If hardcopy maps exist, conversion to electronic polygon vector data will be necessary. If data for different time periods exist, conversion to raster and automated change detection undertaken.			
Information product (output)	National and regional maps depicting land use and land cover polygon data. Classified, symbolized land cover and use classes. If possible, areas of land use change. Information from maps summarized and presented as tables and graphs.			
Of note:	Agreement of land use and cover classes is essential to efficiently compile all information and undertake land cover change. All data require QC and conversion to common coordinate system and other standards (e.g. metric/imperial system).			

Protocol for accessing data:

- Jamaica - Government agencies (Forestry) freely share data on request, and are guided by the national data sharing policy, which ultimately allows for intra-governmental cooperation.
- Belize - The LIC (Land Information Centre) is responsible for assessing land cover and land use. They share compiled data (not raw data) and there are some data distribution restrictions to small islands.
- Dominica - Ministry of Environment, Natural Resources, Physical Planning and Fisheries shares data on request. No formal policies exist here or at Ministry of Agriculture and Forestry.
- Saint Lucia - no GIS land use information gathered from survey. Further consultation with stakeholders required.
- Guyana – Data at the Guyana Lands and Survey Commission is generally available to government institutions and most available to public with acknowledgement.
- Barbados – The Lands and Survey Department presumably has more data but they did not reply. Further consultation with stakeholders required.

Issue:	Protected areas and parks			
User need:	Comprehensive protected areas dataset for the region.			
Purpose:	To serve as an up-to-date reference and be used in conjunction with other data in analyses.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:** Attribute information such as type of protection, date declared, responsible entity etc.	**GIS:** Protected area boundaries (hardcopy maps, vector electronic data)
Data sources:			Jamaica – NEPA, Forestry Belize – health of areas (TIDE, Healthy Reefs, and the Belize Audubon Society) Dominica - Ministry of Environment, Natural Resources, Physical Planning and Fisheries Guyana - Lands and Survey Commission of Guyana	Jamaica – NEPA, Forestry Belize – boundaries (LIC), health of areas (TIDE, Healthy Reefs, and the Belize Audubon Society) Dominica - Ministry of Environment, Natural Resources, Physical Planning and Fisheries Guyana - Lands and Survey Commission of Guyana
Database spec:				
GIS spec:	If hardcopy maps exist, conversion to electronic polygon vector data will be necessary.			
Information product (output)	National and regional maps depicting protected areas and related information (type of protection, date declared, responsible entity etc.). Information from maps summarized and presented as tables and graphs.			
Of note:	All data require QC and conversion to common coordinate system and other standards (e.g. metric/imperial system).			

Protocol for accessing data:

- Jamaica - Government agencies (NEPA, Forestry) freely share data on request, and are guided by the national data sharing policy, which ultimately allows for intra-governmental cooperation..
- Belize - The LIC (Land Information Centre) is responsible for assessing protected areas boundary information and they share compiled data (not raw data); some data distribution restrictions to small islands exist. With regards to data residing at Health Reefs and Toledo Institute, data is shared upon request and signing of an agreement.
- Dominica - 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. Ministry of Environment, Natural Resources, Physical Planning and Fisheries shares data on request; no formal policies exist here.
- Saint Lucia - no GIS protected areas information gathered from survey. Further consultation with stakeholders required.
- Guyana – Data at the Guyana Lands and Survey Commission is generally available to government institutions and most available to public with acknowledgement.
- Barbados – The National Conservation Commission of Barbados and the Coastal Zone Management Unit are two key organizations associated with parks and protected areas; however 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.

4.2.6 Category 6: Agriculture and Food Security

Issue:	Agriculture productivity			
User need:	Comprehensive repository of agricultural production data.			
Purpose:	To serve as an up-to-date reference and be used in conjunction with other data in analyses and climate change impact assessment.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:**	**GIS:**
Data sources:			Jamaica - crop production (RADA, MOAH); sweet potatoes (Climate Studies Group) Belize crop production reports (Ministry of Natural Resources and Agriculture) Dominica - agricultural productivity (Ministry of Agriculture and Forestry) Barbados - hydrological and meteorological influences on agriculture, crop productivity (CARDI)	
Database spec:	Automated calculation of average values (monthly/yearly etc.) and other statistical parameters.			
GIS spec:				
Information product (output)	Calculated productivity values presented as tables and graphs.			
Of note:				

Protocol for accessing data:

- Jamaica - Most information at MOAH is public information. Data modelled and owned by UWI (Climate Studies Group) is available upon request depending on the source and with acknowledgement; however some data may not be released prior to publication. RADA's Farmer Registration Database (ABIS) is available on line. Personal information on farmers is restricted and retained within RADA. No specific policies in place except for ABIS and all requests for information not available on line to be channelled through ABIS Manager.
- Belize - Ministry of Natural Resources and Agriculture share compiled data (not raw data); some data distribution restrictions to small islands exist.
- Dominica - No formal policies exist at Ministry of Agriculture and Forestry.
- Saint Lucia - 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.
- Guyana – 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.
- Barbados – 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 from CARDI is available for distribution upon request.

Issue:	Soil quality			
User need:	Comprehensive soil quality dataset with soil type, productivity, and status.			
Purpose:	To serve as an up-to-date reference and be used in conjunction with other data sets such as hydrological, climate, and infrastructural development for modelling and analyses.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:** Soil quality information (type, productivity etc.)	**GIS:** Soil type delineation (hardcopy maps, vector or raster)
Data sources:			Belize - Ministry of Natural Resources and Agriculture Barbados - Department of Emergency Management, CIMH	Barbados - Department of Emergency Management, CIMH
Database spec:	Appending descriptive information to soil type boundaries.			
GIS spec:	If hardcopy maps exist, conversion to electronic polygon vector data will be necessary.			
Information product (output)	National and regional maps depicting soils information. Information from maps summarized and presented as tables and graphs			
Of note:	All data require QC and conversion to common coordinate system and other standards (e.g. metric/imperial system). Spatial resolution may vary depending on the heterogeneity of the landscapes. Further consultation required to ascertain additional sources of information for the region.			

Protocol for accessing data:

- Jamaica – Soil data not gleaned from survey responses.
- Belize - Ministry of Natural Resources and Agriculture share compiled data (not raw data); some data distribution restrictions to small islands exist. .
- Dominica - 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.
- Saint Lucia - No explicit reference to soil quality data that was collected. Further consultation with stakeholders required.
- Guyana – No explicit reference to soil data that was collected. Further consultation with stakeholders required.
- Barbados – 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.

4.2.7 Category 7: Water: Availability, Quality, and Use

Issue:	**Water Availability**			
User need:	Spatial coverage of the amount of available water – both for consumption and other purposes (industrial). Risk of water resource depletion is also a user need.			
Purpose:	Assess the availability of water by measuring water table depth and surface water.			
Data requirements (inputs)	**Hydro:** Ground water and surface water measurements	**Met:**	**Enviro:**	**GIS:**
Data sources:	Jamaica – WRA, WINDALCO, NWC, UNEP. Belize – Met Service Hydrology Unit, WASA, Belize Water Service, Rural Water Unit. Dominica – DOWASCO (CaribHYCOS / PPCR project) Saint Lucia – WRMA gathers hydrological data from three automated stations. Guyana – GWI and the Guyana Met Service collect water level. Barbados – Barbados Water Authority			
Database spec:	Text data (water level) to be appended to location data (geographic coordinates)			
GIS spec:	Point data sets with water levels to be available as either a vector or raster format file.			
Information product (output)	National and regional scale maps as follows which show water levels as per point data collected. Could also show a 2D graph of water level at any given point that is selected.			

Of note:	Jamaica has perhaps the most significant amount of water availability data collected. The data is collected by different organizations so a standard format must be established for this data. The simplest format is to have water level, geographic coordinates. This can then be either shown in tabular, 2D graph, or map output. This data is typically stored in spreadsheets, databases, or ASCII files by organizations. Some sort of common format will be required for transfer to C-READ. ESRI has a product called World Available Water Web Viewer that can serve as a good reference and perhaps even a source of data: http://www.arcgis.com/home/item.html?id=cd115ecdacad4abbbe3331ecd3c901d8

Protocol for accessing data:

- Jamaica - WRA monitors groundwater levels and change in storage of aquifers at 3300 points. WINDALCO has well and surface water surveys. UNEP has regional and project level water availability data. NWC collects water level data at water treatment plants. Each of the organizations stores their water level data in spreadsheet (some in database/paper/shapefile) format. This data can be converted to the desired format importing into C-READ – perhaps ASCII or .csv. Each organization indicated that they do share this data with other organizations but a data sharing agreement will likely be necessary.
- Belize – The water data collected in Belize is generally the stage / discharge / and water level at rivers. It is not clear whether or not they have wells or boreholes they measure the water table depth at. The data that is gathered by the Met Service is shared under certain licensing agreements. Similar agreements will be needed if this data is to be shared with C-READ.
- Dominica – The CaribHycos / PPCR project is in development. . Nick Calendar or Jerry Meier from the World Bank should be contacted about accessing their data. Alternatively Pierre Briquet from the actual Carib HYCOS project should be contacted. The Met Service of Belize stores their hydrological data in their HOMS database. They have data sharing and licensing agreements for their hydrological data.
- Saint Lucia – The WRMA gathers data from three automated stations. They indicate that they are underfunded for monitoring equipment. This data is stored in an excel spreadsheet. The data is only measuring surface water depth. These do not indicate water table depth (from using some form of active remote sensing)
- Guyana – The hydrological monitoring data comes from GWI and the Guyana Met Service.
- Barbados – BWA is primarily responsible managing access and use of water resources. CIMH, Ministry of Environment, Water Resources and Drainage. Specific data formats have not been 100% ascertained for Barbados (contact them for more information)

Issue:	Water Quality			
User need:	Comprehensive assessment of the quality of water that could be consumed by the public.			
Purpose:	To serve as an up to data reference for the quality of water in each country as well as regionally. Can be used in conjunction with other data sets such as precipitation, and water availability to determine causal factors in negative effects on water quality – for instance if there were a problem with a bacteria in the water supply – other data sets could be used to assess the potential for dispersion.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:**	**GIS:**
Data sources:	Jamaica – NEPA, NWC, UNEP Belize – Ministry of Health / National Water Quality Laboratory Dominica – DOWASCO Saint Lucia – WRMA Guyana – GWI and Guysuco Barbados - Barbados Water Authority			
Database spec:	Text data (levels of certain water quality parameters) to be appended to location data (geographic coordinates)			
GIS spec:	Point data sets with water quality parameter levels to be available as either a vector or raster format file. This would allow for spatial mapping of things such as nitrate or phosphate levels across a watershed or region.			
Information product (output)	Graphs of water quality parameter levels at certain sites. For example level of nitrate at the outflow are of an industrial activity. Maps can also be created for certain water quality parameters.			
Of note:	Organizations from Barbados, Saint Lucia, Dominica, and Belize did not specify exactly what parameters they were sampling for. This will need to be rectified in the design of C-READ. It is possible that water quality monitoring be divided into two categories: one for quality of water supplied to the public for consumption and use, the second for environmental water quality (eg. water bodies, ground water, effluent, and coastal zone)			

Protocol for accessing data:

- Jamaica - NEPA collects data from 200 stations. NWC also samples more than 400 locations for water quality, UNEP has coastal / marine pollution data. There may be some inconsistencies with respect to data collection methods between these organizations, however, the NWC stated that their data is in spreadsheet format and presumably UNEP and NEPA also have their data electronically stored. Data sharing agreements will be required between C-READ and these organizations, but it seems that data sharing with other organizations is a common practice with these groups.
- Belize – The Ministry of Health is reported to have monitored boreholes to assess the quality of water. It is not clear if this program is currently functioning. Data is shared on an as-needed basis. Data from other organizations such as the Belize Water Service, the Rural Water Unit, and WASA, might be useful, but the MOH is the primary source for water quality analytics.

- Dominica – DOWASCO is the organization responsible for water quality in Dominica. They did not provide a detail description of the type of data they gather. Further inquiry with them is required into data type and access protocols.
- Saint Lucia – WRMA is the organization responsible for water resource management in Saint Lucia. They did not indicate what kind of water quality parameters they sample. Further inquiry into the parameters they sample, the format of the data, and the protocol for sharing is required.
- Guyana – The water quality data sets from GWI and Guysuco are not integrated. GWI stores their data in an excel spreadsheet and they also indicate that they share this data. Guysuco captures water quality data from their operations and stores the data in spreadsheets. They share their data with the EPA. Data sharing agreements will be required but both parties seem open to sharing data.
- Barbados – BWA is the organization in Barbados responsible for water quality. They did not indicate what parameters they are sampling or the format of the data they gather. Further investigation with them will be required to understand specifically what data format is being used and what parameters are being sampled.

Issue:	Water use			
User need:	Overall assessment of the use of water resources			
Purpose:	To serve as a data reference for the consumption of water over certain periods of time.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:**	**GIS:**
Data sources:	Jamaica – WRA, NWC, WINDALCO Belize – WASA Dominica – DOWASCO Saint Lucia – WRMA Guyana – GWI Barbados - Barbados Water Authority			
Database spec:	Text data (levels of water consumption) to be appended to location data (geographic coordinates)			
GIS spec:	Point data sets with water consumption levels to be available as either a vector or raster format file.			
Information product (output)	2D graphs of water consumption over different time periods. Possibly mapped water consumption.			
Of note:	WASA, DOWASCO, WRMA, GWI, and the Barbados Water Authority did not indicate what water consumption data they gathered. The data that they did indicate they gather was stored in spreadsheet format and they did share it. Further investigation is required. The USGS has a software system for water use by state, that can perhaps serve as a reference point for C-READ water use functionality: http://ga.water.usgs.gov/edu/wups.html			

Protocol for accessing data:

- Jamaica - WRA data tends to be stored in spreadsheets as is NWC. This data is shared with other organizations hence with agreements in place sharing with C-READ could be possible.
- Belize – No detailed data information for water use was provided by WASA. Further investigation is required.
- Dominica – DOWASCO did not indicate what consumption data they gathered. Further investigation is required.
- Saint Lucia – WRMA did not report what water consumption data they collect. They did indicate they gather surface water depth and store them in spreadsheets. Further inquiry will be required with WRMA.
- Guyana – GWI did not report if they gather water use data. Further inquiry with them is required.
- Barbados – Barbados Water Authority is responsible for reporting on water consumption data. They did not report on what data they gather. Further investigation is required.

4.2.8 Category 8: Energy: Use, Generation, and Availability

Issue:	Energy use			
User need:	Comprehensive repository of energy usage data, readily available online.			
Purpose:	To serve as a reference point for energy use within each country and regionally. This data could also be a proxy for GHG emission estimates as well.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:**	**GIS:**
Data sources:			Jamaica – NWC, JBI, CHEVRON, NEPA, RUBIS Belize – Belize Electricity Limited, Belize Ministry of Energy Science & Technology and Public Affairs – Public Utilities Commission Dominica – N/A Saint Lucia – N/A Guyana – N/A Barbados – N/A	
Database spec:	Text data (levels of energy consumption) to be appended to location data (geographic coordinates)			
GIS spec:	Point data sets with energy consumption levels to be available as either a vector or raster format file.			
Information product (output)	2D graphs of energy consumption over different time periods. Possibly mapped energy consumption.			
Of note:	Stakeholders from Belize, Dominica, Saint Lucia, Guyana, and Barbados did not provide data for this issue. More inquiry is required with appropriate stakeholders in each of these countries.			

Protocol for accessing data:

- Jamaica – The specific data format and sharing protocol of the data NWC gathered was not reported. Further inquiry with NWC and associated organizations is required.
- Belize – Belize Electricity Limited did not report if they collected energy consumption data. Further inquiry is required.
- Dominica – There was no response from stakeholders in Dominica for this issue.
- Saint Lucia - There was no response from stakeholders in Saint Lucia for this issue.
- Guyana - There was no response from stakeholders in Guyana for this issue.
- Barbados – There was no response from stakeholders in Barbados for this issue.

Issue:	Renewable energy sources			
User need:	Comprehensive repository of renewable energy sources, readily available online.			
Purpose:	To provide data on renewable energy sources – their characteristics and potential in each country.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:**	**GIS:**
Data sources:			Jamaica – Met Service, WRA Belize – Belize Electricity Limited, Belize Ministry of Energy Science & Technology and Public Affairs – Public Utilities Commission Dominica – N/A Saint Lucia – N/A Guyana – N/A Barbados – N/A	
Database spec:	Text data (levels of renewable energy production) to be appended to location data (geographic coordinates)			
GIS spec:	Point data sets with energy consumption levels to be available as either a vector or raster format file.			
Information product (output)	2D graphs of renewable energy production over different time periods. Possibly mapped renewable energy production.			
Of note:	Stakeholders from Belize, Dominica, Saint Lucia, Guyana, and Barbados did not provide data for this issue. More inquiry is required with appropriate stakeholders in each of these countries.			

Protocol for accessing data:

- Jamaica - The Met Service and the WRA did not provide specifications for the data they gather in relation to renewable energy production. Further information is required.
- Belize - There was no response from stakeholders in Belize for this issue.
- Dominica - There was no response from stakeholders in Dominica for this issue.
- Saint Lucia - There was no response from stakeholders in Saint Lucia for this issue.
- Guyana - There was no response from stakeholders in Guyana for this issue.
- Barbados – There was no response from stakeholders in Barbados for this issue.

4.2.9 Category 9: Socio-Economic Status

Issue:	Industry Activity			
User need:	Comprehensive repository of data on industrial activity, readily available online.			
Purpose:	To provide data on industrial activity – in each country.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:**	**GIS:**
Data sources:			Jamaica – N/A Belize – N/A Dominica – N/A Saint Lucia – N/A Guyana – N/A Barbados – N/A	
Database spec:	Text data (levels of industrial activity) to be appended to location data (geographic coordinates).			
GIS spec:	Point data sets with industrial activity to be available as either a vector or raster format file.			
Information product (output)	2D graphs of industrial activity over different time periods. Possibly mapped industrial activity.			
Of note:	No stakeholders in Jamaica, Belize, Dominica, Saint Lucia, Guyana, and Barbados provided data for this issue. More inquiry is required with appropriate stakeholders in each of these countries.			

Protocol for accessing data:

- Jamaica - There was no response from stakeholders in Jamaica for this issue.
- Belize - There was no response from stakeholders in Belize for this issue.
- Dominica - There was no response from stakeholders in Dominica for this issue.
- Saint Lucia - There was no response from stakeholders in Saint Lucia for this issue.
- Guyana - There was no response from stakeholders in Guyana for this issue.
- Barbados – There was no response from stakeholders in Barbados for this issue.

Issue:	Socio-economic status			
User need:	Comprehensive repository of data on socio-economic status, readily available online.			
Purpose:	To provide data on socio-economic status – in each country.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:**	**GIS:**
Data sources:			Jamaica – PIOJ, NEPA Belize – N/A Dominica – N/A Saint Lucia – N/A Guyana – N/A Barbados – N/A	
Database spec:	Text data (levels of socio-economic status) to be appended to location data (geographic coordinates).			
GIS spec:	Point data sets with socio-economic status to be available as either a vector or raster format file.			
Information product (output)	Map of socio-economic status.			
Of note:	No stakeholders in Belize, Dominica, Saint Lucia, Guyana, and Barbados provided data for this issue. More inquiry is required with appropriate stakeholders in each of these countries.			

Protocol for accessing data:

- Jamaica - PIOJ creates poverty maps and NEPA creates socio-economic maps. The technical characteristics of these maps – projection, format, etc. needs to be assessed in order to determine how they are to be integrated into C-READ.
- Belize - There was no response from stakeholders in Belize for this issue.
- Dominica - There was no response from stakeholders in Dominica for this issue.
- Saint Lucia - There was no response from stakeholders in Saint Lucia for this issue.
- Guyana - There was no response from stakeholders in Guyana for this issue.
- Barbados – There was no response from stakeholders in Barbados for this issue.

4.2.10 Category 10: Critical and Emergency Infrastructure

Issue:	Disaster Response			
User need:	Disaster response information related to vulnerable areas as well as disaster impact management needs, available online.			
Purpose:	To serve as a comprehensive repository of disaster response available online and easily accessible.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:** Environmental data pertaining got disasters – water level, storm path, storm strength.	**GIS:** Vulnerable areas.
Data sources:			CDEMA - Jamaica – PIOJ, NEPA Belize – Belize National Emergency Management Organization, Red Cross, Dominica – Met Service of Dominica, Hurricane Information Centre Saint Lucia – NEMO Guyana – Civil Defense Commission Barbados – DEM, Met Service	
Database spec:	Text data (disaster vulnerability and response infrastructure) to be appended to location data (geographic coordinates).			
GIS spec:	Point / polygon data sets with disaster vulnerability to be available as either a vector or raster format file.			
Information product (output)	Maps that delineate areas vulnerable to disasters. Point data that givens anecdotal description of disaster vulnerability and response mechanisms.			
Of note:	There was not an abundance of information provided from the electronic survey in relation to data requirements for disaster response and vulnerability. Further inquiry with CDEMA will be required about specifically which data sets they have.			

Protocol for accessing data:

- Jamaica – NEPA, PIOJ, and perhaps other organizations will need to be consulted about sharing data.
- Belize - Belize National Emergency Management Organization, Red Cross, will need to be consulted about data sharing.
- Dominica –Met Service of Dominica, Hurricane Information Centre will need to be consulted.

- Saint Lucia – NEMO does not gather information itself but coordinates with frontline agencies. NEMO should be the point of contact for accessing disaster response data in Saint Lucia.
- Guyana – Ministry of Health, Met Service, Belize National Emergency Management Organization, and Belize Emergency Response Team will need to be consulted about data sharing.
- Barbados – the Department of Emergency Management and the Met Service will need to be contacted about data sharing.

- NOTE: Some of the Geonodes in the region provide emergency shelter maps.

Issue:	Maintenance and security of critical infrastructure			
User need:	Monitor the status of critical infrastructure that relates to managing the impacts of disasters.			
Purpose:	To provide data that relates to the status of critical infrastructure that is essential for the management of impacts of disasters to ensure they continue to function when needed.			
Data requirements (inputs)	**Hydro:**	**Met:**	**Enviro:** Environmental parameters that contribute to disasters – eg. water level, storm path, etc.	**GIS:** Maps of Critical Infrastructure
Data sources:			CDEMA - Jamaica – Office of Disaster Preparedness and Emergency Management Belize – Belize National Emergency Management Organization, Red Cross, Dominica – Saint Lucia – NEMO Guyana – Civil Defense Commission Barbados – DEM	CDEMA - Jamaica – Office of Disaster Preparedness and Emergency Management Belize – Belize National Emergency Management Organization, Red Cross, Dominica – Saint Lucia – NEMO Guyana – Civil Defense Commission Barbados – DEM
Database spec:	Text data (disaster vulnerability and response infrastructure) to be appended to location data (geographic coordinates).			
GIS spec:	Point / polygon data sets with critical infrastructure shown in vector format.			
Information product (output)	Maps showing location and status of critical infrastructure.			
Of note:	There was not an abundance of information provided from the electronic survey in relation to data requirements for critical infrastructure. Further inquiry with CDEMA and in-country stakeholders will be required about specifically which data sets they have.			

Protocol for accessing data:

- Jamaica - The Department Disaster Preparedness and Emergency Management will need to be consulted about what data they store, format, and accessibility.
- Belize - The Belize National Emergency Management Organization, Red Cross will need to be consulted about what data they store, format, and accessibility.
- Dominica - CDEMA will need to be consulted about what critical infrastructure data they store for Dominica, format, and accessibility.
- Saint Lucia - NEMO will need to be consulted about what data they store, format, and accessibility.
- Guyana – Civil Defense Commission will need to be consulted about what data they store, format, and accessibility.
- Barbados – The Department of Emergency Management will need to be consulted about what data they store, format, and accessibility.

NOTE: The DEWETRA platform is focused on gathering much of this information, therefore there is potential for coupling C_READ and DEWETRA here so as to avoid redundancy.
Some of the Geonodes in the region provide emergency shelter maps.

5. Functional Requirements

5.1 Overview of C-READ Functional Requirements

There range of responses was wide with a variety of requests for C-READ functions, however, there were a number of common themes that came through from the respondents in the six partner countries. Our team has reviewed the responses to specifically three questions from the electronic survey:

Q. Which geospatial climate and hydrographic monitoring products would be most useful for informed decision-making in your sector?

(Country responses shown in Annex B)

Q. Which other information products or mapped indices would be most useful for informed decision-making in your sector

(Country responses shown in Annex C)

Q. Please provide a list of queries that your organization may request from the DMS - eg. What are the average monthly precipitation, land slope, land cover type, and soil type, at a particular location?

(Country responses shown in Annex D)

The suggestions provided by stakeholders were synthesized and grouped according to their common function. These functions form the core list of the functional requirements of C-READ. There is overlap between some of these different functions and through further analysis and stakeholder input some of them may be grouped together.

5.2 List of Functional Requirements by Category

5.2.1 Category 1: Meteorological and Hydrological Data and Projections Functions

Reporting and Visualization of Meteorological Data

The system should display meteorological data as it is collected in each of the partner countries. The Gap Analysis showed that several organizations are gathering met data, some with a full suite of parameters from automated weather stations and some from rain gauges. This data should be standardized and integrated into the C-READ system (precipitation, temperature, wind speed, wind direction, humidity, atmospheric pressure). The standards established by CIMH should be consulted with and followed. The data should be either raw data or temporal averages. This will depend on what format the organizations submit their data in. Most only submit temporally averaged data. These values need to be geo-located too.

This data will need to be shown geospatially and also in graph format. There should be some selection mechanism for daily/weekly/monthly precipitation. Forecasting and projections should be addressed for meteorological data and climate models output can be downscaled to present different scenarios. Time series analysis should be done as well with historical meteorological data used.

Potential Data Products:

- Maps of average monthly values of chosen meteorological parameters (precipitation, temperature, and potentially others) over the region (eg. precipitation for July 2001 in Barbados). The spatial scale for these maps should be changed through a zoom function). SPI (Standard Precipitation Index over 1, 3, 6, and 12 month intervals).
- Graph of chosen meteorological parameter (precipitation, temperature, and potentially others) over time (y axis = met parameter; x axis = time). The graphs could show average monthly (or yearly) values for the whole country or values from individual stations.
- CIMH is already providing or will provide this information. C_READ can be connected with CIMH's data repository.

Reporting and Visualization of Hydrological Data

The system will need to display hydrological data. Hydrological data needs to be displayed – statically and preferably dynamically. There needs to be a standardized format in which the data is gathered. Data will need to be displayed geospatially. Dominica has been some integrated. In Dominica and Jamaica there are employing some advanced hydrological monitoring system. Dominica is planning to enhance their water monitoring system with a World Bank / Climate Investment Fund PPCR project that will

gather water resource baseline data and develop a hydromet network for data sharing. Mr. Jerry Meier has suggested that once information on topography, soils, land cover, and rainfall are known, then river flows can be determined using CAUHSI or HEC-RAS hydromet modelling software. Nick Calendar (ncallender@worldbank.org) and Jerry Meier (gemintpan@aol.com) should be consulted on this. The Carib HYCOS project which funds the data gathering networks is led by Jean-Pierre Briquet (jean-pierre.briquet@ird.fr). Jamaica has an extensive set of field-based sensors for surface water (200) and about the same for ground water (200). They have stream flow / river gauges on major rivers as well.

Evaporation / evapotranspiration, salinity and water quality will also be required. Jamaica and Dominica as well as those that worked on CARIWIN should be consulted in order to determine the best means of storing, standardizing, modeling, and visualizing hydrological data. Flood risk should be one key aspect of hydrological data management as well as drainage patterns linked to infrastructure. Soil Moisture should also be included in this. Projections for water availability based on the balance between water presence and that extracted will be useful.

Potential Data Products:

- Data products that are present in the NWIS implemented in Jamaica, Grenada, Guyana (http://www.cimh.edu.bb/?p=nwis)

Climate Change Scenarios

A module devoted to CC scenarios that can then be correlated against infrastructure, land use, etc. This may be included in the meteorological data section or could be a standalone section. It will require the use of CC model output that is downscaled and then queried against other geospatial data sets.

Potential Data Products:

- Map showing vector data output of different scenarios – eg. expected changes in precipitation and temperature levels

5.2.2 Category 2: Hazards and Risks Functions

Drought Risk Assessment

All countries have expressed the need to have the capability to produce drought metrics. This could be in the form of a map that presents the likelihood or risk of drought in certain regions in each country. The data will be drawn from the hydrological set as well as the meteorological set. The drought risk can be linked with impacts and industrial activity. For instance, queries that tell where is most vulnerable to a drought can be cross-referenced to land use data that shows where agricultural activity is. A food security output could then be produced.

Potential Data Products:

- Drought risk products that are present in the NWIS implemented in Jamaica, Grenada, Guyana (http://www.cimh.edu.bb/?p=nwis).
- NWIS uses SPI as a parameter in drought risk – Barbados is in the process of incorporating other parameters. CIMH should be consulted (A. Trotman)

Flood Risk Assessment

The risk of flood is of utmost concern to all countries. This is primarily for the rainy season but could also apply to sea level rise. Basically, users will need to query the system to assess in what regions there will be vulnerability to floods. The data for this will need to be drawn from the hydrological set of data for each island. Infrastructure data will be required for the impact aspect of this. For instance, if a region is flooded and has high valued tourism operations on it, then the risk will be high. In cases where the region flooded is not used or is low value, then the risk will be less. We will need to have infrastructure and population data to determine the impacts. Drainage systems will also need to be included. An aspect of this will also be storm surge and sea level rise.

Climate change informed IDF curves are required here too.

Potential Data Products:

- Map showing risk of flood based on hydrological and meteorological data (SPI)
- Consultation will be required for IDF curves and incorporating climate change parameters.

Hurricanes and Storm Surge Risk

Areas that are exposed to risk of damage due to hurricanes need to be identified in maps. This will be dynamic data created by drawing on the hydrological data and infrastructure data. Topography and coastal zone information will be required for the storm surge assessment.

Potential Data Products:

- Map showing infrastructure and communities exposed to hurricanes and storm surges

Disease and Pest Risk

Maps or data relating to pests and diseases to humans, animals, and plants should be included. This will be especially important for the relationship between climate change and the emergence of pest outbreaks. Several countries see this as a priority. Risk metrics should be included.

Potential Data Products:

- List of potential pest risks per region – could be a vector map with a list that appears for each region when it is selected. More consultation required on this.

Saline Intrusion Risk

Maps or data relating to risk of saline intrusion be included. Topography and environmental parameters are required to estimate this risk.

Potential Data Products:

- Location of areas of risk of saline intrusion in map format

5.2.3 Category 3: Geographical and Biophysical Environment Functions

Topography

Topography of the land must be shown. DEMs (Digital Elevation Models) that have been created with lidar, or from contour maps that have been digitized will be used to do the topography maps. Topography will be an important input into various risk maps such as flood risk and hydrological models.

Potential Data Products:

- Map showing topography – can be a raster image with elevation derived from a DEM, could also be a vector image with contour lines

Ecosystems and Biodiversity Mapping

Maps of the different ecosystems and biogeoclimatic zones will be required. Biodiversity should be included in this report too. This can be cross-referenced against potential or existing land-use data to determine where risks to biodiversity may be. For example, habitat of a sensitive species that is located close to a high-volume agricultural operation may be presented with risks due to future land use or pesticide use.

Potential Data Products:

- Potentially a map showing different ecosystems (vector format)
- Potentially a map showing areas where species are at risk
- Perhaps lists of species present in each ecosystem / or biodiversity indices – consultation required

5.2.4 Category 4: Coastal Zone and Ocean Functions

Coastal Zone

Risk of inundation, sea level rise, erosion, or other forms of impacts should be addressed here. As an example: what is the risk of a 1m increase in sea level rise and what would be the economic or ecological impact?

Potential Data Products:

- Map showing coastal regions with a risk factors (TBD) based on how likely inundation could be. Could cross reference with infrastructural map layer too to determine risk.
- Sea grass
- Mangroves
- Beach profile change

Ocean Monitoring

This will be a set of queries or data sets that show: sea surface temperature, sea level rise, ocean currents, and ocean color (SeaWifs-derived) which shows fluvial run off. Ocean acidification and reef health / hot spots can also be shown here. Bathymetry can be included as well.

Potential Data Products:

- Map – raster data showing sea surface temperature
- Ocean colour can also be shown in the map indicating sedimentation or phytoplankton presence
- Bathymetry – vector map?
- Ocean currents – vector data?
- Reef health
- Tides?

5.2.5 Category 5: Land Cover and Land Use Functions

Land Cover

Satellite data showing land cover types. This should be historical as well. This can come from classified Landsat, MODIS, or SPOT data (or other products). Deforestation or land-cover impacts can also be determined from this.

Potential Data Products:

- Raster maps of classified land cover types: eg. forest, urban, etc. These maps can be taken annually – or over whatever time frame is relevant.

Land Use

A vector polygon map that shows what land is being used for. Historical and present day can be selected.

Potential Data Products:

- Map vector data showing map of land use. Can be over time if data is available.

Protected Areas and Parks

Boundaries of protected areas and parks – marine and terrestrial – will need to be included in the system. Potential impacts on these systems from environmental change as well as anthropogenic activity can then be determined through different queries.

Potential Data Products:

- Vector map showing boundaries of protected areas and parks
- Could overlap other risk maps (SPI drought risk) with these to determine risk to the parks

5.2.6 Category 6: Agriculture and Food Security Functions

Agricultural Productivity

Agricultural crops, fertilizer use, and pesticide use data can be managed here. Productivity can also be assessed. These can be cross-referenced against hydrological and meteorological data to assess potential risks.

Potential Data Products:

- Vector map showing where what crops are
- Food security risk map created when compared with drought risk maps

Soil Quality

Soil types as well as soil capacity (water and infiltration / nutrient levels) will need to be shown.

Potential Data Products:

- Map showing soil types
- Map showing soil capacity based on different parameters (to be determined: soil type, water availability, available nutrients – fertilizer)

5.2.7 Category 7: Water: Availability, Quality, and Use

Water Availability

The availability of water resources will be accessible in this module. Organizations sample data for ground water and surface water levels. These point collections could be used to create maps showing ground water levels.

Potential Data Products:

- Tables of water availability per region
- Maps of water levels

Water Quality

Water quality is sampled by many organizations. This data should be made available on the C-READ system, showing the risk of water contamination or salinity. This could be connected to the hydrological module or be a separate component that is linked to it indirectly.

Potential Data Products:

- Graphs of levels of key parameters sampled for water quality at different locations. Could be a graph of one location, each parameter over time. Eg. Phosphate and nitrate levels over time sampled at a well in Jamaica. Could be a map with points that can be clicked and then parameters chosen for display over time. Consultation required with water authorities.

Water Use

The use of water will be gathered and shown in this module. Water abstraction data is gathered by different organizations. This could be aggregated and shown here.

Potential Data Products:

- Tables of water use by location. Data can be point data on a map that is selected.

5.2.8 Category 8: Energy: Use, Generation, Availability Functions

Energy Use

The use of energy by organizations will be gathered and shown in this module. This will be useful for pollution prevention and climate change mitigation programs and policies.

Potential Data Products:

- Tables of energy use by location. Data can be point data on a map that is selected.

Renewable Energy Sources

Comprehensive repository of renewable resources data, readily available online.

Potential Data Products:

- Tables of renewable energy availability use by location. Data can be point data on a map that is selected.

5.2.9 Category 9: Socio-Economic Status

Industry Activity

Comprehensive repository for industry information for the region easily accessible on line.

Potential Data Products:

- Map of vector data showing different levels or points of industry activity. Can be linked with other risk products to determine vulnerability score

Socio-Economic Status

The social and economic status of communities will need to be ascertained and this data incorporated into the C-READ management system to perform community risk assessments. This demographic and economic data can be gathered from existing sources in partner countries.

Potential Data Products:

- Map of vector data showing different levels of SES. Can be linked with other risk products to determine vulnerability score

5.2.10 Category 10: Critical and Emergency Infrastructure

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.

Potential Data Products:

- Map of vulnerable areas and disaster impacts

Maintenance and Security of Critical Infrastructure

Critical infrastructure should be identified and data relating to its status should be monitored so as to ensure that it continues to function. This data should be in the format most suitable for those assessing the status of critical infrastructure.

Potential Data Products:

- Maps of critical infrastructure
- Anecdotal description of status of this infrastructure

6. Use Case Scenarios

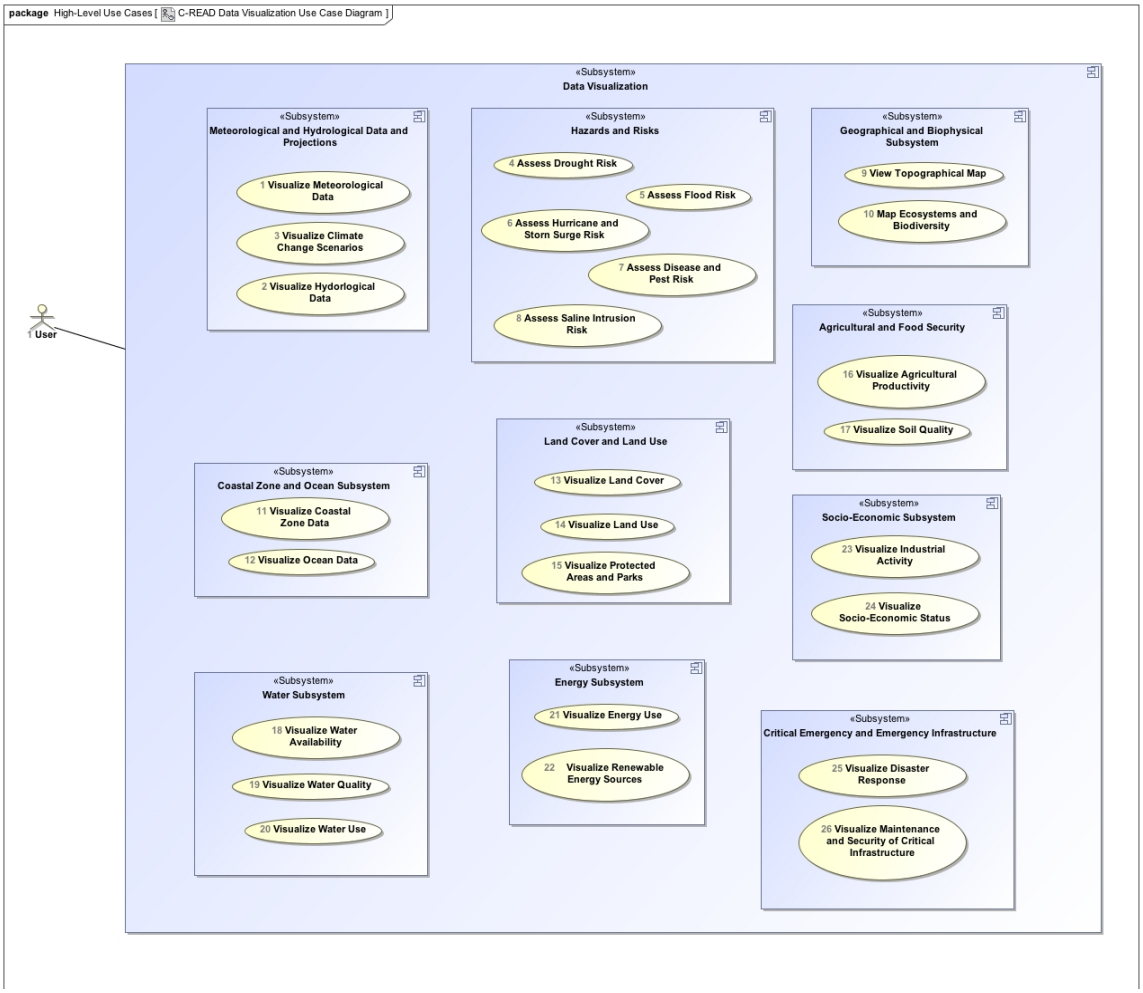
6.1 Overview of C-READ Use Case Scenarios

The range of responses was wide with a variety of requests for C-READ functions, however, there were some overall patterns that became evident with respect to desired system functions. Use cases were also determined based on the functions that our team felt would be required such as: querying for data, accessing geospatial and time-series data, and various uses of integrated data sets and local and regional geospatial data. Each use case has been evaluated and expanded upon in the following section.

6.2 Sample Visualization Use Case Scenarios

Below in Figure 6 is a use case diagram illustrating all of the visualization use cases that have been identified in the functional requirements.

Figure 6: Use Case Diagram for Visualization of Data



The use case flows for each visualization have many commonalities as described by a few sample use cases that follow.

6.2.1 Category 1: Meteorological and Hydrological Data and Projections – Use Cases

Issue: Precipitation and General Meteorological Monitoring

Brief Description

This use case describes the steps a user would take to display and manipulate the precipitation view.

Actors

- Users
- C-READ GUI
- C-READ Web Services

Pre-Conditions

- Drought risk data is available and publicly accessible for the specified region

Basic Flow of Events

1. The use case begins immediately after the user has navigated to the Precipitation view
2. C-READ GUI will retrieve the required data from the C-READ Web Service and display the default map view [refer to Use Case A for map rendering and controls].
3. C-READ GUI will display the following legend:
    a. Precipitation amount legend
4. The following layers will be listed in the Attributes tab (if available and authorized) and their initial visibility state:
    a. Topography [on]
    b. Precipitation amount [on]
    c. Borders [on]
    d. Rivers [on]
    e. Roads/Cities [off]
    f. Drainage [off]
    g. Land Use [off]
    h. Soil Moisture Levels [off]
5. The user will be able to select and deselect different layers and the map will update accordingly.
6. C-READ GUI will display a control allowing the user to specify a timeframe.
    a. Users will be able to specify a date range
    b. User will be able to select from pre-defined, daily, weekly and monthly periods
    c. Users will be able to select between average and normal statistics for display
7. End of use case

References

Refer to Figure 2 for a mockup of the Precipitation interface.

6.2.2 Category 2: Hazards and Risks – Use Cases

Issue: Drought Risk

Brief Description

This use case describes the steps a user would take to display and manipulate a drought risk map.

Actors

- Users
- C-READ GUI
- C-READ Web Services

Pre-Conditions

-
- Drought risk data is publicly available for the specified region

Basic Flow of Events

1. The use case begins immediately after the user navigated to the Drought Risk view
2. C-READ GUI will retrieve the required map and drought risk data from the C-READ Web Service and display the map view [refer to use case A for map rendering and controls].
3. The user will be able to select to view the following layers via the Attributes tab:
    a. High Winds
    b. Significant Waves
    c. Heavy Rain
    d. Much Above Normal Temperature
    e. Much Below Normal Temperature
    f. Excessive Heat
    g. Flooding Likely
    h. Flooding
    i. Flooding Possible
    j. Enhanced Wildfire Risk
    k. Severe Drought [on]
4. A legend will be displayed indicating assigning a separate color for each risk type
5. End of use case

References

Refer to Figure 3 for a mockup of the Drought Risk interface.

6.2.3 Category 3: Geographical and Biophysical Environment – Use Cases

Issue: Topography

Brief Description

This use case describes the steps a user would take to display and manipulate and topography map.

Actors

- Users
- C-READ GUI
- C-READ Web Services

Pre-Conditions

- Topography data is publicly available for the specified region

Basic Flow of Events

1. The use case begins immediately after the user has navigated to the Topography view
2. C-READ GUI will retrieve the required topographical maps/data from the C-READ Web Service and display the map view [refer to use case A for map rendering and controls].
3. C-READ GUI will display the following labels:
    a. Elevation in meters
4. The user will be able to view maps from the following sources (if available):
    a. Streets
    b. Terrain
    c. Labelled Satellite
5. Integration with the following online mapping services will be available:
    a. Google Maps
    b. Bing Aerial
    c. MapQuest Imagery
    d. MapQuest OpenStreetMap
6. End of use case

References

Refer to Figure 4 for a mock-up of the Topography interface.

Issue: Ecosystems and Biodiversity

Brief Description

This use case describes the steps a user would take to display and manipulate the ecosystem and biodiversity view.

Actors

- Users
- C-READ GUI
- C-READ Web Services

Pre-Conditions

- Biodiversity data is publicly available for the specified region

Basic Flow of Events

1. The use case begins immediately after the user has navigated to the Ecosystem & Biodiversity view
2. C-READ GUI will retrieve the required data from the C-READ Web Service and display the map view [refer to Use Case A for map rendering and controls].
3. C-READ GUI will display the following labels:
    a. Number of species
4. The following layers will be listed in the Attributes tab and their initial state:
    a. Topography [on]
    b. Administrative Boundaries [on]
    c. Rivers [off]
    d. Roads/Cities [off]
    e. Land Use [off]
    f. Population Density [off]
5. The user will be able to select and deselect different layers and the map will update accordingly.
6. End of use case

References

Refer to Figure 5 for a mock-up of the Ecosystem and Biodiversity interface.

6.2.4 General C-READ Function – Use Cases

Map View and Controls

Brief Description

This use case describes the user's interaction with the map views used throughout the C-READ GUI.

Actors

- Users
- C-READ GUI

Pre-Conditions

- The user has navigated to a template that renders a map view

Basic Flow of Events

1. The use case begins immediately after the user has navigated to a template with a map view.
2. C-READ GUI will display a map of the entire CCCCC region with the default layers rendered (appropriate to that template).
3. The following widgets will be visible on the map which the user can use to manipulate it:
    a. Pan
    b. Zoom (+/- and a sliding scale)
    c. A dropdown with pre-defined scales that the user can select from
4. The user will also be able to control the map view a mouse:
    a. Zoom can be controlled by the mouse wheel
    b. Pan can be controlled by a click and drag motion
5. As the user manipulates the map by either panning or zooming, the map and the visible layers will update accordingly
6. C-READ GUI will display the following additional controls below the map:
    a. Upload Map: allows the user to upload a new map
    b. Download Layer:
    c. Download Metadata:
    d. Print: allows the user to print the currently visible map and layers
7. C-READ GUI will display the following informational tabs below the map area:
    a. Info: This tab is selected by default and will display the following information about the map:
        i. Title
        ii. Abstract
        iii. Publication Date
        iv. Type
        v. Category

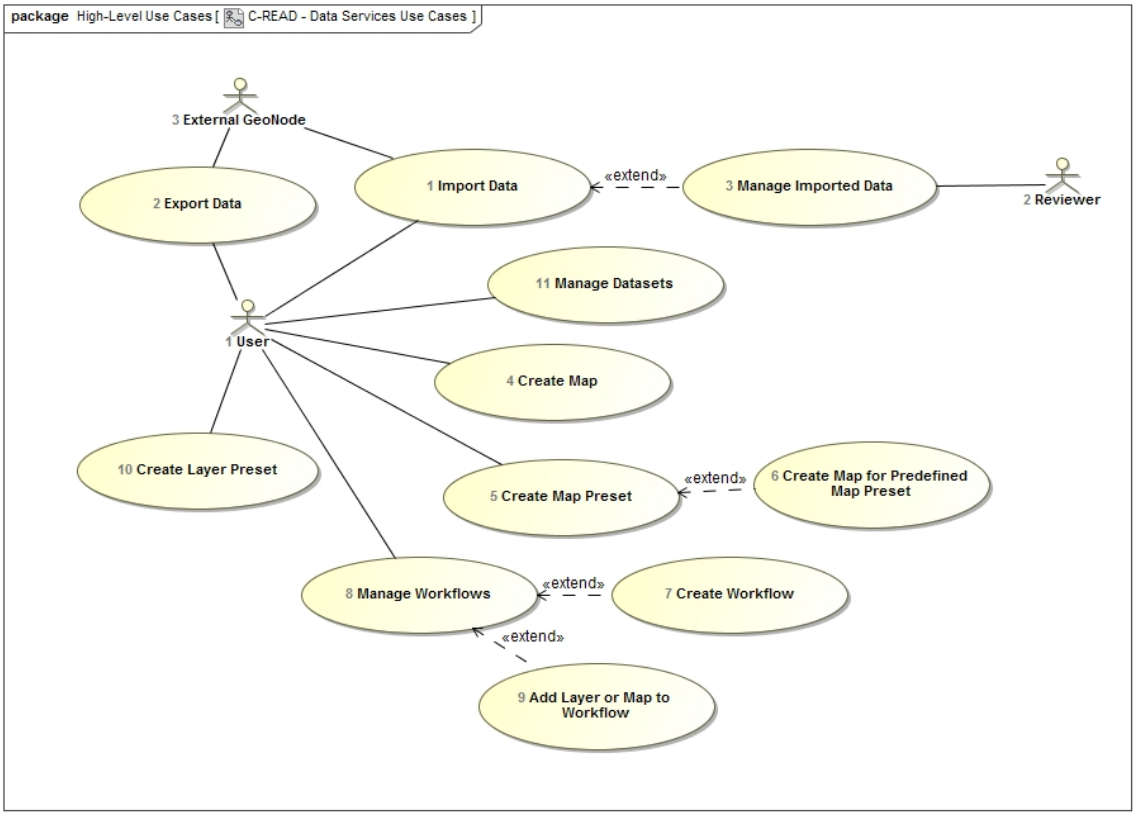
b. Layers: lists all of the layers available for this map along with their descriptions (if available) and the ability to turn them on or off
c. Attributes: displays all of the relevant data associated with the map [details TBD]

8. End of use case

6.3 Data Services Use Cases

Below in Figure 7 is a use case diagram describing the use cases identified for this service:

Figure 7: Use Case Diagram for Data Services



6.3.1 Sample Data Service Use Cases

Layer Preset Creation

Brief Description

This use case describes the user's ability to define a Layer Preset that details the attribute requirements for a layer that is to be uploaded.

Actors

- Users
- C-READ GUI

Pre-Conditions

- The user has already signed on to the C-READ system and has navigated to a template that allows the user to add a Layer Preset.

Basic Flow of Events

1. The use case begins immediately after the user has navigated to a template that allows addition of Layer Presets.
2. C-READ GUI will display a form that will allow the user to input the following information:
    a. Name
    b. List of required columns. Each column has:
        i. Name
        ii. Type
        iii. Unit (where applicable)
        iv. Category
    c. Label column

Data Upload

Brief Description

This use case describes the user's ability to upload a dataset into the system.

Actors

- Users
- C-READ GUI

Pre-Conditions

- The user has already signed on to the C-READ system and has navigated to a template that allows the user to upload data.

Basic Flow of Events

1. The use case begins immediately after the user has navigated to a template that allows addition of maps.
2. The C-READ GUI will allow the user to enter the title, abstract, select a category and upload files to the C-READ system.
3. The user will be allowed to upload supplementary non-spatial data.
4. The user is optionally allowed to select a preset for which the data is being uploaded.
    a. The system validates that the data being uploaded conforms to the prescriptions of the data preset.

5. The user will be allowed to set permissions and define license requirements for the layer.
6. The user is allowed to create or add the layer to an existing folder and add tags to describe the layer.

Map Creation

Brief Description
This use case describes the user's ability to create a map.

Actors
- Users
- C-READ GUI

Pre-Conditions
- The user has already signed on to the C-READ system and has navigated to a template that allows the user to create a map.

Basic Flow of Events
1. The use case begins immediately after the user has navigated to a template that allows addition of maps.
2. C-READ GUI will allow the user to enter the name of the map.
3. The C-READ GUI allows the user to select several layers that will be added to the map.
4. The user is allowed to optionally create or add the map to an existing folder and add tags to describe the map.
5. The user is allowed to set permissions and define license requirements for the map.
6. The user is allowed to save and preview the map.

Map Preset Creation

Brief Description
This use case describes the user's ability to create a map preset.

Actors
- Users
- C-READ GUI

Pre-Conditions
- The user has already signed on to the C-READ system and has navigated to a template that allows the user to create a map.

Basic Flow of Events
1. The use case begins immediately after the user has navigated to a template that allows the creation of map presets.

2. C-READ GUI will allow the user to enter the name of the map preset.
3. The C-READ GUI allows the user to select several layer presets that the map preset will consist of.

Create map for map preset

Brief Description

This use case describes the user's ability to create a map for a predefined map preset.

Actors

- Users
- C-READ GUI

Pre-Conditions

- The user has already signed on to the C-READ system and has navigated to a template that allows the user to create a map for a preset.

Basic Flow of Events

1. The use case begins immediately after the user has navigated to a template that allows creation of a map for presets.
2. C-READ GUI will allow the user to select the map preset for which a map is to be created for.
3. The C-READ GUI presents the user with the list of data presets that are required for each layer of the map preset and allows the user to select a layer for each preset.
4. The user is allowed to save and preview the map created for the selected preset.

Workflow creation

Brief Description

This use case describes the user's ability to create a workflow.

Actors

- Users
- C-READ GUI

Pre-Conditions

- The user has already signed on to the C-READ system and has navigated to a template that allows the user to create a workflow.

Basic Flow of Events

1. The use case begins immediately after the user has navigated to a template that allows creation of a workflow.
2. C-READ GUI will allow the user to enter a title and abstract for the workflow.

3. The user is then allowed to create several stages for the work flow that each have the following properties:
    a. Title of stage
    b. Status (raw, work in progress, unpublished, published, derived)
    c. Data Presets required
    d. Map Presets required
4. The user is allowed to save the workflow.

Add layer or map to existing workflow

Brief Description

This use case describes the user's ability to manage the workflows a dataset belongs to.

Actors

- Users
- C-READ GUI

Pre-Conditions

- The user has already signed on to the C-READ system and has navigated to a template that allows the user manage the workflows a dataset belongs to.

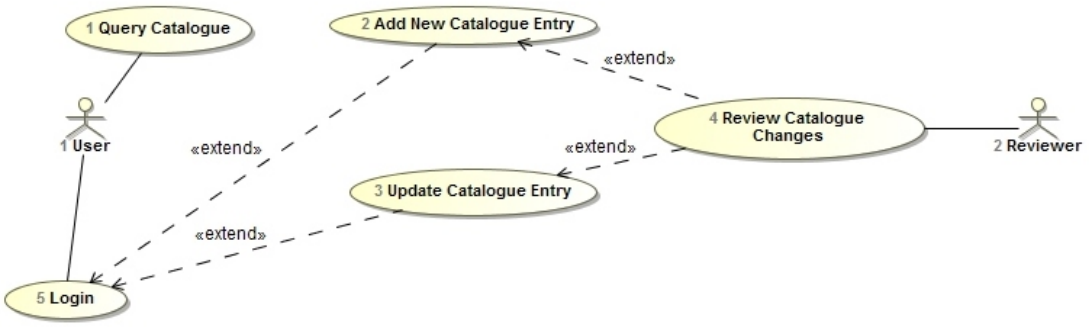
Basic Flow of Events

1. The use case begins immediately after the user has navigated to a template that allows management of the workflows a dataset belongs to.
2. C-READ GUI will allow the user to select the workflow, which the user wants to add the data layer or map to.
3. The GUI then presents the list of stages within the workflow and allows the user to select a stage.
4. The user is allowed to save the workflow.

6.4 Catalogue Service Use Cases

Below in Figure 8 is a diagram of the Catalogue Service use cases:

Figure 8: Use Case Diagram for Catalogue Services



Each use case is quite straightforward.

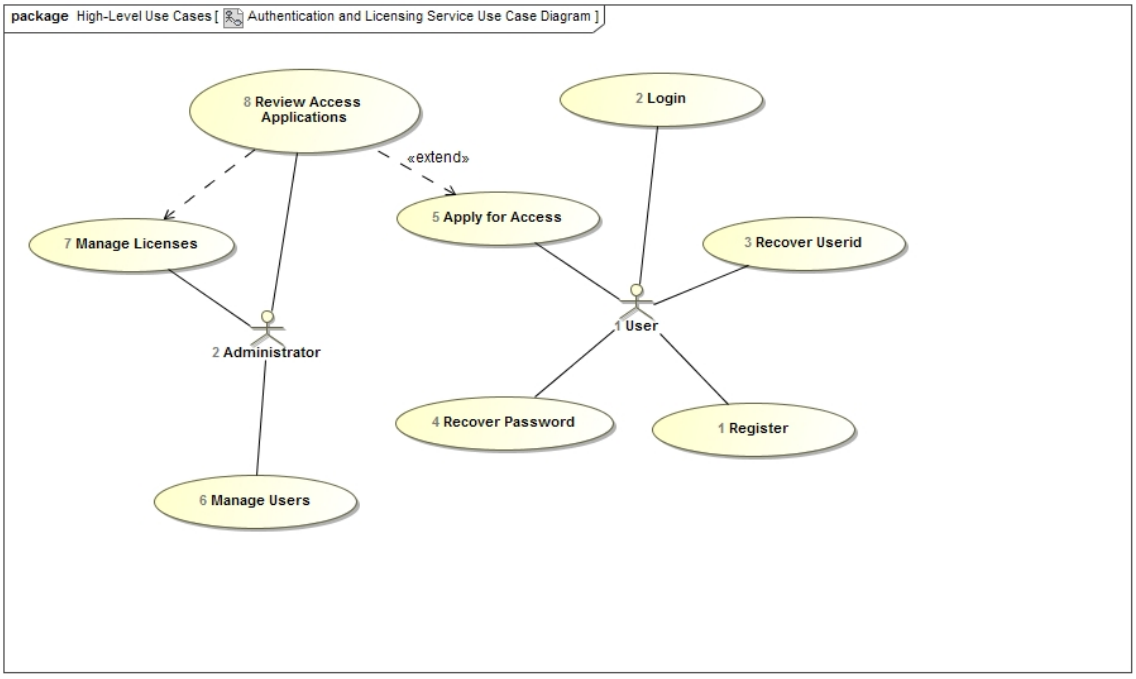
Things to note:

- The User must first log in to add or modify any catalogue entries
- The Query Catalogue Use Case must allow the user to search on at least the following filters:
    - Data type
    - Whether to include licensed data
    - Data provider
    - Location
- Results should be clickable where appropriate (i.e., websites, ftp, etc)
- Before additions/modifications are committed to the Catalogue, a Reviewer must first approve them

6.5 Authentication and Licensing Service Use Cases

Below in Figure 9 is a use case diagram for the Authentication and Licensing Service:

Figure 9: Use Case Diagram for Authentication and Licensing Services



It contains the standard user administration functionality (i.e., login, register, administer users, etc), but also includes support for license management and applications for access to licensed data

7. Conclusions

The general structure and functionality of C-READ is explained in this document. The overall system architecture connects the database structure of MySQL/PHP (or equivalent) and the geospatial functionality of Geonode. C-READ is designed to work as an open platform that will facilitate the sharing and integration of environmental data sets. The sample user interfaces clearly show how these data sets can be layered and merged. Further work is required in order to establish the code for implementing the conceptual design, however, the functionality that has been suggested in this document fulfils the objectives of groups that responded to the electronic survey and match with our team's professional understanding of what is required for environmental monitoring in the Caribbean region.

ANNEX A: User Interface Document

See the pdf document: **C_READ_UserInterface_Nov27_2013.pdf**, which was delivered with this report.

ANNEX B: Jamaica - Monitoring Data Reported from E-Survey

Table 1: 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 2: 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 3: 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 4: 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 5: 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 6: 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 organizations

Table 7: 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 8: 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 C: Belize - Monitoring Data Reported from E-Survey

Table 9: 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 neighbouring 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 10: 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 11: 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 12: 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 13: 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 14: 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 15: 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 partners
	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	Administrative Boundaries	polygon	m	NAD 1927	ArcGIS 10.1	.shp	Yes

Centre	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 D: Dominica - Monitoring Data Reported from E-Survey

Table 16: 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 17: 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 E: Saint Lucia - Monitoring Data Reported from E-Survey

Table 18: 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 19: 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 20: 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 21: 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	Download	Yes
Mabouya		Auto	Surface water depth	Excel spreadsheet	Yes	Download	Yes
Canelles		Auto	Surface water depth	Excel spreadsheet	Yes	Download	Yes

Table 22: 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 23: 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 F: Guyana – Monitoring Data Reported from E-Survey

Table 24: 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 modelling including agrometeorological and Entomological modelling 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 25: 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 Amsterdam	Met Service	Manual	Precip, temp, humid, wind, clouds, sunshine, wind dir, wind run, soil temp, soil moisture, dew point, evaporation,	Spreadsheet / CLIDATA	Yes	Phone / Paper / Satellite	With 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				

	Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration
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, Atmospheric Temperature Wind speed$direction, Gusts,Radiation
MAZARUNI PRISON		
	Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration, Atmospheric Temperature Wind speed$direction, Gusts,Radiation
ALBION FRONT		
	Automatic Weather Station	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		

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

		Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration,
St.Francis Mission	Automatic Weather Station	Atmospheric Temperature Wind speed$direction, Gusts,Radiation
		Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration,
Orealla	Automatic Weather Station	Atmospheric Temperature Wind speed$direction, Gusts,Radiation
		Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration,
Apaikwa	Automatic Weather Station	Atmospheric Temperature Wind speed$direction, Gusts,Radiation
		Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration,
kaieteur	Automatic Weather Station	Atmospheric Temperature Wind speed$direction, Gusts,Radiation
		Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration,
Tumatumarie Falls	Automatic Weather Station	Atmospheric Temperature Wind speed$direction, Gusts,Radiation
		Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration,
St. Ignatius	Automatic Weather Station	Atmospheric Temperature Wind speed$direction, Gusts,Radiation
		Precipitation, Temperature,Wind Run, Sunshine Hours,Soil Temperature, Relative Humidity,Evapouration,
Eclipse Falls	Automatic Weather Station	Atmospheric Temperature Wind speed$direction, Gusts,Radiation
CHARITY		Precipitation
POMEROON	Rainfall	
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 W.B.D.	Rainfall	Precipitation
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
GEORGETOWN PROMENADE GDN	Rainfall	Precipitation
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
LESBEHOLDEN 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	Rainfall	Precipitation
BERBICE WHIM	Rainfall	Precipitation
APAIKWA		Precipitation
MAZARUNI	Hydromet	
BARTICA DEM STATION	Rainfall	Precipitation
CHINOWEING	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
WARAMADONG	Rainfall	Precipitation
Crab Wood Creek	Rainfall	Precipitation
Corentyne # 44 Village	Rainfall	Precipitation
Corentyne 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	Climatology	Precipitation, Temperature,Wind Run, Sunshine Hours,Atmospheric Temperature,Soil Temperature, Relative Humidity,Evapouration
AWAREWAU	Rainfall	Precipitation
NAU		
RUPUNUNI		
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	Rainfall	Precipitation
FORESTRY		
STATION		
BETTER	Rainfall	Precipitation
HOPE		
ESSEQUIBO		
CAPOEY	Rainfall	Precipitation
LAKE		
SAXACALLI	Rainfall	Precipitation
ST.DENNY'S	Rainfall	Precipitation
MISSION		
NAAMkYCK	Rainfall	Precipitation
BEEHIVE	Rainfall	Precipitation
ENTERPRISE	Rainfall	Precipitation
E.C.D		
FRIENDSHIP	Rainfall	Precipitation
E.C.D		
LAND OF	Rainfall	Precipitation
CANAAN		
SAM ATTA	Rainfall	Precipitation
POINT		
SOESDYKE	Rainfall	Precipitation
FORESTRY		
STRATHAVO	Rainfall	Precipitation
N		
ABARY IR	Rainfall	Precipitation
BARA BARA	Rainfall	Precipitation
BUSH LOT	Rainfall	Precipitation
COPEMAN	Rainfall	Precipitation
SITE		
DE	Rainfall	Precipitation
EDWARDS		
FOULIS	Rainfall	Precipitation
GRASS HOOK	Rainfall	Precipitation
HELENA #2	Rainfall	Precipitation
LITTLE	Rainfall	Precipitation
BIABOO		
MARAKABI	Rainfall	Precipitation
NOVAR	Rainfall	Precipitation
MAHAICONY		

PINE GROUND	Rainfall	Precipitation
MAICHONY 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 26: 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 27: 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,	Excel	Yes	Downloa	Yes

			ground water depth, discharge, abstraction, turbidity, pH, fecal coliforms, total coliforms	spreadsheet		d	
Canelles		Auto	Surface water depth, ground water depth, discharge, abstraction, turbidity, pH, fecal coliforms, total coliforms	Excel spreadsheet	Yes	Downloa d	Yes
Mahaica River at St.Cuthbert's Mission	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
East Demerara Water Conservancy at Flagstaff	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Kairuni River at Kairuni bridge	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Loo River at Lin/Soes. H/way Bridge	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Lamaha Canal at Shelter Belt	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
St.Francis Mission	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Berbice River at Itabru Falls	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Canje River at Digitima Creek	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Canje River at Reynold's Bridge	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Canje River at Karia Kuri nr 3 Sisters	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Ikuruwa River At Belcum	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Mazaruni River at Kamarang	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Mazaruni River nr. Apaikwa Falls	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Ikuribisi R at Ikuribisi Falls	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Potaro River at Tumatumari Falls	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Siparuni River at Pakatau Falls	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Burro-Burro River at Sandstone	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Potaro River at Kaieteur Falls	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Takatu River at St. Ignatius	Met Service	Auto	Stage, discharge	Paper/databa se	-	Paper/typ e	Yes - CIMH
Demerara	Met	Auto	Stage, discharge	Paper/databa	-	Paper/typ	Yes -

River at Great Falls	Service			se		e	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	Met	Auto	Stage, discharge	Paper/databa	-	Paper/typ	Yes -

Channel - NE at Flagstaff	Service			se		e	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 - DS of Road Sluice (Gauge Board Only)	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - 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-Conseververancy 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	Met Service	Auto	Stage, discharge	Paper/database	-	Paper/type	Yes - CIMH
Mahaicony 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	Met	Auto	Stage, discharge	Paper/databa	-	Paper/typ	Yes -

Coopeman	Service			se		e	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 28: 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 29: 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 G: Barbados – Monitoring Data Reported from E-Survey

Table 30: 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 31: 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,	Spreadsheet / digital	Yes / no	paper / radio	CIMH and

			clouds, sun duration, atm pressure, wind direction, dew point,				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/user/cardibarbados/	CARDI	Auto	Temp, humidity, dew point, atm pressure, wind speed, wind direction, precip, soil temp, soil moisture, leaf temp, leaf wetness	Digital	Yes	Web	Public (web)
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 32: 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 33: 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		m	GCS Barbados	ArcGIS	shp

parish)		1938		
District emergency organization boundaries	m	GCS Barbados 1938	ArcGIS	shp

Table 34: 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.

ANNEX H: Geospatial climate and hydrographic monitoring products

Q. Which geospatial climate and hydrographic monitoring products would be most useful for informed decision-making in your sector?

Jamaica

- 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

Belize

- 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)

Dominica

- 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

Saint Lucia

- 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

Guyana

- 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

Barbados

- 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

ANNEX I: Information Products or Mapped Indices for Stakeholders

Q. Which other information products or mapped indices would be most useful for informed decision-making in your sector

Jamaica

- 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
- Modelling 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

Belize

- Our reef Health Index is useful - and your data could widen the net of users of such data
- NOAA's 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.

Dominica

- 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.

Saint Lucia

- 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

Guyana

- 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

Barbados

- 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

ANNEX J: Potential DMS Queries from Stakeholders

Q. Please provide a list of queries that your organization may request from the DMS - eg. What are the average monthly precipitation, land slope, land cover type, and soil type, at a particular location?

Jamaica

- 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

Belize

- 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

Dominica

- 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

Saint Lucia

- 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.

Guyana

- 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.

Barbados

- daily precipitation
- daily temperatures
- daily humidity
- soil type
- soil temperature