DE

DESIGN + ENVIRONMENT

MONA GIS

GEOINFORMATICS

PHASE 2: C-READ SYSTEM DESIGN

SYSTEM REQUIREMENTS 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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Caribbean Community Climate Change Centre

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DE Company Information

DE is a company that improves the environmental performance and enhances the cultural communication of professional organizations

We solve problems using design and environmental science

DE is a design and environmental consultancy comprised of professional staff with expertise in various aspects of environmental research, policy, analysis, technology development and business strategy. DE's creative team is comprised of graphic, industrial, and spatial designers whose talents are applied to environmental communications projects such as museums, science centres, world expos, web applications, and print graphics. The DE portfolio of international environmental research projects, corporate clients, and creative projects represents a breadth and world-class quality of work. The synergy between design and environmental science gives DE a unique and highly relevant value proposition.

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

LIST OF TERMS AND ABBREVIATIONS

CARDI	Caribbean Agriculture Research and Development Institute
CARIBHYCOS	Caribbean Hydrological Cycle Observation System
CARIWIN	Caribbean Water Initiative
CCCCC	Caribbean Community Climate Change Centre
CIMH	Caribbean Institute for Meteorology and Hydrology
C-READ	Caribbean Regional Environmental and Atmospheric Data Management System
CUAHSI	Consortium of Universities for the Advancement of Hydrologic Science
DE	DE Design + Environment Inc.
DEM	Digital Elevation Model
DEWETRA	Real time data and information system for hydrometeorological risk forecasting, environmental monitoring, and disaster risk management
DMS	Database Management System
ER	Entity Relationship – Diagram
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center River Analysis System
IADB	Inter-American Development Bank
IDF Curves	Intensity Duration Frequency Curves
NWIS	National Water Information System
PPCR	Pilot Project for Climate Resilience
SES	Socio-economic Status
SLR	Sea Level Rise
SPI	Standard Precipitation Index
UML	Unified Modeling Language

1. Introduction

1.1 Executive Summary

The requirements document is the foundation of the design of the C-READ management system. It is based on the input from the stakeholders that was gathered during the Gap Analysis phase and is an anecdotal description of different functions that stakeholders would like to see. It is not a full design document and is intended to be a working document that will foster input that will contribute to the technical design and implementation of the system. Once the requirements document has been finalized the next stages of the design phase will start. The following outlines the design sequence:

A. Requirements Document – explains the list of requirements that are within the scope of the C-READ management system.

B. Use Case Document – takes the requirements outlined in the requirements document and describes them as a set of use cases and possibly some activity diagrams if required.

C. System Architecture Document – This document describes the hardware, software, and physical architecture of the system. It will include a risk assessment and high level cost estimates.

D. Design Document – This document contains the UML (Unified Modeling Language) structural and interaction diagrams that will form the basis of any development work. It will also include an ER (entity relationship) diagram for the database model.

The requirements that have been identified in this stage of the design process are formative. They may be adapted or combined depending on the input of decision makers and stakeholders. They may also be adapted based on technical constraints.

1.2 Objectives of Requirements Document

The main objectives of the requirements document are to succinctly derive what functional requirements the C-READ system is to fulfill for stakeholders in the partner countries and Caribbean-wide. These requirements have been determined by analyzing the responses that were provided to our team from the electronic survey that was conducted as part of the Gap Analysis phase.

These suggested requirements are the foundation of the system design. We aim to use this list, with the input from CCCCC and other stakeholder organizations to refine these requirements into functional design elements. This will require specifying the input and outputs as well as the functionality and user interface design elements.

2. Requirements

2.1 Overview of C-READ 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.

A summary of the required functions was done and translated into a short form technical design format. This can be found in Annex A.

2.2 List of Functional Requirements of C-READ

1. 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 showed 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.

2. 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 CUAHSI or HEC-RAS hydromet modeling 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 Birquet (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 and 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)

3. 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)

4. 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.

5. 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

6. 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

7. Soil Maps

Soil types as well as soil capacity 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)

8. 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

9. 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.

10. 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.

11. 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.

12. 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.

13. 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?

14. 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.

15. Energy and Water Use

The use of water and 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 water and energy use by location. Data can be point data on a map that is selected.

16. Agriculture

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

17. 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

18. 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

19. 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

3. Conclusions

The nineteen requirements listed in this document summarize the desired functionality that sampled stakeholders in the Caribbean have for the C-READ management system. One of the common themes addressed by the majority of stakeholders was the need for data products that showed risk and vulnerability of environmental and social assets to disasters and climate change. These system products need to draw on a variety of data sets. There will be overlap between some of these functional requirements and a number of them may be able to be realized with one system module, for instance. The technical details of how the data products will be created will be elaborated in the next phase.

ANNEX A: Summary of C-READ Requirements

1. Users will be able to visualize meteorological data for each partner country.
   i. The user can visualize this data either geospatially or in graph format
   ii. The user will be able to specify daily, weekly or monthly precipitation levels for visualization
   iii. The user will be able to perform time series analysis on the data with historical meteorological data

   Questions:
   - Will users also be able to filter by specific countries/regions?
   - Forecasting and projections should be addressed for meteorological data and climate models output can be downscaled to present different scenarios – needs clarification

2. Users will be able to visualize hydrological data for each partner country
   i. The user can select to visualize the data statically and dynamically
   ii. The user can select to visualize evaporation/evapotranspiration and salinity and water quality for countries that collect this data (e.g., Jamaica and Dominica)
   iii. The user will be able to visualize areas at risk of flooding along with drainage patterns linked to infrastructure
   iv. The user will be able to visualize soil moisture levels
   v. The user will be able to project water availability based on the balance between water presence and that extracted

   Questions:
   - What input parameters are required from the user for projections and visualizations?
   - Further discussions and consultations will be required to determine the best means of storing, standardizing, modeling and visualizing hydrological data
   - Will we be required to integrate at some level with CAUHSI or HEC-RES hydromet modeling software and/or the HYCOS project?

3. Users will be able to produce drought metrics from both hydrological and meteorological data sets
   i. Users will be able to visualize drought metrics with a map that represents the risk of drought in certain areas/regions in each country
   ii. Users will be able to overlay land use and industrialization on the drought risk visualization
   iii. Users will be able to produce food security report based on drought risk cross-referenced with land use and agricultural activity

   Questions:

- What format is food security output in and how is it calculated? What kind of queries will the system be required to support? Is any further modeling or statistical analysis involved?

4. Users will be able to perform flood risk analysis based on hydrological data for each island and visualize the results
    i. Users can visualize the results with infrastructure data and drainage systems
    ii. Users will be able to specify storm surge and sea-level rise input
    iii. Users will be able to input climate change informed IDF curves (?)

Questions:

- What input parameters will the user be required to perform flood risk analysis?
  - We will need input from water management agencies and others about the accepted methods of determining flood risk.
- Exactly how will this risk be visualized or communicated in the output of the system?
  - We could simplify this to different categories of risk: Extreme, High, Medium, Low, or Negligible. Kind of like the forest fire approach in Canada. We calculate a risk score (probability of event X impact = risk), which then is scaled to a normalized score. Let's say 1 to 100. 75 plus if high, we then show any geographic area with 75% risk or higher as RED – this is shown then on the GIS platform in a raster file with that pixel being RED. That is just my 5-minute analysis of this. Clearly we will need to dig deeper, but having this question established is the first step.
- How will storm-surge, sea-level rise and IDF curves be inputted into the system and/or visualized in the output?
  - We will need input from water resource management agencies in order to determine the appropriate way to assess this and visualize it

5. Users will be able to view ecosystem and biogeoclimatic zone maps for each country
    i. Users will be able to produce biodiversity reports
    ii. Users will be able to identify areas at risks to bio-diversity by cross-referencing against potential existing land-use data

Questions:

- What filters/input will the user be allowed to define for the reports?
- How will users be able to identify the at-risk areas?

6. Users will be able to visualize hurricane and storm surge risk
    i. Users will be able visualize areas at risk of hurricanes and storm-surges on a map using dynamic data drawn from hydrological data and infrastructure

Questions:

- What filters/input will the user be able to enter to produce this visualization?
  - We will need expert input for this function

7. Users will be able to visualize soil types and soil capacity via maps

8. Users will be able to visualize topographical data via digital elevation maps (DEM)

Questions:

- Will topographical data be in DEM format before entering the system? Or will they need to be created from raw lidar data or digitized contour maps?
  - We will need to get an idea of what is currently used. Some responded with a detailed explanation of their topographic data, others not.

9. Users will be able to visualize water quality maps
   i. Users will be able to visualize areas at risk of contamination or salinity

Questions:

- Will this piece be connected to the hydrological module or a separate component completely?
  - We need to establish what connectivity is required between different system requirements

10. Users will be able to visualize coastal zones
    i. Users can visualize inundation, sea level rise and erosion

Questions:

- How is this different from what's covered in Requirement #6?
- What specific other types of data will the user be able to overlay with this data aside from topographical?
- Will any additional modeling or analysis be required of the system?
  - We may be able to combine this with hurricane risks and storm surges, or at least have these modules linked. We will need to see linkages between infrastructure on the coast and natural risks posed to them.

11. Users will be able to view land cover maps
    i. Users will be able to compare against historical land cover type maps

12. Users will be able to view land use maps
    i. Users will be able to compare against historical land use maps

13. Users will be able to visualize ocean monitoring data via maps

14. Users will be able to visualize disease and pest risk

Questions:

- How will risk metrics be calculated visualized?
- How will disease/pests be correlated with climate change?

    - We need to consult with experts on this

15. Users will be able visualize energy and water usage

Questions:

- Will this be a report?
- What inputs are required from the user?

    - Jamaica mentioned they gather this data to assist with environmental management programs. We will consult with them as to how it may be integrated into C-READ.

16. Users will be able manage agricultural data

    i. Users will be able to manage crop, fertilizer user, and pesticide use data
    ii. Users will be able to determine productivity
    iii. Users can cross-reference with hydrological and meteorological data to perform a risk assessment

Questions:

- How will agricultural data be input into the system?
- How will productivity be determined?
- How will risk assessment be performed?

    - We need the input of Ministries of Agriculture as well as UN FAO and CARDI

17. Users will be able to model climate change scenarios

    i. Users will be able to correlate climate change scenarios against infrastructure, land use, etc

Questions:

- How will these climate change scenarios be modeled? What input is required from the user?
- The 'etc' needs clarification
- What will the output be? How will it be visualized (via maps or a report)?
- There seems to be some overlap between this requirement and #6 and #10

    - This is likely a function that is global that is built into previous requirements (6 and 10 and others, perhaps). The output will likely be risk maps based on what we are looking at – eg. Impact of CC on biodiversity (this would be a risk map with biodiversity and CC layers as input). Now the modeling part of this will need attention. We presume we will use existing GCM models that are commonly used in the Caribbean. These may need to be downscaled spatially. The MGI group has experience with this as does 5C and CIMH. We will have to build this out a bit and determine technically how this will work. One main output will be risk maps. There may be some reports.

18. Users will be able to perform community risk assessments

Questions:

- How will this be modeled/visualized?
- What input is required from the user?

  We can use the same as above CC impacts from the models, HOWEVER we will need to include socioeconomic data that is geospatial such that we can see that with a x % increase in temperature, area X in Jamaica will be drought stricken. Within area X there is 25% of that area that has a mean annual income of less than 2,000 USD per year, making them the most vulnerable. That is a crude breakdown. We will consult with 5 C on the actual factors that are most important to incorporate. The "map logic" of this is not that bad though, mostly a series of Boolean functions on different map layers.

19. Users will be able to perform risk assessments to protected areas and parks

Questions:

- How will this be modeled/visualized?
- What input is required from the user?

  - Perhaps similar to pest risks to agriculture, but in this case we focus on parks and protected areas. Eg. If there is a x % increase in temperature, then what impact will this have on protected areas that are subjected to that. We will need to build in what potential vulnerabilities that different protected areas have. We need input from 5C on this.

Assumptions

- The system will have access to the following data:
  - Meteorological (to be standardized as dictated by CIMH) in either raw or temporal averages format
  - Hydrological (standardized – TBD)
  - Infrastructure
  - Topographical

    - Population
    - Drainage
    - Land use (vector polygon)
    - Soil type
    - Soil capacity
    - Water quality
    - Landsat/MODIS/SPOT data for land cover
    - Ocean-related data (sea surface temperature, sea level rise, ocean currents, ocean colour, acidification, reef health / hot spots, bathymetry)
    - Disease and pest
    - Energy and water usage
    - Agricultural
    - Demographic (socio-economic)
    - Boundaries of protected areas and parks (marine and terrestrial)
- All data that requires map visualization must be geolocated
- The system will only fulfill the requirements for those areas that possess the required data

ANNEX B: 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 modeling and projections/Topographic maps
- Flood modeling 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 C: 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
- Modeling of pollution impacts/Ecosystem change given climate change impacts/Vulnerability assessment tools
- Projected maps for risk analysis. /Satellite imagery. /Topographic maps.
- Rainfall data
- River flow/Watershed status/Sensitive and high density habitat areas
- Satellite imagery of the sites /Maps that show wells, water, sensitive areas among other receptors
- Satellite maps
- Trends in rainfall, temperature, evaporation, and stream flow and groundwater/Impact of variation in rainfall, temperature and evaporation on groundwater recharge. /Variation in water resources availability due to climate change
- Urbanization indices on bauxite lands
- What if scenarios? /Impacts of Climate Change on specific economic sector - tourism? /Impacts of Climate Change on specific resource management issues - Fisheries, Water, Mangrove Forests, Coral Reefs

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 modeling 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 D: 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 modeling 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 modeling for ground water and also air dispersion modeling
- 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