
# Integrating Watershed & Coastal Areas Management in the Caribbean Small Island Developing States [IWCAM]

# Capacity Assessment of Geographic Information Systems Capabilities of the Caribbean:

REGIONAL ASSESSMENT REPORT

Prepared by

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**TABLE OF CONTENTS**


| | | Page |
|---|---|---|
| 1. | INTRODUCTION | 1 |
| | Background | 1 |
| | Objectives | 1 |
| | Methodology | 2 |
| | Limitations & Caveats | 2 |
| | Report Outline | 2 |
| 2. | COUNTRY SUMMARIES | 3 |
| | Antigua & Barbuda | 4 |
| | The Bahamas | 6 |
| | Barbados | 8 |
| | Cuba | 9 |
| | Dominica | 11 |
| | The Dominican Republic | 12 |
| | Grenada | 14 |
| | Haiti | 15 |
| | Jamaica | 17 |
| | St. Kitts & Nevis | 19 |
| | St. Lucia | 21 |
| | St. Vincent & the Grenadines | 23 |
| | Trinidad & Tobago | 25 |
| 3. | REGIONAL SYNTHESIS | 27 |
| | Software Infrastructure | 27 |
| | Hardware Infrastructure | 28 |
| | Human Resources | 29 |
| | Data Resources | 29 |
| | Summary Matrix | 31 |
| | Recommendations | 33 |
| 4. | REFERENCES | 35 |
| | APPENDICES | 36 |
| | Appendix A: Inventories of Geographic Data | 36 |
| | A1: Antigua & Barbuda | 36 |
| | A2: The Bahamas | 38 |
| | A3: Barbados | 40 |
| | A4: Cuba | 42 |
| | A5: Dominica | 44 |
| | A6: The Dominican Republic | 46 |

A7: Grenada 48
A8: Haiti 50
A9: Jamaica 52
A10: St. Kitts & Nevis 54
A11: St. Lucia 56
A12: St. Vincent & the Grenadines 58
A13: Trinidad & Tobago 60

Appendix B: List of Institutions Consulted 66

Appendix C: Survey Questionnaire 68

LIST OF ACRONYMS

| | |
|---|---|
| APUA | Antigua Public Utilities Authority |
| CARILEC | Caribbean Association of Electric Utilities |
| CATHALAC | Water Center for the Humid Tropics of Latin America & the Caribbean |
| CBD | United Nations Convention on Biological Diversity |
| CEHI | Caribbean Environmental Health Institute |
| CIGEA | Environmental Education, Management and Information Center, Cuba |
| CNIGS | National Center for Geospatial Information, Haiti |
| COTS | Commercial off the Shelf Software |
| CPACC | Caribbean Planning for Adaptation to Climate Change Project |
| CZMU | Coastal Zone Management Unit |
| DCU | Development Control Unit, Antigua & Barbuda |
| ESRI | Environmental Systems Research Institute, Inc |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GPS | Global Positioning Systems |
| GRENLEC | Grenada Electricity Services, Ltd |
| ICT | Information & Communication Technology |
| IT | Information Technology |
| IWCAM | Integrating Watershed & Coastal Areas Management in Caribbean Small Island Developing States Project |
| LAN | Local Area Network |
| LUCELEC | St. Lucia Electricity Services, Ltd. |
| NEMA | National Emergency Management Agency, Trinidad & Tobago |
| NODS | National Office of Disaster Services, Antigua & Barbuda |
| OAS | Organization of American States |
| OGC | Open Geospatial Standards |
| ONEV | National Environment Observatory, Haiti |
| PC | Participating Country of the IWCAM Project |
| PGDM | Post-Georges Disaster Mitigation Project, Antigua & Barbuda |
| RS | Remote Sensing |
| SDE | Spatial Data Engine |
| SEMARN | Secretariat on the Environment & Natural Resources, Dominican Republic |
| SERVIR | Mesoamerican Regional Visualization & Monitoring System |
| UNCCD | United Nations Convention on Land Degradation |
| UNDP | United Nations Development Programme |
| UNEP CAR/RCU | Caribbean Regional Coordinating Unit of the United Nations Environmental Programme |
| USAID | United States Agency for International Development |
| UWI | University of the West Indies |
| VINLEC | St. Vincent Electricity Services, Ltd. |
| WASA | Water & Sewage Authority, Trinidad & Tobago |

# 1. INTRODUCTION

## *Background*

The Caribbean Environmental Health Institute (CEHI) and the Regional Coordination Unit of the Caribbean Environment Programme of the United Nations Environment Programme (UNEP-CAR/RCU) are co-executing a regional initiative known as the Project on Integrating Watershed and Coastal Areas Management in Caribbean Small Island Developing States (IWCAM). The overall objective of the project is to strengthen the commitment and capacity of the participating countries to implement an integrated approach to the management of watersheds and coastal areas.

The project recognizes the important role of Geographic Information Systems (GIS) technology as a tool for integrated data analysis and management and is seeking to incorporate the use of GIS in various components of the project. It aims also to expand and improve GIS capacity and use in participating countries. Mindful of the complexity and cost associated with effective and efficient use of GIS, the project has commissioned the conduct of a detailed capacity needs assessment which will inform the process. The Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) was been contracted to undertake the assessment.

## *Objectives of the Study*

The capacity needs assessment will examine the functions, procedures, products, data, tools and human resources available in each agency and use this information to determine GIS and Information and Communications Technology (ICT) requirements in relation to the performance of the functions of the agency. The assessment will provide the basis for the conceptual design of a road map to guide the effective development and use of GIS for IWCAM in the wider Caribbean.

Within the framework of this assessment, this initiative has had certain specific objectives:

- Assess hardware and software needs of PCs in relation to the generation, maintenance, analysis and presentation of relevant GIS information
- Evaluate relevant information sharing protocols in PCs;
- Assess the quantity and quality of existing data related to GIS in PCs and estimate the average cost of acquiring the necessary data sets (whether available or missing) in each PC;
- Conduct information audit to include the evaluation of relevant metadata standards;
- Assess relevant institutional infrastructure/administrative protocols in PCs with respect to the generation, processing/analysis, presentation, sharing and dissemination of data and information for watershed and coastal areas monitoring and management with particular reference to GIS data;
- Assess relevant human resource capacities and training needs (in relation to basic usage of GIS platforms and analytical applications in support of technical outputs) related to GIS in PCs;

- Identify, evaluate and assess the challenges, constraints and problems with respect to the use of GIS as a management tool in PCs
- Identify, evaluate and assess the challenges, constraints and problems for mainstreaming the use of GIS as a tool in watershed and coastal areas monitoring and management in PCs

***Methodology of the Study***

The study has been conducted in four phases. In Phase I, a survey questionnaire (see **Appendix C**) was used to gather information on the status of the use of spatial data and the potential for spatial analysis and modeling. In Phase II, interviews and site visits were conducted with key personnel of agencies with mandates that have an impact upon watershed and coastal area management as well as with external agencies whose activities have an impact on Information Technology (IT) operations of the key agencies (see **Appendix B** for agencies consulted). In Phase III (the current phase), a draft report of the study will be presented for feedback. Phase IV will entail the preparation and submission of the final assessment report.

As noted, the IWCAM Project's objective in conducting this assessment has been to evaluate capacity for the application of GIS as a tool for management, planning and monitoring of the environment. Exhaustive survey questionnaires were developed, producing much input material per country. However, as the main focus of the project is regional, issues are addressed as a whole, seeking to synthesize those cross-cutting issues affecting a substantial proportion of the Project's participating countries. In follow-up to the desktop survey, this report relies not only on the surveys carried out, but also on other existing assessments (although in many cases such assessments are outdated). With regard to the definition of 'capacity' in GIS, three main principles are examined: (i) human resources, (ii) data and informational resources, and (iii) hardware and software resources

***Limitations & Caveats***

It should be noted that while, of necessity, each country possesses a complexity that cannot be adequately represented in a synthesis report such as this, focus of this assessment is actually on assessing what needs are, at the country and at the regional level. In seeking to provide a regional perspective on GIS implementation in the Caribbean, only summaries of each country's situation are provided here. Furthermore, it should be emphasized that what is presented in this regional assessment report pertains to the situation within the region at the time the assessment was conducted (i.e. in early to mid - 2007). It should, for instance, be acknowledged that the institutions listed here and their capacities will change with time. As an assessment, this report merely presents a snapshot in time of the implementation of geographic information technologies across the Caribbean.

***Report Outline***

The following parts of this report are divided into three main sections. Firstly, syntheses are presented of status of national GIS capacities within the thirteen respective IWCAM participating countries. Secondly, a regional summary of the most outstanding issues is

presented, with a particular focus on needs that exist with regard to expanding the application of GIS as a management tool across the Caribbean. Lastly, in anticipation of the Road Map document that is going to be prepared, some ideas are presented on exactly how the application of GIS in the Caribbean might be strengthened.

## 2. COUNTRY SUMMARIES

The following describes overall geographic information systems (GIS) capacities in countries. Assessments are presented in terms of the following:

- *Overall Focus & Current GIS Activities*
- *Data Resources*
- *Information Technology Resources*
- *Summary*

That is, for each of the countries, an overview is presented on how GIS is generally being applied, as well as relevant ongoing activities that were divulged during the survey process. As this assessment focuses on GIS capacity particularly in terms of data resources, human resources, hardware and software, these resources are also detailed. Finally, the overall situation in the country is briefly summarized with some reflections on the way forward for GIS implementation.

The countries examined here include all of the IWCAM Project's participating countries:

1. Antigua & Barbuda
2. The Bahamas
3. Barbados
4. Cuba
5. Dominica
6. The Dominican Republic
7. Grenada
8. Haiti
9. Jamaica
10. St. Kitts & Nevis
11. St. Lucia
12. St. Vincent & the Grenadines
13. Trinidad & Tobago

## ANTIGUA & BARBUDA

Antigua is the largest of the Leeward Islands with an area of 280 sq. km. It differs from neighboring islands in that it does not have a mountainous landscape and lush green vegetation. The island is relatively flat with approximately 70% of the island less than 30m above sea level. The coastline is undulating and characterized by bays, rocky headlands and a number of coral reefs. World Bank estimates place the population at approximately 80,000 people at mid-year 2005. Roughly 60% of the population is concentrated in and around the capital city of St. John' and along All Saints Road which connects St. John's to Falmouth. Most of the remaining population is distributed in small villages strung out along other roads.

A central feature of the economic development of Antigua is its transformation over the last two decades from an agricultural to a service economy. Agriculture has declined in relative importance and in 1994 agriculture accounted for only 4 % of GDP compared with 20% in 1960. The service, construction and transportation sectors have increased their share of GDP because of "spin-off" from expansion in the tourism sector, which is one of the major sectors in the economy.

### *Summary of Current GIS Capacity*

In Antigua & Barbuda, the overall focus of GIS activity is on map production. The limited spatial analysis and report generation that are conducted are directly related to the availability of GIS resources. The country's **Development Control Authority (DCA)** and the **National Office of Disaster Services (NODS)** have made some advances in the use of GIS for physical planning and hazard vulnerability assessment. Additionally, GIS capacity is also present at the **Antigua Public Utilities Authority (APUA)** and the **Survey Division of the Ministry of Agriculture, Lands and Fisheries.** Otherwise, GIS capacity in Antigua & Barbuda is very limited. Historically, GIS development in the nation has been driven by projects such as CPACC and PGDM.

Currently, the two main agencies implementing GIS in Antigua & Barbuda are the **Antigua Public Utilities Authority (APUA)** and the **Survey Division of the Ministry of Agriculture, Lands and Fisheries**. As noted, GIS is also employed by the NODS and the DCA. Both of these agencies have adequate hardware and software installed and a complement of staff trained in a wide range of IT and GIS skills. In other agencies there is a severe need for hardware, software, qualified staff and training. Survey information suggests that there is very limited sharing of data and GIS resources between agencies. As a result, agencies are isolated and unable to benefit from each other.

Where the Development Control Authority was also once the home to a robust GIS unit, its functions are also worth exploring. The DCA is responsible for the planning and management of physical development. It performs the following primary functions:

- Executing activities related to physical planning, and
- Development control

In order to perform its functions and activities, the Department relies on the following datasets:

- Topographic data
- Thematic data
- Aerial photographs and
- Satellite Imagery

The DCA had a robust GIS unit that was disbanded and this unit is currently being re-assembled. The Department is in the process of re-building its catalogue of thematic maps that included physical, hazard and anthropogenic features. There are a number of issues with GIS data. These issues include problems with data currency, access, inconsistency, accuracy and a lack of spatial dimension. There are issues with regards to sharing data with other agencies, the adequacy of storage devices and fragmented data. There is also a lack of historical data, metadata, data dictionaries and official sanctioning of data. The Department produces maps for government agencies. DCA facilitates NODS and Agricultural Departments in the plotting of maps. No fees or charges are applied to data dissemination.

Compared to other IWCAM participating countries, the available data on Antigua & Barbuda is fairly current. **Table 1** below illustrates the characteristics of some of that spatial data currently available for Antigua. **Appendix A1** contains a more detailed inventory of data available at a national level for Antigua & Barbuda. Complete coverage is available for the island. Topographic maps are available for 1970 and cadastral for 2005 at very large scales. Aerial surveys were conducted in 1970, and more recently in 2005. Satellite imagery is available for 1989 and 2001. As such, mapping and imagery is, by and large, available at the scale required to support GIS activities and development.

**Table 1: Selected Spatial Data Available for Antigua & Barbuda**

| Year | Scale / Resolution | Title | Source |
|---|---|---|---|
| 1970 | Not stated | Aerial photographs | |
| 1970 | 1:2,500<br>1:5,000 | Topographic sheets | UK Directorate of Overseas Surveys |
| 1980 | 1:50,000 | Topographic sheets | US Southern Command |
| 1989 | 30 meters | LANDSAT | NASA / USGS |
| 2001 | 1 meter | IKONOS | GeoEye, formerly Space Imaging |
| 2005 | 1:1,250<br>1:2,500<br>1:5,000 | Cadastral data | Surveys Division |
| 2005 | 10 cm | Aerial photographs | |
| 2006 | Not stated | Hydrographic | Map Tech |

Overall, the island of Antigua is just beginning the development of GIS. The majority of existing GIS software, hardware and trained staff are concentrated in the Surveys Division and APUA. The operating systems are Microsoft Windows-based. ArcGIS and ArcView are the GIS software used. The only database management software indicated was MS Access and its application is very limited. There is a general absence of IT, GIS and data standards and policies. Agencies indicated facing the full range of issues and challenges with regards to GIS and data.

In summary, Antigua & Barbuda is a nation in which GIS finds limited application but nonetheless one which does possess potential for greater application. Interviews did indicate that senior managers of the various relevant government departments were aware of the potential applications of GIS. Overall, there are particular limitations with respect to hardware, software, and human resources. Because of the nation's size, the economies of scale concept could be effected in Antigua & Barbuda, with respect to the development of an integrated national GIS / ICT plan.

## THE BAHAMAS

The islands of the Commonwealth of the Bahamas constitute one of the three areas that the Caribbean is typically divided into, the others being the Greater Antilles and the Lesser Antilles. The Bahamas is located in the northeastern part of the Caribbean Sea. The nation forms an archipelago, with its approximate area of 13,878 square kilometers (5,358 square miles) spread over roughly two thousand cays and seven hundred islands. In mid-2004, World Bank estimates placed the population of the nation at 320,000 inhabitants, nearly 70% of whom live in the capital, Nassau.

### *Summary of Current GIS Capacity*

The Bahamas appears to be relatively advanced in its application of geographic information systems and related technologies. Because of the Bahamas' particular vulnerability to tropical storms and hurricanes, agencies interviewed in the context of this assessment indicated applying related technologies to the monitoring of potentially harmful weather systems. Additionally, in the Bahamas, GIS is applied to the management of data and information on the general state of the environment.

It is notable that, as in the case of Jamaica (where GIS implementation is also considered relatively advanced), the Bahamas' national framework for GIS implementation includes the introduction of GIS to various levels of the educational system. Perhaps related to the country's relatively large size, there are a number of agencies implementing GIS in the Bahamas, including:

- The Bahamas Environment, Science and Technology (BEST) Commission
- Bahamas National GIS Centre
- Disaster Preparedness Office
- Department of Land and Surveys
- Department of Meteorology
- Department of Physical Planning, Ministry of Public Works
- Ministry of Agriculture and Fisheries
- Department of Fisheries, Nassau
- Department of Statistics

As in only a small number of countries in the Caribbean, the Bahamas is actually served by a national framework for GIS implementation, finding expression in the establishment of a **Bahamas National GIS Centre**.

That Centre has its origins in the early 1990s when a number of the utility companies decided to pool their resources to foment GIS implementation. In the late 1990s, the 'Bahamas National GIS Project' received further funding from the Inter-American Development Bank and the Japanese Government. The Centre, however, was officially inaugurated in March 2004 in the Office of the Prime Minister. The Centre's mandate is "to serve as the government's technical focal point for the collection and management of geo-spatial data" on the nation, and "to provide training and technical support to governmental agencies. The Centre's Mission is to promote, educate, coordinate and advance the practical and efficient use of GIS technology in the Bahamas."

From the interviews, it seems that one of the problems with spatial data resources for the Bahamas is that caused by the fact that the nation is spread across roughly 700 islands (although the majority of these are uninhabited). As a part of the overall Bahamas Environment, Science and Technology Commission (BEST Commission), the Department of Meteorology, for instance, indicated the need for the following GIS-related applications:

- Air Pollution tracking and modeling
- Flood Management
- Hazard Risks Analysis
- Non-point pollution Analysis
- Hydrological Modeling

In terms of data resources, while it was evident that, as in other Caribbean countries, remote sensing imagery, aerial photographs, topographic maps, thematic maps, survey plans, and drawings are available and in use, the availability of updated data was cited as a problem. In terms of how available information is integrated into decision-making, **Table 2** below indicates some of the information products provided by the Bahamas Meteorology Department to the general public, for instance, while **Appendix A2** includes a more detailed listing of available data for the Bahamas.

**Table 2: Types of Information Products developed by the Bahamas Meteorology Department**

| Information Product | Frequency of generation | Method of access | Dissemination fee or charges | Format of the Product | Current and Potential Users |
|---|---|---|---|---|---|
| Forecasts | 4 per day | | None | Digital | Public |
| Weather Summary | Monthly | | None | Hardcopy | Public |

While GIS is not used as a management tool per se within the Meteorology Department, as in a number of other departments around the Caribbean, work has been initiated into integrating such data into a 'GIS environment.' As such an overall data / report digitization process has recently begun since a large amount of data has been collected since 1920 to include rainfall information since 1918. Most of the data for 26 islands is reflected on spreadsheets and in books. It was pointed out that data is missing throughout World War II. There are plans to pursue aggressive digitization of this information. Significantly, the Department indicated plans to mainstream GIS

and utilize in their main activities of weather observation and forecasting. However, the Department does not have any budget for GIS and has not developed any applications.

Operating systems are, for the most part, Microsoft Windows-based. The main GIS software applications being used include ESRI's ArcView 3.x and ArcGIS platforms. Database management software was largely limited to MS Access, as well as MS Excel for management of tabular data.

Where a proliferation of institutions employing GIS in a country generally seems to indicate an advanced state of GIS capacity, this is true of the Bahamas, where there are several institutions noted which are implementing the technology, and a number of others which have plans to mainstream the technology into their operations. Additionally, as in only a few Caribbean nations, the Bahamas possesses a national coordinating entity for GIS activities in the form of the Bahamas National GIS Centre. It is therefore recommended that future IWCAM interventions in the area of GIS interact with the Centre.

## BARBADOS

The island of Barbados is one of the Lesser Antilles and is the easternmost Caribbean island. The nation is a mere 430 square kilometers (166 square miles), and with a population estimated in mid-2005 by World Bank at 270,000 inhabitants, roughly 53% of which inhabit urban areas. This makes Barbados one of the most densely populated nations in the world. The island is relatively flat, with its highest point being Mount Hillaby in the center of the country. Barbados is divided into eleven (11) administrative parishes, with its capital at Bridgetown on the southwestern coast of the island.

### *Summary of Current GIS Capacity*

Barbados has traditionally been recognized as one of the more advanced in its application of GIS technology. This has applied overall to the level of training as regards the available human resources, the data that is readily available, and the tools that are likewise available for the management and exploitation of the available data. Nonetheless as is noted later, apparently lacking in Barbados is an overarching framework for GIS implementation as present in nations such as Jamaica or the Bahamas.

As with other countries in the region that are assessed as having fairly advanced GIS capabilities, within Barbados there are a number of institutions which are applying GIS. Institutions applying GIS include:

- Barbados Water Authority
- Central Emergency Response Organization
- Coastal Zone Management Unit
- Drainage Unit of the Ministry of Public Works
- Environmental Division, Ministry of Health
- Land & Surveys Department

- Statistics Department

However, within the context of the IWCAM Project's objectives for supporting the application of GIS as a management tool in the context of coastal and watershed management, the major institution in Barbados is the **Coastal Zone Management Unit**.

In terms of institutions consulted, it was indicated that GIS is used as a management tool for all functions, with senior executives having been introduced to GIS and consulting the technology to support their decisions. The CZM Unit in particular indicated using GIS to produce maps but nonetheless requiring resources to obtain more personnel, and access to training to adequately mainstream GIS and update the software. That lack of human resources (both people and training) has limited the applications to which GIS has been applied in Barbados.

As indicated in **Table 3** below, data resources are fairly updated for Barbados, with fairly recent and almost complete coverage of the island by aerial photography and high resolution satellite imagery. **Appendix A3** also indicates specific data required but not available.

**Table 3: Selected Spatial Data Available for Barbados**

| IMAGERY | Scale | Year | Area covered | Source |
|---|---|---|---|---|
| Aerial Photography | 1:10,000 | 2000 | West and south coast | Terra Remote Sensing Inc., Canada |
| Aerial Photography | 1:10,000 | 1998 | Northeast and southeast coast | NERC UK |
| Quickbird satellite imagery | 0.6m | 2004 | Northern part of country | Digital Globe |

Opadeyi et al (2003) had noted that "the absence of a visible national GIS database is still a management challenge along with the absence of data dissemination policy." There has been no indication that this lack of a national GIS database, for instance, has been substantively addressed. However, as a country in which GIS has proliferated to a number of institutions, the state of GIS implementation in Barbados must nonetheless be considered relatively advanced where the Caribbean is concerned. As indicated in the interviews conducted, and as in a number of other countries, in Barbados there is a desire for further training as involves the use of GIS technology for environmental management.

## CUBA

Located in the northwestern Caribbean Sea, the Republic of Cuba consists of the island of Cuba – largest island of the Greater Antilles and in the Caribbean – and a number of other smaller islands, including the Isle of Youth. The nation's total area is roughly 110,861 square kilometers (42,803 square miles). According to the World Bank, 2005 mid-year estimates placed the population at 11.3 million inhabitants, of which approximately 76% was urbanized. The nation is divided into fourteen provinces and the special municipality of the Isle of Youth. Approximately 2.3 million Cubans inhabit the capital of Havana.

### *Summary of Current GIS Capacity*

As can be expected for a country of its size, in Cuba there is a diversity of institutions utilizing GIS in a variety of applications. In Cuba, there are institutions such as Aguas de la Habana which utilize GIS in the management of water resources, to others like Plan Maestro which utilize GIS for management of historical landmarks. Cuba's Environmental Education, Management and Information Center (CIGEA, in Spanish) is a major user of GIS, although a number of other organizations also have substantial expertise with GIS.

Cuba stood out as one of the few nations in which the interviews revealed problems with Internet bandwidth. The organizations consulted indicated having access to very limited Internet bandwidth, which affected their operations and ability to connect to the rest of the region.

In terms of hardware resources, while the variety of these organizations, for instance, possessed the use of servers for storing their information, such servers were not always physically located in these institutions' offices. Additionally, there was an overall lack of software capacity for satellite image processing, which was in turn viewed as a need by the persons interviewed.

**Table 4** below provides a sampling of some of the spatial data available for Cuba. A much more extensive list is provided in **Appendix A4**. In terms of the spatial data resources which exist for Cuba, it is evident that for the most part there is a great variety of data available for the nation of Cuba. Additionally, the majority of datasets exist in digital as contrasted with analog formats.

**Table 4: Selected Spatial Data Available for Cuba**

| Types of Data | Map Scale | Map Source | Year of Production | Last Updated |
|---|---|---|---|---|
| Base map | 1:500 | GeoCuba | 2004 | 2007 |
| Land parcels | 1:500 | Plan Maestro | 2006 | 2006 |

In Cuba, databases are generally updated annually, but as in a number of the other Caribbean countries, database management is not generally done using specialized software. This data structure problem is complicated by an overall accompanying lack of metadata development.

In terms of overall human resources, for a variety of reasons, professionals working in GIS in Cuba are multidisciplinary. This lack of dedication to GIS has obvious adverse consequences in terms of the level of skill that can be honed in the use of the tool. Respondents interviewed indicated a need for training in the use of Global Positioning Systems as well as in remote sensing.

Financial resources are particularly absent for the acquisition of GIS software, and this is further complicated by international trade restrictions which limit Cuba's access to American commercial off-the-shelf GIS software. Hence, open source GIS solutions have proliferated in Cuba.

Overall, in terms of the available human and data resources, and software and hardware infrastructure, Cuba's overall capacity in GIS can be considered suitably advanced when compounding factors are considered. The institutions consulted indicated a strong need for capacity-building, particularly where it comes to human resources. Specifically, capacities in

remote sensing and Global Positioning Systems (GPS) should be addressed, as well as GIS applications for environmental monitoring. Interest was also expressed in building capacity in the use of web mapping applications.

## DOMINICA

Dominica, a small island developing state, is situated at approximately 15º 25'N and 61º 20'W, between Martinique to the south and Guadeloupe to the north, in the Eastern Caribbean chain of islands. With a total area of 291.1 square miles (754km$^{2)}$, this volcanic island is the most mountainous and rugged island in the Lesser Antilles. Two of the highest peaks in the Lesser Antilles are found in Dominica, namely, Morne Diablotins 4,381ft (1,447m), and Morne Trois Pitons 4,221ft (1,394m). The island has one of the highest drainage densities in the world, having some 365 rivers flowing in deep, narrow valleys over short distances to the sea. Their significant hydroelectric potential contributes as much as 56% of the island's electricity.

The population of Dominica, estimated at 70,000 (2003), lives mainly on a narrow coastal plain. Twenty-eight (28) per cent of its people are under 15 years old and the economically active population makes up 64% of the population. Its per capita Gross Domestic Product (GDP) is an estimated US$5,400, with the sectors of agriculture, industry and services contributing 18%, 24% and 58% respectively to the GDP (2002).

### *Summary of Current GIS Capacity*

In Dominica, the importance of GIS has been recognized and it is currently being used as a tool. Maps and reports are being produced and used to support decision-making to some extent. The most urgent needs appear to be technical support, hardware procurement and software maintenance. There is a need for training of staff in all GIS related topics, particularly data conversion. The availability of trained staff would enable the expanded use of GIS. There is a need to budget for the development of GIS and to produce policies and standards to guide this development. The Physical Planning Division and the Lands and Surveys Division are leading agencies for GIS development in Dominica.

**Appendix A4** considers the spatial data required for each agency interviewed in Dominica. From this list, it is evident that the agencies need to have a comprehensive spatial database of physical, hazard and anthropogenic features. The common requirements of the Divisions are an indication that efficiencies could be gained by sharing of datasets.

The Physical Planning Division has some of the required datasets in digital and hard copy formats for Dominica. The Division wishes to have an updated dataset of all data related to physical and anthropogenic features, and a hazard inventory in one common projection and coordinate system to facilitate the development of applications.

The Lands and Surveys Division has a fairly comprehensive digital dataset on physical and anthropogenic features, yet they possess many data quality issues. Required datasets are hydrogeology, census districts, environmentally sensitive areas and electricity supply lines.

**Table 5** below shows the characteristics of the spatial data currently available for Dominica, dating from 1989 to the present (with more detail presented in **Appendix A4**).

**Table 5: Selected Spatial Data Available for Dominica**

| Year | Scale / Resolution | Title | Source |
|---|---|---|---|
| 1989 | 1:2,500<br>1:5,000<br>1:10,000<br>1:25,000<br>1:50,000 | Topographic sheets | UK Directorate of Overseas Surveys |
| 2007 | 1:2,400 | Survey plans | Lands and Surveys |
| Unknown | 1:2,500 | Cadastral | Lands and Surveys |
| 1992 | 1:10,000 | Aerial photographs | North West Geomatics Ltd. |
| 2000 | 30m | LandSat satellite imagery | NASA / USGS |

The agencies surveyed in Dominica have hardware and software but they require spatial data in the same projection and coordinate system. The acquisition of a large format scanner by the Lands and Surveys Division would assist in the production of such data. The only database management software used is Ms Access and this use is limited. As would be expected there are significant problems and issues with regards to the use of database software and an absence of database standards, policies and procedures. There is a need for the implementation of database management software to make better use of the data the agencies already possess. This will require training and technical support.

In Dominica, in terms of overall planning for GIS for instance, the Lands and Surveys Division has a GIS / ICT plan. Mainstreaming GIS into the roles and responsibilities of the Divisions could be done through the development of a data automation plan, improvement in database management, training of staff, procuring relevant equipment and establishing data standards and policies.

## THE DOMINICAN REPUBLIC

The Dominican Republic shares the Caribbean's second largest island of Hispaniola along with the Republic of Haiti. The Dominican Republic occupies approximately 48,442 square kilometers (18,810 square miles) or approximately two-thirds of Hispaniola, on the eastern portion of the island. According to World Bank mid-year estimates, in 2005 the Dominican Republic's population stood at approximately 8.9 million inhabitants. Sixty percent of the population was likewise estimated to inhabit urban areas. The nation is divided into thirty-one (31) provinces, with the capital of Santo Domingo located in its own province, the Distrito Nacional ("National District"), with approximately 2.3 million people inhabiting the capital in 2006.

### *Summary of Current GIS Capacity*

In the Dominican Republic, the major institution implementing GIS in an environmental management context is the Secretariat of the Environment & Natural Resources (SEMARN, in

Spanish). As can be found in a number of environmental ministries across the region, the use of GIS is not centralized to a single unit or department within SEMARN. A number of SEMARN's divisions use GIS to some extent, and the utility of the tool is at least well recognized across a dispersed audience. Divisions within SEMARN utilizing GIS include the Environmental Information Division, the Environmental Quality Division, and the Climate Change office. Evidence suggests that while GIS capacity should not necessarily be fully centralized within SEMARN, that GIS implementation might nonetheless benefit from more central operations (i.e. it was clearer that certain divisions were making more use of the technology than others). It should be noted that the use of GIS in a variety of divisions within a single ministry goes against the norm but is nonetheless promising for the application of the technology.

**Table 6** below is a sample of spatial data available for the Dominican Republic, with an elaborated version in **Appendix A6**. These tables indicate significant data needs. For instance, the nation's current land use data, while at a fairly detailed scale of 1:25,000 was updated over ten years ago, making such data inadequate for assessment of the current state of the environment. Likewise, **Appendix A6** indicates the absence of a number of key datasets. Full coverage of these datasets of the entire country is complicated by the fact that after Cuba, the Dominican Republic is the second largest nation (area-wise) in the Caribbean.

**Table 6: Selected Spatial Data Available for the Dominican Republic**

| Types of Data | Map Scale | Map Source | Year of Production | Last Updated |
|---|---|---|---|---|
| Land Use | 1:25,000 | 1984 aerial photos | 1986 | 1996 |
| Watershed boundaries | 1:50,000 | Cartographic institute | 1989 | 2001 |
| Census divisions (analog) | 1:20,000 | National Statistical Office | 1992 | 2002 |

One of the limitations expressed, for instance, was the regular occurrence of electricity blackouts which limit ability to work uninterrupted.

As noted, GIS is used in a variety of institutions within the Dominican Republic. GIS is fairly well recognized and widely used. While much of the country's environmental information exists digitally in GIS format, lacking is suitable infrastructure for sharing of information between institutions, as well as a well-defined data structure. Database management is accomplished using Microsoft Access. Metadata does not exist for a large amount of the available spatial data.

As in many of the other countries surveyed, there has generally been a lack of funding specifically for the development / application of GIS. As such, the application of the tool has generally been project-driven.

In terms of human capacity, there is a need for overall training in technologies related to GIS, but there is (as in the majority of other countries in the Caribbean) a lack of funding for development of the tool. Specific areas of need include database management, remote sensing and

development of web mapping applications. Interest was also expressed in professional development for strengthening of human capacity in the use of GIS technology.

## GRENADA

Grenada, with its dependency of Carriacou and Petit Martinique, is a small island developing state, situated at approximately 12º 07'N, 61º 40'W in the Eastern Caribbean chain of islands. With a total area of approximately 344km$^2$ (132.8 square miles), Grenada is the most southerly of the volcanic islands in the Lesser Antilles. The highest peak in the island is the volcanic centre of Mount St. Catherine standing at 910 meters (2,757 feet).

The population of Grenada, including Carriacou and Petite Martinique, is estimated at 102,632 from the 2001census. 35.1% of its people are under 15 years old and the economically active population makes up 61.3% of the population. Its per capita GDP is an estimated US $5,000 (2002), with the sectors of agriculture, industry and services contributing 7.7%, 23.9% and 68.4% (2000) respectively to the Gross Domestic Product. (Source of statistics: Central Intelligence Agency (CIA) Fact Book, 2003 found at: http://www.cia.gov/cia/publications/factbook/geos/gj.html.)

### *Summary of Current GIS Capacity*

In Grenada, though the importance of GIS has been recognized, it is currently not being used to any great extent in the agencies surveyed. Maps and reports are being produced and used to support decision-making. The most urgent needs appear to be technical support, hardware and software maintenance. There is a need for training of staff in all GIS related topics. The availability of trained staff would enable the expanded use of GIS in the agencies. There is a need to budget for the development of GIS and produce policies and standards to guide this development. The Land Use Division appears to be a major source of spatial data on the country.

**Appendix A7** considers the spatial data required for each agency interviewed in Grenada. From this list, it is evident that the agencies need to have a comprehensive spatial database of physical, hazard-related and anthropogenic features.

The Land Use Division appears to be a major source of spatial data on the country while GRENLEC has some data but requires data on census districts and administrative/political boundaries. As no information on digital data was available from the Physical Planning Unit, the data required is unknown.

The main data source is from topographic maps of 1982, though the Land Use Division has access to aerial photographs of 1992 and 2005 IKONOS satellite imagery, which covers Grenada.

**Table 7** shows the characteristics of the spatial data currently available for Grenada.

**Table 7: Selected Spatial Data Available for Grenada**

| Year | Scale / Resolution | Title | Source |
|---|---|---|---|
| 1982 | 1:25,000 | Topographic | Directorate of Overseas Surveys,(DOS),UK |
| 1992 | 1:13,000 | Aerial photographs | Information not available |
| 2005 | 1m | Satellite imagery | IKONOS |

Due to the low level of completion of the questionnaire, it is difficult to ascertain the needs of the agencies surveyed. The Land Use Division needs data of higher quality and a budget for GIS hardware, software upgrades and training. The only database management software used is *Ms Access.* As would be expected there are significant problems and issues with regards to the use of database software and an absence of database standards, policies and procedures. There is a need for the implementation of database management software. This will require training and technical support.

## HAITI

The Republic of Haiti occupies the western third of Hispaniola, sharing the second largest Caribbean island with the Dominican Republic. The Republic also includes a number of smaller islands adjacent to Hispaniola. Haiti's terrain is extremely rugged, with the nation occupying approximately 27,750 square kilometers (10,714 square miles). Haiti is divided into ten (10) administrative Departments. Mid-year estimates for 2005 from the World Bank place Haiti's population at approximately 8.5 million inhabitants, with 39% inhabiting urban areas, and roughly 1.2 million people inhabiting the capital of Port-au-Prince.

### *Summary of Current GIS Capacity*

Currently in Haiti, a great deal of effort is being invested in the fine-scale mapping of the entire nation. The nation is being re-mapped at the detailed scale of 1:20,000 and finer, in an effort to update existing topographic base data from the late 1970s when the second aerial survey of the country had been undertaken. In addition to this fine scale re-mapping of the country, which appears to be overall unique in the Caribbean, a relevant GIS initiative that has been planned is the development of a National Environmental Observatory (ONEV, in French) in conjunction between Haiti's national GIS center and the Ministry of the Environment. Representatives from the Ministry of the Environment indicated that the goal of the National Environment Observatory will be to make use of GIS and remote sensing in particular to monitor the state of Haiti's environment, providing data which can also meet the needs of international environmental conventions such as the United Nations' Conventions on Biological Diversity (CBD) and Land Degradation (UNCCD).

While it is noted that in a number of Caribbean countries, GIS activities are project-based (i.e. projects drive priorities), it seems that in the case of Haiti, while GIS activities are financed substantially with external project resources, because of the existence of a national framework, such funding is being channeled according to already-established national priorities for GIS.

In Haiti, as in only a few other of the countries evaluated, there exists a central entity with responsibility for coordinating the nation's activities in the area of GIS. In 2006, political support led to the passing of legislation for the creation of the National Center for Geospatial Information (CNIGS, in French). The predecessor to the CNIGS was the Remote Sensing and GIS Unit (UTSIG, in French) which had been established in 1996 in the Ministry of Planning and Foreign Affairs.

The CNIGS has a legally established mandate for coordinating the GIS activities across Haiti. It collaborates with the few other national entities which have GIS capacity. For instance, and as noted earlier, the CNIGS will be collaborating with Haiti's Ministry of the Environment for the development of the National Environment Observatory which will make much use of remote sensing for the regular monitoring of environmental changes. For their part, representatives from the Ministry of the Environment indicated that the Ministry did not itself yet have GIS capacity but would be working with the CNIGS to train at least one technician, who would be dedicated to the ONEV.

As indicated in **Table 8** below, it is evident that the nation of Haiti is well-served by strong data resources. The island has been mapped in high resolution aerial photography and satellite imagery fairly recently. **Appendix A8** also shows that a great deal of data is available for Haiti at suitable scales.

**Table 8: Selected Spatial Data Available for Haiti**

| Year | Scale / Resolution | Title | Source |
|---|---|---|---|
| 1978 | 1:20,000 | Aerial photographs | N / A (only available in analog format) |
| 2002 | 1:20,000 | Aerial photographs | N / A |
| 1978 | 1:100,000 | Topographic maps | N / A |
| 2000+ | 1m | Satellite imagery | IKONOS (partial coverage) |
| N / A | 30m | Satellite imagery | LandSat (partial coverage) |
| 1998 | 10m | Satellite imagery | SPOT |

Because of the implementation of a national plan for GIS, which had led to the acquisition of a large quantity of data at a fine scale, Haiti was one of the few countries in this assessment that did not indicate the need for data as one of their more significant needs. In fact, it is apparent that Haiti has the necessary inputs for developing or acquiring its own data rather than relying on external sources. This includes, for instance, staff expertise in areas such as photogrammetry and digital image processing.

In addition to substantial project support for GIS development in Haiti (channeled to the CNIGS), the Government of Haiti also dedicates substantial resources (estimated to be US $920,000 for 2007) for the national GIS focal agency. Additionally, resources for that center's operations are also obtained through the center's provision of services and products. The end result of such investment in GIS in Haiti is the existence of substantial information technology resources for GIS implementation. Specifically regarding GIS software applications, ArcGIS 9.1, ERDAS Imagine, GeoConcept, GeoImage and MapInfo are in use in Haiti. Database management software in use includes Oracle Spatial as well as MS Access, and considerable server resources (i.e. a 5TB disk array exists for management of spatial data).

## JAMAICA

As the third largest island in the Caribbean, Jamaica is one of the island nations of the Caribbean's Greater Antilles (the other islands being Cuba, Hispaniola and Puerto Rico). The country's approximately 10,991 square kilometers (4,244 square miles) are divided into fourteen (14) parishes. World Bank mid-year estimates for 2005 place the population of Jamaica at approximately 2.7 million inhabitants, with some 52% of the population inhabiting urban areas. The nation's capital is located at Kingston, and according to the Statistical Institute of Jamaica, approximately 660,000 people inhabited the greater Kingston area at the time of the last census in 2001.

### *Summary of Current GIS Capacity*

In Jamaica, there is a multitude of institutions employing geographic information systems in their operations. Additionally, Jamaica possesses a national framework for GIS implementation which includes the introduction of GIS at various levels within the educational system. This supports the assessment by King et al (1998) that GIS implementation in Jamaica was advanced, compared to other Caribbean nations. With regard to the institutions employing GIS, government institutions implementing the technology *at present* include:

- Ministry of Agriculture and Lands
  - Forestry Department
  - Rural Physical Planning Unit
  - Mines and Geology Division
  - National Land Agency
  - Spatial Data Management Division
  - National Irrigation Commission
  - Sugar Industry Research Institute
  - Rural Agricultural Development Authority (RADA)

- Jamaica Bauxite Institute

- Ministry of Local Government and Environment
  - Meteorological Services
  - National Environment & Planning Agency
  - Office of Disaster Preparedness and Emergency Management
  - National Solid Waste Management Authority
  - Parish Councils
  - Portmore Municipality

- Ministry of Housing Transport, Water and Works
  - National Work Agency
  - Jamaica Urban Transit Company
  - Water Resources Authority

- Ministry of Finance and Planning

  - Planning Institute of Jamaica
  - Statistical Institute of Jamaica

  - Office of the Prime Minister- Ministry of Development
    - Electoral Office of Jamaica

- Ministry of Education, Youth
  - Institute of Jamaica
- Jamaica National Heritage Trust
- University Of Technology
- University Of The West Indies (Mona)
- Ministry of Health
- National Water Commission
- Jamaica Public Service

- Ministry Of National Security
  - Jamaica Constabulary Force
  - Jamaica Defense Force
- Urban Development Corporation

A National GIS Coordination body was established in 1991, and is still in operation (Land Information Council of Jamaica – LICJ). This body has the following objectives:

1. Maximize the use, distribution and creation of publicly funded data products and services.
2. Create and maintain a highly skilled, relevant and innovative geoinformatics workforce to build the infrastructure through education, skills formation, and research and development initiatives.
3. Form stronger coordination arrangements and communication with users of spatial information.
4. Coordinate the development and adoption of a minimum set of geospatial standards focused on data quality that enables integration with other data sets.
5. Spatial data users are able to find and access existing data sources and services with minimum impediments.
6. Facilitate all geospatial data providers acting on accord on policy issues such as access and pricing, copyright and privacy.
7. Facilitate the creation of innovative, strong and high value-added geoinformatics sector.

From both the interviews conducted and the available publications on the different institutional web pages, it is evident that there is a large collection of spatial datasets at several organizations. However, little information was provided on the update status and other characteristics of the datasets. In terms of data available, high resolution digital imagery is available for the whole country for a *fairly* recent period (2001). Additionally, detailed cartography at scales of 1:12,500 and 1:50,000 are also available in vector format, although many of these have not been updated since 1981.

**Table 9: Selected Spatial Data Available for Jamaica**

| Year | Scale / Resolution | Title | Source |
|---|---|---|---|
| 2001 | 1:2,000 | Aerial photographs | Spatial Innovision (partial coverage – Kingston, St. Andrew, Portmore, Spanish Town, Montego Bay) |
| 2001 | 1m | Satellite imagery | IKONOS (full island coverage) |

While it was indicated that both software and hardware tools are available, a point commonly expressed during interviews was that resources are limited for regular upgrades. Additionally, it was expressed that although human resources needed to accomplish activities are at times inadequate in terms of number of staff, personnel do possess relatively advanced levels of training and expertise. Responding agencies pointed to insufficient capital and resources as major challenges in the performance of their primary activities, but did not provide estimated cost for such activities.

In terms of the overall software infrastructure for GIS implementation, a substantial proportion of the agency representatives interviewed mentioned that there were no plans to upgrade to the latest software versions because of the high cost of such upgrades. Software has generally been acquired through projects or donations, and software maintenance fees are not paid regularly after initial acquisition. The hardware infrastructure for GIS implementation apparently faces a similar fate in a number of agencies. Replacement of obsolete equipment happens only when additional resources become available to supplement regular budgets. While in some cases a regular budget is contemplated for GIS hardware, software and training, it seems to be very limited.

Overall, the staff operating the GIS and IT departments is highly skilled, and major efforts are made to keep them up to date, in spite of limited resources. Another challenge noted was the lack of staff in required numbers for the implementation of organizations' primary activities. Inter-agency coordination has effectively produced policies and standards for almost all of the topics asked in the questionnaire (**Appendix C**), and they have been adopted and implemented at most organizations working with GIS in the island.

IT personnel and high speed internet access were identified as some of the more pressing needs. Relational Database Management Software is used in several institutions to manage their datasets, with a number of them implementing spatial database engines such as ESRI's SDE within their database servers. Other institutions indicated publishing their spatial information through web map servers (both Open Source and proprietary), though OGC standards are not widely used.

## ST. KITTS & NEVIS

St. Kitts and Nevis is a twin island federation in the northeastern Caribbean. St. Kitts is the larger island and has a total area of 168 sq km. The island is shaped like a baseball bat and separated from Nevis by a three-km-wide channel called The Narrows. Nevis operates under a system of

self government administered by the Nevis Island Administration. The island is 3 km to the south east of St. Kitts and is 93 sq km square. St. Kitts has a rugged topography with large areas of the island being inaccessible. These uninhabitable areas include mountain ranges, water bodies and rocky bluffs. The island's topography is dominated by Mount Liamuiga, a live volcano, which rises to a height of 1,156 m. The island of Nevis is a single volcano. It has a round shape with an average radius of 5.5 km. Nevis Peak sits in the center of the almost circular island and rises to 985m. The population of St. Kitts was estimated to be 34,930 by the population census of 2001. A 1998 estimate puts the population of Nevis at 10,080.

***Summary of Current GIS Capacity***

In St. Kitts and Nevis, GIS is currently being used as a tool. Maps and reports are being produced and used to support decision-making. The importance of GIS has been recognized. The most urgent needs appear to be technical support and software maintenance. There is a need for training of staff in all GIS related topics. The availability of trained staff would enable the expanded use of GIS. There is a need to budget for the development of GIS and produce policies and standards to guide this development. The Physical Planning Departments in St. Kitts and Nevis are the focus of GIS development and the islands depend heavily on these units.

**Appendix A10** considers the spatial data required for each agency interviewed in St. Kitts and Nevis. From this list, it is evident that the agencies need to have a comprehensive spatial database of physical, hazard and anthropogenic features. The common requirements of departments are an indication the efficiencies could be gained by sharing of datasets. The Department of Physical Planning and Environment has almost all required datasets available in digital format for St. Kitts. The landslide inventory and erosion data are the only datasets required that are not available digitally. Electrical supply lines data is incomplete and the water supply data requires updating. Currently, there is a great demand for a forestry map.

The Water Services Department has a very limited digital map dataset. Most of its maps are available in hardcopy. The Department indicated that a number of maps required are unavailable (refer to **Appendix A10**). It is instructive that all these maps are available at the Department of Physical Planning and Environment and most are in digital format. The two departments have a close relationship and as such it is unlikely that the lack of information is caused by unwillingness to share data. The issue is more likely one of limited data dissemination. The Department of Physical Planning, Natural Resources and Environment of Nevis has produced a number of thematic map layers as indicated in **Table 10**. 51% of the data indicated as required is available in digital format. 49% of the datasets are not available.

**Table 10** shows the characteristics of the spatial data currently available for St. Kitts and Nevis. Complete coverage is available for St. Kitts. The Physical Planning, Natural Resources and Environment Department of Nevis is in the process of completing topographic and thematic mapping for the island at 1:2,500.

**Table 10: Selected Spatial Data Available for St. Kitts and Nevis**

| Island | Year | Scale / Resolution | Title | Source |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| St. Kitts | 2007 | 1:2,500<br>1:25,000 | Topographic | Lands and Surveys |
| | 2001 | 1:25,000 | Aerial photographs | |
| | 2000/2001 | | Satellite imagery | Infoterra |
| Nevis | 1991 | 1:10,000 | Aerial photographs | |
| | 2001 | 1m | IKONOS | |
| | 2006 | 1m | Quickbird Panchromatic | SII |
| | N/A | 30m | LANDSAT | |

The islands of St. Kitts and Nevis have hardware but they require network technical assistance and maintenance support. The GIS software is concentrated in the Physical Planning Departments and there is a need for software upgrades. The only database management software used is Ms Access and this use is limited. As would be expected there are significant problems and issues with regards to the use of database software and an absence of database standards, policies and procedures. There is a need for the implementation of database management software. This will require training and technical support.

The Department of Physical Planning, Natural Resources and Environment in Nevis did indicate that the major weakness experienced was the maintaining of database currency. This Department indicated that the establishment of a multi-Environment GIS would further the mainstreaming of GIS into the functions of the department.

## ST. LUCIA

Saint Lucia is a small island developing state in the Eastern Caribbean chain of islands. It possesses a total area of 238 square miles (616 $km^2$), this volcanic island is mountainous and rugged, with numerous rivers flowing in deep, narrow valleys over short distances to the sea. The highest peak, Mount Gimie (3117ft or 950m), is in the southwestern part of the main north-south trending axial ridge.

The island has a tropical marine type of climate, being affected by the prevailing Northeast Trade winds throughout the year. The dry season is from January to May and the wet season from June to December. Saint Lucia is affected by tropical storms and hurricanes, mainly from June to November, during the wet season. Roughly 20% of the island is covered by tropical rainforest vegetation that provides habitats for a wide range of flora and fauna. The population of Saint Lucia is estimated at 162,000 (2003), with 31% of its people under 15 years old and 64% being the economically active population. The country is actively diversifying its economy from bananas to tourism and offshore banking. Its per capita GDP is an estimated US $5,400, with the sectors of agriculture, industry and services contributing 7%, 20% and 73% respectively to the GDP (2002) (CIA Fact Book 2003).

### *Summary of Current GIS Capacity*

In Saint Lucia, the importance of GIS has been recognized and it is currently being used as a tool to undertake analysis, support decision-making and in the preparation of maps and reports. The most urgent needs appear to be IT support and software maintenance. Though many of their staff have been trained in GIS, there is still need for training of staff in all GIS related topics,

particularly in rectifying data quality issues. Senior executives' exposure to the usefulness of GIS would enable the expanded use of GIS throughout the agencies surveyed by budgeting for its development and supporting the establishment of policies and standards to guide this development.

The Forestry Department of the Ministry of Agriculture, Forestry and Fisheries, the Mapping Section of the Ministry of Physical Planning, Environment & Housing and the St. Lucia Electricity Services Ltd. in Saint Lucia are major agencies that use GIS to support many of their activities.

**Appendix A11** considers the spatial data required for each agency interviewed in Saint Lucia. From this list, it is evident that the agencies need to have a comprehensive spatial database of physical, hazard and anthropogenic features. The common requirements of GIS data by these agencies are an indication that efficiencies could be gained by sharing of datasets.

The Forestry Department has almost all required datasets on Saint Lucia available in digital format. Data that is not available are on water bodies, hydrogeology, aquifers, rainfall, flood hazard zones, erosion, government buildings, recreational parks, and waste management sites. The Department does not have data on electrical and water supply lines.

The Mapping Section has a limited spatial digital dataset, as shown in **Appendix A11**. It possesses data on elevation, roads, water courses and some anthropogenic features. A more comprehensive list of digital data is available at the Physical Planning Section with which the Mapping Section works closely.

The **Table 11** shows the characteristics of the spatial data currently available for Saint Lucia. Coverage ranges from 1:500 to 1:50,000.

**Table 11: Selected Spatial Data Available for St. Lucia**

| Year | Scale | Type of data | Source |
|---|---|---|---|
| 1992<br>1984<br>2004 | 1:10,000<br>1:25,000<br>1:25,000 | Aerial photographs | Surveying and Mapping Sections |
| 1982 /1995 | 1:1,000<br>1:2,500<br>1:25,000 | Topographic maps | DOS<br>UAM |
| 2007 | 1:500<br>1:2,500 | Survey plans | Surveying and Mapping Sections |
| 1992 | 1:25,000 | Forest Management Plans | Forestry Department |
| 1984 | 1: 50,000 | Thematic maps | OAS |
| 1968 | 1: 25,000 | Soils | UWI |

The agencies surveyed in Saint Lucia have hardware and software but they require budgets for network technical assistance and maintenance support. The only database management software used is *MS Access* and this use is limited. As would be expected there are significant problems and issues with regards to the use of database software and an absence of database standards,

policies and procedures. There is a need for the implementation of database management software. This will require training and technical support.

None of the agencies interviewed had a GIS / ICT plan. The agencies surveyed experienced numerous issues with data quality. Some suggestions on actions to be taken toward the mainstreaming of GIS into the roles and responsibilities in the Mapping Section are that all existing data on parcels and plans be in digital format and placed in a database for easy query and analysis. The database should be organized via a LAN and all data should be archived. GIS was seen as integral in the production of tourist and road maps of the island, among others. Mainstreaming of GIS in the roles and responsibilities of the Forestry Department can be through the exposure of the entire staff to the usefulness of GIS in decision-making. At LUCELEC, mainstreaming of GIS into the roles and responsibilities are on–going seminars for senior level management and obtaining certification for GIS technicians prepared by CARILEC and from an approved educational institution.

## ST. VINCENT & THE GRENADINES

Saint Vincent and the Grenadines is a small island developing state in the Lesser Antilles and comprises 30 islands, inlets and cays, with a total combined area of 150.2 square miles (389 sq km). The volcanic island of Saint Vincent, with an area of 132.8 square miles (344 sq km), is mountainous and rugged, with numerous rivers flowing in deep, narrow valleys over short distances to the sea. The highest peak, Mount Soufrière standing at 3,952 ft (1,234 m) in the northern part of the island, is associated with a stratovolcano, the Soufrière volcano. The islands of the Grenadines stretch over a distance of 45 miles to the south of the main island, St. Vincent. They are much smaller than the island of St. Vincent, less rugged and possess white, sandy beaches.

The population of St. Vincent and the Grenadines is estimated at 116,812 (July 2003 est.) with 28.2% of its people under 15 years old and 65.5% making up the economically active population. 85% of the population lives on the narrow coastal strip below 5m and less than 5 km from the high-water mark. 80 % of its infrastructure and 90% of its economic investment lie within this narrow zone (OAS, 2000). Roughly 90% of the population lives on the main island of St. Vincent.

The country's economy is based mainly on agriculture from bananas and arrowroot, manufacturing industry, construction and mining, tourism and services. Its per capita GDP is an estimated US$2,900 (2002 est.) with the sectors of agriculture, industry and services contributing 10%, 26% and 64% respectively to the GDP (CIA World Factbook 2003).

### *Summary of Current GIS Capacity*

In St. Vincent and the Grenadines, GIS is currently being used to a limited extent as a tool by some agencies. The most urgent needs appear to be technical support and software maintenance. There is a need for training of staff in all GIS related topics. The availability of trained staff would enable the expanded use of GIS. There is a need to budget for the development of GIS and

produce policies and standards to guide this development. Relevant agencies include the Physical Planning Unit and the Fisheries Division.

**Appendix A12** presents the spatial data required for each agency interviewed in St. Vincent and the Grenadines. From this list, it is evident that the agencies need to have a comprehensive spatial database of physical, hazard and anthropogenic features. The common requirements of departments are an indication the efficiencies could be gained by sharing of datasets.

The Physical Planning Unit has most of its data for St. Vincent and the Grenadines in digital and hard copy formats. The source of their spatial data is over 15 years old, coming from aerial photographs, topographic maps and survey plans. There are many issues with data quality at this agency. Their staff has received limited training in GIS and there are plans for mainstreaming GIS into the agency. They do not have database management software for effective management of their data. This may be as a result of lack of a budget for IT at the agency.

The Fisheries Division requires digital data on physical and anthropogenic features, and hazardous phenomena. It does not possess any GIS software and their staff has limited training in GIS. However, the Division will soon be using GIS for resource mapping but it recognises that a lack of expertise may hinder the rapid development of GIS within the Division.

VINLEC has very limited data for use in GIS. It has a budget for IT and possesses numerous hardware and database management software. Its senior executives have been introduced to GIS techniques and the agency has plans for mainstreaming GIS into its operations.

**Table 12** shows the characteristics of the spatial data currently available for St. Vincent and the Grenadines. The country does not possess comprehensive digital data for use in GIS. Their source of data comes mainly from topographic maps of the country, which are at least 30 years out of date, and aerial photographs and survey plans of more recent vintage.

**Table 12: Selected Spatial Data Available for St. Vincent & the Grenadines**

| Year | Scale | Title | Source |
|---|---|---|---|
| 1983 | 1:2,500<br>1:25,000 | Topographic | Scanned maps from Forestry Division |
| Not known | 1: 2,500 | Survey plans | Lands and Surveys Division |
| 1999 | 1:10,000 | Aerial photographs | Lands and Surveys Division |

The islands of St. Vincent and the Grenadines have some hardware but do not have updated GIS software. There is need for more up-to-date data on physical, anthropogenic and hazard-related phenomena so that full use can be made of GIS when it is introduced fully into these agencies. There is a need for the implementation of database management software in the Physical Planning Unit and the Fisheries Division. The agencies surveyed indicated that training and technical support, improved interagency connectivity, and an annual budget for IT are in urgent need. Although no plans for mainstreaming of GIS into these agencies were articulated, they recognize that GIS would be useful in the decision-making process.

## TRINIDAD & TOBAGO

The Republic of Trinidad and Tobago is an archipelagic state in the southern most Caribbean. The country covers an area of 5,128 square kilometers (1,979 sq mi) and consists of two main islands, Trinidad and Tobago, and 21 smaller islands. Trinidad is the larger and more populous of the main islands; Tobago is much smaller, comprising about 6% of the total area and 4% of the population. Unlike most of the English-speaking Caribbean, Trinidad and Tobago is a primarily industrialized country whose economy is based petroleum and petrochemicals. (*Source: World Factbook*)

### *Summary of Current GIS Capacity*

Overall, the Republic of Trinidad & Tobago is traditionally recognized as one of the powerhouses in the Caribbean where the application of GIS technology is concerned.

In Trinidad, the importance of GIS has been recognized. Agencies indicated that GIS could support and improve the efficiency of functions. Agencies generally have adequate hardware and software installed and a complement of staff trained in basic GIS skills. There is a need for GIS training particularly in advanced topics. Survey information suggests that there is very limited sharing of data and GIS resources between agencies. As a result, agencies are isolated and unable to benefit from shared experiences. There is considerable duplication in effort, cost and data.

Currently, there are a number of agencies using GIS to varying degrees, however, the focus of GIS activity is on map production. The limited spatial analysis and report generation is directly related to the level of GIS skills available. GIS needs to be integrated into agency functions and used more widely as a decision making tool. Agencies need to budget for GIS and produce policies and standards to guide this development.

**Appendix A13** considers the spatial data required for each agency interviewed in Trinidad. From this list, it is evident that a comprehensive spatial database of physical, hazard and anthropogenic features is being developed in Trinidad. There are some common data requirements between departments, which indicate that efficiencies could be gained by sharing of datasets. In order to facilitate this, a policy on data sharing must be developed by the Government.

**Table 13** shows the characteristics of the spatial data currently available for Trinidad. Complete base map coverage at a range of scales is available for the island. Considerable spatial data is available. Mapping and imagery is available at the scale required to support GIS development.

**Table 13: Nature of the spatial data currently available**

| Year | Scale | Title | Source |
|---|---|---|---|
| 1994 | | Topographic map of East Port of Spain | Lands & Surveys Division |
| 2002 | 1 meter | IKONOS | Town and Country Planning Division |
| 2002 | 30m | LANDSAT | Town and Country Planning Division |
| 1977 | 1:25,000 | Topographic map of Trinidad and Tobago | Lands & Surveys Division |
| | 1:10,000 | Arima Topographic Map (3) | |
| 1995 | 1:75,000<br>1:150,000 | Disaster Response Maps (8) | NEMA |
| 1985 | | Tobago Reef localities (6) | NEMA |
| | | Topographical plans of an area at Wallerfield (6) | |
| | 1:9,000 | Ward of La Brea (2) | |
| 1972 | 1:25,000 | Contour Map of Trinidad | |
| | 1:10,000 | Aerial photograph of Point Lisas Industrial Estate | |
| 1995 | 1:5,000 | Point Lisas Industrial Estate Layout Plan | |
| | 1:115,000 | Provisional Hazard Map for M.T.B.E Contamination of Groundwater in Trinidad | WASA |
| | | North East Trinidad WASA Facilities | WASA |
| 1999 | 1:150,000 | Watershed Boundaries in Trinidad | |
| 1986 | 1:7,000 | Trinidad Aerial photographs | Min. of Agriculture |
| 1991 | 1: 150 000 | Trinidad showing Electoral Areas of the Municipal Corporations and the Regional Municipalities | |
| 1992 | | Synthesis map: Indigenous Forest of Trinidad (2) | Forest Division |
| 1982 | 1: 150 000 | Planning Regions and Settlement Areas in T&T | TCPD |
| 1998 | 1: 100 000 | Geological Map of Trinidad and Tobago | Ministry of Energy |
| 1980 | | Tobago National Parks and other Protected Areas | Ministry of Agriculture |
| 1986 | 1: 75 000 | Trinidad Aerial photographs | Lands & Surveys Division |
| 1986 | 1:2500 | Scarborough (Aerial) (3) | TCPD |
| 1994 | 1: 150 000 | Land Use Classification for Trinidad and Tobago (Aerial) | KAIRI Consultants |
| 1979 | | Caroni Swamp National Park Site Layout | |
| 1989 | 1: 5000 | Hydrogeological map of (1) Trinidad and (2) Tobago | WASA |
| 1996 | | Network of World Network of Biosphere reserves | UNESCO |
| 1992 | 1: 150 000 | Trinidad Central Sewered Areas and STPs within their wards and hydrometric areas | WASA |
| 1992 | 1: 50 000 | Tobago Functional & Non-Functional STPs and productive animal farms within Hydrometric Areas | WASA |
| 2001 | | Offshore areas under exploration showing licensed and open areas | Ministry of Energy |
| 1997 | 1: 25 000 | County of St. Patrick –Ward of Cedros (Topographic Map) (3) | Lands & Surveys Division |
| 2001 | | Victoria Mayaro Forest Reserve (GIS) | Geometrics Surveying |

| | | | |
|---|---|---|---|
| | | | Consultants Limited |
| 1986 | 1:10,000 | Aerial photography | Lands and Surveys |
| 1994 | 1: 25,000 | Aerial photography | Lands and Surveys |
| 2003 | 1: 10,000 | Aerial photography | Lands and Surveys |
| 2004 | 1m | IKONOS of Maraval area | |

Trinidad has been involved in the development of GIS for a considerable period of time and a number of agencies are using GIS to various extents. Most agencies use GIS to produce maps and there is limited emphasis on either database development or spatial analysis. There is GIS software, hardware and trained staff scattered throughout agencies. The operating systems are Windows based. ArcGIS and ArcView are the dominant GIS software used. A mix of database management software is used but Microsoft Server and MS Access dominate however, there is limited spatial database development. There is a general absence of IT, GIS and data standards and policies. As a result agencies indicate the full range of issues and challenges with regards to GIS and data.

None of the agencies interviewed indicated having a GIS / ICT plan. There is an obvious need to develop these plans for agencies in Trinidad. The EMA completed the SWOT analysis. It was apparent that skilled staff exists but there is a need for additional resources and training.

## 3. REGIONAL SYNTHESIS

It goes without saying that there are multiple ways to sift the wealth of information provided on the snapshot of the state of GIS capacity and implementation in the Caribbean. As in the case of the country summaries, this regional summary will examine GIS capacity from the multiple angles of human resources, software and hardware resources and data resources.

While this regional assessment does not benefit, for instance, from benchmarking the IWCAM Project's thirteen participating countries with countries from another related region (for instance, Central America), it can nonetheless be concluded that overall GIS implementation in the Caribbean is at an intermediate stage of development. This likewise means that there exists significant potential across all of the participating countries for further application of the technology for improved coastal areas and watershed management, as is the overarching goal of the IWCAM Project.

Without recounting the individual cases, it can be said quite generally that capacity varies across the region (i.e. from country to country), and within countries (i.e. from institution to institution). The reasons for these differences in development can no doubt be generalized as having been caused by different social, economic, and institutional conditions, among others.

*Software Infrastructure*

In GIS application software being employed, it should be noted that in the case of at least one of the countries (i.e. the largest and most populous nation in the Caribbean), trade restrictions have greatly impacted the choice of analytical software available to that country. Where most of the nations of the Caribbean are utilizing software applications developed by the Environmental Systems Research Institute (ESRI), the nation of Cuba stands out as one which for the most part

does not take part in that standardization of the software which is being employed. This is, of course, not to place a premium on commercial off-the-shelf software (COTS) but merely to state the reality that the glaring majority of the institutions surveyed across the 13 PCs were making use of commercial software such as ESRI's ArcGIS ® 8.x – 9.x and ArcView ® 3.x software applications.

If the region is almost standardized in the GIS application software being used, it would seem that the countries are also, for the most part, standardized in the lack of use of certain software, namely database management software for managing data structures. That is, the vast majority of the institutions surveyed did not, for one, appear to be utilizing much in the way of database management software for their data holdings. Rather, most of the institutions surveyed seemed to be simply employing Microsoft Access to a limited extent for database management, although other options such as ESRI's Arc Spatial Data Engine (ArcSDE) ® and ArcGIS Server exist.

In various interviews the respondents pointed out that while funds for software upgrades (as well as for hardware upgrades) were often sparse, it was also recognized that the technical personnel were not, in any event, making full use of the GIS software applications already available to them. Obtaining the latest versions of software in order to exploit newly-added functionalities was therefore not considered crucial to performance of daily activities. In fact, many organizations responded that GIS application software had only been acquired through projects or donations. Most organizations consulted indicated that they did not have budgets for obtaining new software.

Additionally, the information received indicates that satellite image processing software such as ERDAS Imagine ® are utilized to a far lesser extent than standard GIS software applications. This has implications in terms of the analyses being conducted. If lack of access to satellite image and raster processing software is indeed a reality, this would mean, for instance, that the ability to conduct change analyses using satellite imagery or digital aerial photography would be limited. Information received seems to corroborate this in that many of the countries indicated having outdated vegetation and land cover maps which are generally the products of classification of remotely-sensed data such as aerial photography or satellite imagery. In addition to a potential need for such types of software, this might point to a need for building of human capacities in that area.

Across a number of countries, the field of web mapping enticed the interest of a number of survey respondents. Where the technology is relatively new, a number of institutions expressed interest, for instance, in developing up web map services and hence being able to serve their content over the Internet.

*Hardware Infrastructure*

It is difficult to really characterize whether existing hardware resources are adequate for the implementation of GIS activities. It is difficult to make such a judgment call partly because of the ever changing state of technology. For instance, the hardware resources required just five years ago to run ESRI's ArcView 3.2 software, for instance, have radically changed compared to the resources required to run ArcGIS 9.2. Virtually no institution indicated that hardware was the

limiting factor for why it had not implemented a GIS (though of course no institutions without GIS had been consulted).

It should nonetheless be noted that while institutions are by and large making do with current hardware resources, perhaps tasks could be performed more efficiently with access to greater hardware resources. For instance, certain institutions have found it more effective to manage their data resources using servers and formal data management software, while other institutions without such resources are forced to make do with desktop computers and external storage on portable hard drives. Overall, it seemed that most institutions did not have hardware upgrades budgeted and that upgrading of hardware was hence sporadic.

*Human Resources*

The main human resource issues encountered seemed to be that in some cases, institutions simply do not have the numbers of technical personnel necessary for the performance of tasks. This goes beyond GIS-related activities per se as a number of institutions are simply strapped for personnel overall, not just information scientists. The other main issue encountered seems to be the level of training and expertise of current technical personnel. This second issue, however, varied from country to country. Representatives from countries such as Jamaica emphasized the high level of skill of their current base of professionals. Domain expertise is related to the level of GIS training and expertise, however, as many of the responding organizations indicated interest in utilizing GIS in the range of applications noted in the survey questionnaire (e.g. water pollution modeling, air quality monitoring, etc.). This apparent lack of advanced application of GIS therefore points to a need to strengthen human capacities.

It bears noting that in the Caribbean there are a number of institutions such as the University of the West Indies which have made great strides in strengthening human capacity in GIS across the region.

*Data Resources*

In terms of available data resources across the region, it is a mixed picture. The annexed survey questionnaire, for instance, lists the range of problems with data. Of these, a number of issues with data resources stand out, largely pertaining to the lack of updated data and to the absence of documentation of existing data.

For example, in almost every single country examined, the tracking of land use change is limited by the lack of updated data. It bears reminding that multilateral environmental agreements such as the Convention on Biological Diversity, Convention to Combat Desertification and the Framework Convention on Climate Change – to which virtually all thirteen PCs are signatories – all require regular updating of land use change and related data, for instance. While many countries possessed fairly high resolution satellite imagery and / or aerial photography, this data was usually outdated or in the process of becoming obsolete.

Related to such data, in the case of the topographic sheets which are based on such data, almost all countries were relying on topographic sheets developed at latest in the early 1990s (i.e. data

more than 15 years old). With project funding from the European Union, Haiti seemed to be the only country in the entire region attempting to recreate its topographic sheet series.

Most countries also exhibited a lack of documentation of their data (a data management issue). Metadata (i.e. data about data) are simply not being developed for existing spatial data. This is problematic for a variety of reasons. For one, lack of data documentation usually leads to inappropriate use of data because analysts were unaware of certain characteristics of the data. Additionally, combined with staff turnover, lack of metadata also leads to the loss of knowledge about data and loss of the data's history. Presence of metadata has the positive effect of leading to data discovery. In a few cases, the lack of data documentation led to institutions interviewed asserting that certain types of data did not exist, only to be contradicted by other institutions which asserted having possession of such data.

Further regarding data resources, following from the data that most institutions indicated was available to them, it seems that a number of institutions are unaware of a number of data resources available on the Internet, particularly as it relates to satellite imagery. Sites such as the Global Land Cover Facility (www.landcover.org), for instance, offers 30m LandSat satellite imagery of the entire world (including all of the Caribbean) for the periods circa 1980, circa 1990 and circa 2000. There are also a number of other data resources on the Internet that perhaps institutions are unaware of. Through the Land Processes Distributed Active Archive Center (LP DAAC: http://edcdaac.usgs.gov/main.asp), daily satellite imagery from the MODIS sensor can be downloaded, which allows for monitoring of a number of atmospheric, terrestrial and marine environmental variables, such as:

- *Aerosol concentrations*
- *Atmospheric profiles*
- *Dissolved organic matter concentrations*
- *Fires*
- *Ocean chlorophyll concentrations*
- *Sea surface temperature*
- *Vegetation indices*

While MODIS data are available at only coarse resolutions (between 250m and 1km), in other parts of the world (e.g. in neighboring Central America – see www.servir.net), the data is being used for daily environmental monitoring, complementing data being collected by *in-situ* sensors. Furthermore, it should be noted that there is a great variety of data available, particularly remotely-sensed data, which might be used to strengthen GIS capacity in the Caribbean.

**Table 14: Summary of GIS Capacity in IWCAM Participating Countries**

| COUNTRY | Antigua & Barbuda | The Bahamas | Barbados | Cuba |
|---|---|---|---|---|
| **Area (sq. km)** | 442 | 13,878 | 430 | 110,861 |
| **Population** | 74,000 | 321,000 | 272,000 | 11,353,000 |
| **Key institution(s)** | APUA | Bahamas National GIS Centre | BWA, CZMU | CITMA, CIMAB |
| **GIS software** | ArcGIS | ArcGIS | ArcGIS | Open source |
| **Database software** | MS Access | ArcSDE | MS Access | MS Access |
| **Updated topographic sheets?** | No | No | No | No |
| **Last update** | 1980 | | | |
| **Most recent detailed Imagery** | 2005 | N / A | 2004 | N / A |
| **Source** | Aerial | | Ikonos imagery | |
| **Overall level of GIS implementation** | Low | High | Medium | High |

| COUNTRY | Dominica | Dominican Republic | Grenada | Haiti |
|---|---|---|---|---|
| **Area (sq. km)** | 751 | 48,671 | 344 | 27,750 |
| **Population** | 79,000 | 8,998,000 | 80,000 | 8,549,000 |
| **Key institution(s)** | Lands & Surveys Division | SEMARN | Land Use Division | CN IGS |
| **GIS software** | ArcView | ArcGIS | ArcGIS | ArcGIS |
| **Database software** | MS Access | ArcSDE | MS Access | ArcSDE |
| **Updated topographic sheets?** | No | No | No | In process |
| **Last update** | 1989 | | 1982 | 1978 |
| **Most recent detailed imagery** | 1992 | N / A | 2005 | 2002 |
| **Source** | Aerial | | Ikonos imagery | Aerial |
| **Overall level of GIS implementation** | Medium | Medium | Low | High |

| **COUNTRY** | **Jamaica** | **St. Kitts & Nevis** | **St. Lucia** | **St. Vincent & the Grenadines** | **Trinidad & Tobago** |
|---|---|---|---|---|---|
| **Area (sq. km)** | 10,991 | 261 | 539 | 388 | 5,130 |
| **Population** | 2,701,000 | 42,000 | 152,000 | 121,000 | 1,311,000 |
| **Key institution(s)** | Ministry of Agriculture & Lands | Dept of Physical Planning & Envt. | Forestry Dept. | Physical Planning Unit | Buccoo Reef Trust, IMA |
| **GIS software** | ArcGIS | ArcGIS | ArcGIS | ArcView | ArcGIS |
| **Database software** | ArcSDE | MS Access | MS Access | MS Access | MS Access |
| **Updated topographic data?** | No | In process | No | No | No |
| **Last update** | 1992 | | 1995 | 1983 | 1977 |
| **Most recent detailed imagery** | 2001 | 2001 | 2004 | 1999 | 2002 |
| **Source** | Ikonos | Aerial | Aerial | Aerial | Ikonos imagery |
| **Overall level of GIS implementation** | High | Low | Medium | Low | High |

*Recommendations*

The previous sections have provided a general review of the state of GIS capacity across the Caribbean in the IWCAM Project's thirteen PCs. As a follow-up to this rapid assessment, a "***Road Map Towards Effective Mainstreaming of GIS for Watershed Management in the Caribbean***" document has been developed which outlines the framework for how capacity can be built in the utilization of GIS as a management tool for coastal areas and watersheds.

**It should be noted that within the context of the overall IWCAM Project, the Road Map document itself presents in detail the substantive recommendations on the way forward in addressing the issues identified in this regional assessment.** Nevertheless, in excerpting and referring back to the Road Map, eight areas for developing overall GIS infrastructure have been identified. These include:

1. **Comprehensive needs assessment –** This assessment has served as a 'rough and ready' assessment of overall GIS capacity across the thirteen PCs. For capacity to be strengthened, a more in-depth and comprehensive assessment of individual country and institutional needs must be undertaken. The survey questionnaire utilized in this survey attempted to tease out some of the needs of the various responding institutions.

2. **Acquisition and management of data and databases –** Significant issues identified through this assessment include that (i) institutions often do not have access to the data they require to conduct their work, and (ii) overall, institutions exhibit limited capacity to manage their data resources. As such, significant attention has to be given to how institutions might acquire the data that they do need. Additionally, capacities in data management (through databases, for instance) must also be strengthened.

3. **Acquisition and management of technological resources –** It goes without saying that without the tools (i.e. software and hardware) to perform spatial analyses institutions cannot have GIS capacity. Attention must therefore be given to ensuring that institutions have the appropriate technology resources for conducting their spatial analyses.

4. **Development and management of human capacity** – Perhaps the most important element in the entire picture of 'GIS capacity' is human resources. As mentioned, more pressing issues in human capacity include the absence of trained personnel in large enough numbers, and to a certain extent, the lack of training and expertise of existing human resources. Where the availability of suitable numbers of trained technical personnel available to work in various institutions will be a function of budget, nevertheless the level of training is something that can be addressed fairly easily. In the Caribbean there exist resources such as the University of the West Indies which has trained the scores of GIS analysts currently working across the region.

5. **Development and management of institutional environment** – As noted, in a small number of countries in the Caribbean, significant advances have been made in the development of national frameworks to facilitate GIS implementation. These include the

frameworks in place in the Bahamas, Jamaica, Haiti and other nations of the region. In order to support the mainstreaming of GIS as a management tool, institutional frameworks must be addressed. For instance, the roles of various institutions with respect to this theme will likely have to be figured out.

6. **Development of products and services** – In terms of GIS capacity, a distinction must be made between information products (for instance, statistics, maps and reports) and raw data itself. One of the key areas which must be addressed is how GIS can be used to produce various information products as well as services for the spectrum of decision-makers. For instance, a number of the institutions identified already provide products and services to both the public and the commercial sector.

7. **Continuous monitoring and evaluation of the system** – A key need that has to be addressed is how GIS can be applied for monitoring and evaluation. This extends to the related technology of remote sensing in which information can be extracted, say, from regularly updated satellite imagery to provide estimates of environmental change.

8. **Funding mechanisms and political support –** It must be emphasized that GIS technology can only be utilized for environmental management if there is both financial and political support. As noted earlier, in many cases there is limited financial support for the maintenance of GIS systems within organizations. Additionally, in a number of organizations, there is little support for the application of GIS because managers are simply unaware of the technology's potential.

In conclusion it must be reiterated that according to this rapid assessment of GIS capacity in the Caribbean, the state of GIS capacity varies across the Caribbean, from country to country, as well as within each country. At the regional level, different countries vary in their experiences with and applications of GIS.