# Roadmap Toward Effective Mainstreaming of GIS for Watershed Management in the Caribbean



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## List of Acronyms

| | |
|---|---|
| AOCRS | African Organization for Cartography and Remote Sensing |
| CADM | Caribbean Disaster Management Project |
| CARICOM | The Caribbean Community |
| CATHALAC | The Water Center for the Humid Tropics of Latin America and the Caribbean |
| CBO | Community Based Organization |
| CDERA | Caribbean Disaster and Emergency Response Agency |
| CEHI | Caribbean Environmental Health Institute |
| CIDA | Canadian International Development Agency |
| CPACC | Caribbean Adaptation to Global Climate Change |
| CRTO | Regional Remote Sensing Centre |
| DBMS | Database Management Systems |
| EEZ | Exclusive Economic Zone |
| e-GIS | Enterprise Geographic Information Systems |
| ESRI | Environmental Systems Research Institute |
| FAO | Food and Agriculture organization of the United Nations |
| EMA | Environmental Management Agency of Trinidad and Tobago |
| GEF | Global Environment Fund |
| GIS | Geographic Information Systems |
| GNSS | Global Navigational Satellite Systems |
| ICT | Information and Communication Technologies |
| IMA | Institute of Marine Affairs of Trinidad and Tobago |
| IWCAM | Integrated Watershed & Coastal Areas Management |
| LAN | Local Area Network |
| LICJ | Land Information Council of Jamaica |
| M&E | Monitoring and Evaluation |
| NGO | Non-Governmental Organization |
| OAS | The Organization of American States |
| RCSSMRS | Regional Centre for Services in Surveying, Mapping and Remote Sensing |
| RECTAS | Regional Centre for Training in Aerospace Surveys |
| SRS | Satellite Remote Sensing |
| SWOT | Strengths, Weaknesses, Opportunities, and Threats |
| UNECA | United Nations Economic Commission for Africa |
| UNEP-CAR/ROU | United Nations Environmental Programme’s Caribbean Environmental Programme |
| UNDP | United Nations Development Programme |
| UNCHS | The United Nations Center for Human Settlements |
| WAN | Wide Area Network |

# Roadmap Toward Effective Mainstreaming of GIS for Watershed Management in the Caribbean

## 1.0 Background and Scope

The watersheds and coastal areas of the Caribbean contain some of the world's most diverse and productive habitats and encompass extensive areas of complex and unique ecosystems. The coastal areas include mangroves, coral reefs, sea grass beds and river deltas, which are an important source of food production; support for a variety of economic activities such as fisheries, tourism and the related uses of recreation and transportation.

The Caribbean Environmental Health Institute (CEHI) and the United Nations Environmental Programme's Caribbean Environmental Programme (UNEP-CAR/RCU) are co-executing the regional initiative known as the Integrated Watershed & Coastal Areas Management in Caribbean Small Island Developing States (IWCAM) Project. The IWCAM Project has the overall objective of strengthening the commitment and capacity of the participating countries to implement an integrated approach to the management of watersheds and coastal areas. The long-term goal is to enhance the capacity of the countries to plan and manage their aquatic resources and ecosystems on a sustainable basis.

The IWCAM Project recognizes the important role of GIS technology as a tool for integrated data analysis and management and thus decided to incorporate the use of GIS in various components. Mindful of the complexity and cost associated with effective and efficient use of GIS, the project commissioned the conduct of a detailed capacity needs assessment study that would guide the process. The Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) was contracted to undertake this study.

### 1.1 Rationale for a GIS implementation roadmap

This Roadmap is based upon recommendations from the assessment and stakeholder input. It consists of steps to be taken to bring capacity up to a level where GIS data can be generated, manipulated and shared among Participating Countries within a common framework. The actions to be implemented as a result of the assessment's recommendations would build data and information management capacity in participating countries and specifically at the level of the IWCAM Demonstration Projects.

### 1.2 Objectives and scope of the Roadmap

The objectives of this roadmap are:

- To provide guidance to effective and efficient GIS implementation
- To identify key resources required for GIS implementation
- To identify key tasks that need to be performed
- To help minimize the risk of failure in GIS implementation
- To identify issues that could impede the mainstreaming of GIS

The scope of the roadmap as presented in this document covers the mainstreaming of GIS at a national level. With some minor adjustment, the roadmap may however, be adapted for programme-wide or region-wide use as well.

# 2.0 Introduction to GIS Concepts

Improvements in information technology have provided unimaginable opportunities to support data analyses and communications in the last two decades. GIS has provided new and exciting ways of acquiring natural resource data and also providing efficient means of processing, managing and integrating this data.

## 2.1 What is GIS?

GIS is an organized collection of computer hardware, software, geographic data and personnel, designed to efficiently *capture, store, update, manipulate, analyze and display* all forms of geographically referenced information (Opadeyi, 1992).

## 2.2 What are the areas of applications of GIS?

The scope of GIS applications is increasing. GIS applications have infiltrated disciplines such as medicine, agriculture, business, environmental management, forestry, civil engineering, archaeology, sociology, and natural science. GIS applications generally set out to fulfill the five Ms of GIS (Longley et al, 2001):

- Mapping
- Measurement
- Monitoring
- Modeling, and
- Management.

Geographical information plays an important role in activities such as environmental monitoring, management of land and marine resources, and real estate transactions. The areas of GIS applications are numerous and growing. Listed below are major areas of applications that have benefitted from developments in GIS (Goodchild and Kemp, 1990):

- management of natural resources
- environmental impact analysis
- hazardous or toxic facility siting
- groundwater modeling and contamination tracking
- wildlife habitat analysis
- zoning, subdivision plan review
- land acquisition
- maintenance of ownership

It is generally believed that GIS concepts and principles could be applied to solve or simplify any problem that has spatial entities and spatial relationships.

## 2.3 What are the components and sub-systems of GIS?

GIS consists of the following components illustrated in **Figure 1**: hardware; software; data and database; and user interface. These components are combined to perform various GIS functions. The *hardware component* is the combination of computers, printers, plotters, scanners, digitizers and networking devices. The *software component* is the combination of a collection of integrated computer programs. Software modules are assembled to handle data collection, storage, processing, analysis, and retrieval functions of GIS. The *Data and Database component* is the backbone of a full-fledged GIS. Data collection and database management are known to account for almost 75% of the total investment in GIS. Base data relevant to the intended use of the system must be collected and loaded on the computer before any full utilization can be achieved. The *User Interface* is people related. It deals with human resource development and management. It addresses the relationship between GIS developer, GIS users and the funding agencies.

These components have led to the development of four (4) subsystems (DeMers, 1997):

a. Data input subsystem that collects and preprocesses data.
b. Data storage and retrieval subsystem that organizes and manages data.
c. Data manipulation and analysis subsystem that transforms data into information.
d. Information reporting subsystem that displays or presents results in a user defined format.

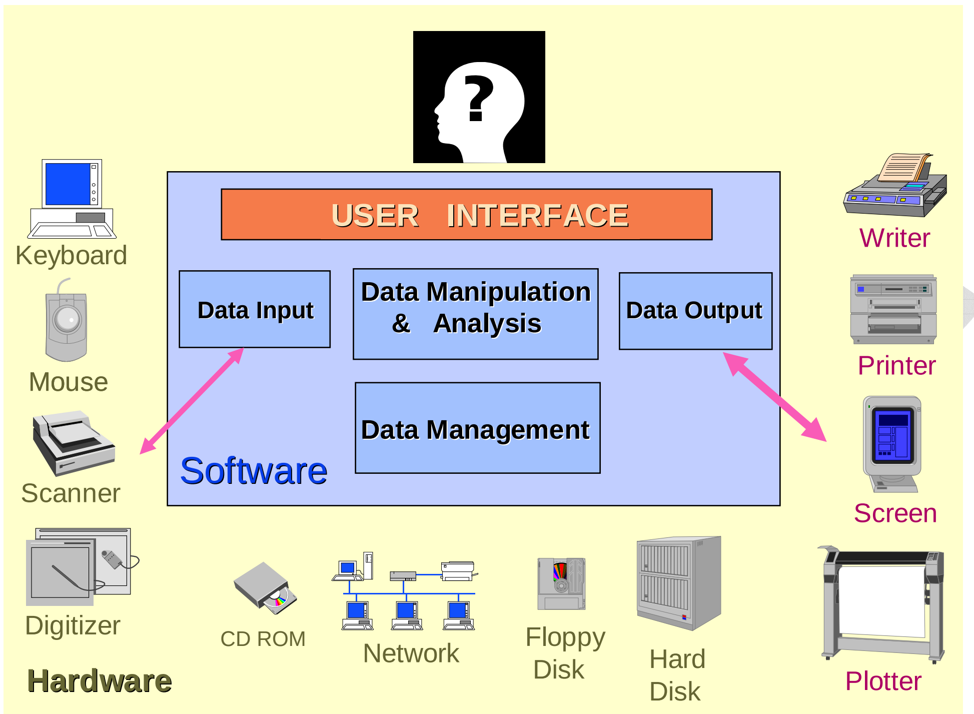


Figure 1: Components of GIS

## 2.4 Who are the users of GIS?

The following professional fields have found GIS invaluable to their regular activities (Longley et al, 2001; Bernhardsen, 2002):

a. Health care managers
b. Service delivery companies
c. Transportation authorities
d. Forest managers
e. Farm managers
f. National and local governments
g. Transportation managers
h. Land managers
i. Utilities service providers
j. Disaster managers
k. Operation and maintenance engineers
l. Town and regional planners
m. Security and safety managers

## 2.5 What are the five questions a GIS could answer?

GIS may be used to find answers to the following spatial questions or queries:

- What features are situated at this **location** and what are their characteristics?
- Where are the spatial features that have a particular set of **conditional** characteristics?
- Within a specified timeframe, how have the characteristics of a specified set of spatial features changed? and what are the **trends** in this change over time?
- What are the spatial **patterns** of occurrence or non-occurrence of a particular set of spatial phenomena?

- What are the spatial models that define the behavior of a particular spatial interaction between a set of spatial entities?

## 2.6 What are the benefits of GIS?

The increasing use of GIS in varying professional fields has produced both tangible and intangible benefits that are enough to sustain its use into the future. The following benefits have been advanced for the use of GIS natural resource management (Dale and McLaughlin, 1988) (Star and Estes, 1990) (Aronoff, 1989):

- It provides integrated data storage and data retrieval capabilities.
- It encourages a more systematic approach for the collection of data.
- It can reduce the overall costs of data collection and management by facilitating data sharing among users.
- It increases comparability and compatibility of diverse data sets.
- It makes data accessible to a wider range of decision-makers.
- It encourages the spatial analysis of environmental impacts that would otherwise be more easily ignored because of analytical difficulty or high cost.
- It improves access to information and service to the general public
- It supports the decision making process
- It provides for effective communication on spatial issues

## 2.7 What are the scopes of GIS implementation?

There are three scopes of GIS implementation. These are single-purpose projects; department-wide applications; and multi-departmental enterprise systems. The single-purpose scope is usually the starting point for most GIS user agencies. GIS is introduced to fulfill the objectives of a particular project and obtain a set of products. The project provides for the hardware, software, data, and personnel required. At the end of the project, the agency may adapt the provision of these products to their regular functions, retain the personnel involved and assume responsibility for the maintenance of the GIS. The Departmental-wide scope is designed to cater for one or more applications directly related to the primary functions of a Department. The design of such a system requires a better understanding of the current and future needs of the Department and definition of the benefits to be derived from the use of GIS. At this level, the cost of GIS implementation is included in the recurrent budget of the Department and adequate human capacity is built to support the system. The Multi-department scope is similar to the Department-wide scope but more complex in design and management. It relies primarily on data sharing and information communication over spatially dispersed agencies of an organization or a government. This scope reduces data and process duplications and facilitates information consistency throughout the enterprise.

# 3.0 GIS Implementation Approaches in the Caribbean

Significant investments have been made in the implementation and use of GIS in the Caribbean. International development agencies, such as the Canadian International Development Agency (CIDA), have provided aerial photographs, satellite imageries and training to help local governments use modern, cost effective techniques to support their sustainable development agendas. To date, however, very little progress has been made and few tangible results are available to demonstrate the effectiveness of these investments. One major reason for this deficiency is the sporadic and uncoordinated approach to the implementation and uses of GIS resources.

The implementation and use of GIS facilities in developing countries rarely follow a holistic strategy. A reactive rather than pro-active approach has evolved. Two factors account for this - the lack of an understanding of the need to coordinate technology-driven solutions with capacity building; and the high capital and human resource investment which must be injected in order to obtain maximum benefits. Despite these factors, GIS technologies are slowly but steadily penetrating the region and are increasingly relying on natural and physical resource management. Four patterns of GIS implementation have evolved. These are project-domain, departmental-domain, national-domain, and regional-domain approaches as shown in Figure 1. This categorization does not include two of the domains of GIS that have been most active in Canada, the United States and Europe – municipal and inter-municipal information systems. The fact that these domains are largely inactive in the Caribbean reflects the high degree of centralization and sectorialization in government and administration, as noted above, and the very limited functions, and even more limited resources that are afforded to municipal and inter-municipal structures in the region.

## 3.1 Project-Domain Approach

GIS implementation with the project-domain approach focuses on a single purpose, such as the production of local-area land use plans and flood hazard mapping. Hardware and software resources are acquired to provide specific support for the project objectives. These projects are often initiated and undertaken by consultants with limited local involvement. On completion of the project, GIS products are provided to the local agency and the hardware and software used for the project are either left with the local agency or returned to their country of origin depending on the pre-project arrangements.

The Organization of American States (OAS) in 1987 commissioned the University of Pennsylvania to undertake a Natural Resources Assessment for Agricultural Development Project in Antigua. The project used a GIS to prepare digital databases. The project, however, did not provide for capacity building and the computer resources used were returned on completion of the project (System Caribbean Limited, 1994). In Nevis, a Canadian engineering firm undertook a National Park Suitability study using the SPANS GIS software. The databases involved were developed in Canada. Local involvement was limited to the cartographic presentation of digitized data and generation of simple queries.

The value of project-domain GIS initiatives is quite limited as they often lack capacity building and do not enhance local technical resources. Nonetheless, they may help familiarize local counterparts with the components and utilities of GIS and provide relevant experience for similar projects in the future.

The real advantage of the project-domain approach is that it minimizes the difficulties inherent in all three of the implementation perspectives highlighted by Campbell and Maser (1995). As foreign-based project teams with significant international experience typically apply GIS procedures that have been used on other projects by professionals in their organization, they are familiar with the technology and the relationships between players are well known and not likely to be disturbed by project activities. Further, the focus on a single project makes it relatively easy to devise a rational management structure as data gathering is more focused.

### 3.2 Departmental-Domain Approach

The departmental-domain approach improves on the scope of the project-domain approach by including capacity building. Instead of focusing on a specific project objective, the GIS is designed to serve encompassing departmental goals and functions. In a number of Caribbean states agencies project-based GIS facilities have developed into departmental-domain. These agencies have committed a significant portion of their budgets to GIS technology, data automation and related capacity building. They have also become points of reference for other agencies that are planning to invest in GIS resources. For example, the Water and Sewerage Authority of Trinidad and Tobago that initially began with a modest digital mapping activity in support of its engineering functions, now uses GIS to support a much wider role in the Authority.

CIDA has financed departmental-domain GIS programs in three states of the Caribbean: St. Lucia, St. Vincent and the Commonwealth of Dominica. These initiatives involved the acquisition of computer hardware and software, development of databases and the training of local staff. GIS is now being used for local area planning and environmental protection in these countries (Johnston, 1994):

In addition, the UNDP/UNCHS has provided GIS support in the Physical Planning Units of the following Caribbean states and territories: Grenada, Anguilla, St. Kitts and Nevis, Montserrat and Antigua. This support has enhanced the production capacity of these state agencies in the performance of their functions (Galema, 1994). The introduction of a department-wide GIS facility is much more problematic than the situation for a project-based GIS. In large departments there may be many decision-making units with somewhat different priorities, expertise, methodologies, data requirements, relationships to other departments and degrees of responsibility to the public. Frequently departments have difficulty dealing with the issues raised by Campbell and Masser (1995) with respect to all three implementation perspectives. Vendors often push technology that is not needed or ineffective on internal committees that have limited experience with GIS implementation. The new system often requires a radical restructuring of data acquisition arrangements, data flow and decision steps. These changes require substantial adaptation on the part of individuals within the department who must acquire new skills to play an effective role and worry about their place within the organization. In addition to devising a rational plan for hardware and software purchases, data flow, decision-making protocols and so on, careful consideration must therefore be taken of the structure and culture of the organization.

Implementation of GIS facilities in separate departments without inter-agency coordination may well result in considerable duplication both horizontally and vertically.

Table 1: Selected Departmental-domain GIS Facilities in the Caribbean

- Town and Country Department, British Virgin Islands
- Archibald Research Centre, Dominica
- Physical Planning Department, Nevis
- Physical Planning Department, St Lucia
- Coastal Zone Management Unit, Barbados
- Water and Sewerage Authority, Trinidad and Tobago
- Town & Country Planning Division, Trinidad and Tobago
- Guyana Natural Resources Agency, Guyana

### 3.3 National-Domain Approach

GIS implementation at the national level is usually introduced to reduce redundancy in the acquisition and the use of GIS resources throughout the country. This approach, which is still in its infancy in developing countries, is holistic in nature and strives for a comprehensive approach to data collection, training, and development of applications that span departmental lines.

Belize, Jamaica and the British Virgin Islands are ahead in the development of a national GIS. Jamaica has instituted a National Land Information Council. Belize has a National Land Information Centre, and the British Virgin Islands have established the post of a National GIS Coordinator. Data sharing and pooling of resources towards developing a national digital database is becoming a norm in these countries and territories. Efforts are underway in other countries to develop nationwide spatial databases and provide data sharing among all agencies.

While the development of national databases facilitate data sharing across agencies, they require years to develop and may not have all the attributes that are required by certain agencies or localities within the country. In large countries with decentralized municipal planning and management authorities, such as Canada, a national-domain approach that would support decision-making simultaneously at national, provincial, regional and local levels would be difficult to design and politically impossible to implement. Alternative approaches that allow each decision-making unit some flexibility in system design yet ensures that data may be transferred easily between agencies may be more effective in some instances.

### 3.4 Regional-Domain Approach

The regional-domain approach is currently receiving consideration in the Caribbean. The first experiment in the development of such an approach in this region was initiated in 1990 through the designation of the Institute of Marine Affairs (IMA) as the Regional Centre for Remote Sensing by the Caribbean Community (CARICOM). The Centre received financial support from the CARICOM Secretariat, the OAS and AMOCO Trinidad Oil Company. The Centre has worked on a number of regional projects such as: *"Evaluation of the Resources of the Coastal Zone and the EEZ of Trinidad and Tobago"* and the skills and institutional capacity to analyze high-resolution satellite imagery using remote sensing software has been acquired. Increased funding and the participation of personnel from other parts of the region are, however, urgently needed to fully develop the capability of the Centre (Griffith, 1995).

World Bank/GEF funding in support of the Caribbean Adaptation to Global Climate Change (CPACC) project is another example of a regional approach. It involves the provision of computer hardware, software, databases, and training to 12 Caribbean countries and is a major contributor to GIS utilization in the region.

A regional approach to GIS implementation is particularly appropriate in situations where a large number of small countries with limited resources face common development and/or environment problems. As the Caribbean meets these criteria and moreover has several well established regional institutions, such as CARICOM, this approach is promising in the region. While it would be impossible to consider introducing a comprehensive GIS system that would be used for regional, national and local decision-making, there is much to be gained by developing compatible systems that can be scaled to different levels of intervention and transfer data between countries. Standards for the collection, representation and storage of data that are shared across the region would certainly be helpful in providing comparable information and building robust data management institutions in each country.

A regional-domain GIS can avoid some of the difficulties noted by Campbell and Masser (1995) that may be encountered by departmental and national systems by maintaining a certain level of abstraction. Data standards are best set by technical committees while the selection of which data to use and for what purpose may well need to vary between jurisdictions both vertically and horizontally within the region. These regional technical groups essentially set the table for national and local stakeholders to engage in the vigorous job of decision-making.

### *3.5 Implications of the Evolving Development Pattern*

The evolving implementation approaches can best be described as cautious. The strength of these approaches is that they improve on past mistakes and rely on the experiences of others in the shaping of its future. They have the ability of reducing investment risk by building on existing initiatives. The various GIS initiatives currently implemented in the Caribbean have provided learning opportunities. States and private agencies proposing to acquire GIS resources can undertake inter-state visits to gain and share experiences. The small size of the states also provides opportunities for testing and implementing GIS concepts in a relatively short time and with minimum risk. Opportunities also abound (although not yet tapped) for the sharing of technical and human resources.

This low-risk approach is, however, not ideal for a technology-driven solution. GIS hardware and software are updated and revised at short notice, investment at the project-domain, most often, may not fit into department-domain requirements. The technical resources used at the project-domain may be quite inadequate for large-scale implementation. New training and new database design may be required. Agencies that initially invested in low-end GIS may soon realize its limitations with respect to their department's needs and thus invest additional capital to acquire multi-user computer workstations for an upgraded version. Disparate development of departmental-domain GIS can lead to an uncoordinated national GIS plan. In Trinidad and Tobago, there are over ten departmental GIS sites that have nothing in common beyond the use of similar software. When departmental goals are allowed to flourish without any form of national coordination and collaboration, the possibility exists that those departmental initiatives may become too expensive or impossible to evolve into national-domain. The need for GIS standards must be appreciated and developed for this to happen.

# 4.0 Regional Assessment of GIS Capacity in the Caribbean

As a precursor to developing the GIS Roadmap, the IWCAM project undertook two studies. These are:

- a desktop study that reviewed the GIS capacity building activities in the Caribbean and
- a regional assessment of GIS capacity in the Caribbean.

The findings of these studies, provided below, were used in formulating the roadmap towards the mainstreaming of GIS in the Caribbean.

## 4.1 Evaluation of the GIS Capacity Building Efforts in the Region

### 4.1.1 Objectives of the Study

The objectives of the study are the followings:

- To conduct a literature review of what other projects and agencies have done in supporting capacity building related to GIS in the region;
- To conduct rapid assessment and "Ground truthing" to confirm and validate findings of desk exercise and to update the work done previously.

### 4.1.2 The Findings

The evaluation was done using the following research questions. The findings are provided below:

a) What was achieved to date?
b) What did not worked very well?
c) What are the gaps that need to be filled?
d) What are the challenges to capacity building efforts?
e) What are the threats to capacity building investment?

#### 4.1.2.1 What was achieved to date?

The capacity building investment in the region has provided modest return. Over the past 12years, a large number of persons from both the private and public sectors of the region have been exposed to varying levels of GIS training programmes. All the countries and overseas territories of the regions do have more than one GIS installations. In addition, through the various initiatives, the volume of spatial digital data has increased in all the countries.

Through both in-country and regional training programmes, the pool of GIS skilled personnel has increased in the region. This is more so in countries like Jamaica and Trinidad and Tobago because of their close proximity to tertiary level institutions: the University of the West Indies, St. Augustine, Trinidad and the University of Technology, Jamaica.

In terms of resources, a number of regional projects and institutions (e.g. CPACC, CDERA/CADM, FAO) have provided the required computer hardware and software to countries that participated in their respective projects. The CPACC project in particular provided high-resolution satellite imageries to countries and funded the digitizing of existing hardcopy maps. The provision of these resources facilitated the project and improved the GIS stock of the participating countries.

Investment in GIS development in the region is not only facilitated by external funding, countries like Antigua and Barbuda, Jamaica, Trinidad and Tobago, and Barbados have invested locally sourced funds to improve GIS capacity development. Jamaica, through the provision of GIS short courses at the LICJ GIS laboratory, Trinidad and Tobago and Barbados through the sponsoring of staff in the public service to the Certificate Programme in GIS.

On the Institutional side, Jamaica, Belize, Bahamas, and Guyana have made notable efforts through the establishment of a national coordinating agency or multi-agency Council. This has provided the opportunity for data sharing, data consistency and data dissemination.

The CPACC approach to GIS capacity development in support of its project goals is a model that should be followed. The project undertook the following capacity building tasks that lead to significant increase in GIS human capacity in the region. What is notable in this model is the continuity and consistency in the approach.

- Hosting of a regional meeting of GIS expect to guide the development of training programmes
- Hosting of regional and in-country GIS training courses
- Provision of GIS computer hardware and software
- Provision of digital data to enhance project deliverables.
- Provision of current high resolution satellite imageries to participating countries
- Provision of scholarships for formal training in GIS
- Provision of computer hardware and software resources to a training institution
- Facilitating the development of a training of trainers course.

These efforts has led to improvement of GIS capacity at EMA and IMA in Trinidad and Tobago; Land Use Section in Grenada; Costal Zone Management Units in Belize and Barbados; Fisheries Department in Antigua and Barbuda; Environmental Protect Agency in Guyana to name a few.

#### 4.1.2.2 What did not worked very well?

The following are examples of what did not worked very well:

- The assumption that agencies/countries would be ready to finance or co-finance the training of their staff proved negative.

- The assumption that agencies/countries would be willing to support the maintenance of computer hardware and software acquired through externally funded projects proved negative.

- The assumption that agencies and countries will be willing to fund the collection of new data and the digitization of existing hardcopy data proved negative.

- The assumption that trained personnel will train others in their agencies or country failed for some of the following reasons:
  - Lack of personal capacity of the trained personnel to train others
  - Training programmes are mostly not designed as a training of trainers programmes with adequate additional materials for the trained.
  - Trained personnel too busy to train others
  - Inadequate facilities for in-house training
  - Trained personnel quit job after training by moving to another department or another country.
  - Unwillingness to share with other the knowledge gained

- The assumption that trained personnel will in return use the knowledge gained for the project that sponsored the training programme failed because of some of the following reasons:
  - Trained personnel has no directly responsibility for the project
  - Trained personnel is too senior to implement the knowledge gained
  - Trained personnel lacks enthusiasm for the project
  - Trained personnel lacks the resources needed to immediately use the knowledge gained

    - Trained personnel lacks job security
    - Poor sequencing of training programmes vis-à-vis the project lifecycle
    - Inadequate pre-requisite knowledge of most training participants.

- The assumption that existing digital data are current and are of good quality failed because due diligence was not performed during the project need assessment and the cost required to correct this anomaly during the project was not budgeted for.

- Over simplification of training materials as well as inadequate duration of training programmes has provided participants with very little confidence to practice knowledge gained.

- Lack of on-going technical support for the newly trained.

- Training programmes not designed to meet specific project needs and encouraged to use project derived data.

#### 4.1.2.3 What are the gaps that need to be filled?

A lot of the capacity building efforts of the past 12 years were rightly devoted to basic knowledge and at most intermediate knowledge of GIS. It is time for the region to scale up the knowledge-base to intermediate and advance level knowledge. The following list of training programmes suggested at the meeting of regional GIS experts may be used to bridge the gaps in the knowledge-base.

| GIS Training Required | |
|---|---|
| Needs assessment and user requirements analysis | Development and maintenance of GIS standards |
| Database design, development, integration | Creating and managing metadata |
| Customization of GIS software | Datum and map projection transformations |
| Use of GPS as a spatial data collector | Raster to vector data conversion |
| Building of end-user GIS applications. | Geostatistical analysis |
| Use of satellite remote sensing data | Spatial analysis and modeling |
| Use of digital photogrammetry techniques | Design and development of temporal databases |
| Web-based data dissemination | Project planning, negotiation and management |

The development of the region human capacity in these areas would enhance the effectiveness of GIS in the region. The gaps may be filled by the inclusion of some of these courses into the curriculum of formal post secondary training in disciplines such as: Natural sciences, environmental management courses; social sciences, civil engineering, business management etc.

#### 4.1.2.4 What are the challenges to capacity building efforts?

The followings were noted to be challenges to GIS capacity building efforts in the Caribbean:

- Inadequate or lack of budget to fund GIS capacity development.
- Heavy reliance on external funding means lack of control on the timing and sequencing of training programmes.
- Lack of continuity with frequent staff mobility.
- Training is driven by opportunities and not expressed needs.
- Lack of qualified staff to be trained.
- Inability to retain trained staff.
- Lack of resources to immediately use gained knowledge.

- Lack of institutional support to use gained knowledge.
- Inadequacy of the training programme itself.
- Lack of access to training programmes due to cost and proximity.
- Limited number of training facilities and trainers.
- Inadequate local case study to enhance regional training programme.
- Lack of incentive for the acquisition of new knowledge through upward mobility or increase in salary.

#### 4.1.2.5 What are the threats to capacity building investment?

Four threats that may impact on adequate funding of Caribbean capacity building efforts in GIS are:

- Potential loss of trained personnel to other well paid jobs
- Changing of focus of the trained staff due to promotion to administrative position
- Changing of focus of the agency due to changes in political administration
- High cost of regional short courses and formal training programmes

#### 4.1.2.6 Conclusions and Recommendations of the Study

In order to harness GIS capacity development efforts in the region, the report suggested the followings:

a) Provision of self pace training materials.
b) Development and use of distance education modules.
c) Staff exchanges and short-term attachments in other agencies or countries.
d) Provision of on-site and in-country training.
e) Training of multiple groups across agencies to make the activity cost effective. This would emphasize the importance of collaboration amongst agencies.
f) General announcements of training in the region so that others can participate at their own costs.
g) Scheduling training with other regional activities to maximize cost effectiveness.
h) Determination of the training needs of each country and the development of a structure plan to meet these needs.
i) Development of training of trainers courses.
j) Development of 4 satellite sub-regional training centres:

| Suggested location of sub-regional Centre | Service countries or territories |
|---|---|
| Trinidad | Tobago, Guyana, Grenada, Suriname |
| Jamaica | Haiti, Cuba, Turks and Caicos Islands, Belize |
| St. Lucia | St. Vincent and the Grenadines, Barbados, Dominica |
| Antigua | St. Kitts and Nevis, Anguilla, The British Virgin Islands, Montserrat |

## 4.2 Regional Assessment of GIS Capabilities of the Region

### 4.2.1 Objectives of the Study

The study was designed to assess the functions, procedures, products, data, tools and human resources available in selected GIS agencies in IWCAM participating countries and use this information to determine GIS and Information and Communications Technology (ICT) requirements in relation to the performance of their functions. The assessment was designed to provide the basis for the conceptual design of a roadmap to guide the effective development and use of GIS for IWCAM in the wider Caribbean.

### 4.2.2 The Findings

As part of the background exercises undertaking towards the crafting of the GIS roadmap, a capacity assessment of GIS capability of the following IWCAM project participating countries was undertaken: Antigua & Barbuda, The Bahamas, Barbados, Cuba, Dominica, The Dominican Republic, Grenada, Haiti, Jamaica, St. Kitts & Nevis, St. Lucia, St. Vincent & the Grenadines, and Trinidad & Tobago The assessment examines GIS capacity from the multiple angles of human resources, software and hardware resources and data resources of the region..

#### 4.2.2.1 Software Infrastructure

With the exception of Cuba, the dominant GIS application software being employed in the Caribbean is the ESRI suite of GIS software developed by the Environmental Systems Research Institute (ESRI). Cuba, due mainly to trade restrictions uses Open Source GIS software.

The countries for the most part lack the full use of database management software and remote sensing software. Most of the institutions surveyed seemed to be simply employing Microsoft Access to a limited extent for database management, where other options such as ESRI's Arc Spatial Data Engine (ArcSDE) ® and ArcGIS Server exist.

Funds for software upgrades (as well as for hardware upgrades) were often sparse, it was also recognized that the technical personnel were not making full use of GIS software applications. 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.

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. The ability to conduct land cover change analyses using satellite imagery or digital aerial photography is thus limited. Many of the countries do have 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 the processing and analysis of remote sensing data.

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.

#### 4.2.2.2 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 that 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, where 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.

#### 4.2.2.3 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 a great number 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.

#### 4.2.2.4 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 the 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 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.

### 4.2.3 Conclusions and Recommendations

Based upon this regional assessment, seven areas for mainstreaming GIS in the region were identified. These are:

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 the various responding institutions had.

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 that 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 the 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 end-user applications, products and services – In terms of GIS capacity, a distinction must be made between information products (for instance, statistics, maps, reports) and raw data itself. One of the key areas that has to 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. 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.

# 5.0 GIS mainstreaming in the Caribbean– The "Roadmap"

The two background studies identified a number of common issues with respect to the implementation of GIS at a national level in the region. These include:

- The lack of an overall national GIS strategy. Haiti and Cuba highlighted mechanisms employed in order to tackle this issue.
- The lack of resources to train GIS personnel.
- There is also the overall lack of understanding of the uses of GIS for the management of critical natural resources.
- The project-approach mechanism also resulted in the redundancy of GIS applications.

In order for the region to adopt a systematic approach to the implementation of GIS, there the need to engage in a public education campaign where real examples are used and a process of implementing GIS and its use is simulated. This would show how GIS can facilitate decision making with respect to the management of natural resource. This section presents a roadmap for GIS mainstreaming in the Caribbean. In designing the roadmap, current status of GIS infrastructure in the region was considered as well as the current level of global development in information and communication technologies. As stated earlier, the main aims of the roadmap are the following:

- To provide guidance to effective and efficient GIS implementation
- To identify key resources required for GIS implementation
- To identify key tasks that need to be performed
- To help minimize the risk of failure in GIS implementation
- To identify issues that could impede the mainstreaming of GIS

Towards the fulfillment of these aims, seven components were identified as being needed for the development and maintenance of effective mainstreaming of GIS at national levels in the Caribbean. These are

1. Comprehensive needs and requirements assessment,
2. Acquisition and management of data and databases,
3. Acquisition and management of technological resources,
4. Development and management of human capacity,
5. Development and management of institutional environment,
6. Development of end-user applications, products and services, and
7. Monitoring and evaluation of the system.

The relationships between the components are illustrated in Figure 2. Component 1 should first be implemented, for it provides the strategic direction to the rest of the other components. Using the results of component 1, Components 2, 3, 4, 5 and 6 may be implemented simultaneously if the technical and financial resources are available. Component 7 should be considered during the implementation of components 2 to 6 but implemented after the system has been built. Component 7 as Figure 2 shows has a bi-directional flow to all the other components, thus, requiring a continuous examination of how well the goals and objectives of each of the other components have been met.

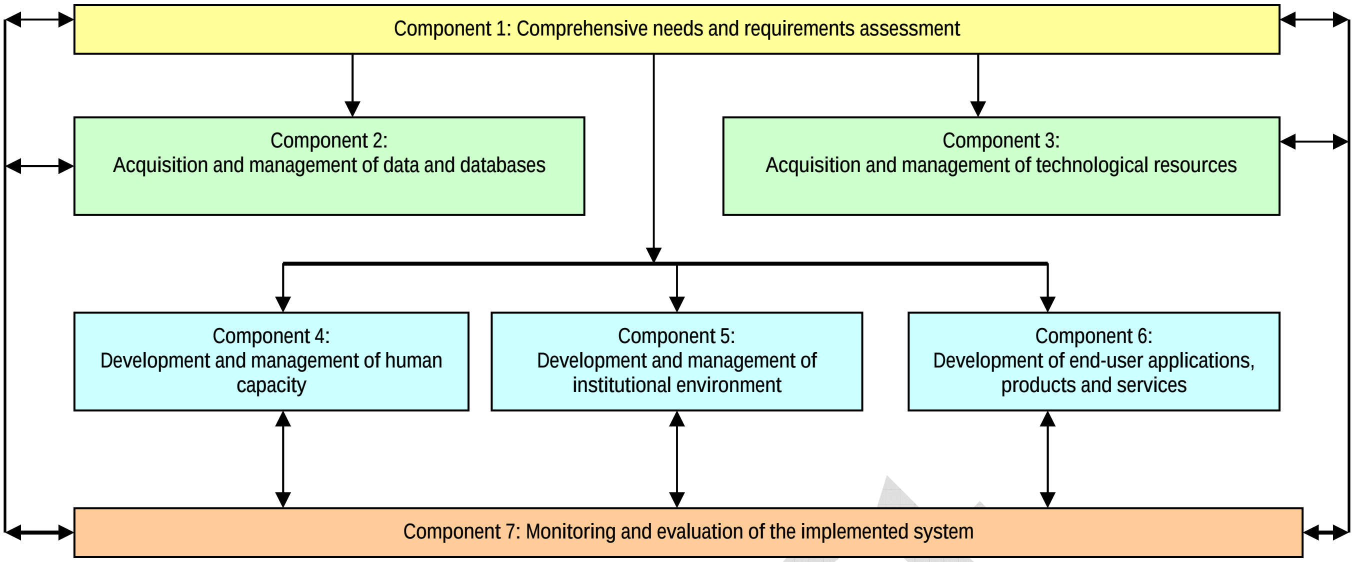


Figure 2: Component of GIS Roadmap

The elements of each of the components are presented in Table 2.

Table 2: Components and elements of the GIS mainstreaming Roadmap

| Component | Elements |
|---|---|
| 1. Comprehensive needs and requirements assessment | Definition and articulation of needs and requirements for GIS mainstreaming |
| | Definition of the scope of assessment |
| | Implementation options and proposed methodology |
| | Identification of critical success factors |
| 2. Acquisition and management of data and databases | Conceptual database design |
| | Logical database design |
| | Development of data management plan |
| | Identification of critical success factors |
| 3. Acquisition and management of technological resources | Design of system architecture options based on the result of the needs assessment |
| | Identification of hardware and software required |
| | Development of hardware and software acquisition plans and options |
| | Design of options for system technical support |
| | Design of options for funding system upgrades |
| | Design of options for system security and safety |
| | Identification of critical success factors |
| 4. Development and management of human capacity | Identification of the human capacity required for GIS mainstreaming in the country |
| | Conduct of an audit to identify the knowledge levels of personnel available for GIS implementation |
| | Gap analysis of human capacity required |
| | Development of action plan for filling human capacity gaps identified |
| | Development of organizational charts |
| | Development of job specifications |
| | Development of a human resource management plan (including succession and retention planning). |
| | Identification of critical success factors |
| 5. Development and management of institutional | Identification of methods, tools and resources required to gain and maintain political, managerial, financial, and legislative support. |
| | Development of action plans for critical support systems. |

| | |
|---|---|
| environment | Identification of critical success factors |
| 6. Development of end-user applications, products and services | A review of potential GIS applications identified during the needs and requirements assessment. |
| | A review of resources required to build the applications and the products and services. |
| | Selection of candidate applications based on certain criteria: number of user departments, timeliness of development, availability of data required, level of impact for public and political support. |
| | Development of strategies for the design, development, testing, roll-out, and maintenance of the GIS applications, products, and services. |
| | Identification of internal and external customers. |
| | Development of a user-friendly interface for non-technical users |
| | Development of business and marketing plans for the GIS applications, products, and services. |
| | Development of strategies for sustainability. |
| | Identification of critical success factors |
| 7. Monitoring and evaluation of the system and its components | Identification of critical activities to be monitored and evaluated. |
| | Development of monitoring tools, timelines, and implementation strategies. |
| | Allocation of responsibilities for M&E strategies. |
| | Development of evaluation parameters, indicators, and benchmarks |
| | Implementation of the M&E strategies. |
| | Identification and implementation of corrective or improvement measures |
| | Budgeting the cost of the M&E exercises. |
| | Documentation of the M&E exercises and dissemination of the results to staff and management. |

## 5.1 Component I: Comprehensive needs and requirements assessment

In order to develop a strategy for mainstreaming GIS implementation in the Caribbean, the first component that should be built is the conduct of a comprehensive needs and requirements assessment for GIS development in the region. This component helps in defining the resources required and the expected outcome of GIS investment. The elements of this component are:

a. Definition and articulation of needs and requirements for GIS mainstreaming
b. Definition of the scope of assessment
c. Implementation options and proposed methodology
d. Identification of critical success factors

### 5.1.1 Goals and objectives

The goal of the needs and requirements assessment is to provide a proactive understanding of how GIS would fit into the roles and functions of institutions that are proposing to implement GIS. It is highly important that the needs and requirements for GIS should be unambiguously defined and articulated to the stakeholders. The definition of needs requires a good understanding of the primary and secondary functions, roles, and responsibilities of the prospective GIS user organizations. These should be defined in specific terms. From this information, a matrix of agencies and functions should be developed from which the following can be identified:

a. Common and/or duplicate functions
b. Complimentary functions
c. Gaps in functions
d. Functions that may be wholly or partially performed by GIS

e. Functions that may be wholly or partially supported by GIS

This exercise would result in the identification of candidate GIS applications, products, and services to be developed as well as the prospective users of these products and services.

The next task is the identification of resources required to meet the needs identified. The needs and requirements assessments may be done simultaneously. The main objective of requirement assessment is to identify and evaluate the GIS resources: data, hardware, software, human resources available.

The specific objectives of the task are:

- Identifying the GIS applications, products, and services needed to support strategic, managerial, and technical functions.
- Identifying the datasets required to support these GIS applications, products, and services. An example of the list of data required for watershed management is provided in Appendix I.
- Identifying, quantifying and evaluating available data.
- Identifying data gaps (data required minus data available).
- Evaluating the quality and currency of existing data relevant to the identified applications and products; and
- Identifying computer hardware, software and human resources available.
- Designing the scope of GIS development based on the needs.
- Proposing implementation plans that include the estimated cost and timeframe of the development.
- Identifying investment risks and proposing mitigation measures.

### 5.1.2 Definition of the scope of assessment

This needs and requirements assessment may be undertaken at either the agency, departmental, national, or regional levels depending on the defined scope of the GIS-supported functions to be performed. At local level for instance, the application may be developed to support real property assessment and taxation. In which case the needs assessment will be limited to the local authority charged with this responsibility. If however, the GIS application is to be designed to support groundwater pollution monitoring, the scope of the assessment would be island-wide or nationwide. A regional scope will involve for example, GIS applications design to model the impact of sea level rise, and storm surge in the Caribbean.

The selected scope of assessment determines the cost and timeframe of the assessment as well as the complexity of support and coordination required for the assessment.

### 5.1.3 Activities

The needs and requirements assessment may be performed using any of the following options:

a. use of an external consultant with support from participating agencies or
b. use of key staff from participating agencies with background in GIS and systems analysis

The following methodological approach is proposed. This methodology may be adapted as deemed necessary.

A. Inception Meeting: This entails a consultative meeting with key stakeholders to identify project implementation issues such as: objectives, expected outcomes, scope of the assessment, resources required, clarify roles and responsibilities, define mechanisms for coordination and monitoring, define timeframe, and milestones.

B. Prepare and get approval for the inception meeting report.

C. Design and get approval for the assessment tools.

D. Conduct technology awareness seminars for the different levels of stakeholders: the purposes of the seminars are the following: introduce GIS concepts and terminologies, explain the needs and requirements assessment process, make clear the level of support required, and the critical success factors.

E. Implement the assessment tools.

F. Review and evaluate existing data and identification of key issues, including data sources, quality, appropriateness of existing data, data gaps, list of digital and analogue data available.

G. Submission and presentation of draft assessment report.

H. Review of draft assessment report by key stakeholders.

I. Modification of draft report and submission of final report.

J. Dissemination of the final assessment report to stakeholders

### 5.1.4 Outputs

The output of the needs and requirements assessment should contain the following:

I. Review of existing functional environment of GIS-related institutions

- List of functions performed and the frequency of their performance;
- List of data required and available to perform these functions;
- Inventory of existing technological hardware and computer software;
- List of available personnel and their GIS-related qualifications;
- The strengths, weaknesses, opportunities, and threats of the institutions as they relates to GIS implementation.

II. Conceptual design of the GIS

- List of potential GIS applications, products, and services needed;
- Design of the implementation scope, scale, and options;
- Computer hardware and communication configuration and specifications;
- Design of computer software environment;
- List of data required to be collected, automated, or transformed;
- Characteristics of personnel and training required;
- Implementation timeline and estimated budget.

### 5.1.5 Stakeholders and Responsibilities

The table below provides an indication of stakeholders and their responsibilities.

| Stakeholder | Responsibilities |
|---|---|
| Assessment team | Design assessment tool<br>Facilitate technology seminars<br>Conduct assessment<br>Prepare and present reports |
| Management team | Seek funding and select assessment team<br>Clarify goals, objectives, and expected outputs of the assessment<br>Ensure access to key personnel and information<br>Review draft reports and approve final report<br>Use report to gain support |
| Participating agencies | Facilitate the assessment process and provide key information<br>Communicate issues critical to the assessment<br>Review draft reports<br>Use report to gain support |

### 5.1.6 Identification of critical success factors

The successful conduct of a needs and requirements assessment study hinges on the resolution of the following critical success factors. The critical success factors are:

a. Development of a comprehensive assessment tool.
b. Ensuring the relevance and adequacy of the assessment.
c. Current and adequate knowledge of GIS and ICT environment and implementation issues.
d. Simplicity and effectiveness of needs assessment tools.
e. Top and middle management support for the assessment process.
f. Adequacy of time and financial resources for the process.
g. Clarity of findings and recommendations made.
h. Effective adaptation of current global ICT environment to local conditions.
i. Comprehensive review of strategies implemented and lesson learned by similar Small Island Developing States e.g. Fiji islands.

## 5.2 Component II. Acquisition and management of data and databases

Data and databases are critical inputs to GIS application. Data on the various spatial entities that are of interest to the region or the intended applications should be collected and entered into a digital database.

### 5.2.1 Goals and Objectives

The goal of this component is to build comprehensive and integrated GIS databases that may be used to perform the GIS applications, products, and services identified in the needs and requirements assessment.

The specific objectives are:

- to design data collection and data automation strategies;
- to collect data required to support development of a digital database;
- to verify the quality of existing and new data;
- to design and develop a versatile digital database in support of GIS mainstreaming;
- to create a data dictionary and metadata standards for the database to be developed; and
- to develop a comprehensive data management plan.

Based upon the results of the GIS needs and requirements assessment, digital databases should be designed and developed. The design of the database should be fully specified and it should include:

- The data model for the database — this will describe the data structure and will emerge from the list of data required;
- Data management tools to be implemented as part of the database, including tools for browsing, querying and updating the database;
- File formats, data types and structures that will be supported by the database; and
- Standards and procedures for updating, maintaining, archiving and expanding the database.

### 5.2.2 Activities

The activities under this component are:

a. Conceptual database design
b. Logical database design
c. Development of data management plan
d. Identification of critical success factors

There are three major activities that need to be undertaken for the development of this component. These are: conceptual database design, logical database design, and data management plan.

I. Conceptual database design: this involves the performance of the following tasks:

a. Data gap analysis: specification of the data required, data available, and data to be collected. The analysis will entail the specification of the following characteristics for each data theme:

- Map scale
- Map projection
- Map datum
- Spatial extent
- Year data was acquired
- Format (digital/hardcopy)
- Sources
- Accessibility

b. Definition of new spatial extent, map scale, time-scope, datum, projection of the data required.

- Spatial extent: project site, community-wide, parish-wide, or island-wide
- Map scale: 1:5,000, 1:10,000, 1:25,000, or 1:50,000
- Time-scope: not more than 15 years, 10 years, 5 years, or less than 1 year old
- Datum: National datum or GWS 84
- Projection: UTM or conical projection

From this analysis, the following can be decided:

- List of new data to be collected.
- List of data to be transformed or re-projected.
- List of data to be digitized.
- Priority for data collection and data automation.

c. Specification of the tasks and options for data automation. The following tasks and options should be considered:

- keyboarding of alphanumeric or tabular data
- Scanning and on-screen digitizing of mapped data
- Scanning and semi-automated raster-vector conversion
- Geo-referencing of scanning maps and imageries
- Use of in-house personnel or contractors
- Quality control and quality assurance methods

- Timeframe for completion
- Budget and sources of funding

II. Logical database design. This involves the performance of the following tasks:

- Development of entity-relation model for the data required
- Specification of feature identifiers (primary and foreign keys)
- Specification of the required attributes for each entity or feature
- Specification of database integration techniques

III. Data management plan. This entails the development of the following protocols:

- Metadata standards
- Data updating methods and time scope
- Identification of data custodians
- Data sharing arrangements
- Data access and data security
- Design and development of metadata systems
- Liability and confidentiality

### 5.2.3 Outputs

The development of this component should result in the following:

- List of existing, available, and usable digital data
- List of existing, available, and usable analogue data
- List of new data to be collected and/or automated
- Selected methods for data automation and data verification
- Quality control and quality assurance techniques
- Fully specify entity-relation diagram
- Logical data models
- Data management plans and protocols
- Metadata standards
- Budget and timeframe

### 5.2.4 Stakeholders and responsibilities

| Stakeholders | Responsibilities |
|---|---|
| Owners/custodians of existing data | Provision of metadata to users<br>Facilitate access to data<br>Maintain the currency and quality of data |
| Data collection service providers | Explore efficient data collection methods<br>Provision of metadata to users<br>Maintain the currency and quality of data |
| Data automation service providers | Provision of metadata to users<br>Managing data integration challenges<br>Facilitate map projection and datum transformation issues<br>Manage multi-resolution data |
| Database developers | Provide a user friendly interface for database users<br>Integrate databases from different platforms |

| | |
|---|---|
| Database manager | Manage access to data<br>Provision of metadata to users<br>Maintain the currency and quality of data |
| Database management committee | Forecast database uses and requirements<br>Formulate data management policies and standards |

### 5.2.5 Critical success factors

The success in the construction of this component is dependent of the following critical factors:

- Availability and access to current and accurate data
- Availability of specialized equipment e.g. large format scanner
- Availability of trained personnel for data collection, conversion, and database development
- Adequacy of data collection techniques
- Adequacy of the quality control and quality assurance strategies
- Adequacy of the selected mapping parameters (e.g. projection, scale, datum)
- Design of a cost-effective data collection program
- Timeliness of the whole process
- Adequate and continuous funding regime
- Official support for data management plans and protocols
- Inter-agency support for the data collection program

## 5.3 Component III: Acquisition and management of technological resources

Improvements in information and communication technologies (ICT) are responsible for the rising interest in the use of GIS as a data management and spatial analysis tools. The careful selection, acquisition, use and maintenance of appropriate ICT in support of GIS objectives are vital to successful GIS mainstreaming.

### 5.3.1 Goals and Objectives

The goal of this component is to identify, acquire and manage ICT that would support efficient and effective use of geographic data for decision making. The following are the specific objectives:

- Design of an appropriate ICT environment
- Development of an ICT acquisition plan that allows for easy access to technological resources.
- Development of capacity for the effective use of the ICT acquired
- Facilitation of a coordinated approach towards resource management and information dissemination.

### 5.3.2 Activities

The activities under this component are:

a. Design of system architecture options based on the results of the needs assessment
b. Identification of hardware and software required
c. Development of hardware and software acquisition plans and options
d. Explore the use of free and open source GIS software
e. Design of options for system technical support
f. Design of options for funding system upgrades
g. Design of options for system security and safety
h. Identification of critical success factors

As an illustration of what is expected in the acquisition and management of technological resources, the design of an enterprise GIS (e-GIS) is provided in this section

#### 5.3.2.1 Design of Enterprise System Infrastructure

The enterprise system infrastructure is the mechanism for meeting the effectiveness and efficiency requirements of a mainstreamed GIS. One of the key elements of IWCAM is unhindered access to watershed data when needed. Using modern ICT, information products can be stored, processed, and disseminated to a variety of stakeholders.

The ICT objectives for e-GIS are the following:

- To facilitate the assembly of existing data held by key agencies.
- To provide data needed for GIS applications.
- To provide mechanisms for the entry, storage and retrieval of data.
- To provide mechanisms for the dissemination of watershed information to stakeholders
- To provide mechanisms for the generation of reports and reviews.

The ICT model for the e-GIS should have the following underlining principles or design parameters. The system should lead to:

- Increased levels of access to watershed information.
- Nationwide decentralization of access nodes.
- Improved integrity of content.
- Improved level of reliability.
- Low-cost implementation

A model IT Architecture is comprised of six (6) basic logical layers as shown in Figure 3: data layer, data processing or application layer, data transportation layer, client layer, security layer and system management layer.

The **data layer** is comprised of mechanisms for data organization, data storage, and data back-up system. It contains all the core data and supporting documents for each watershed entity. The e-GIS will rely on a number of data themes such as:

- Biophysical database D1
- Atmospheric-climate database D2
- Hazard risk database D3
- Anthropogenic database D4

The **data process/application layer** contains all the application servers, operating systems, routine and special applications developed to transform the system raw data into environmental information products requested by the end-users. It also contains transaction rules and work-order management systems.

The **data transportation layer** contains the hardware and software required to move data and products throughout the network of data producers and system users across the country: LAN, WAN, etc.

The **Client layer** is a suite of computer hardware and software that collects users' request data and sends it through the transportation layer to the application layer for processing and returns to the users responses to their request.

The **security layer** contains firewalls, virus protection system, intrusion detection, and user identification. It is an important component that is used to ensure the integrity of the system.

The **management layer** provides functionality for controlling the system's behaviour and accounting for its effectiveness.

#### 5.3.2.2 System Configuration

The goal of the configuration is to provide for:

- efficient serving of data resources to internal and dedicated external clients,
- cost-effective provision of data processing tools to internal clients, and
- effective provision of information products to end-users.

These goals may be fulfilled through the design of a system that allows existing database custodians to continue to keep their data resources and be able to share the data via the LAN or WAN with current and potential end users.

For efficiency, three servers are recommended as shown in Figure 4: A **database server** which allows for the provision of data to requesting and approved users; an **application server** with a suite of GIS application software developed to take full advantage of the investment in the databases. This server will support GIS applications. The **client server** is the gateway for distributing data, products, and functionalities to different users. At minimum, a single server can be used to accommodate the functions of these three servers.

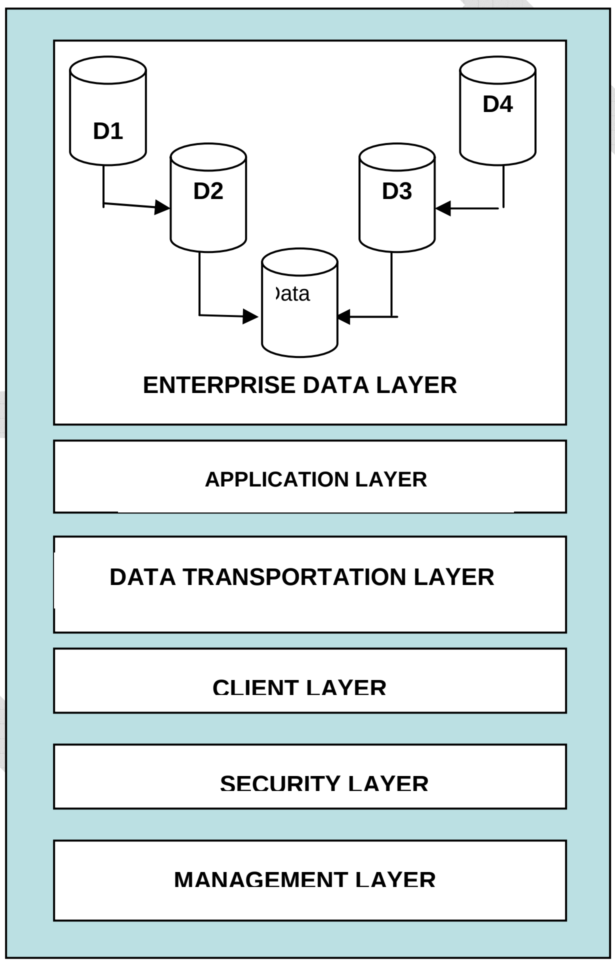


Figure 3: e-GIS Information Technology Architecture

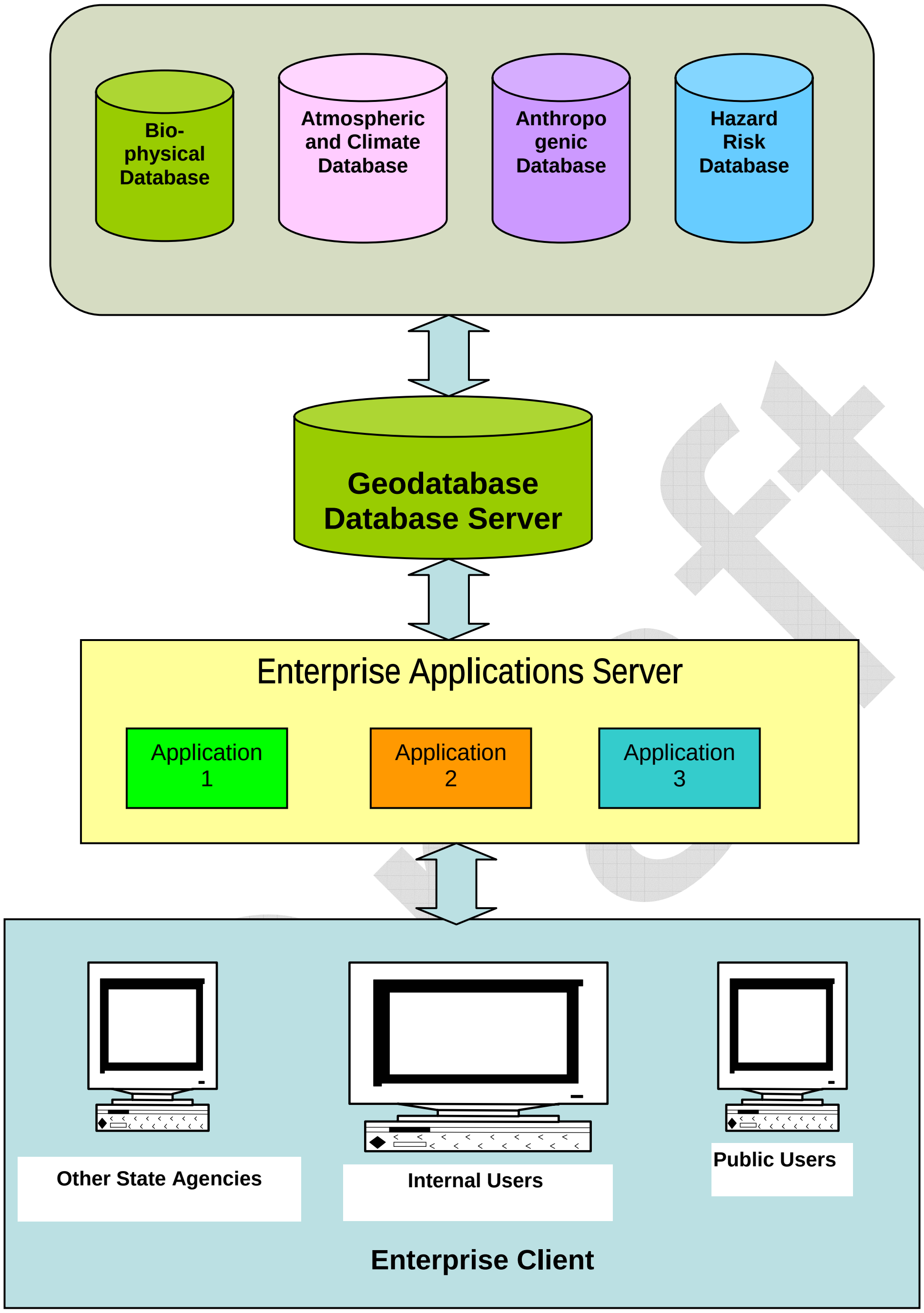


Figure 4: Conceptual Model of e-GIS

### 5.3.2.3 Key Solution Considerations

The implementation of the e-GIS will require an integrated solution that provides intelligent linkages among the various sources of data and utilizes effective web-based technologies to ensure an optimal online experience for the user. A conceptual model for the solution architecture is provided in Figure 5. The following represents key aspects that must be carefully considered in the design and implementation of the system:

- Solution Architecture –The system should utilize a multi-tiered web-based architecture that separates the interface, transaction rules and data. This separation allows for greater flexibility and manageability of the solution as any one layer can potentially be modified or managed independent of the other layer. For example, a modification to the interface may be made without necessarily adjusting the business logic or data. Likewise, certain changes to the business logic functions can be made without having to re-design or alter the system interface or the database. From a management standpoint, this architecture allows for management and control of the data for the system independent of the interfaces or business logic. This simplifies key data management processes such as back-up and recovery.

- Data Access and Linkages – The data that will be required by the system is stored in disparate systems and must be brought together and provided to the end user in a seamless fashion. Areas to consider will include how and when the data will be extracted from these source systems, the merging or integration of the data, the storage requirements and the presentation of the data to the end user. This will be a challenging exercise because of the following factors:

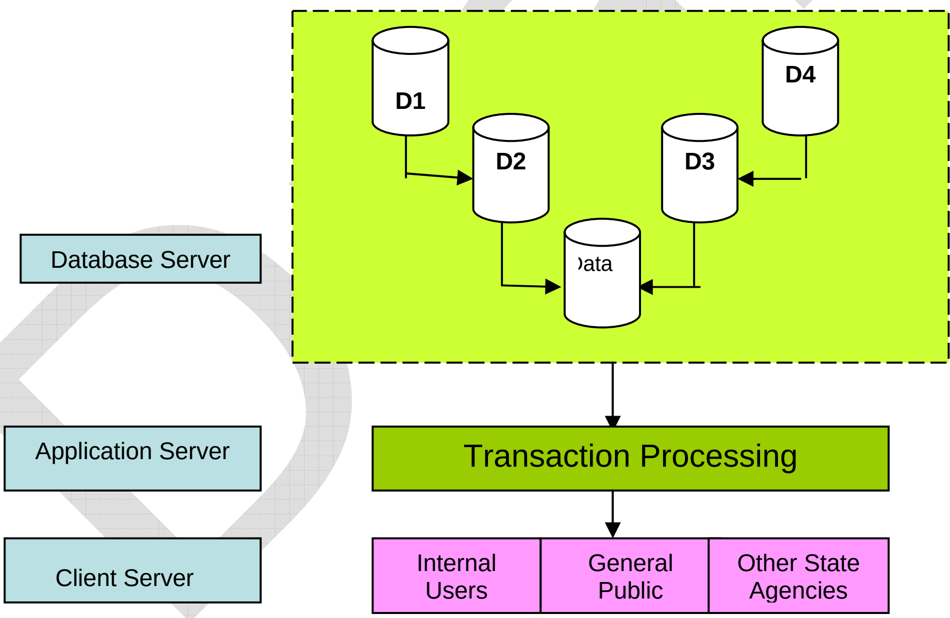


Figure 5: e-GIS Solution Architecture

- The data consists of various formats (database, images, maps, etc)
- The data is not static but is continually being revised and updated in the source systems
- The data is stored in different systems with different business rules and data validation. As a result there will be inconsistencies in certain common fields due to user data entry error, different code schemes, different abbreviations, etc. This means doing straight joins on common fields may not bring back relevant or appropriate data

A clear strategy must be provided that illustrates how these challenges will be addressed in a manner that is efficient and is transparent to the end user.

- Bandwidth Utilization – The system must provide the required functionality in a manner that minimizes bandwidth requirements. A system rich in features can still result in a poor end-user experience if performance is sluggish or there is too much delay responding to requests. Given the limitation posed by the Internet, the design and technology employed in the solution should illustrate how this will be addressed to provide a system that is highly responsive to user actions.

- Security – Security is an integral component of the solution. Apart from catering for different classes of users, the system will also need to handle sensitive or confidential transactions such as online requests. A secure online environment must be provided to protect against unauthorized access to information and malicious users. To ensure this is achieved, the proposed solution must demonstrate a comprehensive security model that highlights the mechanisms that will be employed within the solution architecture. This will consist of the measures that will be used to secure the data, transaction rules components as well as the interface or front-end of the system. This strategy is critical to providing a multi-layered approach that better protects the system from potential attacks. These security measures must utilize the latest and best of breed technologies that work effectively together in providing integrated and comprehensive security to the system.

- Scalability – The system must be designed to scale as demand and use increases over time. The architecture employed will be a significant factor in ensuring this aspect of the system. The solution proposed must demonstrate how the system can be scaled out to ensure that responsiveness is maintained as the number of users increase.

- Extendibility – The design of the system should also cater for extendibility and growth in both the features provided and the number of source data systems that will be accessed. The primary focus for this area will be the ability to add new sources of data. While adding a new source system will result in a change to the solution, the proposed design should address how the new source data will be added in an efficient and consistent manner.

#### 5.3.2.4 Hardware Requirements

Table 3 outlines the recommended minimum specification for the hardware that will be required based on the proposed design. These specifications should be reviewed in light of constant improvement in computer hardware specifications.

Table 3: Recommended Minimum Hardware Requirements for e-GIS

| Computer hardware (Minimum requirement) |
|---|
| Application Server (2) |
| ▪ Intel Xeon processor at 3.0GHz |
| ▪ 3 GB RAM |
| ▪ 400 GB hard disk |
| ▪ CD-ROM |
| Central Database Server |
| ▪ Intel Xeon processor at 3.0GHz |
| ▪ 4 GB RAM |
| ▪ 400 GB hard disk |
| ▪ Tape Drive |

| |
|---|
| ▪ CD-ROM |
| Firewall Server |
| ▪ P3 class machine |
| ▪ 512 MB RAM |
| ▪ 40 GB hard disk |
| ▪ CD-ROM |
| Clients Personal Computers (10) |
| ▪ P3 class machine (Desktops and Laptops) |
| ▪ 512 MB RAM |
| ▪ 40 GB hard disk |
| ▪ CD-ROM |
| Peripherals |
| ▪ Large format inkjet plotters (2) |
| ▪ Laser printers (2) |
| ▪ Colour scanners (2) |
| ▪ Mass data storage devices (2) |
| Physical Accommodation |
| ▪ Office Space |
| ▪ Server room |
| ▪ Air conditioning |
| ▪ Clean power supply |
| ▪ Power backup system |
| Network hardware |
| ▪ Routers |
| ▪ Switches |
| ▪ Wiring |

#### 5.3.2.7 Software Requirements

In this section, software requirements are provided. It should be noted that reference to specific software products is done only to illustrate typical functionalities required. It does not mean that these are the actual software and hardware products that should be acquired at the time of implementation. Given the dynamic nature of the IT industry, a more detailed evaluation of appropriate software and hardware should be conducted at the time of implementation. The following software products and functionalities are proposed for the GIS implementation. The software should allow for the initial creation, editing, analysis and querying of the datasets, including report generation. As this phase is completed, the other software elements will be added to allow for distributed mapping via the Internet/Intranet and fault management and other integrated analysis of assets and customers. Reference to ESRI GIS products does not suggest that this is the recommended GIS software product. It is suggested that GIS software should be evaluated for functionality, ease of use, and cost of acquisition. Other things like, cost of upgrade, steepness of learning curve, and availability of local technical support should also be evaluated.

GIS data creation, editing, processing, visualization tools

Below are outlines of the recommended suite of software that will be required based on the proposed e-GIS design:

| Software Product | Functions |
|---|---|
| ArcGIS Server | Data creation, editing and analysis, DSA network manipulation |
| ArcPAD | Field data collection and information system |
| ArcGIS | Data creation, editing and analysis, report generation |
| ArcIMS | Internet-based data, information product, and application server |

### ArcEditor

ArcEditor will allow for the creation and editing of the vector data formats including shapefiles, personal geodatabases, and multi-user geodatabases. Hence, this software application will be used to create the necessary data layers including buildings, roads and feeder network. ArcEditor adds full capabilities for multi-user geodatabase editing, schema management, and version management. This includes advanced tools for version management, for example, version-merging tools to identify and resolve conflicts. Hence, copies of the main database can be extracted for use in the designing and planning of new services by more than one person and when the final version is accepted, this can be merged back to the main database without problems.

### GIS database management tools

ArcSDE is an example of a gateway that facilitates managing spatial data in a database management system. ArcSDE allows users to manage geographic information in one of four commercial databases: IBM DB2, IBM Informix, Microsoft SQL Server, and Oracle, as well as being able to serve ESRI's file-based data with ArcSDE for Coverages. ArcSDE serves spatial data to the ArcGIS Desktop (ArcView, ArcEditor, and ArcInfo) and through ArcIMS, as well as other applications and it is the key component in managing the existing multi-user spatial database, which will be developed in the existing IBM DB2 relational database management system.

ArcSDE provides new functionality including versioning, direct editing of spatial data, and support for new data types including raster files and locators (addresses). In addition, multi-user geodatabases are managed by ArcSDE. The geodatabase model is an object-oriented model that allows users to add behavior, properties, rules, and relationships to their data. With ArcSDE, the system can benefit from the features:

*Flexibility and Performance:* ArcSDE significantly improves the performance of a complete GIS system by distributing the GIS application between the database server, the client, and the ArcSDE application server. Performance is enhanced through storage methods that provide a fast and compact representation for spatial data.

*Database Portability:* You can move data from one DBMS to another without loss of information through ArcSDE data export and import capabilities.

*Schema Portability:* ArcSDE defines a single logical model for spatial data implemented on top of the particular physical database. ESRI GIS applications and applications developed with ArcSDE's Java and C API will run with little or no change regardless of the underlying DBMS.

*Data Integrity:* ArcSDE manages the integrity of point, line and polygon information added to the database and will not allow ill-formed feature geometry to be inserted (for example a polygon's boundaries must be closed). In addition, ArcInfo and the ArcSDE gateway can be used to implement additional integrity constraints that are not practical to implement in the DBMS itself (for example, you can add editing rules to prevent overlapping polygons or connectivity rules for utility networks).

*Application Programming Interface:* ArcSDE provides GIS functions for advanced application development through open, high-level C and Java APIs for querying and processing spatial information.

*Reduced Database and Application Development Costs:* ArcInfo ArcObjects, ArcSDE Java and C APIs, and MapObjects allow developers to choose the appropriate tools to quickly create focused applications and custom data loaders.

### Internet Map Services Tool

ArcIMS is an example of a solution for distributing mapping and GIS data and services on the Web. Whether you are operating strictly within your organization’s Intranet or sharing information over the Internet, you can use ArcIMS to distribute geographic data to many concurrent users and allow them to do location-based analyses. ArcIMS is a powerful, scalable, standards-based tool that lets you quickly design and manage Internet mapping services. Using the power of ArcIMS technology, the company can provide a wide range of location-based data and services over the Web. ArcIMS features include:

- Integration with ESRI's ArcGIS Desktop products including the ability to publish ArcMap and ArcPublisher documents on the Internet
- Ability to combine data from multiple sources
- Secure access to map services
- Wide range of GIS capabilities
- Highly scalable architecture
- Standards-based communication
- Support for a wide range of clients
- Useful metadata services for indexing and sharing geographic information

In addition, three types of utility software are required. These are:

- Virus protection
- Firewall protection
- Portable GIS data collection, manipulation and data visualization software

### 5.3.3 Outputs

Below are the expected outputs and outcomes of this component:

- System architecture options
- ICT specifications and estimated cost
- ICT acquisition and maintenance plans
- Centralized institution created or identified for National GIS management (establish data securities, inform information policies, data integration, data dissemination)
- Established integrated network to support the center (database servers, IT requirements)
- Development of a national GIS policy or framework

### 5.3.4 Stakeholders and responsibilities

| Stakeholders | Responsibilities |
|---|---|
| Government Information Technology Unit | Maintain approved information and communication technology (ICT) policy and standards of the Government.<br>Develop national capacity for effective use of ICT.<br>Provide access to cost-effective methods towards the acquisition of ICT resources. |
| ICT service providers | Provide clients cost-efficient and appropriate ICT resources.<br>Provide technical support for efficient use of ICT resources.<br>Leverage the cost of ICT resources. |
| GIS software specialists | Update knowledge on the efficient use of ICT<br>Provide technical support to end-users |
| End-users | Communicate new needs to developers<br>Seek better uses of ICT resources |

### 5.3.5 Critical success factors

The following are the anticipated critical success factors for this component:

- Selection of applicable, appropriate, and adaptable technologies.
- Knowledge of current and efficient ICT solutions.

- Easy access and transfer of data.
- Institutionalized funding mechanism.
- Awareness of GIS benefits to the public and senior public officials.
- Availability of reliable power supply and power back-up facilities.
- Availability of local facility for technological support
- Existence of an ICT policy that address among other things, the issue of warranties and upgrades.
- Design of a scalable system

## 5.4 Component IV: Development and management of human capacity

The availability of training and competent GIS personnel is invaluable to the attainment of the objectives of GIS investment. Human capacity in the design and use of GIS is central to GIS mainstreaming.

### 5.4.1 Goals and Objectives

The goal of this component is to ensure adequate supply and retention of the human capacity required for the effective and efficient mainstreaming of GIS in the Caribbean. The objectives of this component are:

- To identify and fill gaps in the supply of GIS-related human resources required
- To develop mechanisms for the continuous supply of relevant human resources
- To develop strategies for effective management of the human capacity needed

### 5.4.2 Activities

The activities required to build this component are:

a. Identification of the human capacity required for GIS mainstreaming in the country
b. Conduct of an audit to identify the knowledge levels of personnel available for GIS implementation
c. Gap analysis of human capacity required
d. Development of action plan for filling human capacity gaps identified
e. Development of organizational charts
f. Development of job specifications
g. Development of a human resource management plan (including succession and retention planning).
h. Identification of critical success factors

Training and education programmes should be considered in the following training modules:

- Introduction to GIS
- Introduction to Satellite remote sensing (SRS)
- Integrating GIS, GNSS, and SRS
- Field data collection using GIS/GNSS
- Database design and development
- Digital cartography and visualization
- Building and using digital elevation models
- Building GIS applications
- Database and systems administration
- Internet map server
- Development and maintenance of GIS standards
- Introduction to Global Navigational Satellite Systems
- Conducting needs and requirements assessment
- Coordinate systems and map projections
- Image analysis techniques
- Database integration
- GIS spatial analysis techniques
- Building and using networks
- Customization of GIS software
- GIS project management
- Networking and system configuration
- Project design, and management

The appropriate use of the following mix of capacity development options should be carefully evaluated:

Informal training

- Training of trainers
- Seminars
- Workshops
- Short courses

Formal education

- Certificate programmes
- Diploma programmes
- B.Sc. degree programmes
- M.Sc. degree programmes

Training programmes should be developed with the following sequence in mind:

- Awareness building
- Basic level
- Intermediate level
- Advanced level

The appropriateness of the following training delivery options should also be evaluated:

- Formal e-learning
- Formal classroom-based learning
- Departmental in-house training
- In-country training with participants from other Departments
- Regional training with participants from other different countries and territories

Before selecting any of these options, the merits and demerits of each option should be carefully investigated vis-à-vis: adequacy of content, cost, timeframe, background of facilitators, availability of learning resources for the trainees, and accreditation of the training programme etc.

Appropriate capacity building opportunities should be explored for the following categories of stakeholders:

- Senior executives
- Senior managers
- Technical or professional managers, and
- Technicians

There is the need to set priorities when designing the training programmes. Depending on the current status of GIS capacity development in the organization, initial emphasis may be placed on the training of technicians followed by training of senior officials. It may also be prudent to simultaneously train these categories of staff in the same timeframe.

In a full-fledge GIS Unit, the following categories of GIS positions should be established. The number of persons hired for these positions would depend on the size of the GIS operations:

a. GIS executive manager
b. GIS products and services development manager
c. GIS database manager
d. System administrator
e. Digital cartographer
f. Database developer
g. Data automation technicians
h. Field data collectors

For a small operation, these positions may be combined into a staff compliment of 4 persons as follows

a. GIS Manager: product and services development
b. Database and system manager

c. Database developer
d. Data Technicians: data collection, data automation and cartography

Staff retention is a major constraint to capacity development in the Caribbean. Investment in staff development may be lost if the trained staff move to greener pastures. Below are some of the strategies that may be used to facilitate staff retention:

- Use of classic binding contracts for a specified period.
- Requirement to train other staff on return from training programmes
- Succession planning
- Recognition of the educational achievements of trained staff through promotion or salary increments
- Providing the trained staff with opportunities to use the knowledge gained
- Opportunities for advanced training and formal certification.
- Creation of an attractive working and learning environment
- Providing the trained staff with a sense of accomplishment
- Keeping the job challenging by encouraging the creation of new and exciting projects

### 5.4.3 Outputs

The expected outputs of this component should include:

- List of human capacity required and available
- List of local, regional, and international capacity building providers
- Capacity building plans, timeframe, and budget
- Organizational charts
- Job descriptions
- Funding options and strategies

### 5.4.4 Stakeholders and responsibilities

Below is the list of stakeholders and the suggested responsibilities.

| Stakeholders | Responsibilities |
|---|---|
| Prospective trainees | Gain the pre-requisite knowledge required.<br>Demonstrate ability to learn and use knowledge gained. |
| Capacity building providers | Develop appropriate training programmes.<br>Monitor and evaluate impact of training programmes. |
| Human resource manager | Seek training options and secure training funds.<br>Institute succession plans through capacity building. |
| Funding authorities | Provide adequate and continuous funding towards capacity building.<br>Monitor the impact of training programmes. |

### 5.4.5 Critical success factors

The anticipated critical success factors for this component are:

- Availability of trained personnel
- Ability to retain trained staff
- Access to adequate training funds
- Quality of training services
- Adequacy of technical resources to use knowledge gained

- Effective sequencing of training programmes
- Access to continuous professional development programmes
- Creation of an environment for revenue generation through the offering of GIS services

## 5.5 Component V. Development and management of institutional environment

The successful use of GIS technology is dependent on the building and maintaining of an institutional environment that facilitate learning, embrace innovation, and encourage collaborative work programmes.

### 5.5.1 Goal and objectives

The goal of the institutional environment component is to develop adequate political, managerial, and public support for nurturing the mainstreaming of GIS applications, products, and services throughout the country or region for effective inter-sectoral coordination of GIS.

The specific objectives are:

- To identify critical administrative, managerial, and legislative support systems needed for effective mainstreaming of GIS.
- To develop appropriate action plans for the development and retention of these support systems.
- To develop adequate plans for monitoring the adequacies of these support systems.

### 5.5.2 Activities

The following activities should be undertaken toward the construction and maintenance of this component:

a. Identification of methods, tools and resources required to gain and maintain political, managerial, financial, and legislative support.
b. Development of action plans for critical support systems.
c. Identification of critical success factors

| Support System | Approaches |
|---|---|
| Political support | Development and use of pilot projects and awareness building seminars |
| | "Selling" GIS applications as means for national compliance and standardized reporting frameworks in support of international agreements |
| | Development of a topical full-fledge GIS applications |
| | Demonstrated public participation through community projects |
| | Cost-benefits analysis |
| | Identification and development of policies and legislation in support of effective and efficient use of GIS |
| Managerial support | Awareness building seminars and technical workshops |
| | Use of newsletters, on-line resources, e-discussion, and user groups |
| | Review and development of inter-agency coordination mechanisms |
| | Establishment of a National inter-sectoral technical coordinating committee or use of existing coordinating committee (dependant on the institutional environment of the country |
| | Establishment of a high-level National GIS Management Council with decision-making powers |
| Regulatory and legislative support | Establishment of a GIS clearinghouse unit or central GIS data repository |
| | Development of metadata standards |
| | Development of data sharing protocols |

| | |
|---|---|
| | Development of data sales agreement |
| | Development of protocols for data access and use |
| | Development of data maintenance regulations |
| | Development of legislation in support of geospatial information management |
| Financial support | Capital budget for the acquisition and maintenance of information and communication technologies |
| | Capital budget for data acquisition |
| | Recurrent budget for data maintenance |
| | Capital and recurrent budget for human resources development and management |
| | Projection of sales and revenues - including self-sustaining mechanism for cost-recovery |
| | Potential for co-funding from other local agencies |
| | Potential for external funding (regional and international) |
| Public support | Public awareness programmes |
| | Marketing of products and services to NGO's, CBOs, and the private sector |
| | Demonstrated public participation through community projects |
| | Building of applications that meet visible needs of the population |
| | Introduction of GIS into primary, secondary, and tertiary school curricula |
| | Fostering private sector partnerships to create relevant applications for private and public sectors |

### 5.5.3 Outputs

Below are the outputs expected out of this component:

- List of critical support systems required for GIS development, implementation and use across the countries from project to national level domain
- Strategies for developing and winning the critical support systems
- Assignment of responsibilities for implementing the critical support systems
- Timeframe and budget for winning the critical support systems

### 5.5.4 Stakeholders and Responsibilities

| Stakeholders | Responsibilities |
|---|---|
| Ministerial champion | Facilitate buy-in by the political directorate<br>Facilitate legislative support<br>Source funding |
| Administrative champions | Facilitate administrative and regulatory support within and among State Agencies |
| NGOs | Promote use of GIS as a public goods for the empowerment of the general public |
| The general public | Demand access to current and accurate data, GIS products and services. |

### 5.5.5 Identification of critical success factors

The critical success factors for this component include:

- Alignment of GIS objectives and results to current goals and aspirations of the government
- Attaining buy-in of all stakeholders
- Demonstrated efficiency in the use of available resources

- Timeliness in the delivery of products and services
- Relevance and adequacy of protocols and regulations

## 5.6 Component VI: Development of end-user applications, products and services

GIS applications, products, and services are the fruits of GIS investments. Without them, investment in GIS can be considered a waste. GIS applications, products and services should be developed to meet the needs of the end-users.

### 5.6.1 Goal and objectives

The goal of this component is to develop and maintain tangible and intangible products and services that may be used to justify investment in GIS resources. The specific objectives are:

- To conceptualize and develop GIS candidate applications, products and services.
- To develop strategies for rolling-out these applications, products and services to as many clients as possible.
- To develop strategies for the maintenance of these applications, products and services.
- To explore other innovative ideas for demonstrating the value of GIS.

### 5.6.2 Activities

The following activities need to be undertaken:

a. A review of potential GIS applications identified during the needs and requirements assessment.
b. A review of resources required to build the applications and the products and services.
c. Selection of candidate applications based on certain criteria: number of user departments, timeliness of development, availability of data required, level of impact for public and political support.
d. Development of strategies for the design, development, testing, roll-out, and maintenance of the GIS applications, products, and services.
e. Identification of internal and external customers.
f. Development of a user-friendly interface for non-technical users
g. Development of business and marketing plans for the GIS applications, products, and services.
h. Development of strategies for sustainability.
i. Identification of critical success factors

The following stages and tasks should be undertaken towards the development of GIS applications:

| Stage | Tasks |
|---|---|
| Design Stage | 1. Identify and specify the *objectives* and the *decisions* required to be made using this GIS application. |
| | 2. Identify and specify the *criteria* required to make the decisions. |
| | 3. Identify and specify the *information* needed in order to evaluate the criteria. |
| | 4. Identify and specify the *data* that must be acquired to generate the information. |
| | 5. Identify and specify the GIS functions which will turn the data into information. |
| | 6. Identify the users of this application. |
| Development Stage | 1. Prepare the data for spatial operations |
| | 2. Perform spatial operations |
| | 3. Prepare derived data for tabular analysis |
| | 4. Perform tabular analysis |
| | 5. Evaluate and interpret results |

| | |
|---|---|
| | 6. Refine the analysis as necessary |
| | 7. Produce the final maps and tabular reports of the results |
| | 8. Customization and development of user-friendly interface |

There are a lot of challenges in developing GIS applications. Some of these are:

- Availability of application models and standards
- Availability of required data
- Availability of skilled personnel
- Steep learning curve
- Availability of funds

The implementation options in application developments are:

- Use of multi-disciplinary professional staff e.g. soil and social scientists, hydrologist
- Contracting of application development consultants
- Purchase and customization of tested third-party applications
- Hybrid of the above options

### 5.6.3 Outputs

The outputs of this component include the following:

- A list of GIS applications, products, and services that need to be developed
- A list of resources required for these applications, products, and services
- Selected methodology from the design and development of the applications, products, and services
- Timeline for delivery of applications and commencement of products and services provision should be identified
- Estimated capital and recurrent cost

Below is an example of GIS applications relevant to watershed and coastal areas management:

| | |
|---|---|
| Noise Pollution tracking and modeling | Environmental Impact assessment |
| Water Pollution tracking and modeling | Monitoring landslide occurrence |
| Air Pollution tracking and modeling | Hazard Risk analysis |
| Soil Pollution tracking and modeling | Non-point pollution analysis |
| Solid Waste management | Hydrological modeling |
| Flood hazard mapping and management | Sediment flow analysis |
| Coastal erosion modeling | Monitoring of affected marine ecosystems (coral reefs) |
| Coastal Water-Quality Modeling | Monitoring species abundance as it relates to the protection of important species in watershed areas. |

Below are examples of GIS products that may be offered to the public:

| | |
|---|---|
| Drainage networks | Soil erosion potentials |
| Watershed boundaries | Transportation networks |
| Slopes and aspects | Digital elevation models |
| Water discharge points | Water quality sampling or monitoring points |
| Trends in land use and land cover | Waste disposal sites |
| Flood hazard maps | Isoheytal maps |
| Depth of ground waters | Soil permeability |
| Special interest atlases | Landuse maps |

Below are examples of **GIS-related services** that may be provided:

| | |
|---|---|
| Map and image georeferencing | Data automation: digitizing, scanning, raster-to-vector conversion |
| GNSS-assisted field data collection | Database integration |
| Image analysis | GPS training |
| GIS training | Cartographic design of thematic map layers |

In addition to the list above, a list of hardware, software, data, and personnel should also be developed.

### 5.6.4 Stakeholders and Responsibilities

| Stakeholders | Responsibilities |
|---|---|
| End-users | Promote the use of GIS applications, products, and services. |
| Application development team | Seek end-user support and develop user-friendly applications |
| Product and service development team | Continuously seek efficiency and effectiveness in the development of GIS applications, products, and services |
| GIS Manager | Seek financial resources towards the sustainability of the system. |

### 5.6.5 Identification of critical success factors

The following are the critical success factors for this component:
- Relevance and adequacy of the GIS applications, products, and services to be provided
- Cost-efficiency of the GIS applications, products, and services to be provided
- Knowledge of application subject matter
- Adequacy of the data required
- Adequacy of the business and marketing plans

## 5.7 Component VII: Monitoring and evaluation of the system

It is difficult to identify and understand all the issues surrounding the development of a GIS. Change is constant and it must be embrace as the knowledge base improves. Monitoring and evaluation are mechanisms for ensuring that the systems so developed are meeting the goals, objectives, and current needs of the end-users.

### 5.7.1 Goal and objectives

The goal of the monitoring and evaluation (M&E) component is to ensure that investments in GIS resources are adequately applied to produce the intended outcome. The specific objectives are:
- To develop and manage monitoring and evaluation methods, tools, and strategies that guide GIS implementation and continued application
- To implement these tools and strategies towards the improvement of the GIS establishment

### 5.7.2 Activities

The following are the activities required to build this component:

a. Identification of critical activities to be monitored and evaluated. These include:
   - current and potential needs of the users
   - currency, accuracy and coverage of data

  - adequacy of software functionalities
  - software renewal licenses
  - hardware performance
  - Users and uses of GIS applications, products and services
  - Proficiency of hired and trained staff
  - Adequacy of political and managerial supports
  - Effectiveness of systems institutional environments: protocols, standards, agreements, and regulations

b. Development of monitoring tools, timelines, and implementation strategies.
c. Allocation of responsibilities for M&E strategies.
d. Development of evaluation parameters, indicators, and benchmarks
e. Implementation of the M&E strategies.
f. Identification and implementation of corrective or improvement measures based on the results of the M&E exercises.
g. Budgeting the cost of the M&E exercises.
h. Documentation of the M&E exercises and dissemination of the results to staff and management.
i. Identification of critical success factors

### 5.7.3 Outputs

The expected outputs of this component include:

- List of M&E activities
- Strategies of M&E activities
- Budget for M&E activities
- Units or personnel responsible for M&E activities

### 5.7.4 Stakeholders and Responsibilities

| Stakeholders | Responsibilities |
|---|---|
| Internal and external audit teams | Implement monitoring and evaluation programmes |
| M&E manager | Seek financial resources |
| GIS user communities | Provide feedback and solicit system improvement |
| National technical committee | Develop monitoring and evaluation programmes |
| National land information council | Seek and review result of monitoring and evaluation programmes |

### 5.7.5 Identification of critical success factors

- Knowledge of M&E issues and measurable parameters
- Support for and compliance with M&E measures
- Adequate funding for M&E activities
- Timeliness of M&E activities as well as corrective measures

# 6.0 Conclusions

## 6.1 Adapting the roadmap

The roadmap was developed as a guide for mainstreaming GIS implementation in the Caribbean. Given the limited financial and human resources of the region, it is necessary that available resources are used efficiently. The following steps should be followed when adapting the roadmap:

Step I: The roadmap may be adopted for the following scope of GIS implementation: departmental-wide, national-wide, or regional-wide environment. The scope of use should therefore, be first defined and the stakeholders within this scope should be identified.

Step II: Identify the key personnel of these entities and initiate formal discussion to get their buy-in. Seek the appointment of a steering committee and a political champion that would guide the adaptation of the roadmap.

Step III: Undertake a rapid strengths, weaknesses, opportunities, and threats (SWOT) analysis of the status of GIS data, technology, and human resources assets of each entity with the goal gaining an understanding the institutional environment of current systems.

Step IV: Based on the report of the rapid SWOT analysis, seek and obtain official approval to develop GIS mainstreaming strategies.

Step V: The steering committee should assemble a technical team of stakeholders who should adapt the roadmap. The technical team should use the roadmap to identify gaps in the existing technological environment, identify social and cultural constraints, and select implementation options based on prevailing social and economic conditions. The reports of the technical team should include: an adapted roadmap, work-plan, budget, roles, and responsibilities.

Step VI: The draft roadmap and work-plan should be disseminated to stakeholders for feedback and buy-in.

Step VII: The revised roadmap, work-plan, and budget should be submitted to the Steering Committee for review and approval and these should be used to seek political approvals and funding.

The roadmap contains best practices for efficient implementation. In using the road map, it is important that the Steering Committee examine the practicality of a proposed activity against the prevailing social, economic, technological, and institutional environment of the country. Innovation and opportunities to maximize investment in technology should however not be sacrifice in an effort to maintain status quo.

The roadmap is a living document developed based on current knowledge and past experiences. It should be updated on a regular basis using experiences and new knowledge.

## 6.2 Towards for a Regional Approach to GIS Mainstreaming in the Caribbean

When one considers the resource management challenges of the Caribbean, the limited human and capital capacity, and the rapidly changing information and communication technology environment, it is imperative that a coordinated and strategic approach be developed at regional level as opposed to local level to take full advantage of opportunities provided by Satellite Remote Sensing and Geographic Information Systems (SRS/GIS).

The idea of developing regional SRS/GIS Centers is not new. The United States National Mapping Division has five Regional Mapping Centres: Earth Resources Observation Systems Data Center (EROS Data Center), Mapping Applications Center, Mid-Continent Mapping Center, Rocky Mountain Mapping Center and Western Mapping Center.

Several of these facilities provide direct data and information access and retrieval services via the Internet to public and private enterprise. The Canada Centre for Remote Sensing plays similar role for Canadian enterprises. The United Nations Economic Commission for Africa (UNECA) established four sub-continent centres in Africa as part of its earth resources services group to provide training and product development services for the continent. Table 4 provides some details of these regional centres.

Table 4 UNECA Regional Centres for Remote Sensing Applications in Africa

| Institution | Location | Main Area |
| --- | --- | --- |
| Regional Centre for Training in Aerospace Surveys (RECTAS) | Ile Ife, Nigeria | Training in aerial surveys remote sensing |
| Regional Remote Sensing Centre (CRTO) | Ouaga-dougou, Burkina Faso | Training in remote sensing |
| Regional Centre for Services in Surveying, Mapping and Remote Sensing (RCSSMRS) | Nairobi, Kenya | Services in surveying, mapping & remote sensing |
| African Organization for Cartography and Remote Sensing (AOCRS) | Algiers, Algeria | Promotion of remote sensing & cartography development |

In the Caribbean, earlier effort towards the development of a regional geospatial centre in 1990 led to the designation of the Institute of Marine Affairs in Trinidad and Tobago, as the Regional Remote Sensing Centre by the CARICOM Ministers responsible for Science and Technology. A Satellite Remote Sensing Unit was thus established in 1992 with the mandate to apply remote sensing technology in the assessment of the coastal and marine environments. The center has undertaken a number of projects that include e.g.: current patterns, oil spill detection, wetlands mapping and sea surface temperature. However, this effort failed to realize the aims and objectives advanced for its establishment due to many reasons, some of which are:

- IMA is a research institute mandated to carry out coastal, marine and oceanographic research and not mapping, spatial data processing and dissemination agency
- lack of regional ownership and thus lack of financial inputs by member states
- Its initial funding from the OAS was primarily project focused: the study of the discharge of the Orinico River
- high staff turnover at IMA.

IMA on its own lacks the resources to push for a regional mandate but instead has followed a national mandate. Its efforts are thwarted by budgetary constraints imposed by its line ministry and national agendas.

In a CIDA sponsored contract report prepared in 1999 by the Oceans Institute of Canada, Halifax and titled “A review of remote sensing methods suitable for coastal zone management in the Caribbean”, the following opportunities and constraints begs for a regional approach (Oceans Institute of Canada, 1999):

## Opportunities

The report concluded that SRS/GIS provide the appropriate tools and techniques for mapping and monitoring the following natural resources in the Caribbean (Oceans Institute of Canada, 1999):

- Vegetation and land cover mapping
- Land use change detection and environmental monitoring
- Wetland identification, characterization, and monitoring of moisture conditions
- Environmental monitoring of marine habitats
- Terrain analysis and bathymetry mapping
- Shoreline change detection

- Floodplain delineation

### Constraints

The report however, identified the following constraints to efficient and effective utilization of RSS/GIS in the region:

- Little resident experience in the use of modern remote sensing technologies and their application to natural resource management and environmental monitoring.
- Aerial photography remains the primary source of information at local and regional level
- Practitioners rely mainly on visual analysis techniques.
- There is little capacity or expertise to select, acquire, analyse, or integrate remote sensing data
- Many institutions are currently not in a position to take advantage of RSS/GIS developments because of three interrelated factors: lack of knowledge, technical capability, financial resources
- Remote sensing data is not only required for coastal areas per se, but also for the entire island territory and their territorial waters.
- Lack of current and high-resolution maps of the natural resources.

### Benefits of a Regional Approach

Taking cue from this report and evidence of several failed national efforts, a new regional approach is needed. The approach would provide the following benefits that are beyond the capability of individual state members:

- A single forum for the negotiation, evaluation, and acquisition of remote sensing imageries from extra regional sources. This would lead to cost savings as CARICOM could use its regional status, strategic advantages and negotiating machinery to obtain imageries at no-cost or at lower cost for member states. This would facilitate accessibility through a regular and sustained data acquisition programme in support of natural resources management programmes in the region.

- A single regional training institute for the training of Caribbean nationals on the use and processing of satellite imageries. This would provide the critical mass and thus, lead to cost saving and development of a high quality training centre. The high cost of setting up and maintaining modern training institutions is prohibitive to most member states. A regional institution would be able to attract leading international trainers and researchers for high quality capacity building in the Caribbean.

- A single one-stop processing centre for the acquisition of Caribbean remote sensing products. A regional capacity for the processing of remote sensing data is a catalyst for continuity, accessibility and effective use of remote sensing products. Most member states cannot afford the cost of establishing and maintaining a data processing unit of their own when one considers the infrequencies at which remote sensing products may be required by some states. It is less costly to maintain a regional processing centre than a local one if one considers the volume of services that could be provided.

- A uniform standard in the use and classification of natural resource phenomenon. A regional approach would facilitate the development of regional standards for the acquisition, processing, integration, classification, and use of remote sensing imageries. This would provide an effective means for comparative studies of natural resource management issues at regional level. Many international initiatives require regional-level data as opposed to local-level data for effective quantification and analysis of global effects e.g. global climate change, millennium ecosystem assessment. A Caribbean standard for the identification, quantification and qualification of natural resources is imperative in the global village.

- An efficient data management programme. In addition to a consistent data collection programme is the need to develop an efficient data management plan. The high investment in data collection may go to waste if there is no consistent data management programme. A regional data management plan would include data sharing and data dissemination protocols and cost recovery strategies among member states.

## The Proposed Caribbean Centre for Remote Sensing and GIS Services

The development of a Caribbean regional capacity for natural resources mapping and monitoring requires a careful and well thought plan considering the geo-political landscape of the region, the cost, the range of users and uses and more so, the need for longevity.

The idea is for CARICOM to initiate the establishment of a regional centre with responsibility for the acquisition, processing, training, and distribution of remote sensing imagery for member states. The centre could be located at one of the campuses of the University of the West Indies or any other regional centre such as the Caribbean Meteorological Institute or the Caribbean Climate Change Centre. It is envisage that apart from the cede funding, this centre should be able to sustain itself through sales of products and services to local, regional, and international clients. Cede funding could be obtained from international donor agencies.

The regional centre would have responsibility for the following:

- Develop a regional mechanism for data collection and data update
- Provide mechanism for data dissemination and data distribution to key stakeholders
- Facilitate capacity building programme for the training to users and specialists
- Be the main custodian of natural resource data for the region
- Facilitate the use of accurate and current data of the natural environment for decision making

If this concept is considered favourable there would be a need to set up a mechanism to examine and recommend appropriate implementation model and plans. CARICOM has a unique opportunity not only to take the lead but also to take ownership of the foregoing benefits for its member states.

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Appendix I:
List of data layers required for watershed management

Appendix I: List of data layers required for watershed management

| | Required | Available | |
|---|---|---|---|
| | | Digital | Hardcopy |
| PHYSICAL FEATURES | | | |
| Coastlines | | | |
| Beaches | | | |
| Watersheds | | | |
| Watercourses: rivers, streams | | | |
| Water bodies: Dams, lakes, ponds, lagoons, swamps | | | |
| Hydrogeology | | | |
| Aquifers | | | |
| Geology | | | |
| Soils | | | |
| Roads – Major and minor | | | |
| Elevation contours | | | |
| Vegetation | | | |
| Rainfall | | | |
| Environmentally Sensitive Areas | | | |
| HAZARD-RELATED DATA | | | |
| Flood Hazard zones | | | |
| Landslide hazard zones | | | |
| Landslide inventory | | | |
| Erosion | | | |
| ANTHROPOGENIC FEATURES | | | |
| Administrative/Political boundaries | | | |
| Census Districts | | | |
| Geographic Place Names | | | |
| Government Buildings | | | |
| Recreational Parks | | | |
| National Parks | | | |
| Schools | | | |
| Land Use Units | | | |
| Airports/Heliports | | | |
| Seaports | | | |
| Waste management sites | | | |
| Electricity generation plants | | | |
| Electricity supply lines | | | |
| Health care facilities | | | |

| | Required | Available | |
|---|---|---|---|
| | | Digital | Hardcopy |
| Water tanks / reservoirs | | | |
| Water supply lines | | | |
| Water production wells | | | |
| Settlements | | | |
| Shelters | | | |
| Place of worship | | | |
| Markets | | | |
| Fishing Centres | | | |
| Historic /Archaeological sites | | | |
| Meteorological Stations | | | |
| IMAGERY | | | |
| Aerial Photography | | | |
| IKONOS satellite imageries | | | |
| Landsat satellite imageries | | | |

Appendix II:

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