Challenges in Developing Spatial Data Infrastructure in the Caribbean

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Abstract. The development of an efficient spatial data infrastructure (SDI) is fundamental to the effective use of GIS capabilities. Even more important is the maintenance of this infrastructure. Inadequacy in SDI incapacitates the development of cost-effective national and regional GIS applications. It is, therefore, imperative that every effort must be made to ensure that an appropriate SDI is developed, managed, and maintained if the Caribbean region is to fully benefit from their investment in GIS over the past 10 years.

This paper reviews the status of SDI in the Caribbean and the challenges faced with ensuring that this infrastructure is effective in supporting GIS demands. This paper concludes by providing suggestions on how the following infrastructure can be improved: geodetic control framework; base mapping; land records; human capacity; and funding arrangements.

1. Introduction

The Caribbean region, located between North and South America, comprises those countries from Guyana to the south to The Bahamas to the north. Many of these countries are islands or continental states, exhibiting a variety of geological structures and natural and human resources.

To effectively and efficiently manage its natural resources, the Caribbean region needs to develop and maintain databases of these resources. The region needs to know what it has, where and in what condition, and how to share this information among users. The most relevant technology available to manage these needs is Geographic Information Systems (GIS). GIS are computerised information systems that are designed to capture, edit, store, retrieve, process and disseminate spatial and attribute data which are referenced to some predefined geographic/geodetic referencing systems. Almost all life phenomena that have spatial relationships can be conceived to benefit from GIS functionalities. The superior data handling and data processing capabilities of GIS are responsible for the increasing adoption of the system in varying fields of application.

The development of an efficient spatial data infrastructure (SDI) is fundamental to the effective use of GIS capabilities. Clinton, (1994) defined SDI as '…the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilisation of geospatial data'. Brand, (1998) further explained that it '…. facilitates the identification, access, use and exchange of spatially referenced information'.

Some of the spatial data issues of the Caribbean are: environmental management; hydrocarbon exploration and exploitation; marine resource management and international marine boundaries. A regional SDI would facilitate locating and visualising data in respect to each of these issues and the exchange of data within and amongst the subject areas and countries of the region as shown in Figure 1. Environmental pollution may be tracked and modelled, so too, the locations of habitats and migratory patterns of aquatic species, and

hydrocarbon deposits mapped and their long-term use predicted. The negotiation process for boundary delimitation may be accelerated and be less contentious. These applications would be made possible through the development and maintenance of a regional SDI.

2. The Status of SDI in the Caribbean

Large volumes of data pertinent to the spatial data issues have already been acquired and mapped for individual countries of the region. Analysis of these data in a regional context has been hampered by the lack of a SDI. In the Caribbean, much of the data available is in analogue form and are mostly out of date. The data that are in digital format are not available online for Internet access. Costs of digital data are generally low, however, owing to the restrictions on availability in flexible formats. Spatial data on the smaller scales are often manually generalised leading to inconsistencies when compared with the large-scale data for the same data theme.

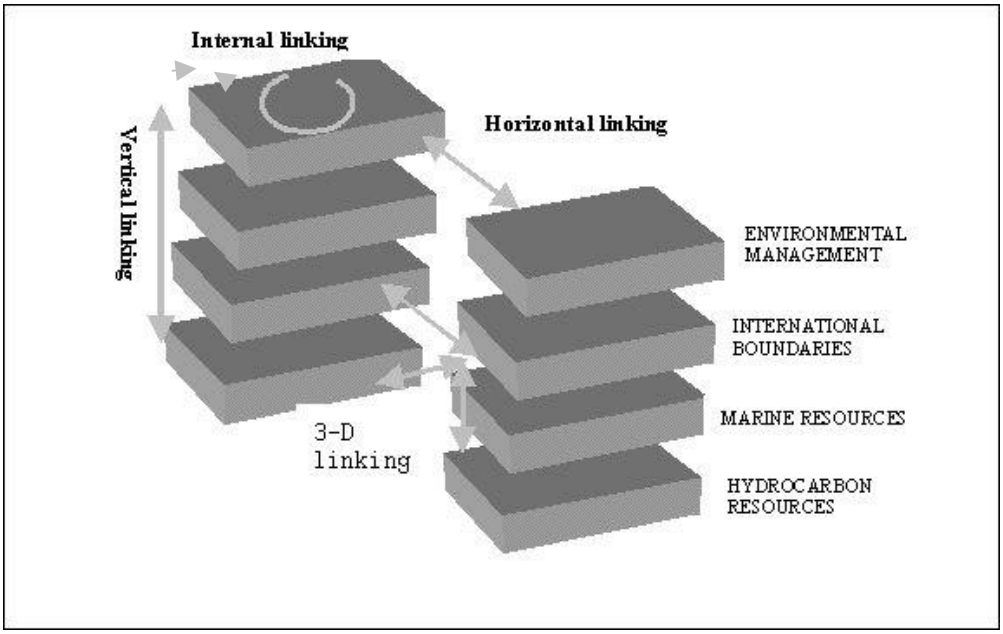

Fig. 1. Some Spatial Data Issues of the Caribbean and possible exchange of data

Presently, no formal arrangement exists for the development of a regional SDI. There are however, some sporadic data acquisition projects being implemented in some of the countries. These projects, it is expected, would provide support for the development of a regional SDI. These projects include:

a) Uniting the vertical datum of the different countries via one regional tidal determination network
b) Map revision.
c) Geodetic linking of countries to a global GPS network
d) Digital cadastre development

One significant ongoing project is the Caribbean Planning for Adaptation to Global Climate Change (CPACC) project, funded by the World Bank, Organisation of American States, and CARICOM. The project seeks to provide tidal data from long term tide monitoring stations in 12 Caribbean countries (Martin, 1997). This would provide a framework for linking height data across the region.

Projects are ongoing in several countries, notably Jamaica, Barbados and Trinidad and Tobago to revise the existing mapping and/or to create new digital databases. However, there has not been any standardisation

of, or communication amongst the agencies responsible for mapping to discuss standardisation of these new digital datasets in terms of format, content or representation.

Several countries have had GPS stations fixed as part of a global network within a programme conducted by the National Oceanic and Atmospheric Administration (NOAA) of the United States Department of Commerce in 1996 (Doyle, 1997). These data may be used to link features captured in the North American Datum of 1983 (NAD83) or the World Geodetic System of 1984 (WGS84) datum.

Individual projects are ongoing in several countries to improve the system of recording rights in land. Barbados for instance, has been preparing a digital cadastre database. About 25 percent of the cadastral plans have been digitised to date (Weekes, 1998). Trinidad and Tobago also has an ongoing consultancy to develop a digital land registry system. This country has also obtained loan funding from the Inter-American Development Bank for the establishment of a national LIS (IDB, 1995). The trend in these efforts is that they are mostly project based, sporadic in nature, spurred by external funding, and are country based.

3. Challenges to SDI Development in the Caribbean

Collins and Rhind (1997) identified the major problems associated with spatial data framework as availability, cost, and standardisation of base layers. Within the Caribbean, problems associated with the sourcing and utilisation of spatially referenced information can be added to the list.

The critical challenges to the development of a regional SDI in the Caribbean include:

a) disparities among the countries with respect to the currency of their maps; completeness of data; experience and technological knowledge and financial capability;
b) lack of communication among the regional Surveying and Mapping Organisations (SMO);
c) use of different geodetic referencing systems; and
d) differences in standards and resolution of data.

These disparities would require that more advanced countries would need to provide supportive roles for less advanced countries. The use of different geodetic referencing systems and the lack of an adequate regional geoidal height model means that transformations between data sets may be inaccurate for many purposes. Transformation parameters need to be derived to convert data effortlessly across the databases of different countries.

Tosta (1997) stated in respect to the SMO of United States of America that increasingly the role of actually producing data would decline while its data co-ordination efforts would gradually increase. Such a trend can be expected in the Caribbean. The SMO of the Caribbean have not yet begun to accept this new role and do not yet have the institutional structure to deal effectively with this new mandate. The SMO of the Caribbean have not yet developed their National Spatial Data Infrastructures and, as a result, there is hardly any congruency in the different datasets of these countries. Developing a regional SDI would require more co-ordination and communication amongst the SMO.

It should also be borne in mind that the creation of a Global Spatial Data Infrastructure (GSDI) has been germinating since the early 1990s and the standards agreed to in any regional arena should be informed by agreements already accepted at international level.

The country-based nature of the data acquisition projects may lead to differing spatial database standards. Co-ordinated efforts would minimise this problem. The resolution of most data would rarely be uniform throughout the region. The task of developing a regional SDI does not imply that data will be acquired at a single resolution. Multiple acquisition systems and resolutions can be adopted, as long as its adoption is fully discussed and agreements are reached. The regional SDI must therefore provide strategies for the integration of data from different sources, different resolutions, and different projections and datums. By displaying such flexibility, the system will be able to attract a larger community of users.

4. Improving the Infrastructure

The lack of co-ordination and comprehensive development strategy for the adoption of GIS technology can be related to inadequate funding, lack of continuity in the implementation of new and workable concepts; lack of coherent development framework; lack of political will. These very issues will also impact on the development of SDI in the Caribbean. The successful development of a regional SDI hinges on the existence and continual maintenance of three basic infrastructural elements: data, technology and institutions.

4.1 Data Requirements

The availability of data is fundamental to the generation of GIS applications. The availability of the data also provides the basic building block for the SDI framework. The variety, magnitude, quality, and currency of available data determine the integrity of information products generated by the system. The acquisition and maintenance of data are major undertakings of time and money. Therefore, the following characteristics of spatial data for the establishment of a SDI should be considered:

- Data needs analysis
- Data acquisition systems
- Data management requirements

The identification of the potential users, both in the public and private sectors, throughout the region and their various data needs must be undertaken through a User Requirements Study (URS). The study would investigate the functions of the agencies in these sectors vis-à-vis the spatial data required to perform those functions. In addition, the current sources of data, the frequency of use, the data format, and the costs of acquisition and management would be determined. The information products generated from the use of the data and the list of agencies to which these products are distributed would also need to be identified. The result of such a study would lead to an understanding of the data demands of each agency, the identification of any duplication in data collection, and the description of the characteristics of each data item.

The accuracy and resolution of data are critical issues in developing a SDI for the region. As much as possible, the accuracy and resolution of the data collected should meet the requirements of a large section of the community of users. In order to meet the needs of the users, the accuracy and resolution requirements of each agency should be determined and considered when selecting the data acquisition system.

Spatial data should be maintained and managed, not only because of the 'high' cost of its initial acquisition, but also to ensure that they provide adequate information products for specific applications. Data management requirements entail the following:

- Updating mechanism
- Storage and retrieval mechanisms
- Data definition and dictionary systems
- Data integration strategy
- Data evaluation procedure

A mechanism for periodically updating data should be developed and funding options identified, to ensure that the data is relatively current. A regional SDI must provide for efficient data storage and retrieval mechanisms so as to accommodate concurrent access by the wide community of users while ensuring security and integrity.

The wide variety of spatial data that will be collected and managed on a regional level requires that each data item be properly identified and defined. The mode of collection, format of storage, accuracy and resolution of each data item must be properly documented in a metadata. The existence of a metadata for the region would reduce duplication in data collection and facilitate access to data.

Users of the system must have confidence that the data accurately depicts reality. A certain level of trust in the accuracy of the data must be evident. Each data item must be adequately evaluated and its correctness guaranteed before it is entered into the database. Error-reporting procedures as well as strategies for adding and deleting data items should be designed and implemented throughout the life cycle of the database.

4.2 Technological Requirements

Recent developments in information technology can support the effort required for the building of a SDI in the Caribbean. These developments have encouraged and improved the multiple and concurrent use of data, facilitated data sharing and provided security to data. The use of wide Area Networks (WANs) and Local Area Network (LANs) are improving the ability to link the various units of a department internally and externally with other regional or international agencies. The architecture, protocol and topology of these networks should be designed after considering the institutional arrangements between agencies.

In the face of competing social and health requirements, expenditure on information technology is often difficult to justify. In order to efficiently utilise computer hardware and software, trained personnel, who understand not only the usage but also the design concepts, are required.

4.3 Institutional Requirements

There are four main institutional requirements, which must be developed and maintained for the proper functioning of the SDI. These are standards; administrative mechanisms; legal considerations; and financial considerations. The network configuration should allow data items collected by one agency to be shared with other authorised users or agencies. The ability to share data and other resources is dependent on the existence and maintenance of data standards. Standards facilitate portability of application from one computer platform to another and data distribution across agencies.

Coleman and McLaughlin (1992) provided taxonomy of standards required for a regional SDI. The taxonomy identified four overlapping main categories: computer hardware and communication; software; data specifications and data formats; and data sets. Data specifications, data formats and datasets standards are local domain decisions that each country must fully study and develop. They provide specifications for data models, data quality, data layers and associated attributes, data exchange formats, map projection and geodetic datum.

The task of developing and implementing standards requires a collaborative effort of all major spatial data user agencies in the region. In addition, it requires political and financial support to encourage compliance. Standards should accommodate rather than restrict, encourage rather than frustrate and integrate rather than discriminate among potential users of the system.

Administrative mechanisms should, for all practical purposes, facilitate rather than become a bureaucratic ‘bottleneck’ to the operation of the system. In order to realise the establishment of the Caribbean SDI a regional working group would need to be formed to:

1. Initiate communication amongst the major spatial data producers and users in the region
2. Establish a metadata working committee to develop standards for the region.
3. Seek agreements on standards to be adopted.
4. Encourage the use of the standards.
5. Decide on custodianship and security issues.
6. Develop policies on data sharing and pricing.
7. Provide assistance to less developed countries.
8. Gain political support for the project.
9. Represent the region at international fora.

This regional working group would be comprised of technical representatives from each of the countries in the Caribbean region. Each representative would have a duty to:

1. Undertake in-country consultation in order to develop country perspective on the key issues
2. Bring these individual perspectives to the regional body
3. Disseminate the regional perspectives or decisions taken
4. Promote the policies and standards within their country

The membership of the regional working group should be broad based, hence it should comprise representatives of the following stakeholders:

- Public sector
- Private sector
- Research and educational institutions
- Professional organisations
- International funding agencies

These stakeholders would provide inputs on such issue as metadata standards, data security, and use of modern technologies. There are some legal issues to be considered. Some of these include access, privacy, ownership, confidentiality, and liability. Access to the content of the database needs to be controlled or regulated. Such control should, however, be in line with other constitutional rights e.g. 'freedom of information'. Levels of access must be provided for different categories of persons and agencies. Ownership of the data collected by the various agencies implies responsibilities with regard to the accuracy and currency of the data.

Continuous funding is required for the development and improvement of a SDI. The sales of information products generated from the systems are becoming an alternative source of funding. The question of sales of data, centres around the problem of pricing digital data. There are various concepts to pricing policy including management cost recovery, market value pricing and direct cost of distribution. The appropriateness of each of these concepts should be adequately investigated.

5. The Future of a Regional SDI

Fuller (1999) defined a Global Geospatial Information Network (GGIN) as a mechanism for connecting users to an array of globally distributed providers of seamless data, information and knowledge bases about the earth. This type of Network is seen as the future of spatially oriented data and information. Whereas the goal of the regional SDI would be to make available in digital format the existing data products at uniform standards and formats, the GGIN will make available online a blanket of data for the region, linked to the other global data, in a seamless, unrestricted way. Users would be able to access themes they require for the defined geographical limits that they need, enabling them to build the products fit for their specific use.

A regional SDI would go some way towards achieving the goal of developing such a global network. Other requirements beyond those described for the creation of the regional SDI would have to be attained in order to achieve the transparent navigation through a seamless database. These requirements are:

- To move away from the creation of individual data products to the provision of spatial data
- To assign/accept responsibilities for bridging gaps in data
- To assign/accept responsibilities for validating and certifying data for inclusion in the Information Network pertaining to the region.

The current status of spatial data infrastructure in the region is some distance away from achieving such a model of data organisation. However, growth in information technology especially in the area of digital mapping tends to be exponential so it would be wise to start preparing for the GGIN scenario.

6. Conclusion

The challenges faced in the development and maintenance of a SDI for the Caribbean must be addressed urgently to prevent the wastage of resources that would persist if data continue to be acquired on a national basis, according to national standards. The Caribbean region has not yet begun dialogue on the establishment of a regional SDI. In fact, it has not yet dealt adequately with that of a national GIS. There are many benefits to be derived from the establishment of a regional SDI, such as that of managing effectively the resources of the region. We must look towards the regional data becoming a part of an eventual GGIN.

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