

SOME CONSIDERATIONS IN THE DEVELOPMENT OF GIS DATABASES

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INTRODUCTION

Geographic Information Systems have evolved and developed in the major industrial countries. Socio-economic conditions, political and administrative frameworks support the development of spatial databases and the successful implementation of Geographic Information Systems. While the information revolution that lead to the development of this new trend is emerging in developing countries, in transplanting the technology, there are several factors that need to be considered. In North America and Europe where the technology was originally developed, it took about 30 years to evolve to the current growth of GIS. Introducing GIS or database concepts into developing countries which are culturally, socially, economically and politically different from developed countries, needs to be done with care, otherwise it can be an expensive or a frustrating process.

Socio-economic realities and priorities in developing countries are different from those of industrialized countries. As Taylor (1991) indicates, GIS and database development should respond to those realities and priorities. Implementation of a GIS and database development is very expensive and maintenance of software and hardware may be obstacles in the full realization of GIS potentials. Therefore, after the initial introduction, GIS and database development should continue within a sustainable framework. While international agencies can play a major role in transferring the technology to developing countries, local experts should address the issues of data compatibility, user interface development, and make the

Design and development of a spatial database requires several factors such as data needs, data compatibility, and supportive technical and administrative framework. While the applicability of these techniques to resource management is being realized in developing countries, are in a disadvantaged position in relation to the most of the factors. The technology can be transferred but the framework that supports the existence of that technology should be developed within the society. This paper examines these issues facing developing countries in the design and implementation of GIS data bases and suggests possible solutions.

knowledge available to the general user.

Adopting GIS technology by a planning agency or research organization cannot be considered as the solution to problems. The GIS should be viewed as a tool required to solve the problems which are spatial in nature. As the relevance of GIS to developing countries have been addressed elsewhere (Batty, 1990; Yapa, 1988; Yapa, 1991; Yeh, 1991), this paper limits its scope to the issues related to database development.

DEVELOPMENT OF SPATIAL DATABASES

Geographic Information Systems are computer systems that can input, hold, and manipulate data describing locations on the earth's surface. It can assist in solving complex planning and management problems and can be an integral part of manage-

ment and conservation of resources in developing countries. Development of a GIS database is one of the key elements that determines the success of any GIS. Spatial database concepts are central to GIS and differentiate GIS from other computer map drawing packages (Rhind, 1989).

Whether it is in developed or in developing countries, designing a spatial database involves several steps. Once the goals of a particular GIS system are determined, spatial data and attribute information of the objects are acquired and converted into digital format, and the relationship between spatial and attribute data established. The database should be manageable in terms of technical and institutional cost considerations, should consist of data that satisfy common needs of many users, and should be structured to maximize its utility (Johnson, 1989). When designing the database, Johnson identifies eight-step process which is outlined below:-

1. Evaluate current and future needs of the user community
2. Inventory current digital data holdings
3. Perform quality assessment of digital data holdings.
4. Consider future application demands.
5. Identify the most critical data to be stored and prioritize the remaining data for storage consideration.
6. Develop data organization strategy.
7. Implementation plan.
8. Perform implementation of the database.

Proper organization is an essential part of the successful implementation of a database. Databases should not be developed to perform a particular application and should have long range objectives with the ability to integrate with other databases and other GISs. As it is very expensive and difficult to maintain huge amounts of spatial data, only the required data need to be computerized. Further, Chambers (1989) lists some of the major factors that influence a GIS database design, such as data needs of the applications that will be developed, availability and format of existing data required to support the applications, update and maintain procedures, size of the database, hardware platform/configuration, organizational structure of the users and facility, budget, and management support. This indicates that database design alone is an integral part of a successful implementation of a GIS.

SPATIAL DATABASE DEVELOPMENT ISSUES IN DEVELOPING COUNTRIES

GIS database development has been a problem at developing countries, and in the 1989 International Conference on Geographic Information Systems Applications for Urban and Regional Planning, concern was expressed about the way GIS were being implemented in developing countries and Edralin (1991) indicates that it was perhaps a reflection of the current situation. The issues related to database development can be due to problems with the data to be used, or to technical, economic, administrative and management issues.

In a spatial database, both attribute and spatial information on certain objects are encoded according to some database structure and the relationship between different themes are established. To do this, data should be collected and encoded objectively. In general, as much as 80% of all information held by government agencies are spatially referenced (Franklin, 1992) but most of these data are still in paper map form (Evans, 1989) and in most cases, they were not collected objectively. In addition, they do not have socio-economic and other attribute data associated with spatial data. Therefore, it is difficult to maintain or update, and because of the incompatibility of the maps produced by different agencies, data can rarely be coordinated or integrated. In most cases, maps are not complete or have outdated information with poor accuracy. Referring to the African situation, Hastings and Clark

(1991) say that database development needs to start from nothing.

Most of the GIS programmes include relational database management (RDBM) capabilities. They are used to manipulate both spatial and non-spatial (attribute) data. However, GIS software generally do not come with RDBM software such as Dbase, Oracle, Rbase, Paradox, and Fox base (Pittman and Thrall, 91). In many cases, data need to be transferred back and forth between GIS software and RDBM software. When selecting a particular dbase system for database development, it is important to explore the compatibilities with existing software as well as interface capabilities with other popular existing software such as Quattro Pro or any spreadsheet formats.

Standardized spatial information helps data transfer, minimizing the cost incurred in duplicate data encoding, improves the quality, reliability and accuracy of both spatial and non spatial data. However, data standardization and integration are still major issues even in industrialized countries. Different agencies or states use different classification schemes so that the same object may be classified differently. The impact of incompatibility of data is severe in developing countries where funds to develop diverse databases for specific applications are limited. Another factor that limits the data transfer is the data security and the authority. Some agencies are reluctant to share data they possess and do not want to take the burden of updating information. This may be because some data need to be protected because of their confidentiality, but there are no clear guidelines on which data should be kept confidential or how data distribution can be managed.

There are also some technical problems associated with database development in developing countries. When Geographic Information Systems were introduced to developing countries, it was done within a technical environment and initial expectations were too high (Hastings and Clark, 1991). In most cases the goals were not achieved due to technological problems. A Geographic Information System integrates data, computers, software programs, database structures, the skill of the users and technical problems can be incurred at any of these levels. These may be related to the software interface, data format incompatibility, or to hardware problems. In a developing country such a problem can hinder the database de-

velopment and GIS implementation for several months.

Lack of basic guidelines in database design and base map production have caused problems when GIS are being introduced into a developing country. Base map production is also hindered by lack of standardized geo-coding system. Suitable case studies and literature are generally difficult to obtain and software manuals do not help the user in applying the software to a particular problem. Much software is not user friendly (Scholten and Padding, 1990) and often manuals are difficult to comprehend without a sufficient technical knowledge.

The problems associated with GIS development are compounded by management issues. Yeh (1991) identifies lack of staff and management support and staff training as some management issues. Without the support of all levels of management, the database development, and often, the entire GIS project can be threatened.

GIS AND DATABASE DEVELOPMENT WITHIN A SUSTAINABLE STRATEGY

Geographic Information Systems will not be the answer to all questions in developing countries. But, if properly used, it can be an efficient tool in assisting decision making. The decreasing cost of computers makes GIS more affordable in developing countries. International agencies such as UNCRD, UNESCO, UNCHS, IDRC, World Bank, ADB provide funds and technical expertise in transferring technology but GIS and database development needs to be achieved without external dependency. International agencies and expertise play a major role in introducing the technology but the environment that supports the technology should be developed within the society. Local technical expertise, training, research, user interface development, user education, a data management strategy, and the realization of GIS application potentials within their socio-economic priorities are required for the GIS project to be successful.

In the first instance, when adopting the technology, Geographic Information Systems and database development should not be viewed as a technological introduction. As a problem solving tool, GIS is highly appropriate to developing countries and it can drastically reduce the cost of data gathering, providing accurate information, and

guide decision making. Before designing the database, it is important to have a clear idea about the application areas where GIS can be used, aims of the application, type of output expected once the project is completed, and who will be using the information. For example, GIS may be applied within regional and local planning framework to study ground water potential, open grazing, decreasing vegetation cover, erosion modelling, salination studies, urban expansion, habitat monitoring, and suitability analysis for agricultural crops. Accordingly, database development should be undertaken and the expectations should be achievable. Once the database is installed, it is reasonable to allow approximately 9-12 months before the full realization of potentials. It is advisable to use the GIS and database to produce some thematic maps before undertaking any projects which require spatial analysis.

Expert assistance may be required at the initial stages of database development and base map production. However, this will be of limited use if the nature of spatial data, and associated attributes are not relevant to the socio-economic framework of the community.

Base map development can be carried out using existing maps (lower accuracy), extracting information from aerial photographs (a low cost scanner can be used), or using some existing digital (remote sensing) or survey data (high accuracy). However, it is very important to develop some standardized guidelines in base map production and database development.

Database design is a continuous process. Updating existing information and adding new information or attributes are essential for future expansion of the database. Software and hardware need to be changed in the expansion process and accordingly some adjustments to data need to be done. Even though most of the software can process data in different formats, it can be a frustrating process when a new GIS is being installed. It is not necessary to have expensive sophisticated software or hardware to implement a reasonable GIS project. Availability of user friendly software can be obtained from conference displays, software review articles, examining some demonstration programs provided by software manufacturers or by consulting the GIS academic/user community or by linking to some spatial data related electronic mailing systems.

Initial database design should not start with a scale that is not compatible with existing resources. It is better to start with a pilot project and through experience it can be extended to applications of concern. Both database development and GIS implementation should be undertaken within a sustainable strategy. Unlike in major industrialized countries, facilities such as journal articles, conference, educational videos, seminars, and workshops are limited in developing countries and constrain GIS staff's ability to improve their skills required in efficient database design and GIS project implementation and educate novice users. Therefore, it is very important international agencies or countries that support developing nations by introducing GIS should provide material which will allow user to improve their skills and intellectual knowledge. Unfortunately, journal subscriptions, conference registration and travels are expensive items and difficult to afford when limited foreign exchange is required to support socio-economic priorities.

Automation of existing management tasks and implementation of a GIS can change the administrative and management structure of an organization. Data security, authority, maintenance responsibilities should be determined initially when acquiring GIS and implementing the database. Potentials of GIS and database development to the institution need to be realized and educating the management is very important for a healthy and a long life of a GIS system. Therefore, it is important to have a central authority to monitor GIS work and data distribution/management. GIS can change the organizational structure of an institution by improving the efficiency of existing tasks. Database development and GIS introduction should be thought of as an aid in decision making. It is important to understand how the GIS can be used in improving the welfare of the whole community.

Universities and research institutions can play a major role in developing an environment that supports GIS within a sustainable framework through educating management and users. It is vital that all levels of management understand what a GIS is and its limitations. Workshops and training programmes should focus on topological properties, basic introduction to hardware and software components, guidelines to database developments, and also how to put a problem with spatial context into a GIS perspective.

Some, more experienced users, may benefit from training programmes concentrating on computer programming and database design and development. These skills, although not essential, would accelerate progress in a GIS project. Other important topics such as user interfaces, scale and projection changes, georeferencing, and raster and vector systems should be addressed when the GIS project is in progress.

Digital data are encoded as points, lines, and areas/polygons. When a land cover/use attribute is converted to a digital form in a GIS, an attribute becomes a layer of information integrating both spatial and non-spatial information about the attribute. To use spatial data to produce thematic maps and spatial analysis, it is often necessary to change scale, format data differently, change projections, correct topological errors, and maintain data integrity as new information becomes available. Solutions to these problems which are technical in nature, should be available within the society.

Generally, when a problem in technical or application nature arises, institutions need to depend on international experts, and, in most cases, different experts are approached which may not solve the problem (Hastings and Clark, 1989). The most viable method is to develop a network outside the GIS community who are exposed to wider GIS/database development experience and knowledge. For a user in a developing country, electronic mailing system (E-MAIL) is the best, low cost media to develop contacts with the other users. There are a number of user groups where one can seek solutions to some technical and application problems. For instance, electronic user groups such as GIS-L, COMP.INFO SYSTEMS, GIS, SCI.MAGE, PROCESSING, AAGMSG, and GEOGRAPH concentrate on spatial data applications while there are some other electronic mailing systems coordinated by software manufacturers. By connecting to these systems a user can get suggestions in relation to questions, information about suitable software, hardware or can involve in discussions.

CONCLUSION

There is no doubt that the GIS technology can be a valuable tool or a resource to developing nations, specifically to the management of natural resources and to the economic development. However, full utilization of this technology can be realized only if

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a sustainable development of the technology can be achieved. This may be done through the continuous support of the agencies introducing the system and the GIS community both in developing and developed countries.

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