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Geographic Information Systems in Developing Countries: Issues in Data Collection, Implementation and Management

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Abstract
Decision making at the national level in both developing and developed countries requires the integrated use of information from a multitude of sources. Both local and national governments in many developed countries have found geographic information systems (GIS) to be a critical tool in resource management, regional planning, and economic development. Unfortunately, the practical use of GIS in many developing countries is hampered by the lack of accurate and detailed spatial and demographic data, political considerations, and management issues. To highlight importance of these issues, we present a framework for GIS adoption in less developed countries and discuss these and other constraints in the context of this framework. We also offer ideas for technical, managerial, and policy initiatives that should be helpful in addressing impediments to GIS adoption. These ideas are summarized in a set of propositions and a related framework that shows our expectations about the impact of these initiatives on implementation success.

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Geographic Information Systems in Developing Countries: Issues in Data Collection, Implementation and Management

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Decision making at the national level in both developing and developed countries requires the integrated use of information from a multitude of sources. Both local and national governments in many developed countries have found geographic information systems (GIS) to be a critical tool in resource management, regional planning, and economic development. Unfortunately, the practical use of GIS in many developing countries is hampered by the lack of accurate and detailed spatial and demographic data, political considerations, and management issues. To highlight importance of these issues, we present a framework for GIS adoption in less developed countries and discuss these and other constraints in the context of this framework. We also offer ideas for technical, managerial, and policy initiatives that should be helpful in addressing impediments to GIS adoption. These ideas are summarized in a set of propositions and a related framework that shows our expectations about the impact of these initiatives on implementation success.

INTRODUCTION

The role of centralized planning, management, and decision making is continuing to increase in importance in many developing nations because of increasing pressures from overpopulation, depletion of natural resources, and financial instability (Todaro, 1994; Gillis, et al., 1992). As is the case with most planning and decision making activities, insufficient and inaccurate information will hurt these efforts. In fact, Todaro suggests that the two most prominent factors limiting the success of planning efforts in less developed countries (LDCs) are the lack of adequate data and a shortage of trained decision makers (1994, Ch. 16).

Spatial data is particularly valuable for planning and development efforts because they describe the geographic distribution of economic resources, population, and other relevant factors. However, the collection, management, and application of spatial data can present unique and seemingly insurmountable problems for organizations seeking to leverage this data. Reasons for this situation include:

1. Data describing the geographic distribution of a nation's resources are often difficult to collect, they are hard to verify, and they typically change frequently.
2. Many information systems do not adequately handle spatial data; therefore development personnel, managers, and computer specialists working in LDCs may have little or no experience with these types of data resources or the software used to manage and analyze them.
3. There are political issues associated with the implementation of any governmental information system that may be exacerbated by the inclusion of spatial data in the system.
4. Personnel issues associated with system development in any country may also be more important in LDCs or because of the use of GIS technologies.

Mennecke and West briefly mentioned many of these obstacles to GIS implementation in their paper summarizing the role of GIS as a decision support and administrative tool for governments in LDCs (1998). This paper builds on this earlier work by exploring these and other obstacles to implementation in greater detail and by offering solutions that will help economic developers to find, create, and better manage both spatial and attribute data resources. Government policy makers, system developers, and academics working with support systems for decision making in LDCs will have a richer understanding of how to improve the chances of a successful GIS implementation.

The next section of the paper reviews the role of GIS in national-level decision support systems to provide background information for the discussion that follows. Next, we present factors influencing the adoption and diffusion of GIS in developing countries and present a model that will be used to frame the remaining discussion. The next two sections present, respectively, data collection and management problems associated with implementing a national level GIS and strategies for overcoming these difficulties. Following this, we discuss managerial, technological, and policy initiatives that should prove useful in advancing GIS use in LDCs. The paper is concluded with a discussion of our conclusions and recommendations for additional research.

THE ROLE OF GIS IN GOVERNMENT DECISION MAKING

The potential for using any technology to support governmental decision making is driven by the match between the capabilities of the technology and the needs of its potential users. This section reviews the common requirements of governmental decision makers in developing countries and presents a brief overview of the capabilities of GIS and its role in governmental decision making. For a more detailed exploration of the pertinent capabilities of GIS in government decision making see Mennecke & West (1998).

A vital role of government in both developed and developing nations is to foster economic development; that is, to encourage "a process which makes people … better off by increasing their command over goods and services and by increasing the choices open to them" (Elkan, 1995; p. 8). To do this, governments must foster and manage the interrelationships between business development (e.g., retail and service providers), industrial development (e.g., wholesale goods and service producers), and community development (factors supporting infrastructure and the quality of life) (Harman, 1990; Moriarty, 1980; Wagner, 1978).

A major difference between developed and developing countries is the degree to which existing institutions help to manage these interrelationships. In developed countries mature markets and bureaucracies play a large part in the management process. In many developing countries, however, decisions that might otherwise be handled by private sector organizations often default to institutions in the government sector.

One trend in economic development for LDCs is an increasing reliance on developing private market solutions to economic problems (Elkans, 1995). Even though this approach removes the government from direct planning and control at the micro level it does not remove the burden of macro economic and policy analysis from government decision makers. To perform policy analyses effectively, however, LDCs need information about the economic and market conditions both within their country and at broader scales. Harman (1990) suggests that these analyses can be performed with the aid of *market information systems*. These systems have three components:

1. A data inventory (e.g., past, present, and forecasted data about market conditions)
2. Lead indicators (e.g., indices used to measure and predict changes in market conditions), and
3. A decision support system (i.e., a method, process, or technology used to monitor market conditions and determine effective responses to changes) (p. 75).

Planning at the national level therefore requires the availability of accurate aggregated data pertinent to a wide range of national objectives coupled with tools to support analysis and decision making. Of interest here is the fact that modern GIS can be used as a decision support system and as a platform from which a data inventory and lead indicators can be collected, managed, and analyzed. In fact, Mennecke and West (1998) built on the work of Yapa (1991) by making the case that GIS is important for LDCs as an *appropriate administrative technology*. GIS is an appropriate administrative technology because, when utilized at both the national and local levels, its capabilities for managing attribute and spatial data can be used to better manage important national resources in the context of their location. In this way, GIS has great potential for use as a coordination tool that facilitates more efficient data collection, data management, and planning. While GIS cannot address the entire range of strategic decisions faced by the government of an LDC, they do provide capabilities that make them suitable for this use without precluding the use of more traditional strategic decision support systems (Brudney & Brown, 1992; Drummond, 1995; Grupe, 1992; Mennecke and West, 1998; Worrall, 1994). In fact, modern commercial GIS products can often be seamlessly integrated into existing information systems both at the client level as well as in organization-wide systems.

GIS ADOPTION AND DIFFUSION IN DEVELOPING COUNTRIES

In his seminal work on the adoption of innovations, Rogers (1983) proposed a model to explain the rate of adoption of innovations that is useful to guide research on the adoption of technological innovations in LDCs. Rogers' model includes 5 variables that are expected to influence the rate and success of adoption:

1. The attributes or characteristics of the innovation
2. The type of innovation decisions that need to be made for adoption
3. The nature of the social system in which the adoption will take place
4. The nature of the communication channels available to spread information about the innovation
5. The extent and characteristics of the promotional efforts

made by change agents.

The Rogers model is useful for guiding our discussion of GIS use in LDCs. However, because the characteristics of GIS and spatial data are somewhat unique relative to the characteristics of other information technologies, GIS presents a unique set of problems for government and non-government organizations seeking to develop and implement useful spatial decision support applications (Onsrud & Pinto, 1991).

We have therefore synthesized a new model from Rogers' five variables and show how these factors could influence GIS adoption in LDCs (Figure 1). We have concluded that a logical way to view the factors affecting GIS adoption and use is to collapse these variables into two broad categories: technological and organizational factors. For example, GIS is a unique technology that requires special data, software, hardware, and personnel for it to be used effectively. Thus, its technological attributes will likely determine where and how it is or can be used. Similarly, when organizational and managerial issues are considered, we expect that the decision-making process, organizational communication, and the social system in which GIS is managed and used are likely to influence the adoption and diffusion process.

We will use this GIS implementation framework to guide the discussion in the remainder of the paper. Because many researchers have had a limited exposure to GIS technologies, it is worthwhile to review and discuss some of the factors that affect the use of GIS in LDCs. Following this, we review the factors that are likely to inhibit GIS adoption in LDCs followed by a discussion of strategies that may prove useful for improving the success of GIS adoption initiatives.

FACTORS INHIBITING GIS ADOPTION IN LDCs

The GIS adoption framework suggests two variables that are likely to have a significant influence on the adoption and diffusion of GIS in LDCs. We first discuss several GIS attributes that are expected to have an impact on GIS adoption. Following this, we discuss organizational issues associated with the adoption process.

Technological Characteristics of the Innovation—Difficulties Acquiring Spatial Data

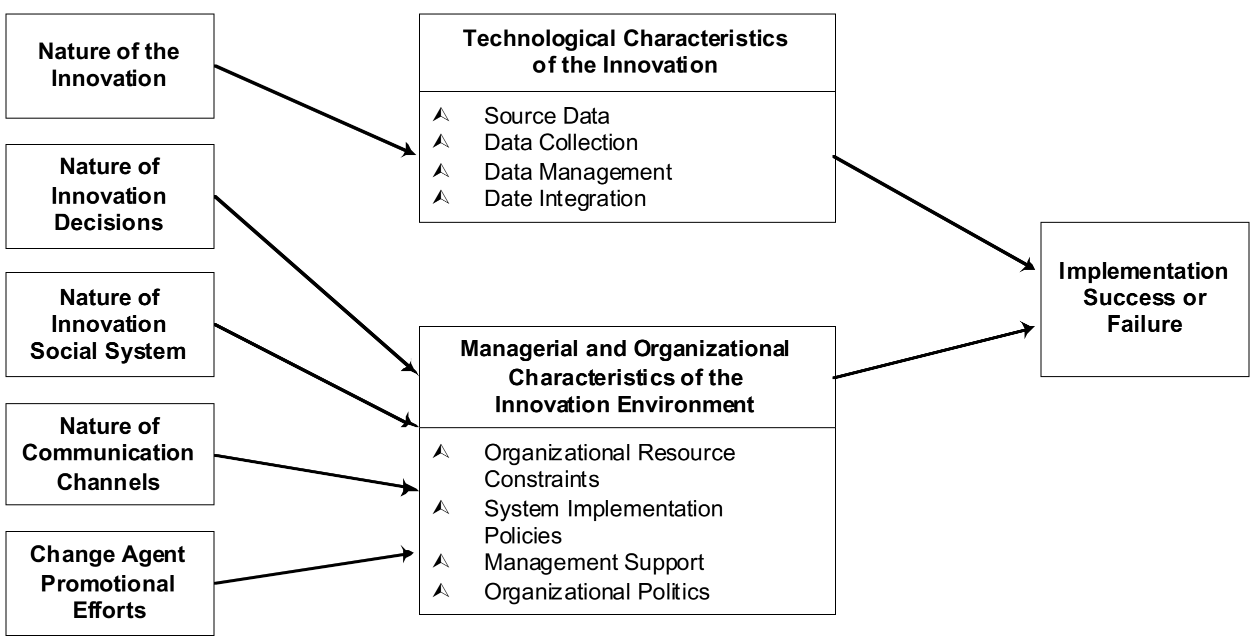
The nature of spatial data makes collection efforts difficult even in small, developed nations. As a consequence, there is currently only a limited amount of spatially referenced data available to support analysts and decisions makers working in LDCs. This problem was articulated by Gerland (1996) who noted that, "The problem remains that very little of this information is spatially referenced and organized, making it difficult or even impossible for analytical studies, monitoring, planning, and decision-support to take place" (p. 9).

Spatial data of interest to governmental decision makers can generally fall into three categories, physical, political, and socioeconomic. We will see that there are difficulties with the collection of each of these types of data as well as difficulties managing and integrating data from different sources.

Physical Data

Physical data is about features of the ground, land masses, bodies of water and waterways, roads, railroads,

Figure 1: GIS Implementation Framework



forests, mountains, etc. In many LDCs the traditional approach to developing GIS-ready physical data has been to digitize existing paper maps. Often, however, paper maps are old and fraught with errors. Leddy and Fuller (1996) provide a compelling illustration of this in their study of GIS use in the Philippines. They found that the U.S. Army Mapping Service created the primary base maps used to generate digital maps in the 1940s and 1950s Because of their age, these maps contain many inaccuracies, inconsistencies, and discontinuities.

When considering the problem from the national level, paper maps have other problems. Unless these maps were generated under a comprehensive national-level initiative, characteristics such as scale, content, and symbology on maps will differ among areas of the country. The Philippines' experience is not atypical since the surveying and mapping activities required to make new maps are tedious and costly and therefore would strain the budgets of regional and national governments in most LDCs.

Political Data

Political data is about artificial designations that define an area as being part of a political entity. While some political boundaries follow physical features such as coastlines, rivers, etc., others are arbitrary or historical. Some are disputed with maps drawn by one entity showing the boundary in one location and others showing the boundary elsewhere. Some boundaries are flexible whereas other may be fixed permanently. In the United States and other countries city limits, census blocks, and voting districts all change over time. In areas such as sub-Saharan Africa the position of entire villages can move as climatic, political, and other factors force large segments of the population to migrate. Political data is also problematic because boundaries must be recorded manually, aerial imagery most often cannot be used to directly detect the mad-made divisions between two provinces, districts, or countries.

Socioeconomic Data

Socioeconomic data is about populations, economics, and social patterns. Recording socioeconomic data presents some of the same difficulties found with political data, plus an additional set of unique problems. Governments are interested in their populations but people are notoriously difficult and expensive to count. Recording detailed information about the population, such as income, gender, ethnic background, profession, etc., increases the cost of data collection. Economic information can be similarly difficult to garner. Overhead imagery may reveal a building and may even indicate that it is a factory but usually cannot detect the products made. Imagery may indicate that land is in agricultural use but not the kind of crop or a precise measure of yields.

The difficulty of collecting socioeconomic data is illustrated by the World Bank's Living Standards Measurement Study (LSMS) (Gerland, 1996). The objectives of the LSMS are to develop new methods for monitoring the progress of efforts to raise living standards, to identify the consequence of government policies, and to improve communication between national statistical offices. Unfortunately, as of 1995, only eighteen developing nations were consistently involved in the survey.

Data Management and Integration

In addition to the specific data collection problems mentioned above, spatial data presents some integration and management challenges that are especially important for data used at the national level. In particular, when differences exist in the measures and collection methodologies utilized in different regions, comparisons between areas will be difficult or impossible (Walker & Young, 1997). Gerland (1996) identified a variety of integration problems that exist for socioeconomic data. These include:

- Missing positional information
- Inconsistent classifications and methodologies
- Use of different spatial units
- Use of different levels of aggregation or resolution
- The presence of spatial data gaps
- Different time references for the data

Since spatial data include both attribute and positional information, each of these issues is relevant.

Another problem arises when maps created at different scales must be integrated (Clarke, 1995).[1] The only way to resolve this problem is to identify a common scale and increase the scale (reduce the detail) of the larger scale map until it conforms to the scale of the smaller scale map. For example, one province might possess detailed information about boroughs or neighborhoods within its major cities while a second only possesses information about its cities as a whole. If data for the two provinces were to be compared, the larger scale maps containing the neighborhood data would likely need to be aggregated to a smaller scale (i.e., to the city level) so that valid comparisons could be made. In the process, the detailed information may be underutilized or lost. This type of problem is common in GIS applications and is a unique characteristic of geographic data management.

Organizational Characteristics of the Innovation Environment

The technical problems associated with GIS implementation are not the only hurdles facing governments in LDCs; a host of managerial and organizational issues associated with decision making also have the potential to impede GIS adoption and diffusion.

GIS Development and Constrained Resources

Accurate and timely spatial and socioeconomic data are difficult to obtain and, as a result, require a significant financial investment by any organization seeking to use GIS. Furthermore, in most cases an investment in GIS hardware, software, and data will not lead to tangible benefits until long after the initial investment is made (Deichmnn, 1996). Leddy and Fuller noted that "… a comprehensive GIS for urban planning takes 3-5 years to design and implement, in which case it would likely cross administrations, and possibly be canceled before tangible benefits are realized" (1996, p. 9). Because of this, fiscally constrained regional and national governments will often find it difficult to justify the initial investment when other, more pressing projects compete with the seemingly abstract benefits offered by GIS (Innes & Simpson, 1993).[2]

Another resource constraint that LDCs face is the availability of trained personnel. Although software vendors have begun to develop low cost, easy-to-use products that make the initial investment in GIS more affordable,[3] these products generally do not offer the sophisticated capabilities present in more advanced systems. Unfortunately, only the more expensive and sophisticated GIS products enable users to engage in large-scale spatial data collection and analysis activities. Users of the sophisticated products, though, require extensive training. Training is not only expensive and time consuming, but it also can lead to retention problems. Leddy and Fuller (1996) observed that when Filipino government employees acquire even moderate levels of training and competence in GIS, they were likely to move to more lucrative non-government positions.

Organizational Politics

Organizational politics have been observed to have a significant impact on the implementation of GIS in public sector organizations in the United States (Pinto & Azad, 1996) and it is to be expected that this influence is not unique to developed countries. In examining the impact of organizational politics on the implementation of information technologies, Danziger, Dutton, Kling, and Kraemer (1982) observed that information technology changes the power relations between organizational members, thereby providing motivation for members to take (political) actions that secure or maintain power.

In particular, information technology has the potential to change power relations in three ways (Danziger et al., 1982; Drory & Romm, 1990). First, the possession of information often assists those who possess it to be more successful and therefore more powerful. Second, since information technology is often an important resource for organizational members, control over this resource provides the person wielding this control with significant power over other organizational members. Third, those who hold power over information technology may be perceived as technically sophisticated or advanced.

These observations related to the role of information technology in general have been related to the implementation of GIS. In a case study of two public sector organizations in the United States, Pinto and Azad (1996) tested six propositions about the role of organizational politics on GIS implementation that were derived from organizational theory and theories of information technology implementation. They found support for all of their propositions suggesting that GIS implementation is likely to be impacted by factors similar to those that affect the implementation of other information technologies.

In this context, one of the most important issues that LDC governments and aid agencies face is conflict over GIS and other information technology resources. An important factor leading to conflict is the willingness of LDC governments, service organizations, and private firms to collaborate in the development and administration of GIS technologies and data. In reporting on issues related to data sharing and coordination, Leddy and Fuller observed that, "A major problem is the ownership of data and competition between agencies" (1996, p. 10). This is a particular problem when significant resources have been expended to develop and collect spatial data and technologies by local governments or agencies. This type of problem is likely to arise not only because of interpersonal and institutional constraints, but also because these organizations likely do not have significant formal protocols established for the exchange of resources and information.[4] Of course, limited or nonexistent inter- and intra-organizational communication networks will also work to inhibit the adoption of new technological innovations (Rogers, 1983).

OPPORTUNITIES FOR PROMOTING GIS USE IN LDCs

Despite the impediments to GIS system development discussed thus far, strategies and techniques derived from theory and prior research are available to countries that wish to implement decision support capabilities using GIS. As with the discussion of the constraints on the GIS adoption process, the organization of this section following the outline suggested by the GIS implementation framework. First, we will discuss initiatives intended to improve access to or availability of GIS data in LDCs followed by a discussion of initiatives intended to improve the use and management of GIS technologies.

Technological Characteristics: Data Access and Availability

The previous section discussed the expense and difficulty associated with acquiring spatial data. This subsection outlines three strategies for reducing the cost of acquiring and integrating this data.

Data Management: An Infrastructure for Data Formats and Cataloging

Governments can take steps to reduce the incompatible and incomplete spatial data due to the adoption of different standards by different data producers. One of the first steps is the development of national-level base maps for use with all other data collection efforts. These base maps would include major political boundaries and significant geographic features. These maps can be as simple as rectified remote satellite imagery (RSI) or topographic maps (see discussions later in this section) but they accomplish two important goals. First, national base maps eliminate the expense of each database producer creating their own base maps. Reducing the overall cost of data creation should lead to more data being produced. Second, national-level base maps automatically impose national standards for projection, scale, and resolution of data layered on these maps. National level efforts such as the TIGER and earlier DIME files in the United States clearly demonstrate how this type of policy initiative can significantly reduce the expense of data acquisition, improve the availability of data for smaller-scale users, and promote innovative uses of the data and related technologies.

A second set of standards pertains to attribute data used in GIS and other applications (National Research Council, 1994). These standards should establish attribute domains for commonly used attributes and establish a metadata repository and national level data dictionary of data elements. This step will facilitate data sharing and integration, and reduce data collection redundancy. A standardized data dictionary should enable users to identify what data is available, where it is located, and in what format it is recorded.

Data Acquisition Strategies

Even though collecting spatial data can be expensive there are strategies and techniques to reduce these costs and promote wider use of GIS as a DSS technology. In particular, global positioning systems (GPS) and remotely sensed data offer the potential to provide vast quantities of useful data for LDCs at relatively low cost.

Modern GPS technology allows users to utilize inexpensive devices to record their position. By equipping agency employees with GPS devices the location of objects of interest can be recorded as a routine part of employees' jobs. By investing in slightly more sophisticated, yet still affordable, hardware and software employees can link GPS inputs directly to laptop computers that can record specific attribute data as well as a geographic location. Dugger (1997), for example, showed how GPS and ground surveys could be used to create boundary maps showing the location of solid waste disposal sites throughout remote areas in Thailand. Similarly, Hightower et al. (1997) used GPS technology to collect land use data and data on mosquito breeding habitats in the Lake Victoria region of Africa. In both of these cases, personnel accomplishing field activities as a normal part of their duties also used GPS to collect spatial data.

Another source of data for map creation is remotely sensed data such as that from aerial photographs and satellites (Bhatt, 1992; Karnik, 1993).[5] A distinct advantage of remotely sensed imagery is that the maps created using this technology are usually significantly less expensive than those created using ground-based approaches. Pratt, et al. (1997), showed that a mapping project using RSI combined with field verification can significantly reduce costs for data collection when compared to field mapping alone. An additional advantage of RSI is that high quality data for most parts of the world are available from both public and private sector organizations (Goodrich, Haar, & Mindreau, 1996). For example, the Russian government has begun to sell satellite imagery from intelligence gathering satellites through commercial outlets. At the same time, NASA has also begun a program called the NASA Commercial Technology Network[6] to promote the use of NASA technology for commercial applications. In one project, data from NASA satellites were used by a small coffee company in the United States to produce detailed maps showing information about types of vegetation (e.g., coffee versus other flora) and crop health (NASA, 1994). The maps allowed managers in the firm not only to improve their own understanding of the coffee market, but also to help farmers and government administrators in Central and South America to better manage their agricultural resources.

RSI from commercial organizations have also been used to aid development efforts in LDCs. Haack, Craven, and Jampoler (1996) used SPOT satellite imagery to capture data about the extent of urban expansion in Kathmandu, Nepal. Similarly, Corbley (1997) used RSI to create resource and man-made structure maps for urban planning and natural resource management in India. In fact, an increasing number of LDCs have invested considerable resources in developing their own satellite-based remote sensing capabilities. Brazil, for example, plans to invest more than $1 billion in satellite technology over the next few years (Goodrich, Haar, & Mindreau, 1996).[7]

The use of RSI for map creation offers several advantages over other techniques. Images can be effectively used to identify the precise location of a variety of features as well as the characteristics of those features. Imagery is particularly useful when used to identify physical features such as roads, villages, natural resources, and other objects of physical interest (Wang, Treitz, & Howarth, 1992) making these maps very suitable foundations for the previously discussed national-level base map inventory. In addition, imagery is also useful for comparing data over time. In Tijuana, Mexico, for example, aerial photographs and maps from two time periods were merged and compared to update and quantify urban growth (Bocco & Sanchez, 1995).

Data Acquisition Policies

Even with support for base map creation and technologies to facilitate automatic mapping generating a complete inventory of spatial data for national decision making as described in Mennecke and West (1998) can be a daunting challenge. Such an inventory should include topographical, transportation, communication, education, defense, agricultural, commercial, population, etc., data. Many LDCs will lack the resources needed to engage in comprehensive data collection strategies on their own. This subsection suggests alternative arrangements for data gathering.

For example, organizations from developed nations seeking to establish operations within an LDC will likely have the wherewithal to collect data for their own operations. Therefore, when a LDC government lets contracts for telecommunications, transportation, construction, etc., the contract should include provisions requiring contractors to provide suitable datasets pertaining to the location and attributes of the objects of interest (e.g., microwave towers, railroads, mines, wells, etc.) in established formats. The permitting process should be designed so that it is required that reports be submitted using GIS techniques and that the organizations include other data of interest as part of their survey or development activities. The City of Raleigh in North Carolina, for example, is in the process of adopting this practice in that they will require that all new building and construction permits include blueprints and maps in a format compatible with the City's computer aided design and GIS systems.

LDCs can also form mutually beneficial partnerships with aid agencies, U.N. organizations, universities, and other organizations that have an interest in supporting these countries. Pohl (1995, 1996) completed a digital mapping project for Indonesia by integrating SPOT optical imagery and radar imagery using digital image fusion techniques. This project was funded by a European research agency, ITC, in cooperation with the University of Hanover and the Indonesian agency for surveying and mapping. When completed, Indonesia took possession of high quality base maps for large tracts in a remote portion of the country. At the same time, ITC and its researchers were able to test a new procedure for doing mapping in tropical environments.

Organizational Characteristics: GIS Management and Use

This paper follows in the path of Mennecke and West (1998) by assuming that GIS of interest to developing nations will be true systems, part of organizational or governmental processes that affect policy and behavior. To the extent that this is true, it is necessary to realize that a wide body of existing research applicable to the implementation of information systems in general also applies to the implementation of geographic systems. This research encompasses user acceptance, managerial support, critical success factors, managing end-user computing, etc., and addresses the managerial and organizational issues discussed earlier.

MIS/GIS Infrastructure and Planning

Robey and Sahay (1996) studied the implementation of similar mission critical GIS in two county governments in the United States and observed two different outcomes with respect to the success of the systems. They reported on the importance of user training, user acceptance, and a planned implementation as determinants of the GIS system implementation.

These design and implementation issues remain problematic in organizations with mature data processing departments and experienced personnel. They could be exacerbated in LDCs to the extent that they lack experienced personnel. It is important, therefore, that good systems analysis, design, and implementation practices be followed in the construction of GIS systems of the sort envisioned here. Furthermore, this suggests that GIS need to be developed and established in the context of their intra-organizational roles as tools that crosses departmental and organizational boundaries (Gerland, 1996). In other words, because location is an issue that most units within local and national governments, aid agencies, and commercial firms must address, it is important that a centralized, top-down approach to GIS design is used (Mennecke & West, 1998; Nedoviæ-Budiæ & Godschalk, 1996).

Organizational Politics and GIS Adoption and Use

There are several useful prescriptions for addressing the issue of organizational political behavior that can be used by LDCs attempting to implement GIS technology. Pinto and Azad (1996) suggest that political behavior can be used for positive purposes and point out that in the context of organizational politics there are three broad groups of organizational members:

1. Those who are "naive" and believe that organizational political behavior is unpleasant, it should be avoided at all costs, and is should be ignored because in the end, the truth will win out;
2. Those who are "sensible" and believe that politics is inevitable, it can be used to further organizational goals, and negotiation and bargaining should be used to maximize the potential benefits that may arise from political behaviors; and
3. Those who are "sharks" and believe that politics represent an opportunity to engage in self-serving and predatory behavior.

To maximize the potential for successful GIS implementation in the face of political behavior, managers must operate as *sensible* organizational actors by learning to view organizational politics as a tool rather than as an obstacle (Pinto & Azad, 1996; Pinto, 1997). Specifically, Pinto (1997) suggests that managers should develop "appropriate" political tactics, which means being sensitive to the concerns of powerful stakeholder groups and developing strategies for influencing and negotiating with political actors. To accomplish this, managers should consider the concept of "WIIFM"

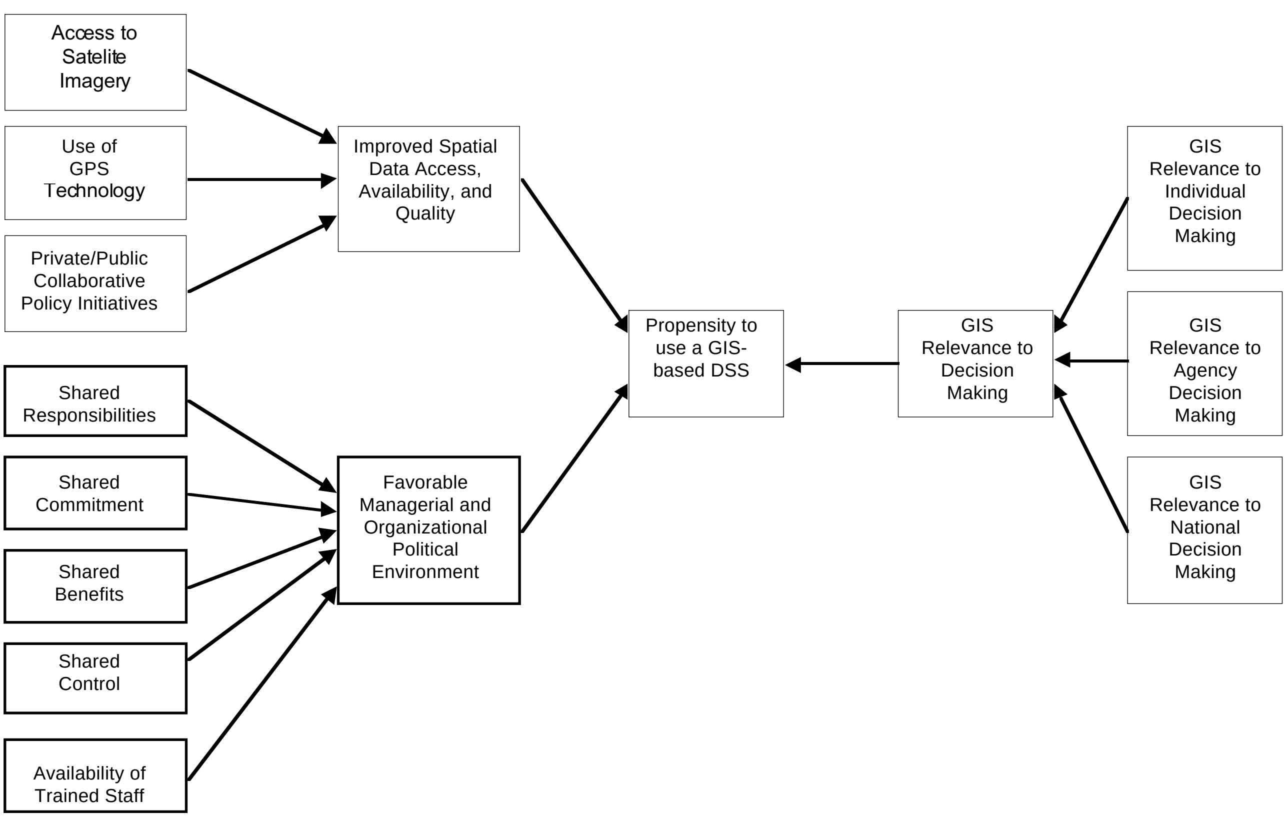
(What's in it for me?) in order to identify the factors that will motivate organizational actors who are likely to engage in organizational political behaviors.

Although these suggestions are useful for project managers and administrators who are managing specific GIS implementation efforts, these recommendations do not address the problem of how to implement policies and procedures that will encourage these positive behaviors by individual managers. To do this, LDC governmental organizations must take a more strategic view of positive uses of organizational behaviors. The National Research Council (1994) provided several suggestions for developing organizational strategies for promoting successful inter-organizational partnerships in sharing geographic data. These suggestions, while designed for state and local governments in the United States, have application for developing partnerships with other organizations and for promoting positive uses of intra-organizational political realities in LDCs. Specifically, their prescriptions, when applied to the context of organizational political behaviors, suggest that organizations must develop policies that encourage the following:

1) Shared Responsibilities: Specific responsibilities for all organizational participants who are likely to be impacted by the implementation of the GIS should be defined and agreed to prior to the project's initiation;
2) Shared Commitment: The costs for the GIS project should be shared as equally as possible by all of those parties that are likely to benefit from the new system;
3) Shared Benefits: Benefits should be received by organizational members in a manner that is consistent with their involvement and commitment to the program;
4) Shared Control: Control over the decision making process should be apportioned in a consistent manner to the commitment required of and benefits received by each organizational member.

These guidelines for developing GIS in a political climate are reminiscent of Robey, Smith, and Vijayasarathy's (1993) research on the role of conflict and political considerations on the implementation of information technology. In their model, conflict resolution is considered to be an important factor affecting implementation success. Anecdotal evidence suggests that sharing benefits, control, etc. can be beneficial for promoting GIS use. For example, Klein (1995) reports on a successful collaborative development project initiated by Tijuana and Ensenada, Mexico. A conference to discuss the role and potential benefits of GIS in land management led to a jointly developed and owned GIS system. Early efforts to identify and quantify shared benefits of the new system were identified as a key influence on the project's success.

Figure 2: Variables Influencing the Propensity of LDCs to Use a GIS-based DSS



IMPLICATIONS AND FUTURE RESEARCH

We conclude this paper with a summary of the factors that affect the propensity to use GIS as a DSS technology in developing countries. These relationships are drawn from this paper and our earlier work (Mennecke and West, 1998). Figure 2 illustrates our synthesis of the influence of these variables — data and technology, managerial and political considerations, and the role of GIS for decision support — on the propensity of LDCs to use GIS as a DSS technology. Note that we structure all of the relationships as direct in that positive influences from factors such as access to satellite imagery, shared benefits, etc., have a positive impact on the propensity to use GIS.

Put another way, these same relationships can be stated more formally in a series of propositions and corollaries.

Proposition 1: GIS data access, availability, and quality in LDCs will improve with increased access to remotely sensed data, GPS technology, and the initiation of collaborative projects with private sector organizations.

Corollary 1A: The propensity of LDC governments and support organizations to use GIS-based decision support technologies will increase with greater access to GIS data

Proposition 2: The organizational political and managerial environment in LDC governments will be more favorable for GIS implementation with increased sharing of responsibilities, commitment, benefits, and control by stakeholders in the implementation process.

Corollary 2A: The propensity of LDC governments and support organizations to use GIS-based decision support technologies will increase with the development of organizational political environments that are favorable to GIS adoption and implementation.

Proposition 3: The overall suitability of GIS as an appropriate DSS technology in developing countries is determined by the suitability of GIS as an appropriate DSS technology for individual and lower level decision making, agency-level decision making, and national level decision making.

Corollary 3A: The propensity of LDC governments and support organizations to use GIS-based decision support technologies will increase with the overall suitability of GIS as a DSS technology.

These relationships are of interest as a foundation for further research in this area but the fact is that considerable new research remains to be done. One of the most important questions revolves around the relative impact of individual factors when different factors move in opposite directions. Work in this paper indicated, for example, that space technologies and new GPS systems are increasing the availability of high quality imagery and base maps for use in developing countries. What we do not know, is how the availability of more and less expensive data will affect GIS usage if the availability of trained staff or the inability to generate shared commitment or shared responsibilities otherwise argue against GIS usage. Future field research is needed to examine these variables in combination to better understand each variable's role in influencing the success of GIS initiatives.

CONCLUSIONS

This paper concludes a two-article sequence on the use of GIS as a DSS technology in developing nations. The first paper (Mennecke & West, 1998) showed how GIS data has the inherent capability of serving as the basis for an integrated decision support system at the highest levels of government in these areas. The natural relationships created by the spatial elements of GIS data provide connectivity and a data organization schema that is not ordinarily available in conventional database management systems. Further, modern hardware and GIS software make this connectivity availability with relatively small investments in software and hardware. In combination, supporting a widespread national infrastructure of GIS data has benefits ranging from the individual project level to national policy making.

This paper, on the other hand, highlighted restrictions on the ability to use GIS as a national level DSS due to data access, managerial, and political issues. The paper also, however, emphasized specific remedial steps to overcome these difficulties. It is appropriate to conclude by emphasizing that solutions to these problems *are* available and that we view the capabilities, opportunities, and contributions of GIS to be worth the effort necessary to ensure successful implementation. We hope that by surfacing these issues that awareness will be raised amongst information systems and other organizational researchers. This is truly a rich area for conducting research on the adoption and diffusion of GIS and other information technologies. Our model should be useful for highlighting many of the important variables that influence this process in LDCs.

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ENDNOTES:

1 A map's scale is "the ratio of distances on a map to the same distances in that part of the world shown on the map" (Clarke, 1995). The terms small scale and large scale are used to describe the relative values of the scales ratio; a small scale map is one where the ratio is large while a large scale map is one where the ratio is small. In a 1:25,000 scale map one unit of measure on the map sheet represents 25,000 units of the same measure on the ground. It shows more detail and is a larger scale than a 1:50,000 scale map.

2 We cannot present this problem as the unique province of LDCs. Prior to the year 2000, the General Accounting Office reported that many U.S. state and local governments as well as the Federal government were behind in Year-2000 preparations for the same reasons (GAO 1999a, GAO 1999b).

3 Similarly, the United Nations has developed products called PopMap and MapScan that are designed for use by developing nations (Vu, 1996).

4 In addition to these issues, legal concerns have also been shown to affect GIS data sharing. For example, King (1995) reported on legal problems that impeded GIS data sharing in the U.S. While pragmatism and different legal traditions may overcome these constraints in developing countries, legal concerns may also pose potential impediments in many LDCs.

5 It should be pointed out that there are problems associated with using data from RSI. Data about land cover and vegetation captured using remotely sensed are often difficult to classify because the spectral signatures of many features are similar and difficult to distinguish (Pratt, Bird, Taylor, & Carter, 1997). As a result, data from RSI must often be examined at a macro level rather than at a more detailed scale. There are similar problems with using RSI to track socioeconomic phenomena. In particular, Bohnet (1995) notes that socioeconomic data possess properties that distinguish them from physical data. As a result, socioeconomic data are more difficult to collect using RSI.

6 See http://nctn.hq.nasa.gov/

7 See *http://www.dss.inpe.br/programas/cbers/ingles/index.html* for more information.

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