OPPORTUNITIES AND CHALLENGES FOR SDI DEVELOPMENT IN DEVELOPING COUNTRIES - A CASE STUDY OF UGANDA

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Abstract

Developments in Spatial data collection and use have led to what are currently known as Spatial Data Infrastructures (SDIs). SDIs are technologies, policies, standards, and human resources to acquire, process, store, distribute, and improve utilisation of geo-spatial information. SDIs are generally believed to play a big role in optimising the utilisation of spatial data, which in turn leads to the development of a nation. SDIs are currently benefiting developed countries, which are characterised by high levels of IT, adequate financial resources and huge quantities of spatial data. However, SDI concepts are now being disseminated into developing countries whose levels of IT do not match those of the developed countries; where most mapping and GIS programs are funded through foreign aid and huge quantities of spatial data are still kept on paper maps. There is still uncertainty as to whether developing countries are ready to utilise the benefits of SDI. Like many developing countries, Uganda is in the processes of developing a national spatial data infrastructure. Initial studies for developing a National Spatial Data Infrastructure and a National Land Information System have been carried out. Data was collected from different institutions, compiled in a CRUD Matrix and analysed using a methodology of assessing individual SDI components. The experience from these studies gives us an insight into what opportunities and challenges are ahead of developing countries trying to develop SDI. Whereas most of the challenges are similar in developed and developing countries, the unique challenges in developing countries are those associated with under-development and multiple donor aid. These challenges require that the components of SDI in developing countries take a slightly different shape but should serve the general purpose of establishing SDI.

INTRODUCTION

Spatial Data Infrastructures (SDI) include technologies, policies, standards, and human resources to acquire, process, store, distribute, and improve utilisation of geo-spatial information. The benefits of SDI have been realised mainly in developed countries where vast quantities of spatial data exist in digital form; data sharing policies are streamlined; internet infrastructure is fast and reliable; and data is comprehensively documented. Several Authors have presented efforts by developing countries to develop spatial data infrastructures, for example see Standley (1997), Economic Commission for Africa (2000), Kalensky and Latham (1998), and Ezigbalike et al. (2000). The authors observe that lack of funds, professionals, spatial datasets, standards, metadata and information sharing
policies are some of the factors hindering the development of SDI's. This has tempted some authors to conclude that Africa and the developing world are not ready for SDI. Although it is evident that the above factors are heavily affecting the rate of SDI development in developing countries, it can also be argued that most of them may be viewed as opportunities. It can be equally argued that acquisition of donor funds to facilitate the capture of spatial datasets in developing countries can create inconsistencies in data formats if not carried out in an SDI framework.

THE SDI CONCEPT

To facilitate the use of spatial data that is collected and stored in scattered digital databases to their full potential, efforts have been made to develop what are now called Spatial Data Infrastructures (SDIs). Spatial data infrastructures are defined variously by researchers and governments in a number of contexts. For example see European Commission (1995) and McLaughlin and Nichols (1992). Ideally, SDIs should include technologies, policies, standards, and human resources to acquire, process, store, distribute, and improve utilisation of geo-spatial information (Executive Order 12906, 1994). The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and the citizenry. The Australian and New Zealand Land Information Council (ANZLIC, 1998) as cited by Rajabifard (2002) defines a national SDI as comprising four core components: an institutional framework, technical standards, fundamental datasets, and clearinghouse networks. Similarly, The U.S. Federal Geographic Data Committee (FGDC) describes the components of an SDI as (Nebert, 2001):

- **Technology** (hardware, software, networks, databases, technical implementation plans)
- **Policies & Institutional Arrangements** (governance, data privacy & security, data sharing, cost recovery)
- **People** (training, professional development, cooperation, outreach)

The above components are illustrated in Figure 1 below.

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**Figure 1: SDI components adapted from Nebert (2001).**
Rajabifard et al. (2000) perceive a spatial Data infrastructure as an initiative intended to create an environment in which all stakeholders can co-operate with each other and interact with technology, to better achieve their objectives at different political/administrative levels. The authors identify outstanding reasons for developing SDI as being: most organisations needing more data than they can afford; organisations needing data that are outside their jurisdictions or operation areas or data that are not available; and different organisations collecting data which is incompatible. Feeney and Williamson (2000) argue that the design and implementation of an SDI is not only a matter of technology but also one of designing institutions, the legislative, regulatory bodies and developing new types of skills. There are several approaches to developing SDIs for different levels of government. However, the diverse nature of distinctions between nations and organisations means that there is not yet a clear agreement on what “spatial data infrastructure” and “Geographical information infrastructure” efforts should or should not include (Coleman and McLaughlin, 1998). Jacoby et al. (2002) observe that there are significant variations in infrastructure developments particularly in regard to legal, economic, scale and organizational considerations. Therefore, optimisation of spatial data utilisation requires that a much greater understanding should be gained of what the data represents, their potential management, technological uses and deviations (Feeney and Williamson, 2000). The development of SDIs is therefore difficult and affected by many factors, including technological development and business needs. Other factors are political decisions and government policy, especially in an environment of micro-economic reform, which has been enthusiastically embraced by many countries over the last few years (Williamson et al., 1998).

SDI DEVELOPMENT IN THE DEVELOPED WORLD

Most Developed countries are at various stages of developing national spatial data infrastructures (NSDI). The factors behind their success can be linked to high levels of technology, availability of funds, trained personnel and political support. Examples of advanced regional SDI initiatives include the US NSDI and the Australian NSDI (ASDI). A more recent initiative launched by the European Commission and developed in collaboration with Member States and accession countries is INSPIRE. The initiative intends to trigger the creation of a European Spatial Information Infrastructure that delivers to the users integrated spatial information services (Smits, 2002). The above three initiatives have adopted a similar model comprising of: fundamental datasets; people who are users, administrators, and also value-added re-sellers; Institutional framework which includes the administration, coordination, policy and legislation; technology which consists of the access and distribution networks, clearinghouse; standards and policy which are required to enable sharing, integration and distribution of spatial data. Through INSPIRE policy-makers, planners and managers at European, national and local level and the citizens and their organisations will be able to access a variety of spatial information from the local to the global level. A number of services will be offered including visualisation of information layers, overlay of information from different sources, spatial and temporal analysis. The spatial information infrastructure will address both technical and non-technical issues, ranging from technical standards and protocols, organisational issues, data policy issues including data access policy and the creation and maintenance of geographical information for a wide range of themes. The framework for implementation of INSPIRE will be through legislation which is expected to be in place by 2004.
SDI DEVELOPMENT IN UGANDA

Economic situation in Uganda

Uganda is a third world country and depends on donor funds to meet a considerable part of its national budget. The history of Uganda is characterised by political turmoil a decade after independence from the former colonial masters. For more than a decade thereafter, the economy of Uganda declined and the little that had been achieved under the colonial administration was lost through wars and dictatorial governments. However, since the late 1980's there has been a considerable rise in the economy. This has been characterised by several government policy reforms, notable of which are:

- Local Government Act of 1997 that aims at improving service delivery and accountability by shifting governments major undertakings from the center to lower local governments;
- Privatization and public enterprise reform policy to reduce the role of the government in commercial activities and increase exposure of retained public enterprises to market signals; and
- Land Sector Strategic Plan (LSSP) for sector wide reforms in land management, conveyancing and utilisation.

These reforms, together with other efforts, are playing a big role in improving the economic situation in Uganda. However, the associated programmes for economic growth have created a great demand for spatial data.

The spatial information industry in Uganda

Like in many other African countries, the spatial information industry in Uganda is not fully developed. Most organisations are still keeping their data as paper maps with very limited analysis. There is a lot of duplication in data collection and storage and a lot of spatial data is not documented. In Uganda, The Lands and Survey Department is charged with formulating government policies and guidelines regarding surveying and mapping. The department also ensures that government and other surveys carried out are of good quality. The department maintains maps at different scales, which they sell to the public at a fee. The national coverage is at a scale of 1:50,000 while the major towns are covered at larger scales ranging from 1:10000 to 1:25000. The 1:50,000 map series (Y32 series) are provided on standard A1 sheets covering rectangular blocks for the whole country. These maps were produced between 1964 and 1969 and do not contain recent changes in topography and other features. There is now a new breed of new data providers who emerged as a result of the inability of Lands and Survey Department to provide the required spatial data. Such institutions now numbering more than ten are well funded by the international donor community and have carried out mapping of their individual facilities at a national level. Most of the institutions are in the field of environmental conservation/ natural resource management where there is a lot of interest from the international community. The institutions are currently maintaining digital spatial databases mainly for the layers that they are mandated to. In addition, other layers are captured to improve the map readability of their products. The above institutions include the National Biomass Study (Forest Department) responsible for mapping the wood/Forest cover and quantify the amount of Biomass in the country, Uganda Bureau of Statistics and the National Wetlands Programme (Wetlands Inspection Division) responsible for conserving and managing wetlands in Uganda. Although the National Biomass Study (NBS) is mandated and restricted to produce and maintain the Land Cover layer, it is now the major...
seller of all other layers in digital form (including roads, administrative boundaries, rivers, built up areas and elevation). NBS does not update digital data of the latter layers since it lacks funds, capacity and mandate to do so. However, the scarcity of digital spatial data in Uganda leads to the purchase of data from NBS even when there is no guarantee of fitness for use in terms of accuracy of content, context and currency.

The fact that the institutions maintaining spatial databases are funded by different foreign donors coupled with the fact there are no existing national standards on data formats has led to different institutions maintaining data that is not easy to share. (Gavin and Gyamfi Aidoo, 2001, p. 157) summarise this problem as follows:

"In the Ugandan case, the lack of standardisation is seen as a major weakness in the implementation process. When data sharing starts, problems concerning data standardisation will immediately start to manifest themselves. The EIS community will then start to pay the price for neglecting these issues. Transformation of data, projecting, re-organising and even recapturing could be necessary in order to harmonise data. Such operations are both labour intensive and time consuming"

A similar observation was made by Swedish Consortium (2001)

“Geographical Information Systems will undoubtedly continue to disseminate the Ugandan Organisations. One is now at a crossroad where to decide to co-ordinate efforts and get the benefit of common investments, or each organisation shall strive to satisfy their own needs. It is no doubt that the first alternative is much more cost effective…. it is equally evident that the consequence of waiting is increased investment to rectify the situation.”

Sharing of data is a requirement in a GIS set-up since no single institution can meet its mandate without use of data from other institutions, it can be urged that the current inability of institutions to effectively utilise GIS partly stems from the problem of inconsistent datasets.

Experiences

Uganda has not gone far in developing a National Spatial Data Infrastructure. However, a number of initial studies have been carried out to evaluate the requirements for its development. The most recent and significant study is the review of the status of Land Information Systems In Uganda, which utilised a modified form of a CRUD Matrix. A CRUD matrix (which stands for Create, Read, Update, Delete) is a modelling tool used in data-oriented methodologies to show processes and their associated data. The hybrid of the CRUD matrix was adapted in this study. It shows data sets on the vertical axis and their associated departments or users on the horizontal axis (see Figure 2 below). The matrix provides information of data ownership, maintenance, use and geographical distribution. Furthermore it gives an insight into institutional mandates and data duplication. The matrix was filled by carrying out physical inspection of spatial datasets in various institutions and holding discussions with relevant personnel in these institutions. The CRUD matrix was used together with other data collection forms that detailed attributes of datasets from various institutions. The aspects investigated included formats, volumes accuracies and physical condition. The data compiled in the CRUD matrix was further analysed to derive salient issues for implementing a National Spatial Data Infrastructure. The method used to analyse Uganda's readiness for SDI was that of analysing individual SDI components as developed by Ezigbalike et al. (2000). In this approach, individual components of the SDI are evaluated one by one. The level of development of the components in a country is used as a measure to determine readiness.
### Findings and discussions

#### Datasets:

Although some spatial data in Uganda exist in digital form, a great amount of data is still not captured or exists in paper form and is outdated. For example, only 15% of the land in Uganda is surveyed and titled which implies that 85% of the land is still unknown to the government. On the other hand it has been identified that even the existing cadastral data cannot be digitised and integrated in a spatial database due to variations in projections and other data quality aspects. This will require fresh field surveys or other data collection techniques to recapture accurate cadastral information in Uganda. Developed countries with advanced SDI spent considerable amounts of time and funds to correct inconsistencies in data formats. Uganda and other developing countries do not have such funds to spend. However, since there isn’t much spatial data in developing countries, there is an opportunity for developing countries to develop SDIs before embarking on massive spatial data collection and hence save on costs to rectify inconsistencies.

#### Metadata:

Nebert (2001) underscores the role of metadata in an organisation. It provides documentation of existing internal geospatial data resources within an organization, permits structured search and comparison of held spatial data by others, and provides end-users with adequate information to take the data and use it in an appropriate context. This aspect of the SDI in Uganda is the most ignored and yet it is one of the most important aspects of SDI especially in developing countries. It is a common practice for donor-financed projects to undertake independent mapping projects even for areas where data exists. It is also not uncommon to find areas that have been mapped more than five times a year. This is attributed to lack of accessibility to information about spatial data availability and potential use. The issue of lack of metadata will derail SDI development unless a culture of documentation is developed in Uganda and other developing countries. Whereas it is understood that the Internet infrastructure through which metadata is searched is less developed in developing countries, it is not enough justification to warrant no documentation of data. As Ezigbalike et al. (2000) also observe, developing countries need to design SDI's with manual metadata which can later be captured into computer systems as they become available.
Standards and policies
The situation of absence of standards and policies is common in developing countries because of low volumes of spatial data. Lack of standards on spatial datasets, metadata, data transfer, software and hardware has negative consequences on SDI development. For countries that depend on donor funds to implement GIS /Mapping projects, there is always a tendency to adopt standards of donor countries. This situation is currently being experienced in Uganda and will certainly cause problems during SDI development. Since its is certain that donor support to developing countries will not stop in the near future, it is better for developing countries to develop SDI to address the above problem.

Institutional framework
Cooperation and partnerships for spatial data activities among the central government institutions, local governments, and the private sector are essential for the development of a robust National Spatial Data Infrastructure (SDI cookbook, 2000). In Uganda, there are no established institutional collaboration frameworks. Data exchanges are commonly done on institution-to-institution basis on demand. Even where mandates were clearly specified, the current demand for spatial data has created practices that are in conflict with the established mandates. This situation will create conflicts of interest among institutions if not well addressed by developing a SDI.

CONCLUSION
Although most of the issues for developing SDIs in developing and developed countries are similar, developing countries face unique challenges and mainly those associated with under development and foreign assistance. The challenges related to underdevelopment include lack of an efficient ICT infrastructure, limited trained personnel and lack of funds. Those related to foreign assistance include lack of coordination of various GIS activities financed by different donor countries and adoption of standards of those countries. Challenges relating to under development require that the components of SDI in developing countries should be based on existing infrastructure but should serve the general purpose of establishing SDI. Underdevelopment of the SDI components should also be taken as an opportunity to build efficient SDIs while borrowing lessons from developed countries. Challenges related to donor funding will be addressed if developing countries could at the earliest embark on practices that promote SDI like developing standards and manually documenting their spatial datasets. If this approach is not taken and standards for datasets and metadata are not developed now, developing countries are at a risk of generating huge quantities of incompatible datasets, which will be expensive for them to rectify.

REFERENCES


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