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The Future Orientation of Geoinformation Activities in Africa

A Position Paper

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The Future Orientation of Geoinformation Activities in Africa

When planning future strategies for spatial information management, governments worldwide sometimes just concentrate on the technology and do not consider other influences or drivers – they do this at their peril. (Williamson 1999)

Executive Summary

The Development Information Services Division (DISD) wishes to raise the awareness of African governments on the importance of geographic information. The main technology for processing geographic data is the geographic information system (GIS). It is therefore pertinent to examine the future orientation of GIS in Africa.

At the lowest level, GIS refers to the software packages for manipulating spatial data. At a medium level, it includes the data collected and the information resources created with the hardware and software tools. The rest of the world has moved beyond the level of GIS as a mere tool, and emphasis is now on how to get spatial data into the wider community, using the technology as appropriate. This calls for a shift in emphasis from GIS and spatial data resources to spatial data infrastructures (SDIs).

There is a lot of economic potential locked away in spatial data collections and this potential is released by making the data widely available. Wide dissemination of these data collections will facilitate better government as communities have access to the data and can get involved in decisions affecting them. Service delivery industries that depend on location and spatial knowledge will benefit from reduced transaction costs and will be stimulated, leading to more economic activity.

The components of an SDI can be listed in several ways. The description adopted in this paper lists them as: data, communications, partnerships, standards, technology and users. The user component is very important because without users, the result will be the proverbial “white elephant.”

There are several technology-related advances related to the SDI. These include the Internet and its use to deliver spatial data service and metadata systems, which have evolved from internal tools used by database and filing systems to manage queries to become products in their own rights. Other relevant advances are clearinghouses and data warehouses. A clearinghouse is a network application (now predominantly Internet based) that allows a user to search for data across the network and download the data set. The system will search the metadata records and display a result showing what data sets are available, with links to the actual data sets where possible. A data warehouse is an extracted subset of various heterogeneous operation data sets to expedite and facilitate access to common data elements. The data providers supply the relevant elements to the warehouse, free their resources from constant routine requests, and therefore are able to concentrate on their main business.

To establish SDIs, there are several issues that African countries need to address. Among them is the issue of coordination of the contributions from various sectors. The coordination arrangement must include a dedicated and independent function to be able to enforce standards and rules. A common arrangement in information management is to assign the coordination to one of the major producers or users. This arrangement sometimes causes conflicts between the interest of the authority and that of the community of users. An analogy is drawn with financial management where the major producers and consumers of funds are never given the responsibility to manage the country’s or organisation’s funds.

Another issue to be addressed is the need to re-engineer the spatial data industry. This may involve re-structuring government departments or agencies involved in providing spatial data and/or spatial services. Other countries have adopted a customer-oriented service model, emphasis being placed on how best to serve the “customer”. Then there is the problem of low awareness of the value of information, especially spatial information, by government policy makers and senior management. The result is that funds are rarely allocated to comprehensive information management projects. Africa also has to address the issue of low skills and the poor state of other physical infrastructure, such as telecommunications, on which the SDI depends.

The SDI should include several data sets maintained by various providers and used by several data communities. One of the important subsets of the data is the environmental subset. This data community has been active in developing environmental information systems in Africa, and has adopted SDI principles even if they have not used the language. On the other hand, two other subsets, the digital cadastre and digital road network, have lagged behind in Africa.

An important source of spatial digital data is remote sensing imagery collected via satellite. Remote sensing technologies have advanced so much that they are capable of providing precise information for many applications faster than conventional mapping, though the costs are still high.

However all the spatial infrastructure activities cost money and Africa has serious financial constraints. An appropriate cost recovery model should therefore be included from the onset.

The Future Orientation of Geoinformation Activities in Africa

When planning future strategies for spatial information management, governments worldwide sometimes just concentrate on the technology and do not consider other influences or drivers – they do this at their peril. (Williamson 1999)

Introduction

This study is part of coordinated activities by the United Nations Economic Commission for Africa (UNECA) to "raise awareness of African governments and other sectors of society on the importance of geographic information in socio-economic development and to identify practical mechanisms to facilitate spatial data collection, access and use in the decision-making processes, both nationally and regionally, through a participatory approach."

Emphasis is therefore placed on the whole structure for the acquisition, management and use of spatial data, and not only on the technology.

The main technology components, geographic information systems (GIS), consist of software packages that are capable of integrating spatial and non-spatial data to yield the spatial information that is used in decision making. They are computer-based equipment, procedures and techniques for manipulating spatial or map data. This is the common meaning of the term GIS. The study does not concentrate on GIS because in this context, it is only a tool used for particular projects to perform particular analyses. Such emphasis may give the impression that the solution to the problem in Africa is the acquisition of computer hardware and software, or the automation of map production for projects. This will result in several idle computer-mapping laboratories looking for projects to support.

In most cases data that are collected for a particular project are useful for other projects. This is more so in the integrated planning environment required for sustainable development, which is where the emphasis is in Africa. Sustainable development also requires that all wastes are minimised and resources re-used as much as possible.

The need to re-use spatial data is also dictated by the recent "commoditisation" of data and information. The costs involved in data collection should be taken into account in project planning; the data collected can be sold or traded for other considerations. Moreover, some data required for particular decisions are transient and may no longer be available to collect when required. Decisions concerning agricultural practices are a good example of ones requiring transient information. Often these decisions will require data on the environment spanning several years. These data must be collected when the events are occurring, even if the needs for them are not present at the time of collection, as the situation may change may no longer be available to collect at the time that may are needed. Therefore there is a need for this type of data to be collected and placed in "data stores" (databases) for future use. Databases of this type become shared resources, which would be maintained continuously. A database, which has been created, maintained and exploited using a GIS—the tool—is itself often referred to as a GIS. Thus at this level, 'GIS' is used as a resource.

But it is not enough to collect and maintain databases in case someone needs it in the future. First, people may not know that they exist. And second, they may not be according to standards that enable them to actually be used. Creating, maintaining and using such data resources usually requires collaboration and co-operation of several user groups and professional disciplines. Such collaboration requires a strategic plan and clearly defined responsibilities and roles. One of the most important responsibilities is that of coordinating the contributions and utilisation of the resources by organisations at national and local government levels, the private sector and academia. Different users (which may be agencies or groups) have to be assigned custodianship responsibilities and use privileges for subsets of the data. General community users would then be able to expect the data to be available, and with network technology, to be accessible transparently. The data resources then acquire the status of an infrastructure. It is only at this infrastructure level that the full investment of spatial data can be realised by all. Also policy makers, and other users can go about their business, doing what they are best at, relying on the infrastructure for their data needs.

Spatial Data Infrastructures

Infrastructure Characteristics

A dictionary definition of an infrastructure is "the underlying foundation or basic framework (e.g., of a system or organization)" (Longman 1984). It is the basic structural foundation of a society or enterprise, a substructure on which other components are based.

An infrastructure has the following characteristics:

- Its users are not conscious of its "ownership". Users are aware that 'somebody' maintains the infrastructure, but do not regard this maintainer as an owner. For example, nobody regards the Roads Department as the owner of the highways, rather, users think of them as custodians or maintainers of that infrastructure.

- As a result of the removal ownership, users it to always be available, even if there is a fee or other consideration for its use. For example, though we pay for electric power, we expect it to be there always.

- The delivery or provision of the service is standardised to a large extent

- As a result of the standardized delivery, users take it for granted because of the ease of use.

- Infrastructures are expensive to develop and maintain, and the returns from the investment are usually long term.

A service that is delivered through an infrastructure is delivered in that manner because it is the most effective and efficient way to deliver it. Imagine supplying water to a community without the usual water infrastructure of reservoirs, pumps and pipes. This would involve going to the source with a container to collect water, as in fact is done in rural villages where the infrastructure for water distribution has not been installed. Other services can only be delivered in the form of infrastructure and there is no imaginable alternative, e.g., transportation and electricity supplies.

Spatial Data as Infrastructure

The main reason why the resources for producing, managing and disseminating spatial data are now being considered as infrastructure is to unlock the potential hidden in data and stimulate economic activity. Referring to LANDSAT images, the Vice President of the Unites States of America said:

> The Landsat program, designed to help us understand the global environment, is a good example. The Landsat satellite is capable of taking a complete photograph of the entire planet every two weeks, and it's been collecting data for more than 20 years. In spite of the great need for that information, the vast majority of those images have never fired a single neuron in a single human brain. Instead, they are stored in electronic silos of data. We used to have an agricultural policy where we stored grain in midwestern silos and let it rot while millions of people starved to death. Now we have an insatiable hunger for knowledge. Yet a great deal of data remains unused. (Gore 1998)

As data collection methods improve, vast stores of data are collected for specific applications. These data sets can be used for other various purposes, but only if the potential users know that they exist and can readily access them. Attention is therefore shifting to the technologies for the efficient dissemination of the spatial data collected and stored in those large "electronic silos", to ensure easy access to them by all decision-makers, including the community at large. It has been recommended that communities be informed and involved in decisions in their areas:

> Most of the creative and productive activities of individuals or groups take place in communities. Communities and citizens' groups provide the most readily accessible means for people to take socially valuable action as well as to express their concerns. Properly mandated, empowered and informed, communities can contribute to decisions that affect them and play an indispensable part in creating a securely based sustainable society (Rockefeller 1996).

This is put differently by the Federal Geographic Data Committee (FGDC) of the United States of America: "Quality of life in a free society is determined by the collective decisions of its individual citizens acting in the home, the workplace, and together as members of the community."

These recommendations and observations are in line with a shift towards customer-centred service deliveries, which ensures maximum satisfaction for little efforts. The current trend in the development of technologies for widespread dissemination of spatial data is to treat spatial data as infrastructure, thus the spatial data infrastructure (SDI) concept.

Comparing the national spatial data infrastructure (NSDI) to the highway infrastructure, McLaughlin and Nichols (1993) wrote:

> By investing in a national highway infrastructure—from interstate freeways and road maintenance programs to vehicle standards and driver education—the country established a platform for a way of life that would have been hard to envision in the Model-T era. The changes directly related to this infrastructure range from the mundane to the profound, and include the car industry, “drive-in” conveniences, better emergency services, and suburban America.
>
> We can’t really imagine what the spatial data marketplace will look like in the 21st century, but we know that without an effective infrastructure it will not reach its potential. Just as the availability of mass-produced maps have become the background for understanding geography and history in schools and for planning summer holidays, spatial information in its new forms will diffuse throughout society.

They go on to say that it will provide geographical referencing for many other types of information and “will help the nation better understand the land and the environment.” They highlighted the potentials for growth in the spatial information industry and suggested: “putting NSDI in place is a prerequisite for realizing this transformation.”

Components of the SDI

SDIs comprise the fundamental datasets (spatial data resource) as well as the interrelationships between these datasets, the management of them, and the means of accessing and distributing those data. The American FGDC (1996) defined an SDI as an “umbrella of policies, standards, and procedures under which organizations and technologies interact to foster more efficient use, management, and production of geospatial data.” It further explained that it “consists of organizations and individuals who generate or use geospatial data, of the technologies that facilitate use and transfer of geospatial data, and of the actual data.” It should at no stage be assumed that SDIs are all about networks and technology (FGDC 1996). An SDI will not function, no matter how good the networking and technology is, if communication channels, standards and procedures, partnerships and data have not been developed.

Data

The actual spatial data that reside in an SDI are obviously the most important competent in an SDI. SDIs cannot exist without spatial data. For spatial data and the resources for maintaining and disseminating them to acquire the infrastructure status, they need to develop to a stage where they are accurate and updated regularly, according to some agreed standards. The collection, storage, maintenance and updating responsibilities should be clearly defined and rationalised to avoid duplication and inconsistencies. It is also required that the dataset be used by members of the spatial data community as, essentially, a base data resource upon which other data sets can be superimposed.

This presupposes the ability to cross-reference data between the various sub-systems based on some common attribute. In geographic applications, the common attribute for cross-referencing is location. Locations information are usually represented as maps, or stored as digital geographic base. This is the base layer on which other data sets are built.

Communication

At its most fundamental level an SDI consists of the individuals who are concerned with spatial data, both users and producers. One of the most important first steps in the creation of an effective SDI is the establishment of good communication channels between individuals and organisations concerned with spatial data (FGDC 1996). The development of good communication channels between individuals and agencies within the spatial data community allows for the establishment of partnerships, standards and procedures that allows for data to be shared/traded/purchased amongst the different data custodians and users. Also included in the communication component are the technologies that facilitate exchanging of information, making the whole telecommunications industry an important player in the development of SDI.

Partnerships

Partnerships develop from good communication, and may be grouped together with the communication component. However, it has been listed separately here to underline its importance. Partnerships are a major achievement in the establishment of an SDI because organisations may believe that they are giving up their competitive edge in order to share, trade, sell or create, data with other organisations (FGDC 1996). This feeling even occurs between departments at the same level of government and within departments. Partnerships are extremely important. The best computer network and set of databases are useless if the custodians of the data are not willing to share, trade, or even sell their data, provided first that the data are in a form that will interest other users.

Common Standards and Procedures

Common procedures and standards facilitate the sharing of data across the SDI to a greater extent. The transportation infrastructure presents a good analogy. In the transport infrastructure standards dealing with rail gauges, road sizes, and the side of the road to drive on are just a few of the many standards that are in place to help people make better use of the infrastructure. Similar standards are required for spatial data infrastructures. Having datasets in an SDI that are stored in different formats means that the sharing of these datasets is difficult due to the many incompatibilities that exist between the datasets. Many software products will not read data made by other software products, and hence the best utilisation of the data cannot be obtained. By having standards, for example for data storage, encoding and transfer, in SDIs, data can easily be shared among a wider community of users and the best possible utilisation of the data can be achieved.

Common standards within an SDI tend to solve many of the incompatibility problems for newly created data, however the legacy data will remain a problem. Organisations have significant amounts of money tied up in the systems that have so much legacy data that are not compatible with other legacy data used by other organisations that very few of them are willing to sacrifice their own investment in order to have an effective SDI. This is why long-term communication is important and a dedicated co-coordinating role is required to negotiate the standards.

Technology

There are two major aspects to the technology component of SDIs. The first aspect is the actual technology that deals with communicating over networks. Much of the SDI technical infrastructure dealing with networks has already been built, or is in the process of being built, by the world's general information technology (IT) industry as they build the global information infrastructures. Computers are getting faster and the telecommunications and computing hardware, software and standards which supports distributed geoprocessing are spreading at a rapid rate (McKee 1996).

The second aspect to the technology component of SDIs is the technology that is required to allow users to actually utilize the data and make sense of the information. It is not only the spatial data capture technologies that are important, but also the data abstracting, modelling and software technology required to maintain the datasets. A key aspect of this is client/server architecture.

Users

The SDI will be of no value if there are no users. This is therefore an important component of the SDI. Included in the user component are individuals, groups and organisations that produced the data sets in the system and maintain various aspects of it. There are also the group of users who add value to the original data sets to produce new data and information products, which then become part of the data and information infrastructure. And then there is the community of users who use the infrastructure to solve problems and support various types of decisions, from a householder using the information from the system to determine where to buy their family house, through the corporate user who uses the system to analyse its customer base, to the government department which uses to plan a development project.

It is not enough to have individuals and organisations classified as users. They should possess appropriate knowledge and skills to perform their roles in the infrastructure effectively, be it providing data, transforming data, managing data or exploiting the resource.

Africa is not short of individuals and organisations with assigned or assumed roles as described above. However, the skill base is still very low. Computer permeation is still low in organisations and government, and so is computer literacy. The result is that operations that should be computerised are still being performed manually. These include operations on/with spatial data. The ability to participate fully in the operations of the infrastructure, and realise the full potential of the data resources is therefore limited.

Associated with this is the state of our educational institutions. Some institutions have not been able to keep up to date with advances in concepts and technology in this area. They are therefore unable to perform their role in the operation of the SDI, which is to produce the skill and knowledge base for the relevant activities. This is due mainly to scarce financial resources, and the fact that benefits from investments in spatial data projects are long term rather than immediate. Politicians and administrators would rather commit the scarce resources to projects that will yield results in time to affect their electoral fortunes and performance appraisal targets.

Technology-Related Advances and Concepts

The Internet and Spatial Data

The Internet, especially the World Wide Web (WWW), is one of the most influential technologies of the Information Age. It has greatly facilitated access to information in a variety of formats:

> Eventually, people will be able to reach out from their homes or businesses to exchange information in the form of voice, video, data, and images in any combination they need, with no more effort than it takes to dial a phone call today. (Benton Foundation 1995)

That promise has been realized through web browser technology that presents a consistent interface with hyperlinks that point to other pages. The result is “a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users’ fingertips.” There is no need to remember names of files, or which computer on the network they are stored on, or even the exact commands to load or view the files or documents. We simply “browse” through a worldwide information resource through hyperlinks.

Each resource has a unique web “address” to which the link points, and which if known can be used to go directly to it, rather than navigating through links on other pages. The links can also be made to point to programs so that instead of opening a document, a program is invoked. The address could be a filename to view, a program to execute, a computer to connect to, or any other resource to use. Thus, instead of referring to filenames or computer names or address, we have a resource locator, the Universal Resource Locator (URL).

The Internet is also extending its reach and application to spatial information services. The problems that still exist in this application are “the limitations imposed by network bandwidth or the amount of data that can physically be transferred in a reasonable period of time across the Internet” (Polley and Williamson 1997). Initially majority of GIS-related web sites “contained marketing or technical information describing hardware and software products, GIS projects or programs, institutional or educational initiatives and research efforts” (Coleman and McLaughlin 1997). As more high-speed, high-volume lines become available, more spatial data services are now offered on the Internet. Coleman (1997) observed four overlapping categories of usage as follows:

1. Advertising: concerned mainly with advertising data products, with maybe, some samples.

2. Data distribution: allowing users to search for specific information and download the relevant data sets.

3. Custom map creation and viewing: providing “just-in-time” mapping using tools that allow for the composition, downloading and display of user-defined custom map products.

4. GIS/Internet integration: integrating a limited amount of front-end query capabilities with the capabilities of DBMS and GIS software packages residing in the background.

The fourth category represents the most advanced stage and is the direction in which spatial data services, especially in the infrastructure environment, are going. This development has been facilitated by the development of metadata engines and open systems computing.

Metadata systems

A very important component of the SDI is the metadata system. Metadata is commonly defined as “data about data” (ANZLIC 1996; Kildow 1996; ANZLIC 1997). Originally, metadata were only used by database and information retrieval systems to describe the internal layout of the data schemes within them (Codd 1990; Korth and Silberschatz 1991). They constituted the “underlying set of rules which tells a software program how to handle data” (Wilson 1998). For instance, a relational database system will consist of tables, queries, reports and forms. Each table will be made up of fields and the fields will have data types and field lengths. There will be relationships between the tables, and data for the forms and queries will be drawn from base tables. There may be integrity constraints enforced in the database. All this descriptive information about components of the database is as important as the data that the user stores and manipulates in the database. Without this information, the system cannot function. All this information is structured in a special section of the database and maintained by the system, usually without the user being aware of its existence. Before any access to the system is completed, metadata records are accessed to determine which tables and fields are necessary to satisfy a user's data request.

Metadata have become products in their own rights, especially in the spatial data management field, where they are used to describe the characteristics of datasets. Characteristics such as the custodian, description of the data, geographic extents of the data, currency of the data, storage format, data quality, contact information to inquire about the dataset are all described. In this context metadata is extremely important for spatial data as it allows potential users of a dataset to determine whether the dataset is useful to them or not. Metadata systems can be established that allow users to search the metadata records for the datasets located on a network. From the results they are able to determine if there are any datasets that may be of interest to them, how to gain access to them, any constraints on using them, etc. Such an application is often referred to as a spatial data directory or, in some cases, a clearinghouse.

Metadata of this type are extremely important as they facilitate the more efficient use of spatial data. This is achieved by allowing potential users of spatial data to search for datasets that may suit their needs. They can look at the metadata record for a dataset and see if it meets the criteria for use that they have set. The record will also tell the searcher the access rights or constraints that the dataset has. All this is very important, as it is usually cheaper to acquire that spatial dataset from another party that has it than it is to produce the dataset oneself. The last thing organisations want to do is to duplicate work that has already been completed by another party.

Clearinghouses

A clearinghouse is a network application that allows authorised users to search and discover data on the network, and obtain the data. Underpinning the clearinghouse activity are the metadata systems containing field-level description of the available data sets. The metadata systems use a common standard to allow consistent querying. The clearinghouse activity of the FGDC "readily available Web technology for the client side and uses the ANSI standard Z39.50 for the query, search, and presentation of search results to the Web client" (FGDC nd). It provides users with a consistent interface over the diverse spatial data collections, stored at various participating sites. A fundamental objective is to provide access to digital spatial data through metadata. If a data set is available online, one of its metadata fields would be its URL. Since it is based on web technology, this field would be hyperlinked in the displayed result. This allows the user to click on the link to initiate download of the data. Some data sets may be too large for online delivery, or there may be a fee payable for the data and/or its distribution. Regular data users would normally have an account with the custodian and would be given an access code. In cases where online delivery is not possible, the link could point to instructions on procedures for offline ordering, or to an order form that can be completed and submitted on line.

Phillips (1998) notes that "clearinghouse can either be a single server that has all the metadata for the entire network, or it could be a system of decentralised servers that are located on a network." When the servers are decentralised, they "may be installed at local, regional, or central offices, dictated by the organizational and logistical efficiencies of each organization" (FGDC nd). FGDC (nd) further notes that all the participating servers are considered as "peers" with no hierarchies. This permits "direct query by any user on the Internet with minimum transaction processing."

Data Warehouse

The original concept of the data warehouse is a "complete repository of corporate data extracted from transaction systems that is available for ad-hoc access by knowledge workers" (Phillips 1998). Applied to spatial data and SDIs, it is the collection of spatial data sets extracted from operational spatial data resources and maintained for more general access. Though the technology allows for spatial data queries to be processed against operational systems maintained by data providers and used by major spatial service provides, it is more efficient to provide data warehouse facilities for general enquiries. Routine decision-makers and public enquirers are expected to refer to easily identifiable data elements that do not change often. By providing the warehouse facility with separate management, the spatial data and service providers can concentrate on their main business. Manitoba's (Canada) spatial data warehouse, the Land Information Navigator, is managed by Linnet. Its purpose is "to collect, store, manage and distribute spatial data on behalf of the data producers of the Province, and to facilitate the sharing and use of land related data" (Linnet 2000). GIS vendors now offer special data warehousing features in their software products.

SDI Issues for Africa

Economic Justification

There are two main points with regards to the economics of geo-information.

1. Political and economic justification for investment by government in the collection and management of fundamental geo-information as a component of National Information and Communication Infrastructure (NICI)

2. Cost-efficient development, production and dissemination of geo-information

To address these points, there is need for a shift in perspective from focussing on the need for mapping and generation of spatial data, to the use of information describing the country's assets and potential in terms of its geography. This includes information about natural and cultural resources, their spatial concentrations and distributions, the presence of other factors that would contribute to exploitation decisions, including access roads and other enabling infrastructures. Spatial information also contributes to good governance and is essential for effective and efficient delivery of services. Knowledge of a country's geography therefore contributes to investment decisions by both foreign and local investors. For example, mining companies will not make investments unless there is documented and accessible knowledge of the geology of the country.

It is, however, not enough to have the data "stockpiled" in files, analogue or digital. Information products from the data should be disseminated widely and easily accessible to potential users to be effective. Access to information by price-takers helps reduce imperfections in the marketplace, which may lead to higher prices.

Unlike other assets, knowledge appreciates in value through use and depreciates in value through lack of use. Knowledge is not exhausted through use or sharing. Rather, new knowledge may be derived through integration of different sets of geographic information from different sectors, leaving the original sources undiminished.

Legacy Data

When an SDI is being developed one of the biggest issues that has to be addressed is what to do with all the legacy data (data that are already in existence). Many countries that have implemented SDIs had near-glut conditions with spatial data in analogue and digital form. This led to the large collections of legacy data that need to be converted or brought into a common standard. A major cost of the SDI implementation is therefore the cost of converting the existing collection of data to conform to the adopted standards. Another problem with legacy data is that they are likely to be stored in various proprietary formats, making the sharing/trading of data more difficult. The lesson to be learned from this experience by new entrants to the geospatial information industry is to plan for SDI from the onset. Africa has spatial data, but it has not reached a "glut" stage. Further developments in spatial data utilisation in Africa should adopt SDI principles to minimise the problems of legacy data when the communications and information technologies become available for a fully on-line, distributed SDI.

Policy and Coordinating Arrangements

African countries are going through a familiar phase that many other countries have gone through in their GIS development whereby different sectors engage in GIS activities without coordination. It is not uncommon to find different agencies collecting the same data at the same or different times. This is especially true in donor-funded projects, with independent funds. It often happens also that data sets of national importance, developed by different departments may not be integrated or exchanged due to non existence of a common standard, and in fact this may be used as an excuse to justify duplication of efforts. In many cases, the duplication may occur because the later projects are not aware of data and information products from earlier projects that could be used by them.

The GIS, as information technology, requires dedicated management arrangements. First there is a need for a geoinformation policy, within an overall information management policy. There is also need for management structures for coordinating the development, use and rationalisation of geospatial data activities, to realise the potential benefits of spatial data resources. The functions to be performed include the coordination of efforts among the stakeholders in the spatial data community to ensure cooperation and partnership, rather than competition. A model of such a policy, for adaptation by African governments is presented in Appendix 3.

Jurisdictions that have gone far toward implementing SDIs have established such coordinating functions, or redefined the mandates of existing organs. The United States has the Federal Geographic Data Committee at the federal level. The establishing circular referred to the "coordination of surveying, mapping and related spatial data activities." Under the "related spatial data activities", it is charged to "coordinate the Federal Government's (of the US) development of the NSDI." The Australia and New Zealand Land Information Council performs similar functions. At the implementation levels, there are state and local government coordinating functions. The province of New Brunswick in Canada created the New Brunswick Geographic Information Corporation (NBGIC) in 1990, now Service New Brunswick with a much broader mandate for information services. And at the federal level, there is GeoConnections, which is tasked with coordinating the national SDI, with a $60 million commitment. In Victoria, Australia, the Office of Geographic Data Coordination (OGDC) was first set up in the Department of Finance to oversee a government wide GIS planning study (Chan 1998) in 1991. Since then, it amalgamated with other government spatial data agencies and metamorphosed into Land Victoria, a new division that is dedicated to the management of GIS/LIS in the State, housed in the Department of Natural Resources and Environment.

Authoritative and Independence Management

It is instructive to observe that the coordinating committees or offices are high level enough to make policy and enforce standards and rules. This is in line with general information management practice. Since information is the currency of the knowledge economy, it requires a dedicated function charged primarily with managing corporate information resources for the good of all. There is a temptation to assign the management responsibility to one of the major producers or consumers of information products. In the case of geospatial information, this is usually the national surveying and mapping (or equivalent) organization. The management responsibility should not be given to such producers or consumers of the information. When this is done, the system over time would evolve to the cater more for the needs of this agency or person.

The recommended practice is for the coordination function to be performed by a representative committee drawn from stakeholders and for it its members to be high enough in the organisational structure to participate in policymaking and be able to enforce rules and standards. "Each member agency shall ensure that its representative on the FGDC holds a policy-level position."

This information management paradigm of independence can be compared with financial management arrangements. The major creators of wealth in many countries are departments responsible for mineral resources, tourism and agriculture. The major spending departments are defence, education, health and welfare. Yet none of these creators and spenders is given the mandate to manage the funds of the country. Usually a very independent and very powerful Department of Finance is the funds manager.

Re-engineering of Spatial Data Industry

Jurisdictions that have advanced in the implementation of SDI have re-engineered the entire geospatial information government structure. Some jurisdictions undertook major restructuring of the departments and agencies that produce, manage and use spatial data. For example, the State of Victoria in Australia started by setting up an Office for Geographic Data Coordination (OGDC) and ended up combining several resource management and land administration functions into Land Victoria. The main area of change has been to move from data ownership to data custodianship. Agencies and organisational units are assigned custodian responsibilities to contribute and maintain specific datasets for the community of users. Privileges and incentives would normally go with such responsibilities. And there is need for policies to involve the private sector in the developments and stimulate relevant economic activities.

Other areas of the industry on that are re-engineered are:

1. The use of modern data acquisition technologies, especially by the national mapping agencies (NMA). Technology makes it possible to be able to create many different products, customized to the needs of individual demanders.

2. A "just-in-time" (JIT) philosophy can be adopted, i.e., products are produced on demand, rather than being stockpiled. This approach avoids the cost associated with the storage of the products, and possibility of wastage that may result if the stockpile is not exhausted by the time they become obsolete and have to be discarded.

3. Rather than setting up spatial data production and management units that may not be fully engaged, the spatial data needs may be outsourced. However, even if production is outsourced, capacity needs to be retained within the outsourcing institution, to avoid "asymmetric knowledge," which may cause inefficiencies.

Customer Orientation

Another common area of change is to shift from focussing on the requirements of the service providers to the needs of the "customer". A major component of spatial data resources are in domain of government agencies. In the past, governments generally did not think of consumers of their services as customers; they were citizens and should be grateful for the service. While the citizens are grateful, they still want to be satisfied. The result is that they have to come back several times to get bits of service before being satisfied. This results in an inefficient use of resources. Governments are now adopting a customer-centred approach to service delivery. Letting the customer decide on what service they need is not only efficient, but it also ensures success in relevant projects.

Spatial Data Standards

Standards and norms are important to facilitate exchange of data compiled by various data providers for common use. Graphic standards are needed for both raster and vector type of information, and also for non-graphic data and metadata.

The International Standards Organisation, Technical Committee 211 (ISO-TC 211) have developed general GIS standards.

It is hereby recommended that African countries should keep themselves informed of these developments and adapt these international standards to meet their specific requirements and constraints. Countries should make use of their academic and research institutions in interpreting and adapting these standards. It should be noted that some countries might not have enough experts, even within their academic sectors. Such countries should be encouraged to make use of the regional centres. The ECA secretariat could also coordinate and mediate the sharing of expertise between countries.

Foundation, Framework or Basic Data

Common to all geospatial data use is geometrical referencing of features and phenomena of interest. It is important that all data sets use a common geocoding geometric reference so that they can be combined and cross-referenced with one another. It will also enable data to be converted by existing conversion programs into a desired geometric fit. Creating foundation or basic data products, on which other layers are based, ensures this. Wherever possible, the provision of base data should be in digital form, with optional paper printout, and not vice versa.

The foundation data products are those data sets needed by more than one government agency for fulfilling their service delivery obligations. They include the location of geodetic control points that define the reference ellipsoid used, and its relation to the International reference frame. Another set of foundation information products is the topography, including the road network, railways, buildings, hydrography, administrative boundaries, etc.

At large scales, the parcel layout with parcel boundaries and uniquely identifiable parcel numbers, buildings and district features, as well as toponomy, need to be included as foundation data.

In some jurisdictions, the foundation data products may also include digital elevation model in all forms, including raster, vector and TIN formats. These will enable digital image products resulting from processes such as differentially rectified satellite images or from a digital orthophoto to be combined with other information products. It also applies to the various elements of topographic information products.

These foundation products form the base for information to be added by users of geospatial data. They facilitate access, responsible use and integration at more affordable costs than without data sharing. Traditionally government co-ordinates and funds the development of national infrastructure, which now includes spatial data infrastructure. Therefore it should be expected that the provision of foundation or framework data, or at least its co-ordination, should be the responsibility of a government agency. In order to do that, the basic data must be identified with structured rules and procedures for their integration and updating.

At its 1999 meeting, CODI-Geo had recommended the establishment of a geodetic African Reference Frame (AFREF), in line with work completed on other continents (e.g. EUREF in Europe). This recommendation is reiterated and the ECA secretariat might seek donor support to quickly establish AFREF as an absolute geodetic reference. This could be established with 2 cm precision for all countries to connect via GPS observations.

Mapping Scales for Development Needs

In the digital age it is necessary to consider mapping scale not as a matter of pictorial representation on printed maps, but as a set of objects, which may be represented at a particular range of scales. Scales should be adopted appropriate to the intended uses of the products. In setting the scales, consideration should be given to required pixel sizes for corresponding digital images and raster products. The table below shows common scales and their uses:

Scales	Appropriate Uses
1:1,000,000	Global scales, equivalent to 1Km pixel size, suitable for climatologically influenced data such as status of vegetation, soil moistures, agricultural productions, etc. Also required to meet obligations under global conventions.
1:200,000 to 1:250,000	Continental and regional scales, equivalent to 30m pixel size, for trans-boundary features such as land cover (e.g., Africover)
1:50,000	National scale, equivalent to 5m pixel size, suitable for monitoring of renewable and non-renewable resources
1:10,000	Urban scales equivalent to 1m pixel sizes, used for urban planning

Regular Updating and Feature Categories

It is not only required to establish the relevant datasets at the required scales and accuracies, but also to include a regular updating system within a specified time frame depending on priorities in that region.

The world average in map updates 1:50000 is still at the rate of once every 50 years. This needs to be decreased to at about 10 years. For the update of relevant features (e.g. roads, settlements, vegetation) an appropriate cost- and time-effective technology needs to be chosen. This is easier for small scales (e.g. 1:250,000), but more difficult for national (1:50,000) and urban data (1:10,000) scales.

Basic topography mapping has too few feature categories (e.g. 15 for roads, hydrography, elevations, toponomy, settlements, etc.) to be of use for land cover data users (who uses up to 100 categories). Land cover data are of high environmental and economic significance, and they therefore also need an update cycle of about 10 years.

Of course all data compiled and updated at different time periods need to be archived for the monitoring of change.

The Awareness Problem

Several studies have pointed to the lack of awareness of the value and role of information in general decision making as a limiting factor in developing spatial data systems in Africa and elsewhere. Most decisions are made on the basis of interest groups and political expediency, rather than on objective decision analysis. This tendency is more acute in spatial decisions. Part of the reason for this is that the traditional visual techniques for processing map data are tedious and limited in scope. The decision makers are not yet aware of the new computer-based techniques. Some that are aware feel intimidated by the technology and do not have the confidence to learn the new concepts and techniques—some truly do not possess the prerequisite knowledge to grasp the new concepts, not having had the opportunity to be exposed to them.

The result of this lack of awareness is the emphasis on more visible and tangible projects like road construction and housing development. It is not always obvious to the decision makers that these projects would be executed more effectively and efficiently if proper planning based on information, were undertaken. Because of this lack of awareness of the role of information, industries and residential developments may be located on prime agricultural land without due consideration to the long term needs of the population, or sensitive land requiring conservation may be farmed intensively further damaging the land. These considerations require various spatial datasets, which cannot be supplied by any one agency alone.

To increase the awareness of the role of information in decisions, government departments responsible for various aspects of land management and rural development should make their decision processes more transparent, and the information input more visible. Often, the decisions are made at the headquarters, without involvement of the local population. All the local population ever see is the actual implementation of the project, thereby strengthening the impression, wrong as it is, that the important thing is the ‘actual work’. There is need for a deliberate policy to make decision makers use more information consciously. This could be done by requiring resource management and spatial services agencies and departments at all levels of government to budget, and account for usage of spatial data in their decision-making processes and demonstrate that communities have been involved in the decision making process.

It is also noted that some national mapping agencies may not be aware of new concepts in geospatial data management, making it difficult for them to effectively serve the general geospatial data user community, who depend on them for the foundation and base data products. These agencies should be made aware of new procedures and concepts, especially a paradigm shift to digital orientation to be able to deliver appropriate geospatial data products to the user community. The ECA and its regional centres could organise a series of short courses and workshops for the national mapping agencies, and other user communities.

The Personnel Problem

Mapping and information technology are high technology and require skilled personnel to maintain and use them. The management of spatial information, from data collection through all stages of processing to dissemination and utilisation, are multi-disciplinary and requires trained personnel with various specialisations. These include surveying, geography, cartography, computer graphics, statistics, planning and database management, forestry, agriculture, land systems, and public administration. While professionals with these specialisations may be available in some departments, they are thinly spread and there are still few with enough cross-disciplinary mix required for the maintenance and application of spatial data infrastructures. Most of the training programmes have tended to emphasise the technical aspects of using GIS, and not enough on the holistic infrastructure concepts. Emphases have been on automating and digitalising their operations.

The introduction of new technology into any organisation usually involves retraining of existing staff. However, as mentioned above, some of them do not have the necessary background knowledge to grasp the new concepts. Others may simply be unwilling to learn new things and will resist efforts to introduce the technology.

Another aspect of the personnel problem is the low morale among workers in some countries. Salaries are so low, and conditions so poor, that workers do not see the need to try harder than is necessary. Thus they do not have any incentive to improve the operations of their department, or even to improve themselves by learning new skills. As a result, in-house seminars and workshops organised as part of continuous retraining of staff are poorly attended. Because of the low remuneration, workers may spend all their spare time moonlighting at other jobs to make ends meet, rather than attend any self-improving professional development program

Capacity Building

Concerted action is needed across the continent to overcome the above personnel problems. Specific recommendations to provide for education and training in geoinformatics and alleviate the shortage of experienced and professional personnel include the following:

1. Establish an African geoinformatics curriculum of a modular system of short courses. These courses are aimed at users as well as professionals/developers. African institutes of higher learning should modernize their geomatics curricula in modular form to be responsive to long-term education at various levels (PhD, MSc, PGD, Technologist, Technician) as well as short-term training and re-training in geoinformatics. To Enhance post graduate Education we should explore and set up articulated MSc and PhD degree programmes consisting of African universities and foreign universities.

2. Conduct a baseline survey of universities and institutions that have the capability to deliver the modular geoinformatics curriculum (MGC). A survey of the ad hoc, user oriented short courses being offered outside the traditional geoinformatics community should also be conducted.

3. The MGC will be run on a cost recovery basis to allow participating institutions to sustain the facility.

4. Establish a network of African universities and training facilities, the Geoinformatics Education Network (GeoEdNet), that will deliver the MGC. An attempt should be made to achieve some level of uniformity across the network to allow greater access to the latest geoinformatics technology.

5. Ensure that the MGS is marketed effectively to help ensure access and avoid duplication.

6. Include foreign affiliates in the network to share curriculum ideas and logistical experiences.

In addition to formal education and training programs, there is further need for professional forums on geoinformatics and for coordination of research and development activities in related areas. The areas of research should include implementation and management of geoinformation projects, and the assessment of outcomes of geoinformation technologies (GIT). Specific recommendations relating to research and coordination activities are:

7. Establish a Network of African Associations of Geoinformatics (NAAG) to facilitate the exchange of ideas within and between the land surveying, remote sensing and other geoinformation production and application communities.

   a. Explore the possibility of establishing a Geoinformatics journal (African Journal of Geoinformatics) to serve as a tool for distributing information and to build a larger sense of community between the many active national, regional and specialist communities. The journal will be in English and French (c.f. Geomatica, the journal of the Canadian Institute of Geomatics). Explore the possibility of making the journal an on-line entity to achieve cost-effectiveness.

   b. Explore the possibility of expanding the existing biannual Africa GIS conference. Include selected training modules.

8. The regional centres of the ECA (RECTAS, Ile-Ife; RCMRD, Nairobi); AOCRS, Algiers; and other similar organizations may coordinate the GeoEdNet and the NAAG, and their associated activities.

9. The GeoEdNet will establish an outreach program to raise the awareness of Geoinformatics in potential user communities. A kiosk that includes posters, leaflets and computer demonstrations of geoinformatics applications should be created and taken to symposia and meetings of potential user groups, such as medicine, agriculture and transportation.

10. Establish a set of pilot applications of GIT in areas of particular relevance. Nodes in the GeoEdNet will carry out these activities. The applications will be used in a GIT applications module. The applications will be documented in an African Geoinformatics casebook. This can be use in the Geo-kiosk and distributed to selected decision-makers.

11. Establish research projects that:

    a. Benchmark GIT vs. traditional methods for applications,

    b. Assess the economics of geoinformation.

12. Introduce a Geoinformatics Project Management module to GeoEdNet. (c.f. University of Laval course).

13. Ensure that training modules and demo applications are matched to available technologies, e.g., Internet and computer hardware.

Utility Infrastructure

The information infrastructure depends on other utility infrastructures, such as, and especially, electricity and telecommunications. In many countries, electricity is only available in the urban centres, leaving large portions of the country without service. These rural areas are also the subjects of the data in the proposed spatial data infrastructure. In fact, much of the environmental and natural resources data would be about these rural areas. Access to the infrastructure should therefore eventually be provided from these centres.

In some countries, even when electricity is available, the supply is not constant and the frequent power outages and associated surges result in damages to sensitive computer and other equipment. The cost of computerisation therefore usually includes costs of ancillary equipment for stabilising and standby generators, costs that are not incurred in developed countries.

Telecommunications infrastructure is also poorly developed. In many countries majority of the citizens still do not have access to telephones, and the waiting lists for phone services are long. Telecommunications agencies, which are still mainly government monopolies, are still struggling to provide voice lines to more people. The provision of data-enabled high bandwidth lines is therefore not yet a priority. And because of their monopolies, they usually block efforts to introduce new communication technologies that may be more suited for the large volumes of data involved in geoinformation.

The full SDI is based on computer networks and the Internet. Internet access in Africa is very expensive compared to developed countries, due mainly to the telecommunications costs. In North America, local calls are free and in Australia they are charged per call and not timed. Users in these jurisdictions can therefore stay on the Internet for as long as it takes to search or browse for relevant information. The African user, on the other hand, faced with timed dial-up connections, will tend not to stay long on the Internet.

In spite of these differences in the availability of other enabling infrastructure components, the data collection should still be in accordance with an established national standard for the whole jurisdiction. While the full SDI should be computerised, emphasis should be on the information content, allowing small and/or remote offices to use "information sheets" to collect the information and have them keyed in at higher levels.

Environmental Information Systems

The major economic activities in Africa are mainly concerned with tourism, agriculture and the production of primary resources. These include forestry products and mining. As with other planning activities, information plays an important role in the management and operational decision-making involved in resource exploitation. Predicting the existence of resources requires information about several aspects of the land and soil. These include biological, physical and chemical properties. Having determined the existence of a particular resource in a particular place, the economic feasibility and environmental and social impacts of exploiting the resource are undertaken. The considerations in these feasibility and impact analyses include the accessibility of the resource location and the relative location of the market for the resulting commodity, the locations and characteristics of other natural resources and settlements that may be affected by the exploitation of the resource in question.

These decisions are spatial in nature and require up-to-date data. The environmental management community, including resource managers, therefore form an important user community for the SDI. This user-community has long recognised the role of compatible information resources for their "business processes." A program of environmental information systems in Sub-Saharan Africa (EIS-SSA) has since been established. Bassole (2000) reports that these resulted from a "continent wide series of National Environmental Action Plans (NEAP's)" which started in the late 1980s to early 1990s in response to the challenges of striking a balance between economic development and sustainable.

> The aim was to help Sub-Saharan Africa countries create operational Environmental Information Systems which meet priority demands of resources users, planners, and decision makers for a better renewable resources management (Bassole 2000).

The original context of EIS was biased towards the technology. However, early experience in implementing them brought out the importance of "establishing an appropriate institutional framework to facilitate the generation of environmental data sets." The strategic orientation document of EIS-Africa therefore defines EIS as:

> … a coordination of actions aiming at allowing for a spread use of environmental information in decision making in the framework of sustainable development. It entails an institutional framework, a network of spatial data management facilities, and data/information policies for making environmental data and information accessible and easily used by individuals and decision/policy makers for national, sub-regional, continental or global needs (Bassole 2000).

The procedure adopted by the EIS programme includes seeking out and harmonising available data sets and developing capacity to use them in environmental decision-making. It also includes developing partnerships with organisations with similar objectives.

Even though the term SDI was not used, the programme applied SDI principles and has attempted to provide a broad range of spatial data services that it should have taken for granted had there been a proper SDI environment. With the developing of similar awareness and capacity among other user communities, especially the surveying and mapping community, the custodianship of some of these data sets can be re-assigned to appropriate sectors of the spatial data community, leaving the EIS community to concentrate on environmental management services.

Cadastres and Land Information

Most economic and subsistence activities on land are organised in spatial units defined by humans. These could be units of ownership, possession, cultivation or administration. Over the centuries, systems have been set up to maintain information for administering land in these units. This is particularly true of ownership and taxation units, which form part of the land tenure and revenue systems respectively. Sophisticated cadastral theories have been developed for the management of these information systems, long before the information revolution. Cadastral systems have been continuously improved and reformed to make them more responsive to the needs of the society. The most far-reaching improvement was the introduction of the multi-purpose cadastre concept, formally linking traditional cadastral information with relevant administrative records into a multipurpose cadastre—hitherto cadastres have been maintained primarily to support land conveyancing (juridical cadastres) and property taxation (fiscal cadastres). At about the same time, the principles of database management were applied to the descriptive information about the ownership, administrative or other proprietary units of land, resulting in land information systems. With advances in information technology, especially GIS technology, computerisation of the graphical or geometrical component of the cadastre became possible, leading to digital cadastral databases (DCDB)

However, the DCDB are not mere computerisation of classical cadastral systems, but a re-engineering of the whole cadastral concept to bring it in line with the information age. Already the multipurpose cadastre concept has established the principles of information sharing and cross-referencing with other records for land administration. The next step in the evolution of the cadastre is the repackaging of the contents of the various cadastres for general public consumption. For example, in Victoria, Australia, property information that can be ordered on line include (Land Victoria nd):

Title (copy or Register Search Statement)	Land Information statement (Local Govt.)
Copy of Subdivision Plan	Building Regulation statement (Local Govt.)
Planning Certificate	National Trust Certificate
Water Information statement	House Contract Guarantee Certificate
Special Meter Reading (water)	VicRoads Information statement
Property Service Plan (Water)	Priority Sites statement (EPA)
Heritage Certificate Section 50	Land Tax Section 97 (State Revenue Office)

One of the theoretical requirements of a cadastre is publicity and previous generations of the systems had been deemed to satisfy this requirement by virtue of the fact that the records are open to public searches at designated offices. It is only with the current information dissemination technologies, especially the Internet, that the cadastre has really become public. Its full potential is now being realised with the facility to integrate it with other records systems as part of the overall information infrastructure.

With the exception of a few countries in Africa, cadastres have been mainly limited to urban jurisdictions where freehold tenures had been introduced by colonial and settler governments. Efforts have been going on to reform cadastres and land tenure systems to apply cadastres nationally. However, it has been suggested that the cadastre may not be relevant in non-urban jurisdictions in Africa (Ezigbalike and Benwell 1994; Ezigbalike 1996). The problem was that technical surveying principles and bias towards the functioning of the land market have driven these reforms. While these were paramount in societies where land transactions form the basis of economic activities, they are barely relevant in others with very little activities in the land market, and non-market driven development priorities. Fourie and Nino-Fluck (1999) have recommended a graphical system with links the cadastral system.

Advances in surveying and information technologies, especially global positioning systems, remote sensing and GIS, have made it easy to establish such information systems that are not necessarily based on ownership and taxation units. With cadastral system now emphasising information contents and ease of access and dissemination over technical measurement and legal issues, which are receding to the background, their relevance and importance will increase. African countries and organisations developing cadastres and other land records systems should ensure that the system can be related and cross-referenced to other data sets in an infrastructure environment.

While the GIS provides for data sets to be related to each other on the basis of their locations, some applications, like amount outstanding on a utility bill, may be pure require only database functionality, without immediate need for the geometrical or graphical data. These applications may still require cross-referencing of data in different databases, or subsets of the SDI. Such cross-referencing is done with unique parcel numbers. The parcel numbering system is therefore an important component of the SDI. They do not seem to be prominent in the literature on SDI because they have been addressed extensively in the days of land information systems and multipurpose cadastres. However, African jurisdictions did not take part in those discussions and should be aware of the importance of compatible numbering systems for the various land records. It should be stressed that emphasis is on compatibility between the numbering systems rather than trying to find a universally acceptable system. This is because there is no universal land unit that is suitable for all parcel-based applications.

Streets and Road

One of the biggest mass-market applications of spatial information is in the area of navigation and finding directions. These applications depend on digital street and highway data. These data sets are now being ported to hand held devices and cell phones enabled with wireless applications protocol (WAP). Car manufacturers are now developing prototypes of cars with on board navigation systems, based on road network data. On line directories are now being linked to digital maps, with zoom and pan capabilities. In the Unites States for instance, a big industry is developing to produce these data sets for cities and towns. The industry is expected to grow as demand extends to more towns and cities, and to keep the data sets up to date.

Africa is a net importer of these technologies. Maps of Africa cities will also be required to be loaded on these products being exported to Africa. Without these maps being available, we may end up buying products with maps of European and American cities, or paying extra to have the features excluded, since production lines would have been standardized at that level of technology.

Governments, professional organisations and industry groups should encourage the spatial data industry to invest in road network data sets. These data sets are also used in delivery and collection services, like package delivery and utilities billing and customer services. However, some major African cities, even some national and State/Provincial capitals, do not have street addresses. Some of these cities may have unique plot numbers, which while very important for cross-referencing information in parcel-based databases, as described above, are not suitable for giving directions. In other jurisdictions, the two systems complement each other. Municipal authorities and planning organisations in Africa should be well advised to review their street numbering system for digital data applications.

Remote Sensing

Usually spatial data sets are developed by converting existing maps and other data into digital form. Many African countries have not maintained their mapping programs and available maps may be as old as 30 years or more. Much development has taken place in that time which is undocumented, especially with the low use of information in their planning. The ideal solution to the problems of non-existent or inadequate maps would be to embark on fresh mapping programs. However, where this is done by traditional mapping techniques, the cost simply renders the option not feasible. Moreover, many African countries do not have dense enough control points for this option. The alternative is therefore to supplement whatever is available with satellite remote sensing images. Two case studies demonstrate how this has been done in Rwanda and Uganda respectively (Hardy 1987; Otto et al. 1987). Since then, the capabilities of remote sensing systems have improved. The IKONOS-2 satellite of Space Imaging can sample the ground at one metre resolution.

> This level of resolution enables satellite imagery to be used as a data source for the wide-range of applications that otherwise requires expensive aerial surveys to be flown. In addition data can readily be acquired for projects in remote regions of the world and areas where access is restricted. (NPA 2000)

“With a pointable sensor, image acquisition attempts can be made in as little as 1-3 days (cloud cover permitting)” (NPA 2000). Remote sensing is therefore no longer a mere supplement for inadequate data. It is now used as a source of timely spatial data for spatial decision analysis. Mason (1998) examined the potential of remote sensing as a source of spatial information for the management of informal settlements. Even if maps were available, they would not have been adequate for this purpose because informal settlements are very dynamic and any mapped data would have been out dated. And ad hoc data collection would not have been adequate either because of the cost and time, and may be technically very difficult due to the high density of small structures. The project also examined the automatic extraction of the “shacks” from the images.

African countries should therefore consider remote sensing as a main source of spatial data, on equal footing with other data sources. This is especially important because the products are already in digital form and allow other processing that traditional data sources do not allow.

However, the establishment of satellite receiving stations may not be cost effective at the national level, especially with the extremely high cost of high-resolution imagery and the equipment needed for the analyses. The possibility of establishing a regional facility for the centralised acquisition of satellite data for the continent should be explored.

Financial Constraints and Donor Contributions

Many African countries are struggling to balance their budgets. Demands on the available funds are therefore rationalised. Information management projects, including geospatial information, usually do not rank high on the list of priorities. This is mainly due to the low information awareness discussed above. One of the effects of the financial constraints is that national mapping agencies, and other geospatial data service providers, do not have access to modern cost-effective and time saving technologies for data acquisition and processing.

The financial constraints are compounded by the fact that the software, hardware and other equipment associated with the collection and maintenance of spatial information are not manufactured in Africa, and have to be imported. This means that their prices are comparatively high. Moreover, much of the funds required for mapping and GIS projects would be in foreign currency, which is in short supply due to balance of payment problems. Other issues discussed above, such as mapping and utility infrastructure, also have a financial aspect. For example, the poor communication network in many countries, which impedes the sharing of data thereby denying GIS users the benefits that accrue from data sharing, will be alleviated if there are more funds available.

The obstacle of insufficient funding of geospatial data activities remains intractable because there is simply not enough money available to African governments to invest extensively in associated technologies. However, if the top decision makers appreciate the importance of information, especially geospatial information, in formulating and achieving their goals, they will give it the attention it deserves.

Presently donors fund many of the existing GIS in Africa on a project basis. These projects and donations are however not coordinated and the duplication associated with lack of coordination diminishes the utility of the donations. The effect of uncoordinated donor interventions may be to create an artificial demand or undermine economies of scale by duplicating supply.

Co-ordination of these donations as well as the collective evaluation of their impacts will bring about greater utility of the donations, and attract more external funding for geospatial activities as donors appreciate its potential benefits.

Other specific recommendations concerning donor contributions are:

1. Donors should be encouraged to contribute to building foundation/framework data within the framework of national policy concerning the systematic building of information infrastructure;

2. Data products emerging from donor-funded projects should be capable of and should be incorporated into the national information infrastructure.

Cost Recovery

Given the scarcity of funds to invest in creating the data sets and acquiring other related technology, the funding of the spatial data infrastructure becomes an important issue to address. It has been established that the provision of foundation data should ideally be the responsibility of the government. The two questions that arise from this assignment of responsibility are:

1. If a government is funding the gathering and management of foundation/framework data, should there be attempted cost recovery against demand from parties outside government?

2. If cost recovery is not attempted, even in the longer term, what mechanisms can be used to ensure that a data producer is producing products on public money for which there is a real demand?

Dale (1995, 52), referring to the computerisation of cadastral data, points out that the expectation of significant increase in productivity may not justify the level of investment required and suggests that it may be necessary:

> … to recover more of the capital costs through the sharing of data and by the sale of the information gathered. Information is a marketable resource and some of the cost can be recovered by selling data to the private sector.

Factors to be considered in adopting a cost-recovery policy include:

1. Higher costs lead to lower demand, i.e. the audience receiving knowledge which could drive further investment or the creation of information products and services is narrowed;

2. There are administrative costs associated with cost recovery;

3. The revenue recovered from the exercise should return to the agency that bears the cost of generating, managing and disseminating the information; otherwise it is not worthwhile.

In a discussion paper for the then Office of Geographic Data Coordination (OGDC), FDF (1996) reviewed the pricing models in North America, Europe and Australia. In the United States, the Federal Government provides data at little or no cost and without a restrictive licensing condition for their supply. The result is “a thriving commercial sector selling value-added products based largely on government data. … The catch is that the data are currently at a low level of accuracy and indifferent quality." It was noted that this approach resulted in extensive coverage and detail, and assess as "ideal as a basis for creating value-added products."

Canada has different pricing policies from the United States. The pricing principles are based on transactions, with a government organisation being set up as a broker between information suppliers and users. An example is Service New Brunswick whose property information may be drawn from three separate databases, which are now being merged although the pricing in some cases is separate. This is possible because of the strong monopoly positions enjoyed by the government cadastral agencies. However, competition developed both within and without the government. With this pricing model, break-even was achieved in 18 months.

In Europe the common pricing models tend to incur substantial costs for the use of spatial data. In the United Kingdom (UK) for instance, "the government policy for the OS (Ordnance Survey) is explicitly to recover full cost." While this approach has yielded significant revenues, it has also created major barriers and it was not clear "that this has been of overall benefit to the countries concerned."

In Australia, the principles are summarised by agreements of the Australia and New Zealand Land Information Council (ANZLIC). These principles "commit governments to data exchange at transfer cost, but still provide for charging for value-added products." There are three levels of charging: full commercial charges for some datasets, transfer cost charges for others, and no-charge provision for teaching and non-commercial research. Phillips (1998) reports that in Victoria,

> A new pricing policy for geospatial information is to be introduced in Victoria, which has the aims of achieving the greatest possible use of GI (Geospatial Information) and creating and stimulating the growth of the markets using GI …
>
> The new pricing policy has taken the approach that if the price of the information is affordable to all those who may wish to use it, enough customers will purchase it to allow the custodian to recover their costs. The new lower prices will help to achieve the two aims of greater usage and growth in the markets, and it will also encourage "non-traditional" users of GI to become involved in the GI industry, thus increasing the health of the industry.

The appropriate pricing model for Africa should also have the above aims of greater usage and growth in the market. However, following the American model strictly will still leave the question of initial funding unanswered. The European full cost recovery models would stifle the development of the spatial information industry, especially with the awareness problem that exists in Africa. The Canadian transaction model gradually recoups the cost over a reasonable time, but the network and communications infrastructure needed for those are still not available in Africa.

With respect to Africa, the awareness problem discussed above would seem to favour the American model. The immediate needs for spatial data do not call for the very high accuracy of European models. More important requirements should be extensive coverage, use of the products and stimulation of the economy. However, the financial constraints preclude a total no-charge approach. So aspects of the Australasian approach should be adopted and some data sets where the market has been established should be charged, with free access to educational, research and not-for-profit organisations to enable them address the personnel problem.

Furthermore, the brokerage aspect of the Canadian approaches should be considered, but with the change that the broker need not be a government organisation. Experience with other services on the continent suggests that government monopolies are inefficient. So, as further efforts to stimulate the spatial data economy and encourage private sector cooperation, the brokerage level could be licensed to a few large private corporations with the means to add-value to the base products before re-selling. These corporations will then invest in developing the components of the infrastructure with a profit motive, overseen and regulated by the government.

Self Analysis

Implemented SDIs have been preceded by several studies, sometimes conducted by international consultants. However, even the best consultants cannot manufacture success if the local practitioners are not fully involved in it. It is also important that before the consultants are engaged, there should be a preliminary description of the problem and expectations of the project. Therefore, an in-house preliminary problem analysis should be undertaken before engaging consultants. It may be discovered after the supposed preliminary in-house analysis that there is really no need for an external consultant.

In line with experience in the successful jurisdiction, the geospatial information industry in Africa should embark on an analysis of its role in, and impact on, the overall economy. Such a study will then help it to decide their future directions and whether an international consultant is required. It should be pointed out here that the consultant who is engaged to set strategy should not be mandated to implement the strategy. Defining the direction and strategy should be a separate project from implementing the strategy.

Whenever any study is to be done on the geospatial information industry, one of the things the consultant or researcher will need is an inventory of spatial data resources. This will include the available spatial datasets and capabilities for processing them. Other descriptive attributes of the datasets are also necessary. That is, we need an inventory of spatial datasets in the country; together such descriptive attributes that will enable us decide the potential value of each dataset in a data sharing arrangement. That is, each dataset has to be described to enable a potential user decide on its usefulness.

The major spatial service providers who produce and use most of the spatial data should classify and tag their data elements. Data used and produced by major spatial services organisations should be identified and documented. Typical producers of geospatial data usually include:

- Government: at national, provincial, local levels
- Private Sector – data, technology, knowledge transfer
- Donors, foreign government and business
- Suppliers of (high resolution) remotely sensed imagery
- Non-governmental organisations (NGOs) and community based organisations (CBOs)
- Parastatals, utilities

Identification of major producers and tagging their data contributions would help identify redundancies and omissions. It will also help ensure that the community is served from the most suitable source.

African national and continental spatial data organisations should review their spatial data management strategies to ensure that their data collections and services will fit into the appropriate level of the SDI. Ezigbalike et al (2000) recommend that:

> While we do not necessarily have to change our terminology to use SDI terms, we should ensure that all spatial data collection projects (including surveying and mapping) are henceforth planned for an SDI environment. However, since we do not yet have the SDI in place, we should then translate the plans into ‘transitional’ arrangements.

Conclusion

This paper started out to discuss the “future orientation of GIS in Africa”. It was established early in the paper that the future orientation of GIS does not lie in the technology itself, but in its use to process data to support spatial decisions and services.

Experience in some African countries suggests that emphasis on the technology might result in the acquisition of hardware, software and peripherals with no clear plans on how to use them. Others might go a step further and use the technology to digitise maps and simply automate map productions, creating large digital databases, which would be locked away for departmental use, with all the flaws of the present manual systems.

Following experience in other jurisdictions, emphasis should be placed on data management and dissemination. The vision is to ensure that spatial data permeates every aspect of society and that they are available to people who need them, when they need them, and in a form that they can use to make decisions with minimal pre-processing. Also the collected data sets should be put to the maximum possible uses by publicising their existence and making them easily available to the widest possible audience. The most efficient and effective way to achieve these two related objectives is to establish spatial data infrastructures, using GIS technology to maintain and exploit the SDI. The future orientation of GIS in Africa is therefore as a ubiquitous tool that is integrated into the SDI concept, rather than as an end in itself.

Recommendations for Immediate Action

Activity	Justification	Implication
Introduce the concept of information budgeting	Information is the currency of the new e-economy and has to be budgeted like other resources.	A project proposal will be deemed as incomplete if it is not accompanied by a breakdown of data needs, including expected processing and any information products.
Introduce concept of "Information Implications Briefs" to the National Mapping Agency and other major geoinformation agencies.	It has been established that there is a lack of awareness regarding the value and utility of geoinformation products among decision-makers. Many agencies may continue to plan projects without adequate provision for geospatial data. The NMA (and other agencies more conversant with geoinformation development) can assist in creating this awareness by identifying national and regional projects that have spatial data implications and preparing briefs for the government as soon as a project is proposed.	More work for the NMA and any other identified agency.
Identify lead agency or person to coordinate further development, including the establishment of a formal coordinating mechanism	There must be a dedicated responsibility to ensure that information required for the preliminary review (below) is compiled.	This initial coordinator should be excused from other duties for the duration of the initial study to concentrate on the study.
Conduct a series of workshops to explain and publicise the SDI concepts	Most of the staff associated with the production and processing of spatial data are aware of GIS and automation, but may not understand their position in an SDI environment. Some may be afraid of losing their influence, while others may have undue expectations of the concept.	The workshops have to be participatory, role-playing workshops, rather than listening lectures. Small groups and sector-specific sessions will be more effective. This will involve more money and time to organise and conduct. Examples pertinent to the sector or community have to be used.
Start national review of spatial data needs and available data sets.	Such review will help identify gaps and duplication of efforts. It will also help in assigning custodianship roles. The result will be used by future in-depth studies. The review will also recommend members of the steering committee.	Every spatial data producing and spatial service-providing organisation should appoint a contact person immediately. Adapt the forms below for the exercise. All agencies and organisations producing spatial data sets, or providing spatial services must complete the forms. Review must include on-going spatial data procurement (and mapping) projects.
Develop web-based self-learning material on spatial data utilisation and SDI advantages	There is need for continued learning to keep abreast of the developments in the field. IT-related concepts, including and especially spatial information, are in a state of flux and practitioners in the field should have access to new material.	Educational institutions should be encouraged to introduce more self-learning early to inculcate that habit. Providers of geospatial education should adapt their existing courses and make them available on the web. Collaboration should be encouraged among African institutions and with

Activity	Justification	Implication
		external institutions
Where no coordinating structure already exists, establish a working group, drawn from the major stakeholders in the spatial data industry, to coordinate development of SDI. Representatives on the group must be senior enough to make binding decisions on behalf of their organisations.	There is need for a body to steer the reform of the spatial data industry. The body must have a reasonable degree of independence.	It may be necessary to engage a consultant to carry out a more detailed analysis of the spatial data industry. The government should be open to the possibility of major departmental restructuring.

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Appendix 1: Example of Data Collection Form for Information Requirements

Information requirements by geospatial issues and decisions involved. To be completed by person(s) who have a good overview of geospatial data activities in the country

Issue	Decisions/Actions Involved	Information requirements	Format/medium
Health Facilities	Establishment and equitable distribution of health facilities	• Demographic data • Capacities of existing facilities • Spatial locations of facilities and population centres • …	•
Educational institutions	• Establishment and equitable distribution of institutions	•	•
Malaria, leichmaniasis, onchocerciasis, Schistosomiasis (identify other health issues and enter rows for them)	WHO strategy: early diagnosis, prompt treatment and environmental management; hygiene education	• statistics on cases, spatially distributed • distribution of vectors • spatial distribution of water pockets for remedial action • water courses: spatial locations, flow and chemical characteristics	•
Land classification and land use planning	Classify land according to characteristics and optimum land use	• climatic data • soil data • topographic data • vegetation cover	•
Land allocation	Allocate land to citizens for various uses	• land classification info to ensure compatibility of use with allocated land • population statistics	•

Issue	Decisions/Actions Involved	Information requirements	Format/medium
Land resource use and management	Ensure that land is used for designated use	• cadastre showing allocated users and uses, continuously updated • Administrative land records • Legal land registers	•
Infrastructure and urban management	Efficient and equitable provision of urban services	• population statistics • statistics and location of existing services: waste disposal, water and power installations • urban road networks	•
Transportation	Provide energy-efficient and safe transport system	• statistics of trips between population and employment centres • topographic data • geophysical data	•
Tourism	Develop and promote eco-tourism	• existing tourist facilities and capacities • statistics on tourist preferences	•
Sewage discharge	Prevent discharge of untreated sewage into the sea	• statistics on coastal population centres • location and capacities of existing sewage treatment facilities in coastal towns	•
Oil pollution	Prepare for oil spill emergencies	• …	•
Industrial wastes	Monitor dumping of industrial wastes and compliance with environmental regulations	• Location of industries and data about their products and input raw materials	•
Toxic metals	prevent contamination of the environment	• …	•
Surface water	Management of water resources as finite resource	• Water bodies and courses with flow and condition data	•
Ground water	Management of ground water to supplement water needs	• geophysical data on rock formations • climatic data on precipitation and evaporation	•

Issue	**Decisions/Actions Involved**	**Information requirements**	**Format/medium**
Water conservation	Ensure sustained use of water for domestic, industrial and agric uses	• Water bodies, water courses, farming systems, • consumption statistics	•
Land Degradation	• Enforce land use practices to reduce land degradation • Ensure security of tenure • Combat desertification	• Land use data • land cover • management practices • population data • climatic data • land allocation • soils • land tenure data (legal land registers)	•
Range land and livestock	Livestock Production	• livestock statistics • agro-ecological zones	•
Forest Resources	• Alternatives to biomass energy • Afforestation and conservation • land husbandry	• Land use classification • vegetation cover • census of endangered species • population data • location of fuel-energy intensive industries • location population densities	•
Biological diversity	• Conservation of unique and endangered ecosystems • National parks, nature reserves and protected areas • Implementation of CITES	• distribution and concentration of unique flora and fauna	•

Issue	Decisions/Actions Involved	Information requirements	Format/medium
Energy Resources	• Reduce dependence on biomass energy • Develop renewable energy sources	• population and socio-economic data • climatic data for solar and wind power developments • forest resources • geophysical data	•
Mineral Deposits	Efficient and environmentally-friendly exploitation of minerals	• distribution of mineral deposits • administrative data on exploration and prospecting activities	•

Appendix 2: Example of Data Collection Form for Information Availability

Information availability by data types. To be completed by every department and agency deemed to be involved in geospatial activities, no matter how slight

Appendix 2: Information availability by types (to be completed by every department and agency deemed to be involved in geospatial activities, no matter how slight)			
Data sets	**Where available**	**Use in decision making**	**Main users**
Geodetic controls			
Cadastre			
Elevations			
Administrative			
Transportation			
Utility networks			
Soils			
…			

Appendix 3: Model Policy and Institutional Framework for SDI

Vision

The geoinformation management vision is to encourage and continually increase the use for geospatial data in the decision making processes for sustainable development, economic growth, resource exploitation, environmental protection, exploitation and management, and social progress and to make appropriate geospatial data and information available and easily accessible to the entire community of users.

Principles

1. Spatial data and information are essential to economic planning and development, and are much a part of the nation's infrastructure as its other elements (e.g., the transportation network, the health care system, telecommunication) and should be accorded the same level of support.

2. All data collected with public funds form part of the nation's corporate data resources and the individual agencies involved in their collection and management are viewed as custodians, and not owners, of such data.

3. The cost of collecting geospatial data using public funds should not be charged to any consumer who should only be charge the costs of distribution, customizing or value-addition.

4. The private sector is encouraged to be a partner of the public sector in the management of geoinformation, and its rights will be recognized and respected.

5. National agencies, producers and users of geospatial data and information should support the geoinformation management vision enunciated here and shall cooperate in the implementation of its objectives.

6. The state should endorse, own and commit itself to the vision stipulated above.

Policy Guidelines

1. There shall be established a national geoinformation framework to enable the following:

   a. The setting up of a national geoinformation committee whose functions are specified in Annex I and with broad representation from the wider society.

   b. Communication between institutional producers and users of data and information to develop partnerships.

   c. Easy access to geoinformation resources by the entire community of spatial data users, employing appropriate information and communication technologies.

   d. Development and maintenance of fundamental data sets.

   e. Establishment and maintenance of a comprehensive geospatial metadata system according to the guidelines stipulated in Annex II.

   f. Development of a critical mass of skilled personnel to maintain the framework and data sets.

   g. Development of appropriate levels of knowledge and skills in the community to effectively use geoinformation products.

   h. Development of appropriate pricing mechanisms for geoinformation products.

2. Every publicly funded development plan shall include a section detailing the geoinformation requirements for its implementation.

3. Every public project proposal dealing with infrastructure development and maintenance, environmental and natural resource management, and spatial facilities shall include an information budget detailing:

a. The data sets required and their likely sources

b. Expected processing and analyses

c. Anticipated Information products

Annex I

The functions of the National Geoinformation Committee are:

1. Advise government on necessary reorganization of government functions to achieve the geoinformation management vision.

2. Oversee the development and management of geoinformation products.

3. Promote the expansion of all sectors of the geoinformation industry, including the identification of new applications.

4. Liase with all professional bodies concerned with the geoinformation industry to harmonize their activities.

5. Promote awareness about geoinformation products and services at all levels of society.

6. Arrange for the production and maintenance of fundamental data sets.

7. Coordinate the production, maintenance and sharing of various geospatial data sets.

8. Develop guidelines on the appropriate methodology for setting up geoinformation infrastructures.

9. Ensure the nation's active participation in regional and international geoinformation activities.

10. Advise the government on changing trends in the geoinformation industry.

Annex II

Adapt relevant extracts from appropriate national, regional and international standards.