54998

Findings
Africa Region

No. 128 February 1999

Environmental Information Systems in Sub-Saharan Africa:
From innovation to management

The development of Environmental Information Systems (EIS) in Sub-Saharan Africa (SSA) in the 1970s and 1980s was slow, in spite of several efforts to introduce the technology. However since 1990, growth has been phenomenal. Whereas, only one or two institutions in each country were previously active in EIS, over 500 EIS related projects are now under way, involving thousands of African experts, plus numerous development partners from NGOs, the private sector, bilateral agencies and international organizations. Not surprisingly, the number of actors involved in EIS construction is expected to increase even further, until all institutions and organizations involved in environmental management have adopted EIS-related technologies. What has happened? To answer this question we must understand the forces that stimulated EIS development in the past and extract lessons to improve EIS efficiency in the future.

The EIS concept as we know it today emerges from several initiatives to promote the more efficient use of data in environmental management. First, the advent of satellite remote sensing in 1972 gave a new perspective to viewing the earth's resources and led to large data and training subsidies to stimulate the use of first Landsat and then SPOT products. Next came the early environmental applications of remote sensing in Africa, championed by UNEP, which used satellite imagery to monitor rangeland dynamics and desertification. Other development agencies, USAID and FAO in particular, supported the application of satellite data for famine and drought early warning. These early efforts fell short from reaching the decision making process, due to weak linkages with national institutions, and more generally, an imbalance between the information produced and the national capacity to use it.

Within the last decade, the tying of EIS efforts to specific products (State of Environment reports), or national plans (National Environmental Action Plans) has moved EIS from a supply-driven to a *demand-driven* orientation. The underlying principle is that EIS should serve a clearly specified management need, and that data should not be collected unless an end

Public Disclosure Authorized

use is defined.

The term "Environmental Information System" only came into wide use in the 1990s, concurrent with the advent of natural resource and environment action plans. The concept reflects our growing understanding of the link between environment and development. Thus, *environmental information* is the data, statistics, and other documents, that enable managers to identify and quantify specific environmental resource categories, and to determine their optimum utilization. Seen in this larger context, an EIS is the institutional and technical response needed to improve the role and benefits of information in environmental management.

Data for EIS come from a wide variety of sources and in different formats. Logically, efficient mechanisms for data access are as important as the availability of the data themselves. Therefore, EIS includes strategies, procedures and institutional frameworks, together with data management tools, that ensure access to environmentally relevant data and allow their analysis. Such systems must be designed to support the needs of a wide range of users and assist them in their decisions.

EIS encompasses several information technology tools, more particularly geographic information systems (GIS). In a sense the integrating nature of GIS provides much of the impetus for EIS development in Sub-Sahara Africa. In the context of EIS, GIS serves to combine geo-referenced information on natural resources with other essential data such as demographics, to support planning, management, and decision-making

Lessons learned

Information Community

An important result from these early initiatives is the creation of pockets of expertise in almost every country, capable of using data processing technologies such as Geographic Information Systems (GIS), DataBase Management Systems (DBMS) and Remote Sensing. Their activities have raised the level of awareness among both data producers and users about the role that EIS can play in decision making. These groups of EIS participants form the beginnings of different *information communities,* which share data and data standards. We also find that these emerging information communities share certain fundamental principles, such as the demand-driven approach. Building such communities is the cornerstone for successful EIS development.

A second finding is that, given the variety of environmental information, no single agency can meet the needs of all potential users, or even expect to become the unique central repository of all environmental data in a country. Thus, current approaches to EIS development embrace the *distributed model* in which data sets are constructed and hosted by institutions with the appropriate statutory mandates. Participating institutions must be committed to the belief that opening access to and sharing their data will enhance their own capacity in the long run.

Institutionally, there is often inadequate recognition and support of *data custodians,* the managers of key environmental data sets. When potential data users are confronted with data inaccessibility, usually due to the custodians' pricing policies or their lack of willingness to share data, they may undertake fundamental tasks such as the digitizing and updating of core data sets, leading to duplication of effort**.** A common example is the repeated digitizing of base maps for the preparation of thematic maps.

Data Infrastructure

To avoid the repetition of data development tasks, data producers must construct *data infrastructure* consisting of core data that can be used and reused. Just as a strong national road network supports development in many sectors, a solid data infrastructure will serve many users and open new doors to environmental applications in the future. The building of a data infrastructure for Africa, particularly of the type and geographic scale required at the local level will require very large investments. Thus, the average topographic coverage of Africa at this scale is less than 3% of surface area, whereas the world average is over 30%.

Metadata

We often find that ignorance of what data exist and their inaccessibility hinders the creation of awareness. On a positive note, a few SSA countries have started establishing catalogs describing existing information resources. These catalogs contain data describing existing data, or *metadata*, which include attributes such as theme, quality, or origin. Analysis of metadata allows potential users to determine whether a data set may be useful in a given application.

Data Interoperability

Environmental management often needs to integrate data from different sources. Easy integration requires that data conform to the same standards. Such data are termed interoperable, since they allow "off-the shelve", "plug and play" usage. A major lesson learned in SSA is that lack of data interoperability often constitute an insurmountable roadblock to the use of environmental information in decision making. The problem lies with the existence of multiple data projections and coordinate systems, different naming conventions, different database structures and the lack of accuracy standards - a particularly insidious issue. Eliminating these problems requires a sustained and coordinated effort by all members of the EIS community to establish a common data architecture, including widely accepted standards.

Applications

The operational objective of EIS is to increase the quality, efficiency and accountability of decision-making processes through *applications* that systematically use environmental information. EIS should always explicitly target their support at specific environmental management processes, following a thorough review and analysis of the extent and manner in which information plays in making decisions. Thus, stand-alone EIS projects should be avoided.

Building Capacity

EIS are knowledge-intensive and their rate of development if closely linked to the level of expertise available. The build-up of in-country capacity to manipulate environmental information has been spectacular. Nevertheless, skill levels remain a constraint on EIS development, in large part because EIS programs seldom invest enough in developing the technical skills of national staff required for full mastery of the new technologies and methodologies that they introduce. On the contrary, for budgetary and institutional reasons many EIS programs are reluctant to invest in long-term capacity building, focusing instead on short-term results

Are EIS efforts having an impact?

The above concepts provide a framework for analyzing EIS implementation. Have information communities been created with clearly identified data custodians? Are core data available and accessible? Do metadata catalogs exist? Have data standards been established allowing data interoperability? Have applications been developed that have an impact on environmental management? Are existing systems sustainable?

A review of EIS efforts shows that these objectives have only been met in very few cases. Is this surprising? What are the reasons? Were expectations realistic?

Nolan's Model

The inherent feature of EIS development is its uncontrolled "dynamism", with a multitude of EIS actors operating as an unruly collection of factions, each with its own valid objectives but pulling in different directions,. The result is a blatant lack of coordination which could be viewed as a serious problem. It would be if it were to continue much longer. However in retrospect, we find that EIS development occurred largely as a spontaneous transfer of technology instigated by a combination of expectations on the part of African experts and the availability of donor funding. This transfer initiated a period of *innovation* led by a few enthusiastic individuals in key institutions. This in turn gradually triggered a period of *contagion*, during which the technology spread across institutions. Seen this way, EIS development in SSA has matched the first two stages of Nolan's Theory for IT adoption and organizational learning, and is typical of how technological innovations spread.

Keeping track of all EIS activities during such a "pioneer" era was impossible, let alone trying to coordinate them or build a common data infrastructure. Thus, it is not surprising that EIS efforts have not to date had a significant impact on environmental management. However, SSA is now at the doorstep of the next stages in EIS development, as predicted by Nolan's model. The first is *control*, where the priority will be to rationalize investments by setting priorities and establishing a global vision. The process has already started across SSA with the creation of committees and coordination structures. The second is *integration*, when EIS will have been integrated in environmental management.

Organizational learning takes place during each of Nolan's stages. By controlled transition through the stages, the most efficient path can be achieved. Earlier training efforts focused on technological issues, corresponding to the needs of the *innovation* and *contagion* stages. Training must now shift to the skills required for the *control* and *integration* phases; such as the capacity to design networked databases, create and maintain metadata catalogs and disseminate them through the Internet, develop applications and decision-support systems, and organizational and managerial skills.

The "Structured Approach"

The move from supply to demand-driven systems in the late 1980s was a turning point in EIS development. The premise of the demand-driven approach is that the anticipated utilization of information in environmental decision making should determine what data are collected and how they are processed, analyzed and disseminated. The demand-driven approach brought greater focus on applications and was a major departure from earlier implementations efforts which tended to be project-oriented ("stop updating the system, the project is over!") or data-oriented ("put these data in the computer, we will figure out later what to do with them!").

In spite of this new orientation, data availability did not translated into greater use, and greater use of data did not necessarily improve environmental sustainability. Looking back on early EIS implementation efforts, we see that they seldom contributed to building the data infrastructure and data architecture necessary for opening the door to user-friendly applications. This can in part be explained by the fact that applications, data and standards have different organizational scopes:

- *Applications* must be customized to support specific decision making processes. As a result their organizational focus is by nature very narrow.
- Many of the databases making up the *data infrastructure* are of interest to a large number of users. For example, a list of villages is of interest both for the study of health services and that of markets for agricultural produce.
- The standards and conventions involved in a the *data architecture* must cover the range of themes that users want to integrate. The names of villages in different data layers must match if health workers are to link poor health to low agricultural production. Similarly, village locations must be harmonized with river locations to explain the occurrence of water-borne

diseases. Thus, the greatest possible number of users must share the same data architecture in order to effectively reduce transaction costs.

Excessive focus on applications can lead to systems organized as parallel "stovepipes", with distinct data infrastructure and data architecture. In this instance, different institutions tend to 1) build duplicate data sets, or 2) use different standards, thus greatly hindering data integration across themes which is indispensable for environmental management.

The solution is to balance the specificity and urgency of information products demanded by decision-makers, already addressed by the demand-driven approach, with the need for long-term strategic investments in data architecture and infrastructure. Such a "structured approach" recognizes that the data architecture and data infrastructure involve issues that go beyond the concerns of individual users and must be looked at in their own right. Debate about EIS institutional frameworks often fail to do this, and this is what generally leads to lop-sided systems.

A key aspect to implementing the "structured approach" is adequate investment in the design of a data architecture that satisfies the integration needs of the primary users targeted by the system, as well as other potential users. Such investment must be done before the construction of the data infrastructure or the development of applications. In contrast, EIS designed according to an informal (non-structured) approach tend to skip the initial investment in the data architecture. As a result they become unnecessarily expensive because data are either wastefully duplicated by different institutions or require extensive corrections before they can be combined.

Another important aspect of implementing the "structured approach" to EIS development is the emphasis put on lifting the numerous institutional and technical barriers to data sharing.

The Way Forward

Development of EIS in SSA is like a plant that had to set its roots before its flowers could bloom. True, a cost-benefit analysis would inevitably conclude that its impact on sustainable development has been minimal. Also true, project targets for the delivery of databases and applications have rarely been met. However, a closer look shows that there has been a tremendous build-up of capacity, in spite of difficult social and political conditions. Furthermore, the analysis of the current status of EIS using Nolan’s Model reveals that our expectations in terms of product targets would have been unrealistic in the best of circumstances.

Nolan’s Model also shows that there is still a long road ahead. More has been done than generally credited, but much more needs to be done before the use of EIS has fulfilled its promise. In addition, future steps must be undertaken with more intellectual and managerial rigor so that available resources can be used in the most efficient manner. The use of the "structured approach" implies a more strategic vision for future efforts, including the systematic use of prototypes as a learning tool, the development of environmental information policy that address managerial and organizational issues, and most importantly much more emphasis on the development of capacity.

Ultimately, the success of national policy should be measured by the extent to which good quality information is brought into decision-making processes. EIS should promote a better understanding among the wider public of available resources (fiscal, natural, human, and administrative) and their exploitation, and should inform decision-makers about the stakes and options in environmental management. The production and dissemination of information must lead to the creation of a literate citizenry empowered to improve their well-being.

Yves Prévost
Environment Specialist
The Environment Group (AFTE1)
The World Bank
1818 H Street NW
Washington, D.C., 20433
yprevost@worldbank.org

Peter Gilruth
Technical Advisor

UNDP/UNSO
304 east 45 Street, New York
New York, 10017
peter.gilruth@undp.org

References

Prévost, Y.A. and P. Gilruth. 1997. Environmental Information Systems in Sub-Saharan Africa. Paper No. 12. Building Blocks for AFRICA 2025.

Nolan, R.L., D.C. Croson and K.N. Seger. 1993. The Stages Theory: A Framework for IT Adoption and Organizational Learning. Harvard Business Scholl Note 9-193-141.

Findings reports on ongoing operational, economic and sector work carried out by the World Bank and its member governments in the Africa Region. It is published periodically by the Knowledge Management and Learning Center on behalf of the Region