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SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

Decision Support Systems for Water Resources Management in Uganda: The Need

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Water is a major factor in the socio-economic fabric of Ugandan society and a major determinant of the development potential of the country. However, management of water resources is a complex problem that typically involves a variety of stakeholder interests and environmental uncertainties. The plurality of concerns establishes a pressing need for improved planning and management capabilities, and in this respect it has been noted that decision-making related to water resource management would benefit from engineering expertise combined with suitable use of informatics. In spite of rapidly advancing computer technology and the proliferation of software for decision support, relatively few Decision Support Systems have been developed, implemented, and evaluated in the field of water resources management in Uganda. Such tools need to be structured to fit in with existing policy frameworks in Uganda's water sector, and should be tailored to the local conditions prevailing in the country.

Introduction

The Constitution of Uganda (1995) under objective XIV provides for the state to fulfill the fundamental rights of all Ugandans to social justice and economic development. The objective ensures that all Ugandans enjoy rights and opportunities and access education, health services, clean and safe water. Furthermore, in objective XXI, the state undertakes "to take all practical measures to promote a good water management system at all levels", and in objective XXVII "to promote sustainable development and public awareness of the need to manage land, air and water resources in a balanced and sustainable manner for the present and future generations".

Monitoring, assessment, allocation and protection of the water resources of Uganda are inherently responsibilities of the State, through its established institutions (specifically the Directorate of Water Development). This responsibility is enshrined in both the 1995 Constitution and the Local Government Act of 1997.

Water is a major factor in the socio-economic fabric of Ugandan society and a major determinant of the development potential of the country. The various uses to which water is put have important implications for the state of Uganda's environment, as does the way water resources are managed. The increasing demand for water in Uganda requires that water use efficiency be improved. As competition grows for scarce resources from different sectors in which unit values of water can differ markedly, there is increasing need for improved management of the resource.

Formulated in 1997, the National Water Policy (NWP) promotes an integrated approach to managing the country's water resources in ways that are sustainable and most beneficial to the people of Uganda (NWP, 1997). This approach is based on the continuing recognition of the social value of water, while at the same time giving much more attention to its economic value. Allocation of both water and investments in water-use schemes aims at achieving the maximum net benefit to Uganda from its water resources both now and in the future.

The current mode of thinking on improving water resources management endorses an integrated, multi-sectoral approach in the prevailing socioeconomic context, including:

- Treating water as a social and economic good;
- Relying on markets and pricing to determine water allocation among various sectors and user groups;
- Involving the beneficiaries and the private sector in managing water at the lowest appropriate level;
- Recognizing that water is a finite resource that contributes to economic development and supports natural ecosystems.

Management of water resources is a complex problem that typically involves a variety of stakeholder interests and fundamental environmental uncertainties. Furthermore, interdependencies exist between regimes (ground water, surface water, land), processes (hydrology, meteorology, hydrogeology), uses (water supply, irrigation, hydropower, recreation), and social, economic, political and environmental concerns (stakeholder priorities, environmental impacts, costs, gender issues, treaties and regulations). The above interrelationships call for the application of an integrated approach to water resources planning and management characterized by informed, fair and equitable decision making.

Integrated water resources management

Integrated Water Resources Management (IWRM) may be defined as "a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Rogers and Hall, 2003). Implementation of IWRM involves the establishment of three "pillars", as illustrated in Figure 1 below:

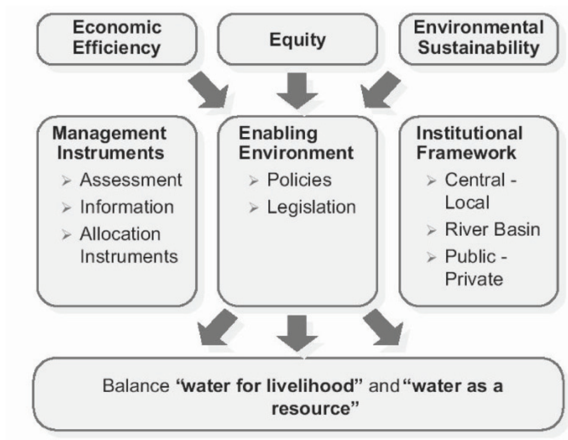

Figure 1. The 'three pillars' of Integrated Water Resources Management: Enabling Environment, Institutional Framework and Management Instruments

Source: Global Water Partnership

IWRM calls for analysis of varying technical, socioeconomic, environmental and political value judgments, and involves complex trade-offs between divergent criteria. The plurality of concerns establishes a pressing need for improved and more comprehensive water resource planning and management, which considers all three dimensions - hydrological, ecological, and socioeconomic – in arriving at management decisions. It has been noted that decision-making related to water resource management would benefit from water resources engineering expertise combined with suitable use of informatics.

Mysiac (2003) reports that in the year 2000, after four years of extensive discussions, the European Union (EU) Council and Parliament adopted Directive 2000/60/EC, also known as the Water Framework Directive (WFD), a common European legislative framework for the protection of water resources. In order to support the implementation of the WFD, a key action line has been dedicated under the 5th Programme Framework to issues related to the sustainable use of water resources. One of the priorities under this action line is the development of decision support systems for water resources management, providing a means of exploring and solving water related issues in an integrated and participatory manner.

Decision support systems

At its broadest definition, a Decision Support System (DSS) is any methodology that is helpful to a decision maker to resolve issues of trade-offs, through the synthesis of information. Within the context of Water Resources management, a DSS would typically contain or rely on information from databases, GIS coverages, computer simulation models, economic analysis models as well as decision models. The actual analytical processes may use linear programming techniques, decision theory or rule-based expert systems.

Several authors, cited by Watkins and McKinney (1995), describe an extension of the DSS concept to what they refer to as Spatial Decision Support Systems (SDSS). This involves the integration of DSS and Geographic Information Systems (GIS). The latter may be defined as a general purpose technology for handling spatial geographic data in digital format, with the ability to pre-process data into a form suitable for analysis, to support direct modelling and analysis, and to post-process results into a form suitable for graphical display. Water resources management issues are usually characterized by spatial features, so it seems logical that GIS become a part of a DSS for water resources management.

A more recent view of what a DSS is regards it as a context or platform for helping all those involved in decision making processes to access the necessary information/data for a useful debate to take place. Bruen (2002) defines a Stakeholder Decision Support System as a DSS which can be used jointly by decision makers, technical experts and other non-technical stakeholders to explore the consequences of combinations of preference schemes and alternative scenarios, in the hope of achieving mutually acceptable compromises. This is also referred to as Participatory DSS.

Few DSSs for water resources management have been found to be in use in Uganda. Examples of those encountered include the Lake Victoria Decision Support System (LVDSS) and the Nile Decision Support Tool (Nile DST), described below. Also currently under development is a Water Resources Engineering and Management Decision Support System (WREM-DSS), which is designed to incorporate and enhance the two desirable attributes (Spatial and Participatory) within the same DSS.

Lake Victoria Decision Support System (LVDSS)

This is a water resources management decision support system being developed for the Lake Victoria Basin. It is a collaborative effort of the Food and Agriculture Organization (FAO) of the United Nations (UN) and its Lake Victoria Water Resources Project on the one hand, and the Environmental Hydraulics and Water Resources Group at the Georgia Institute of Technology in Atlanta, Georgia.

Nile Decision Support Tool (Nile DST)

The Nile DST, developed by the Georgia Water Resources Institute, is prototype software that models the entire Nile Basin system and assesses the tradeoffs and consequences of various cross-sector and basin-wide development scenarios. The system incorporates modules for river simulation and reservoir operation, agricultural planning, and watershed hydrology. It allows the impacts of various levels of regional coordination to be examined, and serves as a cornerstone for information integration. The Nile DST was released by Nile-COM in February 2003.

Water resources engineering and management decision support system (WREM-DSS)

The WREM-DSS is a prototype DSS under development as part of an ongoing study by the Water Resources group of the Dept. of Civil Engineering, Makerere University, within the framework of the Sida/SAREC-funded project 'Sustainable Technological Development in the Lake Victoria Region'. The prototype DSS that is being developed is designed to take full advantage of the traditional spatial capabilities of GIS, together with a focus on enhanced stakeholder involvement in the decision making process facilitated by the embedding of Multi-Criteria Decision Analysis (MCDA) techniques within the decision engine.

The need for DSS development in Uganda

One of the priority actions that have been identified in order to achieve the policy goal of sustainable water resources management is the establishment of planning and prioritization capabilities for decision makers (WAP, 1995). These capabilities are intended to enable decision makers to make choices between alternative actions based on agreed policies, available resources, environmental impacts, and the social and economic consequences. It has been recognized (DWD, 2002(1)) that the capacity at district and lower levels to plan and implement sector activities is low, and additional central support is still needed. Likewise, the capacity at the center (in terms of skills, technology, etc) is also limited. Efforts geared towards building up the requisite capabilities are timely and desirable.

Based on the status of her various Macroeconomic and Human Development indices, Uganda is classified as a 'developing country'. A very topical catchphrase in Uganda today is "modernization", which is viewed as key to addressing the poverty and underdevelopment status prevalent in the country (NEMA, 1996). Within this context, development of appropriate technologies has a crucial role to play. While in the past there has been some skepticism regarding the suitability of modern Information Technology (IT) within an "appropriate technology" framework, there is now a growing school of thought that sees advanced IT as actually underpinning the development effort in underdeveloped countries such as Uganda (Moriarty and Lovell, 2000). This is mainly so in light of the continuing fall in prices and rise in availability of computing power.

There is therefore a need to develop practical tools and methodologies to underpin and support sustainable development and management of the country's water resources, in the form of comprehensive decision support systems that integrate data and stakeholder development priorities. In spite of rapidly advancing computer technology and the proliferation of software for decision support, relatively few DSSs have been developed, implemented, and evaluated in the field of water resources management in Uganda.

Such decision support tools need to be structured to fit in with existing policy frameworks and responsibility allocation in Uganda's water sector. They should be tailored to the local conditions prevailing in the country, and accommodate specific needs as identified by stakeholders in a participatory, bottom-up development framework. By building a DSS, many needs of policy-makers and resource managers in the water sector can be met, such as the provision of mapping capability for land and water resources, a common digital database for information, a suite of spatial analysis tools, development of predictive models, and provision of a basis for evaluation of management alternatives.

Some considerations in developing a DSS for WRM in Uganda

According to Pereira and Quintana (2002), one of the key desirable features of a DSS is adaptability - an adaptive system that corresponds to diverse decision makers' needs, supporting a variety of decision making processes yet independent of any one in particular. Thus, construction of a DSS calls for a concept-driven approach – that is, an approach that begins with the establishment of a conceptual framework and then finds suitable tools and technologies that would support and implement that framework.

Furthermore, mere generation of knowledge about interactions among physical and socioeconomic processes in a watershed is insufficient. The knowledge must be delivered to potential users in a way that maximizes its usefulness in watershed planning and management. In this respect, it would be necessary that a computer-based water resources management DSS feature a user interface that allows easy interaction, is simple enough to be used directly and mastered by local decision makers without the constant support of computer analysts, and presents outputs in formats that are easy to interpret.

Modularity within the context of DSS development means that, starting with the identification of various needs as perceived by the different stakeholders, individual analytical and modeling tools can be developed or adopted and adapted to constitute sub-components of the DSS. A framework would then be established within which each of these sub-component modules can be integrally accessed and utilized in a holistic manner, taking into account the multiple objectives and constraints at play within the watershed as a whole. The use of an open architecture for the DSS would ensure ease of upgrade of component modules, as well as addition of new modules in response to identified needs.

Equally important in the context of Uganda is for the process of development and deployment of the DSS and associated methodologies to be cost-effective, demanding minimum hardware, software and licensing fees. This necessitates the identification, adoption and adaptation of suitable existing tools, models and routines, with particular emphasis on the usage of non-proprietary, inexpensive or widely available industry-standard software tools.

Conclusions

Many decision support systems have been developed to address the problems of water resources management, in different parts of the world, and focusing on different aspects of WRM. The need for a computerized DSS clearly emerges as a result of the increasing complexity of the decision situations caused by the numerous conflicting, often spatially related objectives, and the dissimilarity of stakeholders involved. However there are still open methodological questions about the development and structure of operational DSSs in the field of WRM, and so there is room for applied research in developing tools that match local needs.

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