GIS Technology: Planning for Sustainable Development

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Introduction

- Sustainable development has become a global concept since 1987 when it was broached by the World Commission on Environment and Development. The concept arose from the need to have a balance consideration of social, economic and environmental factors in our developmental efforts. The principles of sustainable development require that interregional and intergenerational dimensions be incorporated into development goals and practices (Box 1).

- 1 Environment: The physical 'carrying capacity' of the environment imposes limits to many human activities and means we must reduce our consumption of resources.
- **2 Futurity:** We have a moral duty to avoid `compromising the ability of future generations to meet their own needs';
- **3 Quality of life:** Human well-being has social, cultural, moral and spiritual dimensions as well as material;
- **4 Equity:** Wealth, opportunities and responsibilities should be shared fairly between countries, and between different social groups within each country, with special emphasis on the needs and rights of the poor and disadvantaged;
- **5 Precautionary principle:** if we are uncertain about the environmental effects of any actions/developments we should apply this principle and err on the side of caution.
- **6 Holistic thinking:** solving a complex sustainability problem requires that all the factors that contribute to that problem be incorporated in the solution
- Box 1. Principles of Sustainable Development Source: Adapted from (CMRE, 1998)

- The issues related to economic, social and environmental principles of sustainable development are very complex and require an integrated approach.

The information required for decision-making cut across different sectors, agencies, spatial boundaries and time frames. Datasets are required to be available at a number of levels, i.e. local, national, regional and global (FIG, 2001).

Therefore, there is need for a platform that will capture, integrate, manipulate and analyze these datasets and present them as information for supporting sustainable development. Better systems of knowledge creation and application need to be included in the strategies of sustainable development (Clark, 2001).

- GIS (Geographic Information Systems) is a computer-based tool that can be used by decision-makers to address complex and multi-dimensional issues that are related to sustainable development. GIS has the capability of storing, displaying, manipulating and analyzing geographically referenced data. It is useful to integrate different components of sustainability assessment for decision-making, planning and management (STOA, 2001).

Aims and Objectives

- This main aim of the study is to review the recent developments in the field of GIS and other related technologies and highlight the potential of these tools for planning for sustainable development. The study will also develop a framework for applying GIS to achieve sustainable development.

Approach

- The approach of this study is to review available literature in the field of GIS and sustainable land use planning. The study will present the findings of the review and case studies on the use of GIS in sustainable development. Based on this review, the study will develop a framework for GIS application in sustainable development.

Sustainable Development and Spatial Planning

- Agenda 21 was adopted by United Nations Conference on Environment and Development to serve as a global guideline for implementing sustainability.

Agenda 21 recognizes the vital role of planning in achieving sustainability as it points out that national strategies, plans, policies and processes are crucial in achieving the goals of sustainable development.

Chapter 7 and 40 of Agenda 21 addresses the need for promoting sustainable land-use planning and management and developing better means of data collection, assessment, analysis and co-ordination.

Planners must be equipped with reliable forecasting tools. Planners need to find practical and available mechanisms that can improve the basis of planning judgments at both the technical and political level (Gwilliam, 1993).

GIS and related technologies

- A GIS can be defined as a computer-based system that capture, store, manipulate, analyze, and display georeferenced data.
- STOA (2001) suggests three main goals of GIS:
- i) acquiring, storing, managing and integrating geographically-referenced data;
- ii) providing tools for data analysis, with the help of mathematical models;
- iii) representing data and the results of the data analyses mainly through thematic maps, charts and tables.

- *Remote sensing technology*
- The science of remote sensing involves collecting data on earth features by detectors from remote platform. Recently, there have been notable improvements in the field of remote sensing. More satellites are orbiting the earth and more information at higher resolutions and shorter time intervals are being collected. High-resolution images such as the IKONOS images (82cm nadir viewing) provide opportunity to obtain more accurate information about earth features and thereby improving environmental monitoring and management. Apart from technical improvements, the cost of acquiring satellite data is also declining thereby leading to wider application of satellite images. Extracting information from images has been enhanced through the developments in image processing methodologies (Herzog, 2000).

Current trend in GIS technology

- Recent trends show that GIS is becoming increasingly connected with other types of information systems and tools, such as general Database Management Systems (DBMS), programming software, 3D Modeling, Virtual Reality and the Internet. Although the connection of GIS to other tools and systems tends to reduce the functionalities of GIS, it generally improves the capabilities and usefulness of GIS in solving decision-making problems. Programming software allows the customization of GIS for specific uses and development of better GIS capabilities.

- GIS functionality is also being embedded in analytical tools such as Space Syntax, Expert System and Spatial Decision Support System. Space Syntax is a technique of modeling and describing spatial configuration.
- An expert system (ES) is a computer program that tries to encapsulate the way an expert solves particular problems. Such a system is designed by crystallizing the expert's problem solving logic in a "knowledge-base" that a non-expert user can then apply to similar problems in a different situation (Rodriguez-Bachiller, 2000b).
- Spatial decision support systems (SDSS) are computer-based systems designed to help decision-makers solve complex spatial problems. SDSS provide a framework for integrating analytical modeling capabilities, DBMS, graphical display capabilities, tabular reporting capabilities and expert knowledge.

Applications of GIS in Environmental Protection and Planning

- Numerous environmental GIS applications have been reported in the literature. The studies include project, local, national, regional and global levels of applications.
- Chen (2002) employed Landsat TM data within a GIS context to show the impact of natural forces and human activities on land cover changes regional sustainable development in Ansan City, Korea.
- GIS has also been applied in impact assessment and promoting the principles of sustainable development. Rodriguez-Bachiller (2000a) highlights the potential of applying GIS in impact assessment by identifying GIS operations that are relevant to impact assessment (Box 2).

Box 2. GIS operations potentially relevant to impact assessment

(i) Storing considerable amounts of information related to a territory
(ii) Displaying rapidly and easily visually appealing maps of such information
(iii) Superimposing maps (map “overlay”) to identify and measure overlaps
(iv) Combining several maps, weighted or not, into composite maps (“map-algebra”) to calculate the value of a composite variable for different parts of the territory
(v) Measuring the size (number, area, length, perimeter) of map features
(vi) Using distances to construct “buffer” zones around certain features
(vii) Drawing contour maps derived from the point-values of variables
(viii) Building pseudo-3D (or “2.5”, as sometimes referred to) models of a terrain, and calculating topographic characteristics (slope, aspect) of its parts
(ix) Identifying “areas of visibility” of certain features on one map from the features of another, using the terrain models mentioned above.

Issues in GIS applications

- database development
- standardization
- access to data
- technology transfer
- legal framework
- institutional framework
- cost.

Framework for applying GIS technologies

- It has been shown that GIS application can only be optimized by integrating it with other systems such as Expert System and Spatial Decision Support System (Rodriguez-Bachiller, 2000b).

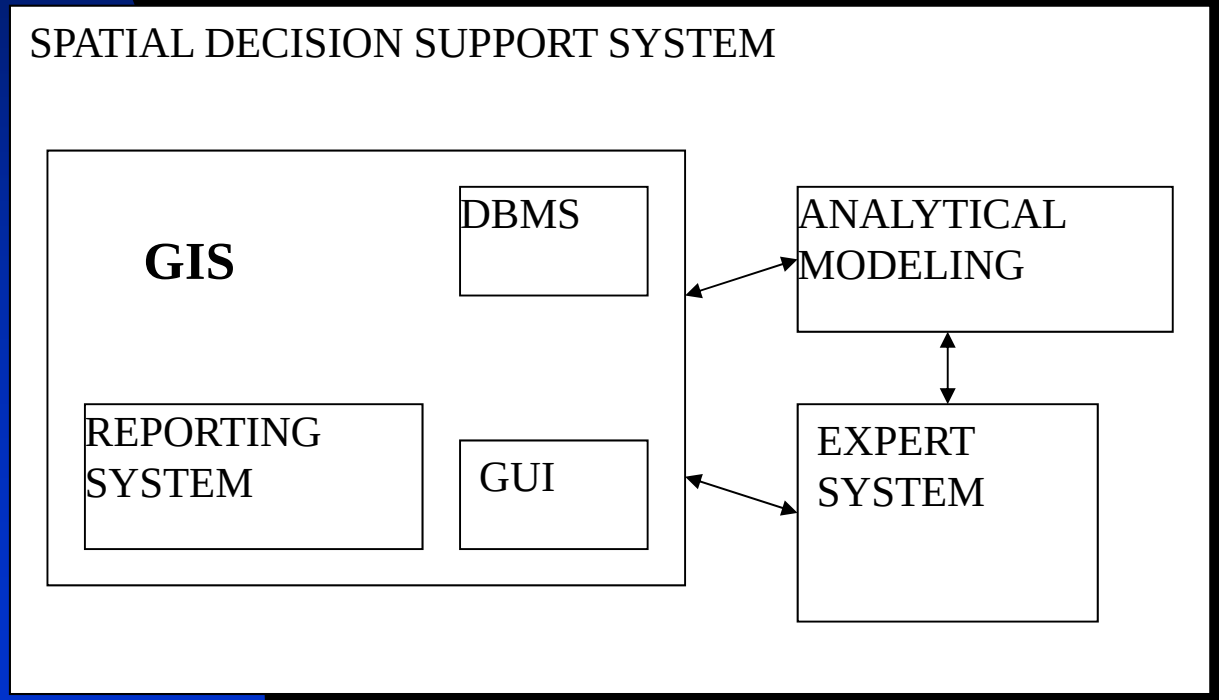

Figure 1. Integration of GIS with other systems.

- The above framework is to optimize the capabilities of GIS at any level of application. Since sustainable development is an interregional concept, there is need to integrate spatial data across the globe for effective implementation of the principles of sustainable development. The basic guideline is that there must be integration of data vertically across levels of decision-making and horizontally within these levels. The process of must be “top-down” but there must be lines of feedback from the populace to promote public participation.

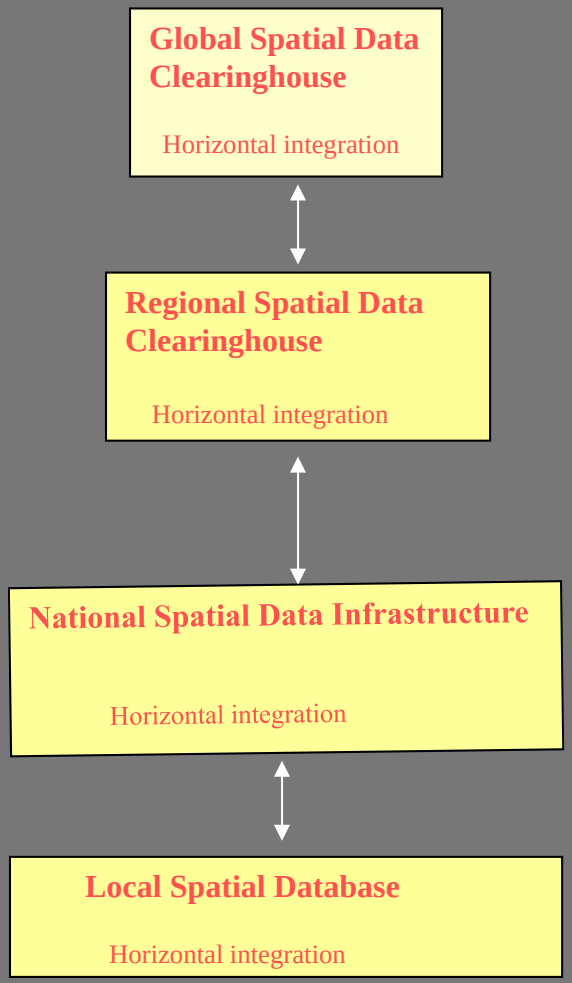

Figure 2. Global framework

Conclusion

- There have been some improvements in GIS technology since its emergence as a tool for spatial analysis. Due to GIS capabilities of database management and spatial analysis, GIS can be applied in helping decision-makers and planners to foster sustainability. However, there are some challenges especially at the global to using GIS as a planning tool for sustainability. The issues of database development, institutional framework, legal framework, data standardization and technology transfer. Also, GIS may not be adequate as a stand-alone system for support decision-making. It has to be integrated with other systems such as ES and SDSS for its application to be optimized.

THANK YOU