GIS in Land Information System

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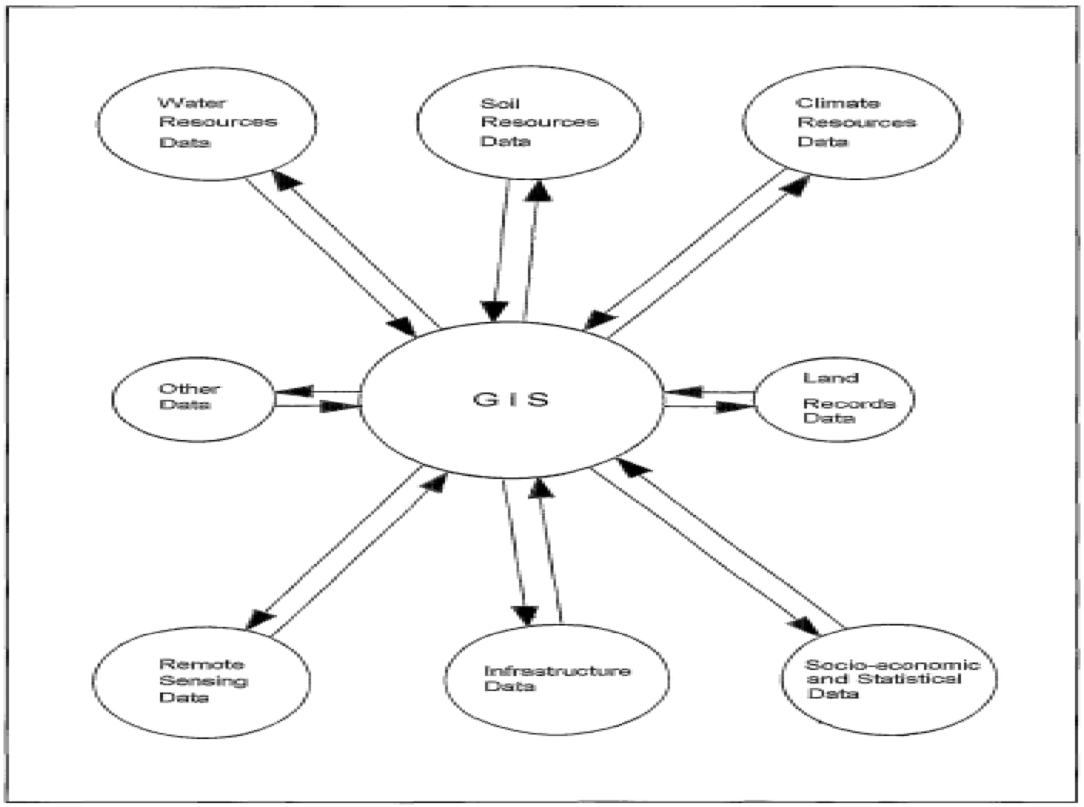
Introduction

Nations, village communities as well as individual land users need to make the best choices among options for the use of land in order to support development without hazard of land degradation, which would endanger sustainable production of food and other rural products. These options of optimal land resources allocation result from complex decisionmaking processes involving the optimal combination of various kinds of information: information about soils, climates, vegetation, present and potential land uses, location of towns and villages, highways, railroads and watenvays, figures on markets, prices, population, health and nutrition. Based on Geographic Information Systems (GIS), computerized Land Information Systems (LIS) have emerged as powerful tools in the management and analysis of the large amount of basic data and information, statistical, spatial and temporal, needed to generate in a flexible, versatile, and integrated manner, information products in the form of maps as well as tabular and textual reports for land use decisions. In recent years FA0 has been developing GISLIS systems in linkage with its agro-ecological zoning (AEZ) and similar models, applying these to tackle issues of land, food and people at global, national and sub-national levels. So far the applications have addressed mainly issues linking land use outputs with other development goals in such areas as food production, food self-suffkiency, cash crop requirements, population supporting capacity, taking into account soil fertility constraints, soil salinity, soil erosion risks and land degradation hazards. WlGle good progress has been made in developing GISLIS based tools for land resources planning, management and monitoring at different scales, practical difficulties are encountered in making these technologies accessible to the casual user of GISLIS in most developing countries. There are problems with lack of data and poor data quality; there are difficulties in training and support for such advanced systems. Because of user need and interest, and the rapid development in computer and systems analysis technology, however, this is an area deserving more attention by GISLIS developers.

The need for GIS-based land information systems

The development of these and related applications involve the analysis and interpretation of large quantities of biophysical and socio-economic data, statistical, spatial and temporal, in order to produce the diverse Ends of infolmation products required in the form of images, maps and botll tabular and textual reports for decision-mahg at various application scales. Up-to-date computing tools of spatial analysis allowing easy access to data and information and their manipulation necessary to produce these. Rapid development in information technology in the last decade has created a unique opportunity for the development of such a tool in the form of multi-purpose land resources information systems (LIS), which can be used to generate quickly and efficiently various kinds of information according to the requirements of different users. The LIS contains computerized databases, models, decision-support tools and a user interface to facilitate its operation (FAO, 1993b).



A Geographic Information System (GIS) is the central element in the configuration of a LIS. GIS'S utility derives from a capacity for dynamic functionality based on the following three main qualities:

-The physical computing capacity to manipulate data, including overlay, join, and desegregate;

- The related capacity to query the data by formulating hypotheses for testing assumptions, defining potential relationships and developing theoretical constructs;

- The capacity to relate two-dimensional and three-dimensional location of earth features, including atmosphere, lithospheres hydrosphere electro sphere, dong with dynamic (speak time) four-dimensional processes, such as represented by functional operations of systems of natural resources appraisal, planning, management and monitoring.

GISLIS is a multidisciplinary undertaking which intimate databases from various kinds and sources, models for data analysis, decision-support tools, computer hard and software and the human resources and institutional framework to operate the system; it is often organized in the fo1-m of a network (Fig. 1). Within integrated GISLIS remote sensing data support advanced mapping and modeling of soil conditions, such as soil moisture, soil type, soil salinity and soil erosion risks, land cover, land use and vegetation. Due to frequent data collection remote sensing enables rapid and effective monitoring of land use change, which is an essential element of land degradation assessments and a determinant parameter of land use sustainability (FAO. 1990; JRC, 1993).

GIS-based land information systems in FA0

In recent years, FA0 has gained valuable experience in the development of such GISLIS'S to address issues of improved integrated planning and management of land and water resources, based on quantified assessments of resources potentials and limitations and the issue of a rational and efficient use of soils, water and nutrients in biomass production. At the core is FAOs effort in the development of its Agro-ecological Zoning (AEZ) Methodology (FAO, 1978-1981) for land resources appraisal which implements the land evaluation approach of FAOs Framework for Land Evaluation (FAO, 1976). AEZ has two components:

- A computerized land resource database;

- A set of (mainly empirical and heuristic) models in the film of computer programs for PC microcomputers.

The land resource database is obtained by combining various data layers (map and tabular data) on the physical aspects of agricultural environments such as soil, landform, climate. The models are used to create the land resource database, calculate land suitability and land productivity, and to determine optimum land resources allocations. Various outputs are generated in both tabular and map form. The power of the AEZ methodology is based on the multipurpose integrated resources database it creates.

The mintages between GIS and AEZ models con be called ad hoc and partial. GIS and rnodels are developed separately. Map input/overlay and map output capabilities of the GIS are used for preparation of the land resources database required by the models. Mode1 processing is outside the GIS. Data flow from the GIS databases into the AEZ mode1 and vice versa. Modeling results are transferred to GIS for further processing and presentation.

One major area of development has been in applying optimization models to sets of AEZYGIS outputs in order to examine alternative regional or district level land use patterns. Such models suggest feasible land use allocation patterns that best safety specified development objectives, e.g. target food consumption patterns, population supporting capacities or rural employment levels.

FLhO AEYGIS studies address a wide range of real-adored issues; improved land use planning (China, Kenya, Mozambique), formulation of population policies (Malaysia, Philippines, China), national agricultural development (Kenya, Bangladesh), agricultural research planning and management Bangladesh and Indonesia). Natural resource management (Brazil), technology targeting (Bangladesh] and disaster preparedness (Philippines and Bangladesh) (FAO, 1994).

The continued development of AEZGIS has also served to expand the spatial ranges, or scales, of its application. mile the underlying concepts of AEZ are valid at any scale, the specific methods and tools of implementation must often differ in order to reflect the changing nature and complexity of decision making at national, district, farm, and even plot, Level. Current development efforts have a much greater focus on application at the farming systems level. Table 1 provides an overview of the various decades at which AEi ZGIS studies have been performed.

However, this list of applications is by no means exhaustive. In reality, AEZGIS approaches are suited to any application in which the relationship between land resources and land uses needs to be explored either in the context of assessing the suitability of land resources for specific uses, or of assessing the likely impact of those uses on the land resources themselves. Furthermore, the ways in which these relationships can be explored are constantly being enriched. Other applications in the policy analysis and planning areas pose what? Questions. The two main types of questions are:

- What if I could modify one or more land resource characteristics? (e.g., by terracing drainage, fertilizer application. liming) or

- What if I could mode current or proposed land use characteristics? (e.g., by the use of genetic mate rils that are more drought resistant, or that have a shorter growth cycle, or by the use of more machinery and less labour, or by the use of crop residues for feed and not for mulching). AEUGIS can estimate the changes either in land use suitability or in environmental adaption hazard that arise from the half if..? Scenario being tested. The broader socio-economic costs and benefits of proposed modifications can then be evaluated.

Different applications interpret and aggregate these data in different ways to suit theîr specific purposes. In general, applications are concerned with the spatial variability of suitabilities and constraints, and how these change under different production scenarios (is., different what $..? questions). Using these information analysts can identify opportunities for, and evaluate impacts of, increased land productivity, land improvement investments, and the introduction of new production technologies and commodities.

In the following, four examples are presented to illustrate the recent application of GISLIS in FA0 at the global and national levels:

1. **AT2010 Study:** Estimation of arable lands and future land reserves.

2. **District Planning:** Land use allocations best satisfying specified developnlent objectives.

3. **Climate Change:** Assessing the likely impacts on agricultural production.

4. **Vegetation and Land Cover Mapping**.