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Utilization Of Existing Data of Hellenic State Agricultural Departments and the Hellenic Cadastre towards the Sound Management of Agricultural Resources through a combined GIS-GPS System

ABSTRACT

The combined use of the Cadastre, satellite data, remote sensing and aero photographs of agricultural registries and the analysis of geographic and pedological data such as soil texture, pH, Electrical Capacity and other, enables a land use management that will respond to the demands of the producers, as well as, to the capacities of the plots or of the agricultural area. This way, the loses of unnecessary fertilization or cultivation activities will be reduced, enhancing also the management of the water potential of the region and contributing to the protection of the natural resources.

The cadastral activities (land distribution, reforestations, expropriations, topographical plotting for investment approval, registries of public properties and other, that have already been conducted by state agencies, will supply an even more complete and organized framework of agricultural areas and resources.

The introduction of GPS and GIS as powerful data collection and management system respectively, provides a plethora of capabilities for decision support according to the decided policies that have to be followed for the development and application of a sound management system of agricultural resources.

INTRODUCTION

Geographic Information Systems (GIS) are computer-based systems that are used to store and manipulate geographic information. This technology has developed so rapidly over the past two decades that it is now accepted as an essential tool for the effective use of geographic information.

The recent and global outbreak of the GIS has created a sudden need of the users of any kind of geographic information to become knowledgeable about this technology.

The use of Remote Sensing and Cadastral for data gathering, allied to the introduction of GIS as a powerful tool to process that data – in combination with information that has being collected using traditional field techniques – helps overcome traditional data volume constraints.

Additionally, powerful data collection tools are satellite based positioning systems (such as Global Positioning Systems (GPS), which were developed for navigation and positioning in three dimensions. The new line of GPS receivers brings technology to GIS practitioners who can populate maps with the location of features such as manhole covers, catch basins, and overflow points. Aircraft, ships, ground vehicles and hand carried by individuals, uses them.

Precision farming aims to optimise the use of soil resources and external inputs (fertilizers and herbicides) on a site-specific basis. Precision farming takes advantage of rapidly evolving GPS technology together with electronic sensors and controllers to monitor crop response under variable inputs and landscape position.

This paper is trying to give a technical support to assist general-purpose local governments (city, town or village), special purpose governments departments (utility management organization, etc.) and to those who provide advice to local governments (consultants, academic units etc.). It is the responsibility of all the above-mentioned agencies to work with each other and see why it is necessary to provide the scientific understanding; to promote research programmes and technologies needed to succeed in achieving a sound management and conservation of agricultural resources of Greece.

FEATURES AND METHODS

GIS BASICS

GIS technology includes aspects of surveying, mapping, cartography, photogrammetry, remote sensing, landscape architecture, and computer science. However, GIS is most closely associated with the study of spatial relationships of the environment and human activities (TeSelle, 1991). Thus, GIS can be used for such broad applications as land use planning, economic analysis, urban planning, social and cultural evaluations, environmental analysis, natural and agricultural resource planning. Spatial databases tend to be large and complicated, and therefore require rapid computational schemes and accelerated, colour graphic monitors.

A GIS project can be large in scope, such as:

- The analysis of global information to identify potential causes of global change;
- Agriculture retailers use GIS to market and efficiently transport fertilizers and agricultural chemicals to growers using national cadastral and GPS databases;
- Corporate agronomists at farmer-owned cooperatives use GIS to monitor production trends;
- Agricultural lenders and crop insurance firms use GIS software to rate and market crop insurance policies;
- Agricultural manufacturers of farm machinery and equipment and industries such as milling, feed pet and livestock, and food manufacturers can apply GIS to marketing, operations, and distribution;
- Agriculture wholesale trade and transport organizations can lower costs by using GIS to calculate efficient truck, rail, and shipping routes for distribution of wholesale and retail seed, fertilizer, and agricultural chemicals. They can use specialized software to move commodities from field to inland grain elevators or processing facilities to export terminals;
- Custom applicators can schedule farm supplies and equipment to arrive "just in time" at farm sites;
- The analysis of one field in a farm to recommend a conservation practice (it may analyse one element at a time-such as the soil resource within a watershed or it may analyse the relationships among many elements simultaneously such as land cover, the soil, topography, hydrography, the ownership boundaries, all at one in an integrated way);
- Simulation modules, supporting systems for taking decisions;
- Precision application of chemical products and crop maps;
- Query data and extract required subsets of spatial and temporal information related to agricultural productivity;
- Produce visualization of the spatial and temporal dynamics of integrated data;
- Incorporate state or other data sets into the GIS system for use.

An example of GIS application on agricultural management would be in farm planning, where the planner would key in the farmer's name. The computer would find, through the cadastral data, the farmer's areas in the field office geographic data base files. The farmer's field would be displayed, along with the soils, roads and streams. Soil interpretations would be generated for each field, identifying highly erodible land and acreage by field. Soils that are suitable for terracing would be displayed and overlayed by field. Several analyses would describe erosion loss or pesticide runoff, predicting the probability of it reaching the stream on ground water. Conservation plan maps and alternative treatment solutions would be generated from the GIS to help the landowner and conservation planner find new methods for improvement.

The advantages of GIS over other graphical techniques are that the databases are geo-referenced, can be easily updated and two or more databases can be overlaid, resulting in greater spatial analysis capabilities.

Although GIS, more than often, is not the "Sea of Tranquillity" for the technical sophisticated computer professional, the development of a successful government-based multi-participant GIS is very dependent on proper management, participation, and supervision. As it is often appeared, the recommended management actions may be the most critical aspect of the GIS development process.

GIS belongs to the class of computer systems that require a time-consuming building of large databases before they become useful. Unlike many other computer applications where a user can start using the system right after the purchase of the hardware and software, the use of a GIS requires that large spatial databases be created, appropriate hardware and software be purchased, applications be developed and all components be installed, integrated and tested before users can begin to use the GIS. These tasks are large, time-consuming and complex, requiring substantial planning before any data, hardware or software is acquired.

It is useful to note that GIS, GPS and Remote Sensing are technological innovations. The requirements for the sound development of the above combination, should follow these rules (Karteris, 1998):
i. Systematic and long term observation of natural environments;
ii. Systematic encoding and data capture;
iii. Adaptation of the monitoring system to the comprehensive region of its implementation;
iv. Widespread data bank and currently easily available to the community.

The adoption of technological innovations from the local government is not always a straightforward process. Several problems are likely to occur such as:

- Greater uncertainty about cost demands
- Not existence of a GIS professional
- Staff not fully understanding the technology prior to extensive training
- A greater likelihood that programmatic changes will be needed during the development phases
- Development time estimates differing from actual task times, etc.

Management needs to anticipate that such problems will occur, and when they do, take appropriate actions and strategic alternatives.
The utilization of new computer technology by an organization for either GIS or other applications, introduces fundamental changes into the enterprise in its thinking about data. Prior information technology allowed data to be collected and related to activities and projects individually. Organized stores of data were the exception rather than common practice. One of the goals of computer systems and database development is to eliminate redundant data collection and storage. The principle is that data should be collected only once and then accessed by all who need it. This allows more accurate data and greater understanding of how the same data is used by multiple departments. The development of a computer system database for different departments and agencies would be successful only if there will be a cooperation in the development of a system. A database becomes this way, an organization-wide resource and is created and managed according to a set of database principles.
Developing a GIS is more than simply buying the appropriate hardware and software. *The only and most demanding part of the GIS development is building the database* (Montgomery, 1996). Choosing the right GIS for a particular local government involves matching the GIS needs to the functionality of the commercial GIS because that require help from larger, more experienced agencies, knowledgeable university scientists and from individual private qualified consultants. GIS development must be viewed as a process rather than a distinct project.
A GIS development cycle is a set of eleven steps which starts with the needs assessment, *where the GIS functions and the geographic data needed are identified*. This information can be obtained through interviewing potential GIS users. Consecutively, surveys of available hardware, software and data are conducted and, based in the information obtained; detailed GIS development plans are formulated.

The eleven (11) steps of the GIS development cycle are (Becker et al., 1999):

1. Needs Assessments

- This is designed to produce two critical pieces of information:
  a) The list of GIS functions that will be needed
  b) A master list of geographic data.

2. Conceptual Design of the GIS

- This includes formal modelling (preparation of a data model) of the intended GIS database and the initial stages of the database planning activity.

3. Survey of Available Data

- This starts when needed data have been identified in the Needs Assessments. This task will inventory and document mapped, tabular and digital data within the local government, as well as data available from other sources, such as federal, state or other local governments and private sector organizations manipulate. This can also be collected through LAN or the global network, and this gathered information will also form part of the metadata for the resulting GIS database.

4. Survey of Available GIS Hardware and Software

- During this activity, the GIS functionality of each commercial GIS system can be documented for later evaluation.

5. Detailed Database Planning and Design

- This task includes:
  a) Developing a logical or physical database design based on the data model prepared earlier,
  b) Evaluating the potential data sources,
  c) Estimating the quantities of geographic data,
  d) Estimating the cost of building the GIS database.

6. Database Construction

- This is the process of building the digital database from the source data-maps and tabular files

7. Pilot Study/Benchmark Test

- This task demonstrates the functionality and performance of the GIS software

8. Acquisition of GIS Hardware and Software

- This task must be done according to the present as well the future needs

9. GIS System Integration

- It is well known that GIS is not a "plug and play" type system. The database, the individual components, the introduction and training of potential users to the system etc., must be done in a careful and organized manner.

10. GIS Application Development

This task referred to:

a) Database Applications, that means all the functions needed to create, edit, build, and maintain the database and, they are usually carried out by the GIS system staff,

b) User Applications, which are provided either as part of the initial software package (e.g. map display, query etc.), or more complex applications which must be developed using a macro-programming language (e.g. Arc Macro Language in ARC/INFO™ and Avenue in ARCVIEW™ .

11. GIS Use and Maintenance

- Formal procedures for maintenance and updating activities need to be created and followed by the GIS system staff and by all users to ensure continued successful operation of the GIS.

REMOTE SENSING BASICS

Remotely sensed data provides spectral reflectance and emittance measurement at pixel location. Spectral signature of a terrain object is dependent on conditions, which influences plants and their production. Variations on topography for example, produce different illumination conditions on the one hand and differing growth conditions for plants on the other

hand which result in different spectral signatures. Plant production is determined by water distribution, radiation, temperature and mineral nutrients, which can be triggered by climate, soil and geographic location as well as by the individual cultivation techniques (fertilizing, time of sowing, row spacing, etc.). This determines leaf area and degrees of pigmentation.
The most important applications of Remote Sensing focus on the agricultural statistics (Silleos, 1999). This includes:

1. Yield prediction
2. Crop area estimation
3. Disease control
4. Monitoring of vegetation development
5. Flood monitoring
6. Assessments of crop damages
7. Soil mapping
8. Modelling soil erosion by the use of Remote Sensing and GIS.

Typical GIS and Remote Sensing applications include monitoring and analysis of agricultural practices, natural vegetation, riparian ecology, water quality and distribution, wildlife and fisheries management, land suitability for irrigation, hydrology and water resources, social and economic change and automated mapping and facilities management (am/fm). GPS receivers can be used for supplemental control during ground-based operations.

CALIS (CALamities Information System) is a research program that is taking place through N.AG.RE.F. (National Agricultural Research Foundation)-a leader state service in Greece for the development of Agricultural Research- and is being supervised by CEO (Centre of Earth Observation) (Toulios, 2000). With the manipulation of satellite data, this program aims to introduce Remote Sensing in the control procedure and evaluation of crop damages that are caused by weather phenomena (high and low temperatures, tempests etc.), as well as the estimated insurance for the farmers. This information can also be accessible through Internet.

GPS BASICS AND PRECISION FARMING

Farming systems are continuing to change in response to economic, technological and social trends. Concerns, about farming techniques, are profitability and environmental impact. Farmers try to adopt new cultivation methods and increase the use of fertilizers, herbicides and insecticides. Precision farming takes advantage of rapidly evolving GPS technology together with electronic sensors and controllers to monitor crop response under variable inputs and landscape position. GPS system provides from a constellation of 24 orbiting radio-navigation satellites, continuous position data, enabling a combination of accuracy and real-time determinations presenting possibilities for guidance of farm equipment and the development of digital elevation models (DEMs) .
Detailed yield map interpretation combined with terrain analysis from high quality DEMs and site specific soil sampling will provide new opportunities for the use of integrated models.

A combination of the above mentioned system with the Cadastral would give results of great importance such as:

1. Location on the territory of specific cultivations by single farmers
2. Location on the territory of specific cultivations by groups of farmers
3. Information about Cadastral parcels
4. Classification and listing of each crop according to variety, the related surfaces, the year of the establishment of the production
5. Registry data distribution to the owners and/or the administrators, etc.

MapObject Internet Map Server can be used to create an interactive map browser for a specific cultivation variety, including the Geographic Data (parcels, TIN, etc.) and the numerical archives (the properties, the registries, the production, etc.) which can be managed in the future on different servers (Oracle servers, SDE-servers, etc.): when viewing parcels, the user can plot a particular query and get complete attribute information.

CONCLUSIONS

Interactive maps could allow citizens to have information about the agricultural production area, as well as the overall cultivated region, or finally, the smaller field with the characteristics that belong to the specific owner; the prices and the availability of yield production or the estimated amount, in case of weather damage. Also, information can be distributed about sale network (from mail-order sailing, to the auction sale, to the cash sale, having the capability to perform analysis on individual report base.

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