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RESEARCH ARTICLE

Reaching the Unreached through Geo-Informatics

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Abstract

Geo-informatics is the science and the technology which develops and uses information science infrastructure to address the problems of geography, cartography, geosciences locations and related branches of science and engineering. It is a science and technology mainly includes Remote Sensing, Geographical Information System (GIS) and Geographical Position System (GPS). Remote Sensing provides data for even unreached areas where physical observations are impossible and GIS backs up to bring the data into visualization and support for 'Decision Making". Whereas GPS concentrate on suitable spot locational aspects. In the proposed article/research paper, it is intended to present the role of Remote Sensing and GIS in unreached areas in the form of Extension fields. Rayalaseema Region of Andhra Pradesh is one of the notified drought prone areas of the nation. In fact the latest techniques have to be applied to unreached areas like Habitat analysis, School Locational analysis, Tribal inhabitation analysis, Precision agriculture, Water resources analysis etc. These tools can be widely used by extension field Professional. Citations have been taken from literature and recommendations.

Introduction

The rapid development of spatial technologies in recent years has made available new tools and capabilities to Extension services and customers for management of spatial data. In particular, the evolution of Geographic Information Systems (GIS), the Global positioning system (GPS), and remote sensing (RS) technologies has enabled the collection and analysis of field data in ways that were not possible before the advent of the computer.

How can potential users with little or no experience with GIS-GPS-RS technologies determine if they would be useful for their applications? How do potential users learn about these technologies? Once a need is established, what potential pitfalls or problems should the user know to avoid?

This article describes some uses of GIS-GPS-RS in Habitat analysis, School Locational analysis, Tribal inhabitation analysis, Precision agriculture, Water resources analysis, provides a roadmap for becoming familiar with the technologies, and makes recommendations for implementation.

Geographic Information Systems

GIS applications enable the storage, management, and analysis of large quantities of spatially distributed data.

These data are associated with their respective geographic features. For example, water quality data would be associated with a sampling site, represented by a point. Data on crop yields might be associated with fields or experimental plots, represented on a map by polygons.

A GIS can manage different data types occupying the same geographic space. For example, a urban control agent and its quarry may be distributed in different abundances across a variety of settlement types in an experimental plot, they can be mapped as distinct and separate features.

The ability to depict different, spatially coincident features is not unique to a GIS, as various computer aided drafting (CAD) applications can achieve the same result. The power of a GIS lies in its ability to analyze relationships between features and their associated data (Samson, 1995). This analytical ability results in the generation of new information, as patterns and spatial relationships are revealed.

The Global Positioning System

GPS technology has provided an indispensable tool for Habitat analysis, School Locational analysis, Tribal inhabitation analysis, Precision agriculture, Water resources analysis. GPS is a satellite- and ground-based radio navigation and locational system that enables the user to determine very accurate locations on the surface of the Earth. Although GPS is a complex and sophisticated technology, user interfaces have evolved to become very accessible to the non-technical user. Simple and inexpensive GPS units are available with accuracies of 10 to 20 meters, and more sophisticated precision agriculture systems can obtain centimeter level accuracies.

Remote Sensing

Remote sensing technologies are used to collect information about the surface of the earth from a distant platform, usually a satellite or airborne sensor. Most remotely sensed data used for mapping and spatial analysis is collected as reflected electromagnetic radiation, which is processed into a digital image that can be overlaid with other spatial data.

Reflected radiation in the infrared part of the electromagnetic spectrum, which is invisible to the human eye, is of particular importance for agriculture studies. For example, chlorophyll strongly absorbs blue (0.48 mm) and red (0.68 mm) wavelength radiation and reflects near-infrared radiation (0.75 - 1.35 mm). Leaf vacuole water absorbs radiation in the infrared region from 1.35 - 2.5 mm (Samson, 2000). The spectral properties of vegetation in different parts of the spectrum can be interpreted to reveal information about the health and status of crops, rangelands, forests and other types of vegetation.

Objectives

The following objectives are formed for the present article. They are

1. To review the geo-informatics technologies
2. To review the main fields of geo-informatics technologies applications
3. To provide a road map for becoming familiar with the technologies, and makes recommendations for implementation.

Applications

The uses of GIS, GPS, and RS technologies, either individually or in combination, span a broad range of applications and degrees of complexity. Simple applications might involve determining the location of sampling sites, plotting maps for use in the field, or examining the distribution of soil types in relation to yields and productivity. More complex applications take advantage of the analytical capabilities of GIS and RS software. These might include Habitat analysis, School Locational analysis, Tribal inhabitation analysis, Precision agriculture, Water resources analysis.

Precision Agriculture

GIS-GPS-RS technologies are used in combination for precision farming and site-specific crop management. Precision farming techniques are employed to increase yield, reduce production costs, and minimize negative impacts to the environment (Zhang et al., 1999). Using GIS analytical capabilities, variable parameters that can affect agricultural production can be evaluated. These parameters include yield variability, physical parameters of the field, soil chemical and physical properties, crop variability (e.g., density, height, nutrient stress, water stress, chlorophyll content), anomalous factors (e.g., weed, insect, and disease infestation, wind damage), and variations in management practices (e.g., tillage practices, crop seeding rate, fertilizer and pesticide application, irrigation patterns and frequency) (Zhang, Wang, & Wang, 2002).

Site-specific data, such as soil characteristics, fertility and nutrient data, topographic and drainage characteristics, yield data, harvester-mounted yield sensor data, and remotely-sensed vegetation indices, are collected from different sources and stored and managed in a spatial database, either contained within the GIS or connected to the GIS from an external source. The analytical power of a GIS is applied to the data to identify patterns in the field (e.g., areas of greater or lesser yield; correlations between yield and topography or characteristics such as nutrient concentrations or drainage) (Zhang et al., 1999).

Once patterns and correlations are illuminated, management practices can be modified to optimize yield and production costs, and minimize environmental impacts caused by excessive applications of fertilizers and pesticides. Site-specific applications of fertilizers, pesticides and other applications can be implemented by dividing a field into smaller management zones that are more homogeneous in properties of interest than the field as a whole (Zhang et al., 2002).

Climate Smart Agriculture

This method was coined by FAO. "Agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation), and enhances achievement of national food security and development goals. The Climate Smart Agriculture approach to Agriculture using Geo Spatial Technologies. The objective is common to use the available information to guide agricultural production, To optimizing the use of inputs and resources including water, land. To improve productivity through more precise use of inputs. To minimize agricultural risk due to pests and diseases and climatic variances. Hence overall improvement in farm incomes while minimizing risk.

Habitat Analysis

The GIS capabilities can be combined with remotely sensed landscape imagery to evaluate the effects of management practices and to assist resource managers and public decision makers in making informed decisions. For example, a GIS-enabled program, VVF, was developed to assess the suitability of a landscape as a species habitat (Ortigosa, De Leo, & Gatto, 2000). VVF integrates user-selected environmental variables to produce habitat suitability maps, and enables the user to create habitat suitability models for a specified area. Another model, LEEMATH (Landscape Evaluation of Effects of Management Activities on Timber and Habitat), evaluates both economic and ecological effects of alternative management strategies on timber production and habitat quality (Li, Gartner, Mou, & Trettin, 2000).

Data Analysis and Display

GIS technology interfaced spatial visualization capabilities with a relational database provide an effective method for analyzing and displaying the impacts of Extension education and outreach projects. This application was demonstrated in the Florida Yards & Neighborhood (FY&N) program developed by the University of Florida Extension to teach home owners and land owners how to reduce non-point source pollution and storm water runoff and protect the environment through landscape practices they exercise in their own yards.

Home owners filled out surveys both pre and post receiving training in landscaping methods. Responses to questions concerning landscape practices were rated as good, fair, or poor and statistical analysis was conducted on before and after scores for each landscape practice using a relational database interfaced with GIS software. Geospatial analysis of the extent of home owner/land owner adoption of these best management practices taught by the program enabled assessment of impact by acreage and location, identification of areas needing greater emphasis, tracking of change, and the ability for policymakers to see impacts in map format.

Forest Management

Spatial technologies are well suited for applications to resource management issues. The ability to interface GIS with relational databases enables integration of large data sets and many variables to support management decisions One example is the Florida Agro forestry Decision Support System (FADSS) (Ellis, Nair, Linehan, Beck, & Blance, 2000). FADSS is a GIS application that integrates geographically linked data on climate and soil characteristics in the state of Florida with a database of over 500 trees and 50 tree attributes. FADSS enables landowners, farmers and extension agents to make management decisions based on site-specific and tree-specific information.

Sustainable Watershed Management

Due to the highly complex nature of both human and physical systems, the ability to comprehend them and model future conditions using a watershed approach has taken a geographic dimension. Satellite remote sensing and Geographic Information Systems (GIS) technology have played a critical role in all aspects of watershed management, from assessing watershed conditions through modelling impacts of human activities to visualizing impacts of alternative scenarios (Tim & Mallavaram, 2003).

The extreme weather phenomena and global warming noted in recent years has demonstrated the necessity for effective flood risk management models. According to this paradigm, a considerable shift has been observed from structural defence against floods to a more comprehensive approach, including appropriate land use, agricultural and forest practices (Alexakis et al., 2013)

Spatially distributed flood information

Recently, space-born microwave active remote sensing, especially Synthetic Aperture Radar (SAR) with its all-weather capability, can provide useful spatially distributed flood information that may be integrated with flood predictive models. Radar imagery is useful for the identification, mapping and measurement of streams, lakes and inundated areas. Most surface water features are detectable on radar imagery due to the contrast between the smooth water surface and the rough land surface. The amount of moisture stored in the upper soil layer changes the dielectric constant of the material and thus affects the SAR return. Because the dielectric constant of water is at least 10 times bigger than that of the dry soil, the presence of water in the top few centimetres of bare soil can easily be detected through the use of SAR imagery.

Soil moisture estimation

The differences in the values between the dielectric constant of water and of dry soil at the microwave part of the spectrum plays a major role in the soil moisture estimation through the use of microwaves.

Data Analysis and Display

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land use / land cover (LULC) changes

Land cover changes may be used to describe the dynamics of urban settlements and vegetation patterns as important indicators of urban ecological environments (Yinxin & Linlin, 2010). Satellite remote sensing provides an excellent source of data from which updated land use / land cover (LULC) changes can be extracted and analysed in an efficient way. In addition, effective monitoring and simulating of the urban sprawl phenomenon and its effects on land-use patterns and hydrological processes within the spatial limits of a watershed are essential for effective land-use and water resource planning and management Several techniques have been reported in order to improve classification results in terms of land use discrimination and accuracy of resulting classes in the processing of remotely sensed data As a result of Very High Resolution (VHR) imagery, real world objects that were previously represented by very few pixels, are now represented by many pixels. Thus, techniques that take into account the spatial properties of an image region need to be developed and applied.

Urban planning

The physical aspects, Demographic aspects, Socio-economic etc., can be studied with the support of Geo-Spatial technologies. Analysis of urban development trends, Analysis and monitoring of land and housing, markets, Development of regional strategic plans, Development of community plans, analysis of school and other educational bus transport, modelling of accessibility to public transport in urban area can be done with the help of Geo-spatial technologies.

Environmental Analysis

Perhaps the most important concern for all of us today is protecting the environment we live and breathe in. Climate change issues are creating havoc with erratic weather patterns affecting everything from crop production to untimely melting of ice glaciers. There is a lot to worry about and immediate action is definitely required. It's not that the world has not geared up to take corrective actions, but we need to do more, and Geo informatics can help us achieve that. Geo informatics has powerful tools. It is enabling every sector to perform better and the environment is no exception.

Human activities and global warming are rapidly contributing to environmental degradation, decreasing glacier area, growth in glacial lake size, unprecedented rainfall, changes in land use and land cover, forest degradation, floods and glacial lake outburst floods, landslides, and shortfalls in agricultural crop production are among the many problems brought on by environmental changes. These issues need timely monitoring and supervision. Effective monitoring of the environment and an improved understanding of the same requires valuable information and data that can be extracted through application of Geo informatics such as Remote sensing , GIS and GPS.

Decision Support System

In geo informatics Geographic Information System (GIS) is a very important in decision support system and science basically deals with the geographical data. GIS is computer system that combines spatial database management, data manipulation, geo/statistical analysis and mapping of geo referenced spatial data. It has great functionality in data management, manipulation, and analysis of data, processing of input data and displaying output data. It is also used to retrieve, manipulate, and analyze data based on the user's request. But it is getting failed in case of decision making. GIS can assist better to decision makers in decision making phase but fail to identify how decision making process happens.

To make GIS most robust in decision making framework, there is need to understand the decision making process and its integrated functionality with GIS. Decision making is the process that leads to a choice between a set of alternatives. Geographical decision-making means analyzing and interpreting geographical information that is related to the alternatives in question. To integrate decision making techniques with GIS, there are three methods are studied: Loose coupling, Tight coupling and interoperable. Author has been decided to use this integrated approach of decision making and GIS to solve the spatial problems in case of land use planning and decision making. Keywords- Geographic Information System (GIS), Decision making, Loose coupling, Tight coupling and interoperable.

Rural Development

From the point of view of direct relevance of remote sensing for rural development and inclusive growth, the main centre is the National Remote Sensing Centre (NRSC), Hyderabad. It is engaged in operational remote sensing activities, and is responsible for aerial and satellite remote sensing data reception/acquisition, processing, dissemination/supply/distribution of data from foreign satellites and exploring the practical uses of remote sensing technology for multilevel applications. It strives to provide end-to-end solutions for utilization of data for natural resource management, geospatial applications and information services for realizing the Indian Space Vision.

The NRSC facilitates various remote sensing & GIS applications for natural resources and environmental management related to food security, water security, energy security, disaster management support and sustainable development. Currently, it is acquiring data from various satellites, viz. NOAA-17, NOAA-18, TERRA, AQUA, ERS and Carto sat. It also acquires and distributes data collected by other satellites like RADARSAT, IKONOS, QUICKBIRD, ORBIMAGE, ORBVIEW and ENVISAT.

The Global Positioning System (GPS) is a satellite-based navigation system consisting of a network of 24 satellites. The GPS technology is being used for quite some time in aerial and maritime navigation. The applications of the GPS technology include various forms of civilian and military navigation, mapping and surveying, habitat inventories and wildlife tracking, etc. Data received from GPS is used as a field check for remote sensing data and also plays a supplementary and complementary role for remote sensing data

Conclusions

Geoinformatics has been dealing with the structure and character of spatial information, its capture, its classification and qualification, its storage, processing, portrayal and dissemination, including the infrastructure necessary to secure optimal use of this information" or "the art, science or technology dealing with the acquisition, storage, processing production, presentation and dissemination of geoinformation.

Geomatics is a similarly used term which encompasses geoinformatics, but geomatics focuses more so on surveying. Geoinformatics has at its core the technologies supporting the processes of acquiring, analyzing and visualizing spatial data. Both geomatics and geoinformatics include and rely heavily upon the theory and practical implications of geodesy.

Geography and earth science increasingly rely on digital spatial data acquired from remotely sensed images analyzed by geographical information systems (GIS) and visualized on paper or the computer screen.

Geoinformatics combines geospatial analysis and modeling, development of geospatial databases, information systems design, human-computer interaction and both wired and wireless networking technologies. Geoinformatics uses geocomputation and geovisualization for analyzing geoinformation and useful for reaching unreached areas and locations for sustainable development.

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