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A STUDY ON HARNESSING AND APPLICATION OF REMOTE SENSING AND GIS FOR EFFECTIVE LAND RESOURCE MANAGEMENT AND PLANNING

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ABSTRACT

Improving land resource management and planning via the use of Geographic Information Systems (GIS) and Remote Sensing (RS) is the focus of this project. In order to optimize land allocation, analyze land use patterns, and estimate resource availability, the project intends to integrate RS data with GIS technology. To gather high-resolution spatial data, the research uses a variety of remote sensing methods, and then processes and analyzes this data using GIS tools. Using RS in conjunction with GIS greatly enhances the precision of land resource evaluations, leading to better decisions. More efficient land use planning and sustainable development may result from better land management techniques, according to the research.

Keywords: Spatial Analysis, Urban Planning, Satellite Imagery, Remote Sensing, technology.

INTRODUCTION

To achieve sustainable development, protect the environment, and advance socially and economically, land resource planning and management must be effective. The complexity of today's land use problems is sometimes beyond the capabilities of traditional land management systems owing to their poor spatial resolution, inaccurate data, and lack of integration. However, there are now potent tools available to circumvent these restrictions because to developments in GIS and Remote Sensing (RS). Acquiring massive volumes of spatial data via aerial surveys and satellite photography is made possible by remote sensing technologies. This data provides comprehensive and current information on land use, land cover, and environmental changes. Geographic information systems, on the other side, make it easy to store, manipulate, and analyze this kind of geographical data, which paves the way for thorough spatial analysis and choices.

A major step forward in land resource management is the combination of RS and GIS. Since ground surveys aren't always feasible or accessible, remote sensing is a great way to get a bird's-eye view of land features and how they've changed over time. Information about urbanization, terrain, soil, and plant cover is part of this. Furthermore, GIS provides a framework for handling and evaluating the gathered geographical data, which is a valuable addition. Effective land use planning relies on the patterns and linkages that may be revealed via the overlay of numerous data layers, spatial searches, and analytical modeling.

The capacity to do in-depth spatial studies that influence land management plans is a key advantage of integrating RS with GIS. To help identify regions at risk of degradation, deforestation, or urban sprawl, for example, land cover categorization, vegetation health monitoring, and land use change detection may be carried out with great accuracy. Also, land suitability models may be made with the use of GIS-based analysis. These models assess the land's potential for different purposes, such agriculture, forestry, or urban development. In this way, planners may adhere to environmental standards and sustainable development objectives by making choices based on data.

Land resource management uses RS and GIS for more than only disaster preparedness and environmental monitoring and infrastructure building. When it comes to risk assessment and emergency response planning, for instance, remote sensing may be a lifesaver in disaster-prone regions. After then, geographic information systems (GIS) may be used to coordinate relief operations, establish safe zones, and schedule evacuations. In a same vein, environmental monitoring that makes use of RS data may monitor ecosystem changes, evaluate the effects of climate change, and provide assistance to conservation efforts.

There are a lot of benefits to using RS and GIS together, but there are also some problems with incorporating both into land resource management. These technologies may not work as intended due to problems with data quality, resolution, or the need for technical knowledge. In addition, researchers, government organizations, and local communities must work together for RS and GIS solutions to be implemented successfully.

Using GIS and remote sensing for land resource planning and management is a game-changer when it comes to dealing with the intricacies of contemporary land use. Land management methods may be made more informed, efficient, and sustainable by using the analytical capabilities and rich geographical data offered by these technologies. With the continuous advancement of technology, RS and GIS have the ability to greatly enhance land planning and resource management. This will allow for the development of strategies that are more robust and adaptable to new problems.

REMOTE SENSING

One use of technology is remote sensing, which allows one to get data about a place or thing without actually touching it. Satellites, planes, or unmanned aerial vehicles (UAVs) equipped with sensors measure the surface and atmosphere of the planet. In order to acquire digital pictures or data for processing, these sensors pick up electromagnetic radiation that is either reflected or emitted by things. Applications such as land use mapping, environmental monitoring, and disaster management greatly benefit from remote sensing since it allows for the precise monitoring of enormous, sometimes inaccessible, regions. Remote sensing aids in the management of natural resources, the evaluation of land cover changes, and the monitoring of environmental events across time by providing precise spatial and temporal data. The insights provided by this technology are vital for making educated decisions and developing strategies in many different domains, including as agriculture, forestry, urban planning, and climate research.

GEOGRAPHIC INFORMATION SYSTEMS

Advanced technologies for collecting, storing, analyzing, and visualizing spatial and geographic data are Geographic Information Systems (GIS). Thanks to GIS's ability to integrate several data layers, users may map and analyze patterns and connections in varied geographical settings. Data, software, and hardware all work together in the system to analyze spaces and create maps and graphs that reveal patterns and insights. With GIS, users can easily handle large datasets and superimpose data on top of one other, including land use, demographics, infrastructure, and environmental variables. In several domains, including transportation, natural resource management, and urban planning, this skill is crucial for making educated judgments. Whether it's for infrastructure development, disaster response, or environmental protection, GIS provides a platform for accessing, analyzing, and presenting geographic data, which aids in effective decision-making and strategic planning.

CASE STUDIES AND APPLICATIONS

Tracking deforestation, assessing ecosystem health, and monitoring the impacts of climate change are all examples of environmental monitoring tasks that have made use of RS. An example of a prominent use of RS is in disaster management. For instance, when storms or floods occur, satellite images may be used to evaluate damage in real-time and plan interventions. Similarly, precision farming is made possible in agriculture by combining GIS with RS. This method maximizes productivity and sustainability via the analysis of soil health, optimization of irrigation, and monitoring of crop conditions. Case studies using geographic information systems (GIS) in public health are also noteworthy. Spatial analysis aids in disease outbreak mapping, health care gap identification, and intervention planning. Insightful and efficient decision-making in a variety of fields is possible thanks to these instances of how RS and GIS technologies improve our capacity to comprehend and control complicated spatial phenomena.

ACTIVE AND PASSIVE REMOTE SENSING

Since sensors can pick up and store electromagnetic radiation, they find widespread usage in remote sensing. Active sensors, such as radar and lasers, are self-sufficient in terms of power generation; they aim an energy beam at a surface and record the amount of that energy that is reflected back. The target's location, height, velocity, and direction may be determined using these sensors by calculating the time between the emission and return. Active sensors have the capacity to transmit their own controlled signals, allowing them to be used whenever needed, day or night, even when no external power sources are available. But passive sensors can't do anything without external energy sources. Passive sensors can only be used during the day as they are powered by the sun. However, passive sensors that do not need an outside light source may detect the Earth's temperature at the longer wavelengths [10].

Methods in Remote Sensing

i. Remote sensing image data: Data collected by satellites like LANDSAT, LISS III, and ASTER may be used. LANDSAT's spatial resolution is 30 m, LISS III's is 23.5 m, and ASTER's is 15 m. For our objectives, the spectral detail and geographical coverage of these photographs were more than enough.

ii. Geometric correction: In order to study the land use and cover characteristics of a specific area, precise registration of multispectral remote sensing data is required. As a means of addressing the inaccuracies introduced by variables including changes in altitude, sensor platform velocity, scan speed and sweep, earth curvature, relief displacement, and similar concerns, geometric correction is used on remote sensing data. The images are processed using the RMS technique for georeference, after which the LANDSAT-7 ETM+ data is re-projected to polyconic projections.

iii. Ground reference data: Ground reference data is crucial for picture analysis in order to classify information accurately, make decisions, and assess the dependability of results. At this point, you need a wealth of background information and a thorough familiarity with the place as references.

iv. Classification scheme: Data collected from photographs is organized using classification methods, which are hierarchical frameworks. The study-relevant and easily discernible categories of a good categorization system are the hallmarks of such a system. Some of the interpretation keys used to decide picture augmentation, contrast stretching, and false color composites include size, pattern, form, position, association, tone, texture, shadows, and resolution.

v. Fuzzy supervised classification approach: All three phases of supervised classification may be handled by this method, and it also supports multiple and partial pixel-level class memberships, which is useful when things go fuzzy. Because pixel categorization boundaries aren't always crisp, our method takes that into account.

vi. Accuracy assessment: When describing the degree of "correctness" of a category or map, the term "accuracy" is often used in thematic mapping that makes use of remotely sensed data. Land cover shown on a thematic map produced from a categorization may be deemed accurate if it corresponds to reality. How well does the resulting image categorization conform to reality or the 'truth,' which is often seen as the most important factor in classification accuracy? The accuracy of the classification could only be evaluated by comparing it to a set of reference pixels that stood in for certain regions of the image. The use of randomly selected reference pixels is one approach to reducing or eliminating bias. In order to get the baseline information, a stratified random sampling method was used. In order to determine the sample size, this technique takes into account the proportionate geographic area of each land use type.

vii. Land Use Classification System: Settlements, forests, farms, undeveloped areas, and other types of ground cover are all examples of land use. We can get a good idea of the growth, decline, and percentage changes in various land uses by comparing data from two separate historical eras. Land use planning, flood control, and other related domains are only a few possible uses for the information and map generated by this approach.

viii. Land Use Mapping and Distribution: We can detect many features, such as bodies of water, forest reserves, urban areas, vegetation, farms, and more, after applying a supervised maximum likelihood classifier to both images. As a result, we can see the dramatic shifts in land use and cover that occurred between the two periods.

In contrast to the more usual methods of ground surveying, remote sensing technologies provide for a bird's-eye view over expansive regions. Data collection rates and the rates at which we get them from different satellites are both subject to change. Satellites are able to detect changes and update data frequently due to their characteristics. Remote sensing allows for the collection of data using a broad variety of invisible light wavelengths, such as microwaves, thermal infrared, ultraviolet, and infrared, among others. As a result, remote sensing techniques may pick up on occurrences that the naked sight would miss. The study of the effects of solar electromagnetic radiation on Earth's surface is an important part of remote sensing. Spectral confusion and misunderstanding may occur because many Earth features reflect the same wavelengths and some of the same characteristics reflect different wavelengths. Systematic ground truth knowledge may be helpful in addressing these difficulties.

REMOTE SENSING APPLICATIONS IN LAND RESOURCE MANAGEMENT AND PLANNING

Soil Resources Management

All agricultural endeavors rest on the foundation of soil, an indispensable renewable resource. It all comes down to the soil fertility and other environmental elements that determine a location's potential crop. Accurate and trustworthy soil data has to be easily accessible. Doing so requires education on their composition, distribution, physicochemical properties, and boundaries. This information is derived from soil surveys, which characterize and map the physical properties of each soil unit. The improved spatial, spectral, and radiometric resolutions of the LANDSAT and IRS satellites have made it possible to map soil at 1:250,000 (NBSS&LUP) and 1:50,000 (IMSD) scales.

Mineral Resource Management

In most cases, natural mineral deposits will not restock on their own. Discovering and evaluating new mineral sources is critical for ensuring that mineral stocks are sufficient to fulfill future needs. Aerial and space-based technologies are mainly used for four purposes in mineral exploration: identifying spectral lithology, controlling structures at regional scale, integrating data, and detecting geo-botanical abnormalities. Exploration targets may be defined and mineralization features can be mapped out with the use of geologic, geomorphic, and tectonic data. The identification and delineation of mineral provinces and target areas is greatly aided by remote sensing technologies, which can detect markers and geomorphologic features. However, these technologies cannot completely replace conventional methodologies. From above, the limestone, sandstone, and shale rocks of the Jaintia hills region in Meghalaya seem quite distinct.

Water Resources Management

This technology has grown from its humble beginnings in surface water inventory to include a wide range of sophisticated management applications. It is currently used for a wide variety of purposes, including irrigation system performance evaluation and diagnosis, nationwide drought tracking, rainfall and snowmelt runoff estimation, reservoir sedimentation prevention, watershed treatment, flood management, and environmental impact evaluation. Using data gathered from space has improved the effectiveness of water management programs on a national and regional scale. There is need for improvement in Ri Bhoi's inland fisheries, as shown on a NESAC-made map of all surface water bodies in the district that are more than 0.22 hectares in size. The government of Meghalaya's Directorate of Fisheries now has access to these maps. Additionally, NESAC has mapped the groundwater potential zones in the East Khasi Hills district to make more potable water available there. More accurate bore hole drilling could be possible using this map.

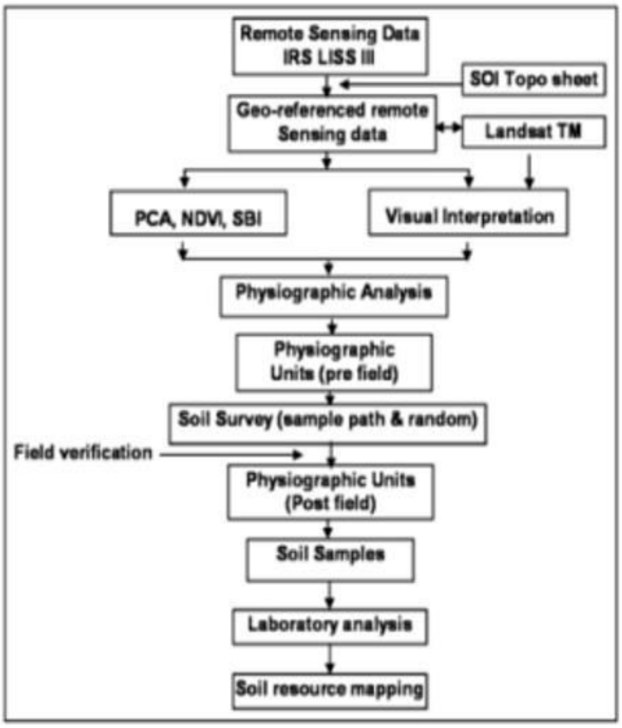

Fig. 1. Method for charting land uses

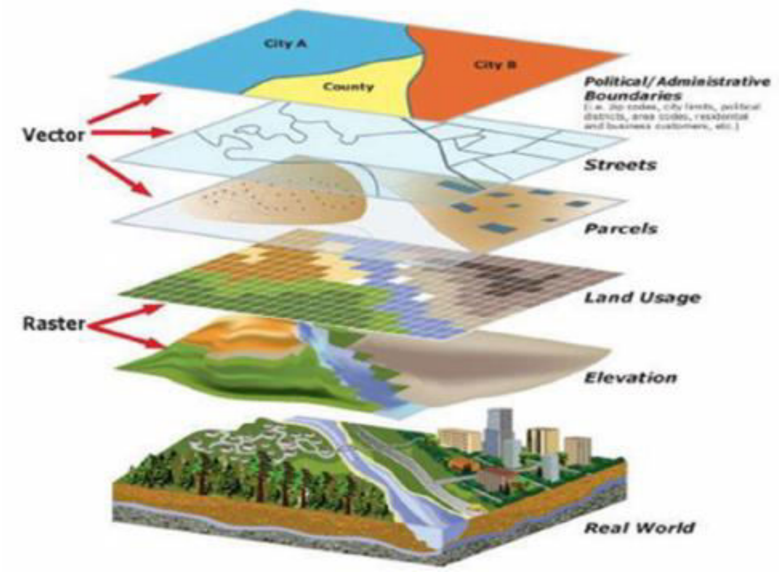

Figure 2: Maps and Software for City Planners

APPLICATION OF REMOTE SENSING AND GIS

Application in Crop-Irrigation Demand Monitoring

The agricultural sector is the largest consumer of freshwater, accounting for over 70% of the global total. For this reason, irrigation water is crucial for increasing harvests. Land surface evapotranspiration (ET) is a key component of the water balance that causes water loss; it has several environmental applications, such as optimizing irrigation water consumption, improving irrigation system efficiency, addressing crop water deficiency, and many more (Michailidis et al., 2009). Two more prevalent problems that lower agricultural production in many semi-arid and dry regions are inadequate water applications and incorrect irrigation schedule. These considerations have led to the recent meteoric rise in the usefulness of remote sensing as a tool for monitoring irrigated land in a variety of geographical conditions. It helps with watering scheduling by keeping tabs on plant water status, determining evapotranspiration rates, and computing crop coefficients. Utilizing surface water efficiently and monitoring consumptive water usage via remote sensing technology have garnered significant attention from irrigation water policymakers.

Application in Crop Modelling

At each time step in the model simulations, we may evaluate yield variables using remote sensed data, thanks to Batchelor et al. (2002), which allows us to use remote sensing to fill in the missing model parameters during field-scale calibration. According to Priya and Shibasaki (2001), one way to get from field scale to regional size is to receive data from crop models in field scale -remote sense. The integration of crop models with remote sensing data has been the subject of several methodologies' proposals (Wiegand et al., 1986; Dele'colle et al., 1992). One method involves calibrating crop models with estimated leaf area index (LAI) values obtained from remote sensing. Another option is to use early yield forecasts, which rely on a mountain of data gathered from growing-season remote sensing equipment to inform crop models. By combining crop models with data from remote sensing, Baret et al. (2006) were able to estimate stress using assimilation approaches.

Application in Agriculture

At a fair price, it converts data from several time and spectrum dimensions into information that may be used to study and track patterns in land development. Geographic information system (GIS) technology provides a flexible setting for storing, analyzing, and displaying digital data, making it ideal for change detection and database creation. Satellite pictures may now be used to track different forms of land cover and estimate biophysical parameters of land surfaces thanks to spectral classification and linear relationships with spectral reflectances or indices (Steininger, 1996). It was useful for determining where on Andaman Island to plant rice and for assessing the soil's limits.

Application in Water Quality Monitoring

In order to regulate and enhance water quality for human consumption, constant monitoring is necessary. For the time being, in-situ measurements and laboratory analysis of water samples are used to evaluate water quality. While these metrics are spot-on at a particular moment in time, they don't provide the big picture of water quality over space and time, which is essential for managing or evaluating bodies of water effectively. Not to mention how time-consuming and expensive they are, and how inefficient they are when compared to regional or national monitoring demands. Using remote sensing tools, we can monitor water quality indicators like temperature, chlorophyll, and turbidity, which is the quantity of suspended sediments. To improve water quality, management plans are developed using the geographical and temporal data collected by satellites, aircraft, and boats equipped with optical and thermal sensors. This data allows for the tracking of changes in water quality indicators. Using empirical relationships with reflectance or radiance, chromaphyll concentrations have also been detected in space and time by remote sensing (Ritchie et al., 1994). Our goal was to develop algorithms that could predict the water quality for several years based on a single date and location, as well as the concentration of suspended particles and the brightness or reflectance. (According to Ritchie and Cooper, 1991).

Forest Management and wildlife habitat analysis

The world's forests have been decreasing in size over the last few decades, despite the fact that they are vital to our ecology and have far-reaching consequences on human existence. One renewable resource that may be restored via sustainable management approaches is forest cover. By using remote sensing data and GIS technologies, a forest manager may get a wealth of information regarding forest cover, the many forest types in a given area, the extent to which human activities are invading forest or protected area land, the development of desert-like conditions, and much more besides. This data is essential for developing forest management plans and for making important choices about enforcing regulations that limit and govern the use of forest resources. It is also possible to assess the condition and suitability of forest regions and habitats for certain animal species using remote sensing data and multicriteria analysis.

CONCLUSION

Studying how to use GIS and remote sensing for better land resource planning and management concludes that these technologies have revolutionary potential. When combined, remote sensing's accurate and up-to-date data with GIS's powerful analytical and visualization capabilities allow for thorough land resource monitoring, evaluation, and planning. Their combination helps with catastrophe preparedness, environmental sustainability, and well-informed decision-making. Sustainable development and the optimization of land use practices are essential for meeting the growing demands of land resource management. With the use of remote sensing and GIS technology, we can ensure responsible stewardship of our planet's resources.

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