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LAND RESOURCE MANAGEMENT AND PLANNING USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS

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Abstract

The natural resources of a country are the foundation for its economic and social growth. Natural resources are vital to a country's economy because they generate wealth and jobs, supply crucial materials for manufacturing, feed and power the population, and heal and cure the sick. Overexploitation causes resource exhaustion because of population growth. The depletion of natural resources has had a domino effect, driving up prices, altering weather patterns, and eroding the economic, social, and cultural gains made possible by those resources' earlier exploitation. Nations must learn to use these resources sustainably if they want current and future generations to reap the advantages. Due to the importance of properly managing these sensitive resources in light of recent developments in information technology, natural resource managers have placed a strong emphasis on remote sensing and geographic information system (GIS) technologies. Managers now have a solid foundation upon which to build data and knowledge that will guide sustainable development decisions thanks to these technologies. Therefore, the purpose of this study is to provide an overview of the use of GIS and Remote Sensing in the context of managing land resources and promoting long-term sustainability.

Keywords: Technology for Land Use Planning, Resource Management, and Remote Sensing

INTRODUCTION

Natural resources include all forms of energy and matter necessary to maintain the myriad activities that lead to production and to satisfy humanity's physiological, socioeconomic, and cultural demands. Renewable natural resources include solar energy, forests, agriculture, fisheries, etc., while nonrenewable natural resources include things like oil, coal, natural gas, etc. The metallic minerals and all the elemental minerals can be recycled. Many variables (including geography, climate, biology, and technology) determine how easily these resources can be accessed and utilized. Because some originate in the ocean and some originate on land, their geographic ranges are diverse. Their availability also shifts over time as use thresholds are reached.

The quantity, location, rate of change/use, and quality of the resources are poorly documented. The existing methods used to keep track of supplies cannot be replicated. Inaccessible terrain and boundaries prevent them from collecting complete data. Some of the challenges in land resource management include the inability to easily transmit data between agencies due to differing standards/formats, the inability to easily find data sources for historical data, and the inability to easily abuse data.

Remote Sensing (RS), Geographic Information Systems (GIS), and Satellite-based Positioning Systems (GPS) are all useful modern tools for assessing and managing natural resources in this setting. Remote sensing (RS) is the practice of gathering data on a target object, phenomenon, or process without physically interacting with it. This is often done from a moving aircraft or orbiting satellite using sensors that can detect signals from across the electromagnetic spectrum. The GIS makes it possible to enter, manage, analyze, and visualize information gathered from RS and other methods. A exact location in terms of longitude, latitude, and altitude can be obtained using GPS equipment. These tools allow for efficient, low-cost analysis of biosphere, geosphere, and atmosphere interactions on a global scale. Space technology is giving helpful data for improving agricultural practices and water management on a local scale. Macro and micro uses of RS and GIS, respectively, include monitoring changes in forest cover and creating developmental plans for afforestation [1-6].

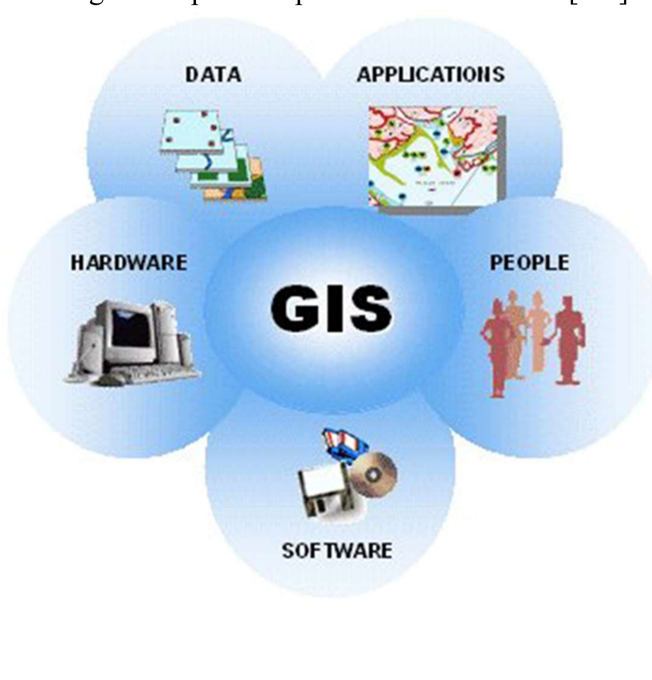

Figure 1: Applications of Remote sensing and Geographic Information System (GIS)

Definition and Scope

The phrase "remote sensing," which has been in use since the 1950s, describes "the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation." In July of 1972, the National Aeronautics and Space Administration (NASA) of the United States launched Landsat-1, marking the beginning of the age of satellite remote sensing. It depends on utilizing picture data collected by various sensors as aerial cameras, scanners, and radar. Information on specific characteristics on Earth can be gleaned through the use of satellite remote sensing, which involves the interpretation of images or numerical values collected from afar. Any number of physical energy distributions are available for use in the equipment designed for this task. Acoustic wave distribution is at the heart of sonar's operation, while electromagnetic energy distribution is at the heart of optical devices like the camera and the multi-spectral scanner. Metaset, NOAA-Advanced Very High Resolution Radiometer (AVHRR), Landsat (French: Satellite Pour observation de la Terre), SPOT (Satellite for Planetary Observation and Analysis), Earth Resources Satellite (ERS) - Satellite Access Request (SAR), and aerial photographs are all examples of satellites that can be used for remote sensing. Remote sensing's primary goal is resource mapping and monitoring.

GIS (or a similar acronym):A computer program called a Geographical Information System (GIS) saves, retrieves, manipulates, analyzes, and displays geographically related data sets for usage in a variety of contexts. In this context, the term "Geographic" refers to elements of space that can be located or located at a certain latitude and longitude on the planet's surface. It's not specified whether the thing is natural or cultural or both. Similarly, the concept of "information" refers to a big body of knowledge on a specific location or thing on Earth. The information includes both qualitative and quantitative characteristics of the physical items in the world. "System" stands for the systems approach, which simplifies the complexities of the world by reducing it to its component elements, such as the many objects and features on Earth's surface. Both vector and raster formats can be used to store and represent GIS information. Geospatial information is stored in a vector data structure as points, lines, or polygons. Things like fire pits and campsites could be represented as points, paths and rivers as lines, and forest types and types of recreational opportunities as polygons. In contrast, geospatial data is represented in a raster data structure as a regular grid of cells where the attribute is applied to the entire cell [7-9].

Raster data can cover an area in a seamless fashion. The Digital Elevation Model (DEM) is a raster data structure since it displays slope, aspect, and elevation in a grid for a region. Logic-based database software, which consists of records and fields, may manage attribute data. As a result, GIS provides a special advantage by attempting to manage and analyze the links between such geographical and attribute data through a single platform. There are three main steps necessary for successfully adopting GIS with georeferenced data. These include gathering sources, entering data, and presenting findings. Geographic information systems (GIS) are capable of storing vast quantities of both spatial (maps) and non-spatial (tabular data). It could be useful for keeping track of and managing land assets. Synoptic assessments of Earth are made easier with the help of remotely sensed data. Today, computers are typically used to collect, store, and analyze data. The most popular remote sensing programs include ERDAS Imagine, ESRI (Environmental Systems Research Institute), MapInfo, and ER Mapper.

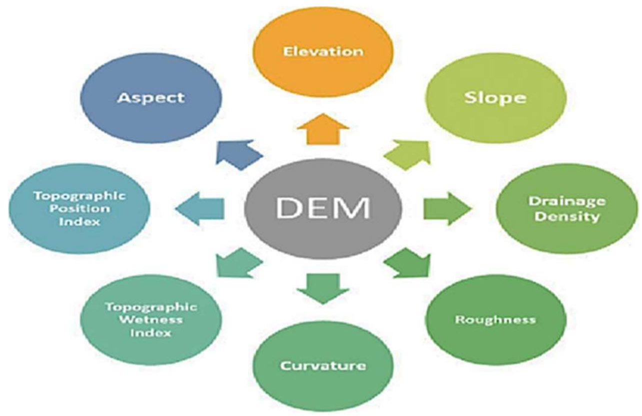

Figure 2: Three use of digital elevation model (DEM)

Active and Passive Remote Sensing

Sensors are used in remote sensing because of their ability to detect and record electromagnetic radiation. Active sensors, like radar and laser, generate their own power, direct a beam of energy towards the surface, and measure the quantity of energy reflected back off of it. By measuring the interval between the emission and the return, these sensors can ascertain information about the target, such as its position, altitude, velocity, and heading. Since active sensors may send out their own regulated signals, they can be used whenever necessary, day or night, regardless of the availability of external power sources. However, passive sensors rely solely on ambient energy to function. Because of their reliance on solar power, passive sensors are limited to daytime operation. The longer wavelengths associated to the earth's temperature, however, can be measured by passive sensors that function independently of any external light source [10].

Methods in Remote Sensing

i. Remote sensing image data: The data from satellites like the Land Remote-Sensing Satellite (LANDSAT; spatial resolution 30m), the Land Imagery System (LISS III); spatial resolution 23.5m), and the Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER; spatial resolution 15m) can all be utilised. These photos were of a high enough quality in terms of spatial coverage and spectral detail to meet our needs.

ii. Geometric correction: In order to analyze the land use and land cover characteristics of a specific area, accurate registration of multispectral remote sensing data is required. In order to account for the distortions and degradations introduced by inaccuracies related to changes in altitude, velocity of the sensor platform, scan speed and sweep of the sensor's field of view, earth curvature and relief displacement, and other factors, remote sensing data undergoes geometric correction. LANDSAT-7 ETM+ data are re-projected to polyconic projections, and the images are georeferenced using these projections with a Root Mean Square Error (RMS).

iii. Ground reference data: Image analysis relies heavily on ground reference data in order to properly categorize information, make judgments, and evaluate the reliability of the obtained results. At this point, you need substantial reference data and a deep familiarity with the location.

iv.Classification scheme: Classification schemes are organizational frameworks for the extracted information from picture data. A good categorization scheme will have categories that are relevant to the research and can be easily identified in the data. picture interpretation is performed utilizing the many interpretation keys such as shape, size, pattern, tone, texture, shadows, position, association, and resolution, and picture enhancement, contrast stretching, and fake color composites are figured out..

a. **Image Classification Techniques:** The goal of this image classification process is to automatically sort each pixel in a picture into one of many predetermined land cover categories. Different spectral features between classes are required for image categorization. Reflectance spectra can be compared to draw conclusions. The results of an image classification are often reliable. To classify an image, a pixel's feature vector is compared to clusters in the feature space that have already been established. After applying this to every single pixel in the image, we have a labeled result.
b. **Unsupervised Classification:** By allowing the software to identify statistical patterns in the data without needing any ground truth data, the unsupervised classification approach is an automated classification method that generates a themed raster layer from a remotely sensed image.

c. **Supervised Classification:** In this scenario, an image analyst monitors the pixel classification process by providing numerical descriptions of the various land cover types contained in the image to the computer algorithm. The usual spectral pattern of land cover classes is defined as training samples. Land cover classes are assigned to picture pixels based on numerical comparisons to the training samples.

v. Fuzzy supervised classification approach: In all three steps of supervised classification, this method can handle fuzziness and support numerous and partial class memberships at the pixel level. This method takes into account the fact that there aren't always clear boundaries between the classes to which a given pixel belongs.

vi. Accuracy assessment: The term accuracy is commonly used to represent the degree of 'correctness' of a map or classification in thematic mapping from remotely sensed data. If the land cover depicted on a thematic map created from a categorization is true to life, then the map can be deemed accurate. The degree to which the derived image categorization agrees with reality or conforms to the 'truth' is commonly understood to be the essence of classification accuracy. The accuracy of the classification must be evaluated using a set of reference pixels that stand for certain locations within the image. By selecting reference pixels at random, bias is reduced or eliminated altogether. To compile the ground reference data, a random stratified sampling strategy was employed. Using this strategy, the sample size for each type of land use is determined by its relative geographic area.

vii. Land Use Classification System: Settlements, forests, farmland, undeveloped areas, and other types of land cover are only few of the many categories of land use. Rates of growth, decline, and percentage changes in land use types can be approximated by comparing data from two distinct time periods. The technique's resulting map and database can be used for a variety of purposes, including flood management, land use planning, and more.

viii. Land Use Mapping and Distribution: Classifications such as Water Body, Forest Reserve, built up Area Vegetation, Farmland, etc. are possible after applying a supervised maximum likelihood classification to both images. This allows for a comprehensive overview of the major land use / land cover features across both time periods.

ix. Advantages over conventional methods

Unlike traditional ground survey methods, remote sensing techniques allow for a comprehensive overview of expansive regions. The frequency with which we receive data from satellites, and the frequency with which different satellites acquire data, both vary. This capability of satellites allows for frequent data updates and rapid change detection. Data can be recorded not only in the visible spectrum but also in the invisible (ultraviolet, infrared, thermal infrared, microwave, etc.) via remote sensing. As a result, remote sensing techniques allow us to notice occurrences that would otherwise be invisible to the naked sight. Solar electromagnetic radiation and its effects on Earth's surface are fundamental to the field of remote sensing. However, spectral confusion resulting to misclassification is extremely common since various earth features can reflect the same wavelengths and the same features might reflect different wavelengths. Systematic ground truth knowledge can help with these issues. Therefore, it is clear that while traditional methods of data gathering are necessary and should be maintained, the efficiency of data collection, in terms of both cost and time, can be improved through the use of remote sensing techniques. These days, it takes barely any time at all to conduct a survey and create a map of a certain area, whether it a hamlet, a plantation, a treatment zone, etc. It is also simple to create, save, and retrieve administrative maps, soil maps, management maps, and other similar types of maps using digital means. Digital mapping makes it simple to create maps of administrative divisions like range, block, compartment, etc. based on easily recognized physical elements like streams, bridges, roads, etc [11].

Disadvantage of geospatial technology

There are likely to be certain practical challenges associated with the use of remote sensing technology in monitoring and maintaining habitats and ecosystems, despite its invaluable applications in several fields of interest. Inherent in most technologies are practical constraints; for example, the penetration of light through water and air is limited. The second drawback of remote sensing is the challenge of determining which sensors are appropriate for a certain task. When it comes to reef structures, for instance, remote sensing is more likely to yield geomorphological than biological information. The sensors' restricted spectrum and spatial resolution is a result of environmental factors including turbidity and water depth.

- Lack of available data, or pertinent information at an appropriate time.
- Coverage of clouds, especially as it relates to tropical biodiversity and land use.
- Disorganized storage of remote sensing data.
- There are significant gaps in data availability and the ability to analyze pictures across regions.
- The still-considerable expenditures associated with data, especially in the case of very high-resolution images.
- Because of the high price of ground-trothing, remote sensing is rarely used alone; instead, it is paired with targeted ground-trothing.

- Issues of independence.
- Most apps still in development have high scaling costs.
- There is not yet a global body responsible for coordinating space agencies.
- It calls for hard work from dedicated professionals.

Figure 3: Advantages and Disadvantages of Web GIS

Information needs in land resources management

Soil, woods, crops, cattle, and so on all fall under the category of "land resource," as do the land-based elements of the hydrologic cycle (snow cover, soil moisture and associated runoff, subterranean water). The vast majority of these areas are utilized for agricultural purposes such as crop production, animal husbandry, fuel wood and fiber production, and land enhancement. The characteristics of the soil, the slope and degree of roughness, the availability of surface and groundwater, the current land cover and use characteristics, the biological conditions, such as disease and insect infestations of crops, grass land, and forest land, urban development, etc., are all examples of the types of information that are essential for managing land resources. Here are several pressing problems that can be greatly aided by remote sensing:

- ❖ Inventory and mapping of resources.
- ❖ Evaluation of present land use practices and projections for the future.
- ❖ Assessment of land resources which are physically useable and economically relevant.
- ❖ Identification of strategies that offer sustained production and other benefits.
- ❖ Analysis of constraints related to resource development - physical, economic or social.
- ❖ Identification of appropriate corrective and conservative measures required for bringing about the desired production and minimizing the environmental damages.
- ❖ Evaluation of changes in the structure and function of land systems.

REMOTE SENSING APPLICATIONS IN LAND RESOURCE MANAGEMENT AND PLANNING

Soil Resources Management

The soil is the foundation of all agricultural endeavors and a vital renewable natural resource. Soil fertility and natural constraints determine a site's potential yield. For this reason, having access to precise and trustworthy data regarding soil is crucial. This necessitates learning about their composition, distribution, physicochemical properties, and boundaries. Soil surveys offer this data by describing the physical properties of each soil unit and plotting them on a map. Soil mapping at 1:250,000 (NBSS&LUP) and 1:50,000 (IMSD) scales have been made possible because to the enhanced spatial, spectral, and radiometric resolutions of the LANDSAT and IRS satellites.

Mineral Resource Management

The majority of mineral resources do not replenish over time. The identification and evaluation of new sources of minerals is necessary to maintain sufficient reserves of these resources to fulfill future needs. There are four main areas of focus regarding the use of airborne and space-based systems in mineral exploration: structural control at regional scale, integration of data, spectral lithology identification, and the detection of geo-botanical abnormalities. Exploration targets are being defined and characteristics linked to mineralization are being mapped out using geologic, geomorphic, and tectonic data. There is no doubt that remote sensing technologies, by recognizing markers and geomorphologic features, contribute significant information to the recognition and delineation of mineral provinces and target areas, even if they cannot completely replace tried and true methods. A satellite image reveals significant differences between the lime stone formations and the sand stone and shale formations in the Jaintia hills district of Meghalaya.

Water Resources Management

This technology has come a long way from its humble beginnings in surface water inventory, and is now used for a wide variety of complex management tasks, including evaluation and diagnostics of irrigation system performance; nationwide drought monitoring; rainfall estimation; snowmelt runoff forecasts; reservoir sedimentation; watershed treatment; flood mapping and management; and environmental impact assessment. Space-derived data has been used by national and municipal water management programs to improve their effectiveness. Ri Bhoi's potential for inland fisheries development is shown on a map developed by NESAC, which details the district's surface water bodies greater than 0.22 ha. The Meghalayan government's Directorate of Fisheries now has access to these maps. NESAC has also mapped the East Khasi Hills district's ground water potential zones, which can be used to improve the efficiency of bore hole drilling and ultimately bring more potable water to the region.

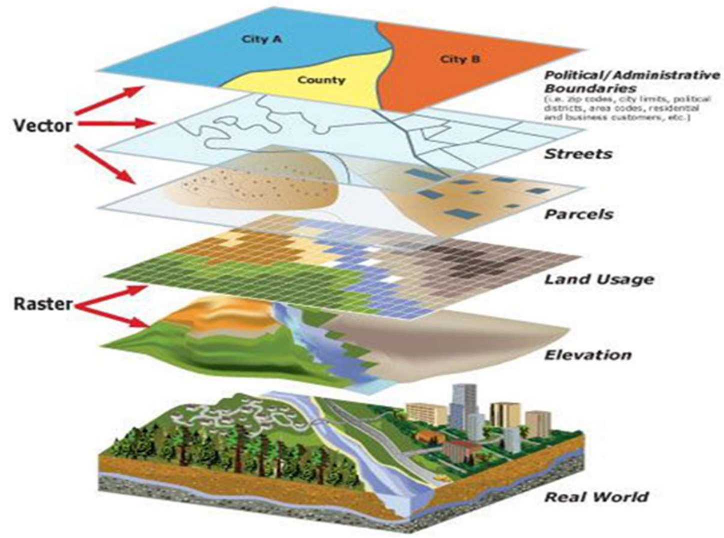

Figure 4: GIS As A Tool for Urban Planning

Application in Agriculture

Recent research has highlighted the potential of remote sensing platforms to provide timely assessments of the agricultural landscape. Precision agriculture is a method of production that encourages adaptable methods of field management based on actual environmental conditions. The system relies on the novel resources and data sets made available by contemporary technologies. technology such as GPS, GIS, yield monitoring equipment, soil, plant, and pest sensors, remote sensing, and variable-rate technology for applicators of inputs are all examples of such innovations. Satellite remote sensing, when combined with GIS, has proven to be an invaluable resource for monitoring changes in both land use and land cover. It generates information useful for analyzing and keeping tabs on land development patterns from relatively inexpensive multi-spectral and multi-temporal data. The ability to store, analyze, and present digital data in a manner that is conducive to change detection and database building is made possible by GIS technology. For example, linear connections between spectral reflectance's or indices and biophysical properties of land surfaces have been utilized to monitor different forms of land cover over time using satellite data. It was put to use in Andaman Island's rice-growing zone mapping and evaluation of soil restrictions.

Forest Management and wildlife habitat analysis

Despite their immense significance to our ecology and the quality of our daily lives, the world's forests have been disappearing at an alarming rate in recent decades. Forest cover is a renewable resource that, with proper management, may be replenished. Thus, a forest manager can use remote sensing data and GIS techniques to generate information about forest cover, including the types of forest present within an area of interest, the amount to which humans have encroached upon forest land or protected areas, the spread of desert-like conditions, and so on. To guarantee that appropriate policies are implemented to regulate and control the use of forest resources, this data is essential for the creation of forest management plans and in the decision-making process. Using multi-criteria analysis, remote sensing data can be used to determine whether or not a given site or forest area is suitable for a given type of wildlife [12-13].

Urban Planning and Development

Conclusions

The enormous rise of our population and the diversity of their needs have continually raised the bar for the efficient use of our land. Food grains for its massive population, raw materials for a robust industrial base, and work opportunities for the bulk of the unemployed are urgent needs right now. Utilizing our land resources in a methodical and effective manner is a key factor in resolving these issues. Information on the state of natural resources and their potential for use, updated regularly, is essential for the development of sustainable land management technology. Combining satellite remote sensing data with other types of data proven to be a powerful tool for fulfilling these specifications. Data storage, processing, analysis, integration, and retrieval were all significantly aided by Geographic Information Systems (GIS). When used in tandem, these cutting-edge technologies pave the way for a potentially useful method in land resource sustainability planning. Each mapped unit of land cover can have properties relating to a database of soil types and erosion features gleaned from conventional sources. The end result is a comprehensive database that may be used for a wide variety of purposes, including environmental protection, urban development planning, agricultural purposes, and forestry.

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