Applications of Remote Sensing and Geographical Information Systems (G.I.S.) in Natural Resource Management

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Abstract

The management of natural resources is important for the development of a country. Due to a rapid increase in the human population and depletion of natural resources, it is essential for a country to learn how to use natural resources (food, fodder, and fuel) in a sustainable manner to ensure the benefits are enjoyed by the present as well as future populations. In recent years, remote sensing and GIS have emerged as important geospatial tools for monitoring the natural resources on Earth's surface. These technologies are widely used for monitoring the health and growth of forests and crops. Incorporating remotely sensed data into a GIS allows for quick calculations and assessments of water levels, water quality, and water-related problems like floods and drought. Remote sensing sensors capture information on earth features like elevation, slope, and drainage pattern, and this data is then integrated with GIS software to extract information on morphometric parameters. Interferometric Synthetic Aperture Radar detects small-scale pre-seismic crustal movements in centimeters, helping to identify areas under an earthquake.

Keywords: Applications, Remote Sensing, GIS, Radar, Satellite Images, SAR and Natural Resource.

1. Definition of Remote Sensing and GIS

Today, there is a huge demand for spatial data by professionals as well as by common users. The need for spatial data is fulfilled by remote sensing and geographical information systems. Remote sensing is the process of gathering information about an area without physically entering that particular area. Remote sensing is the common name for all methods used to collect data at a distance from the object under study by some kind of recording device (Ulrik Martensson, 2011). Aircraft and satellites are the two common platforms for remote sensing of the earth and natural resources (Robert Sanderson, New Mexico Space Grant Consortium). A geographical information system is a computer-based tool that allows us to capture, store, manipulate, analyze, manage, and visualize geographical data. GIS uses a collection of software programs for image processing, overlay operation, buffer analysis, and statistical procedure.

2. Applications of Remote Sensing and GIS

2.1. Applications in crop area estimation

The crops have vital importance for humans and their livestock. Remote sensing can make cost-effective, accurate estimates of crop area. Among various forms of satellite data, optical remote sensing data with higher resolution are preferred for crop delineation and acreage estimation due to the capability of interacting directly with the object under investigation (Sabthapathy, M et al., 2022). The surface reflectance of objects under the visible and infrared regions of the electromagnetic spectrum results from the characteristics of the object, which exhibit different reflectance patterns during different growth stages pertinent to their biophysical characters like moisture, canopy cover, leaf area, and chlorophyll content. SAR imagery has an advantage in overcoming cloud cover and the potential for delivering data in all conditions. Classification is the most followed strategy for extracting information from remote sensing imagery. The information from the classified image is depicted thematically for better and easier visual interpretation.

2.2 Applications in crop monitoring and damage assessment

Remote sensing has a number of ways that lend themselves to monitoring the health of crops. One advantage of remote sensing is that it can see beyond the visible wavelengths into the infrared, where wavelengths are highly sensitive to healthy crop growth as well as crop stress and crop damage. The spectral reflection of an area will vary with respect to changes in the crop health, and that can be measured and monitored by multispectral sensors. It is possible to detect stress in plants by using remote sensing techniques due to physiological changes caused by stress (Menon ARR 2012). Remote sensing can aid in identifying crops affected by insect, weed, and fungal infestations and weather-related damage. Images can be obtained throughout the growing season to not only detect problems but also to monitor the success of the treatment.

2.3. Applications in forest and deforestation mapping

Forests are an important renewable natural resource. There is nothing as practical and cost-efficient for monitoring a timely regional overview of forest cover as a remote sensing device. The Landsat sensors TM and ETM+ can provide the imagery with the longest time series with temporal coverage of the same area, which can be used for monitoring changes in the vegetation cover. Images of earlier years are compared to recent images to measure the differences in the sizes and extents of the forest area. According to Singh (1989), change detection is the process of identifying differences in the state of an object by observing it in different times. The rising human population led to deforestation for settlement and agriculture. The remote sensing serves as monitoring tool to monitor deforestation to ensure that companies are following cutting guidelines and specifications. All remote sensing devices, however, provide a view of often remote and inaccessible areas, where illegal cutting could continue unnoticed for long periods of time if aerial surveillance wasn't possible. High-resolution data provide a detailed view of forest depletion, while radar can provide a view that may otherwise be hidden by clouds.

2.4. Applications in forest health and forest fire monitoring

In remote sensing the normalized difference vegetation index (NDVI) is used to measure the greenness of vegetation. The difference between near infrared (which healthy plants reflect strongly) and red (which plants absorb). NDVI values range from -1 to +1, with values closer to 1 indicating healthy vegetation and near to 0 representing barren lands. The one of the major problem in forest area is forest fire. It is important to have correct and timely knowledge of the total area burned and the type of forest burned. Remote sensing can be used to monitor forest fires and the regrowth following a fire. The routine sensor scanning facilitates observing inaccessible areas and alerting monitoring agencies to the presence and extent of a fire. NOAA AVHRR thermal data and GOES meteorological data can be used to demarcate active fires and remaining "hot spots." Comparing burned areas to active fire areas provides information as to the rate and direction of movement of the fire. Years following a fire, updates on the health and regenerative status of a forest can be obtained by a single image, and multi-temporal scenes can illustrate the progression of vegetation from pioneer species back to a full forest cover.

2.5. Application in structural mapping

A synoptic view of the regional scale is a much different perspective than point ground observations when trying to map structural elements. Remote sensing offers this perspective and allows a geologist to examine other supportive references simultaneously, such as geomagnetic information. Certain remote sensing devices offer unique information regarding structures, such as the relief expression offered by radar sensors. Comparing surface expression to other geological information may also allow patterns of association to be recognized. The Landsat imagery of northern part of Orissa where large regional structure of Simlipal basin is seen in image. Many other important structural features such as Pal Lahara fault, folded iron ore group rocks etc. are seen in the same image (S.K Bhan1983)

2.6. Applications in ocean surface and organism mapping

Remote sensing offers a number of different methods for acquiring information on the ocean and coastal region. Scatterometers collect wind speed and direction information. Altimeters measure wave height. SAR is sensitive to spatially varying surface roughness patterns caused by the interaction of the upper ocean with the atmosphere at the marine boundary layer. The scanning radiometers and microwave sounders collect sea surface temperature data. The information collected by automated instruments can be combined with remote sensing data to produce image maps displaying such things as hurricane structure with annotated wind direction and strength and wave height. SAR data can provide additional information on current, wave, and medium-scale features so as to observe trends over time when optical data are not available due to periods of cloud cover. The above information can be useful for offshore engineering activities, operational activities, and storm forecast operations. Many commercial fishing and aquaculture operators use this information to predict catch sizes and locate potential feeding areas.

2.7. Applications in oil spill detection

An oil spill is the release of oil into the environment, especially in the ocean. Remote sensing has the advantage of being able to observe events in inaccessible areas. Remote sensing can be used to detect the exact location of the oil spills from broken pipelines. It can differentiate phytoplankton and oil spills on the surface of the ocean. For ocean spills, satellite data can provide information on the rate and direction of oil movement through multi-temporal imaging. The SAR sensor has an advantage over optical sensors, as it can provide data under poor weather conditions and in the dark. Users of remotely sensed data for oil spill applications include the coast guard, national environmental protection agencies and departments, oil companies, the shipping industry, the insurance industry, the fishing industry, national departments of fisheries and oceans, and departments of defense.

2.8. Applications in ice types, concentration, and motion

Remote sensing satellite sensors provide the exact area under ice. The areas of ice can be easily demarcated from a satellite image. The microwave energy and imaging geometry combine to provide measures of both surface and internal characteristics of ice. Surface texture is the main contributor to the radar backscatter, and it is this characteristic that is used to infer ice age and thickness. New ice tends to have a low return and therefore a dark appearance on the imagery due to the regular reflection of incident energy off the smooth surface. Old ice has a bright return due to irregular scattering from its low salinity and porous structure. Sea ice and water emit substantially different amounts of radiation, so it is relatively easy to delineate the interface between the two. Remote sensing gives a tangible measure of direction and rate of ice movement through mapping and change detection techniques. Floating ice actually have individual morphological characteristics (shape, structures) that allow them to be distinguished from one another. The floes can be mapped, and their movement monitored for planning optimum shipping routes. Users of this type of information include the shipping, fishing, and tourism industries, as well as engineers involved in offshore platform and bridge design and maintenance.

2.9. Applications in soil moisture

Soil moisture is the water that is in the upper 10 cm of soil, where soil moisture is available to plant roots (Lingli Wang, John J. QU 2009). Remote sensing offers a means of measuring soil moisture across a wide area instead of at discrete point locations. RADAR is effective for obtaining qualitative imagery and quantitative measurements because its backscatter response is affected by soil moisture. Keeping the latter elements static, multi-temporal radar images can show the change in soil moisture over time. The radar is actually sensitive to the soil's dielectric constant, a property that changes in response to the amount of water in the soil. Users of soil moisture information from remotely sensed data include agricultural marketing and administrative boards, commodity brokers, large-scale farming managers, conservation authorities, and hydroelectric power producers.

2.10. Applications in monitoring of water quality

Water is an important natural resource for the growth of fauna and flora. Water is available in the form of saline water bodies and fresh water bodies (lakes, rivers, snow, and groundwater). The domestic and industrial waste lead to deterioration of water quality. The monitoring of water must be done on a regular basis, and remote sensing and GIS play important roles in this regard. Hyper spectral images enable the identification of water constituents based on their unique spectral signature. By studying the reflected energy from water bodies, one can extract information about chlorophyll-a concentration and dissolved organic and inorganic matter. Although inland waters (e.g., lakes, rivers, reservoirs) usually have a higher range of Chlorophyll a and thus a stronger signal, the independent variations in colored dissolved organic matter and particulates have impeded the routine extraction of Chlorophyll a from ocean color measurements inshore (Norsaliza Usali et al., 2010). The suspended sediments increase the radiance from surface water in the visible and near-infrared ranges of the electromagnetic spectrum (Ritchie and Charles, 1996). The information regarding water properties extracted through spectral signature can easily be represented by various GIS software.

2.11. Applications in flood delineation

According to the Food and Agriculture Organization, a flood is an excessive flow of water over land that is usually submerged. Floods cause significant loss to human lives and property. Remote sensing techniques are used to measure and monitor the areal extent of the flooded areas and provide quantified estimates of the amount of land and infrastructure affected by the flood. Unifying remotely sensed data into a GIS allows us for quick calculations and assessments of water levels, damage, and areas facing potential flood danger. Users of this type of data include the flood forecast department, hydropower companies, city planning and emergency response departments, and insurance companies (for flood compensation). The identification and mapping of floodplains, abandoned river channels, and meanders are important for planning and transportation routing.

2.12. Application in drought management

The World Meteorological Organization (WMO) defines drought as a prolonged dry period in the natural climate cycle that can occur anywhere in the world. It negative impacts on the environment, food security, and migration. Remote sensing collects soil moisture data in the surface layer up to 2-5 centimeters below the ground over a large area. Soil moisture is a crucial parameter for early warning of drought. Deficient rain is one of the leading causes of drought events. The visible and infrared techniques and passive and active microwave sensors are used to estimate rainfall through cloud demarcation in satellite imagery and forms of precipitation in the atmosphere. The satellite-based surface temperature estimation is among the indicators of drought monitoring. A low rate of evaporation from plants is a sign of drought. Groundwater plays a critical role in the growth of plants, and remote sensing data, such as humidity, rainfall, and temperature, are used to monitor the amount of groundwater. A deficit in snowpack of a given area could lead to hydrological drought. The reduction in snowpack led to a reduction in soil moisture, water storage, fisheries, vegetation, and irrigation. Therefore, monitoring snow using remote sensors is important to drought assessment.

2.13. Applications in earthquakes

An earthquake is a shaking of the earth's surface. Most of the world's epicenters (a place where an earthquake first arrives) are found along convergent boundaries where tectonic plates collide. The epicenter maps (earthquake-resistant structures) are prepared by remote sensing techniques and geographical information systems. Apart from the earthquake data, geological factors, structural design, soil data, etc., are used to prepare earthquake-resistant structures or seismic zones. Upgrading seismic zones is a continuous process. Moreover, Interferometric Synthetic Aperture Radar detects small-scale pre-seismic crustal movements in centimeters, helping to identify areas under high stress. The post-earthquake damage can be identified through satellite images. The one meter resolution image of Bhuj, Gujarat taken by IKONOS satellite on February 2, 2001 shows extensive damage to individual building as a result of earthquake that struck Bhuj on January 26, 2001(Nirupama, 2002).

2.14. Applications in digital elevation models

According to the United States Geological Survey, "a digital elevation model is a graphical representation of the bare ground surface of the earth, excluding trees, buildings, and any other surface objects." Generating DEMs from remotely sensed data can be cost-effective and efficient. A variety of sensors and methodologies to generate such models are available. Two primary methods of generating elevation data are 1. Stereogrammetry techniques. 2. Interferometry radar, or InSAR (Synthetic Aperture Radar). Stereogrammetry involves the extraction of elevation information from stereo overlapping images, typically air photos. 2. Interferometric radar, or InSAR, is a technique that uses two or more radar images of the same area, taken at different times and positions, to map topography. The InSAR can detect even millimeter-scale movements by analyzing the differences in the phase of radar waves. In geographical information systems, the Shuttle Radar Topography Mission (SRTM) is used for obtaining elevation data on a global scale to generate a complete, high-resolution digital topographic database of Earth.

2.15. Applications in the morphometric analysis

The morphometric parameters of the drainage basin include linear, areal, and relief aspects. The morphometric study of the drainage basin represents the prevailing climate, geology, geomorphology, and geo-hydrological behavior of the region (R. E. Horton, 1945). Remote sensing techniques can be used for mathematical measurement of features of the earth's surface like elevation, slope, and drainage pattern. Survey of India Topo-sheets and ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) elevation data can be used for the generation of a digital elevation data model (Amit Bera et al., 2018). Then information on morphometric parameters such as slope, stream order, and drainage density can be extracted using GIS software like ArcGIS 10.1. The advantage of the use of the remote sensing technique is that it generates quantitative data on landforms, which can be used to support scientific research.

2.16. Applications in solid waste management

Solid waste includes waste from home, factories, and farms. To save the health of people and the surrounding environment, the management of solid waste is an urgent requirement of cities. Remote sensing is an important tool for solid waste management. The satellite imagery and sensors help in identifying potential landfill sites, monitoring waste disposal sites over time, mapping waste distribution and characteristics, and assessing the environmental impact of solid waste. Remote sensing can analyze various factors such as land cover, soil type, and proximity to roads and acumen settlement to find the most suitable site for solid waste. Satellites provide periodic data that allows for continuous tracking of existing solid waste sites, including their growth and changes over time. High-altitude aircraft and satellite data can provide information on solid waste distribution, characteristics, and estimation of solid waste quantities for a given area.

Conclusion:

Remote sensing and GIS collect, store, manipulate, analyze, integrate, and represent natural resource data in less time and with less effort. Remote sensing with high-resolution images is widely used for agricultural purposes, especially for the estimation of crop area and monitoring crop growth and crop damage. Images of earlier years are compared to recent images to measure the differences in the sizes and extents of the forest area. NOAA AVHRR thermal data and GOES meteorological data can be used to demarcate active fires and remaining "hot spots." Comparing burned areas to active fire areas provides information as to the rate and direction of movement of the fire. Incorporating remotely sensed data into a GIS allows for quick calculations and assessments of water levels, water quality, and water-related problems like flood and drought. Remote sensing sensors capture information on Earth features like elevation, slope, and drainage pattern. This data is then integrated with GIS software to extract information on morphometric parameters such as slope, stream order, drainage density, and water characteristics. The satellite imagery and sensors help in identifying potential landfill sites, monitoring waste disposal sites, mapping waste distribution and characteristics, and assessing the environmental impact of solid waste. Interferometric Synthetic Aperture Radar detects small-scale pre-seismic crustal movements in centimeters, helping to identify areas under an earthquake. The areas of ice can be easily demarcated from a satellite image. The microwave energy and imaging geometry combine to provide measures of both surface and internal characteristics of ice.

Abbreviations: VIR- Visible and Infra-Red, AVHR- Advanced Very High Resolution Radiometer, GOES- Geostationary Operational Environmental Satellite, SAR- Synthetic Aperture Radar, GIS-Geographical Information System, DEM- Digital Elevation Model, and RADAR- Radio Detection and Ranging, and NDVI- Normalized Difference Vegetation Index and ETM+- Enhance Thematic Mapper Plus. and ASTER - Advanced Space borne Thermal Emission and Reflection Radiometer.

References :

1. Sabthapathy M. et al. 2022. "Remote sensing for crop area estimation." IIP proceedings volume 2, book 16, part 1, chapter 31.
2. Kumar N, Yamac S. S., and Velmurugan. "Application of Remote Sensing and G.I.S. in Natural Resource Management." Journal of the Andaman Science Association Vol. 20 (1) 1-6 (2015).
3. A Canada Centre for Remote Sensing, "Fundamentals of Remote Sensing"
4. Joy Sanyal and X.X. Lu. 2003. "Application of remote sensing in flood management with special reference to Monsoon Asia: Review." Natural Hazards 283-301.
5. Bimla Verma 2025 "A spatial analysis of post-monsoon surface moisture using MODIS data in Haryana." Sodhpatra: International Journal of Science and Humanities, Volume-2, Issue 9.
6. Virendera Kumar, Kamal Yadav, V. Rajmani 2014 "Selection of suitable site for solid waste management in part of Lucknow city, Uttar Pradesh using remote sensing, GIS, and A.H.P. Method." International Journal of Engineering Research and Technology, Vol. 3, Issue 3.
7. Lingli Wang, John J. QU 2009 "Satellite remote sensing applications for surface soil moisture monitoring: A review."
8. Khalifah Insan and Muhammad Dimyati, 2021. "Remote sensing and GIS application for monitoring drought vulnerability in Indonesia: a review." Bulletin of Electrical Engineering and Informatics, Vol. 10, pp. 3507–3518.
9. Shibendu Shankar Ray Remote sensing applications: Indian experience, Mahalanobis National Crop Forecast Centre, New Delhi, 251-264.
10. David 2023. "Applications of Remote Sensing in Drought Management." Grid GIS Com.
11. Samikshya Panda, V S Yadav, and VK Tirpathi 2024 "Application of Remote Sensing in Natural Resource Management." Journal Springer Sustainable Development and Geospatial Technology, Volume 2.
12. Robert Sanderson, "Introduction to remote sensing," New Mexico Space Grant Consortium.
13. Ulrik Martenson, 2011, "Introduction to remote sensing and geographical information systems," Department of Physical Geography and Ecosystem Science, Lund Univ.
14. Bhan S.K and Krishnanuni K, 1983, "Application of remote sensing technique to geology"Indian Acad. Sci. (Engg. Sci.) Vol. 6 December 1983 pp 297-311.
15. Norsaliza Usali & Mohd H. Ismail, 2010, "Use of remote sensing and GIS in monitoring water quality," Journal of Sustainable Development, vol. 3, September 2010.
16. Nirupama, 2002, "Role of remote sensing in disaster management," ICLR Research Paper series—No. 21.
17. Amit Bera et al., 2018, "Morphometric Analysis of Adula River Basin in Maharashtra, India, using GIS and Remote Sensing Techniques," Geo-spatial Data in Natural Resources, 13—35, 2018.