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COMPREHENSIVE RESEARCH ON REMOTE SENSING AND GIS IN ENVIRONMENT MANAGEMENT WITH DATA ACQUISITION

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Abstract
Environment mapping, mineral exploration, agriculture, forestry, geology, water, ocean, infrastructure planning and management, disaster mitigation and management, etc. all benefit greatly from the use of remote sensing and geographic information systems. Remote sensing and geographic information systems (GIS) have been more important over the past few decades as means of gathering data on nearly every facet of the planet. There has been a proliferation of uses for satellite data with high spatial and spectral resolution in recent years. Over the past four decades, remote sensing and geographic information systems (GIS) have made substantial contributions to India's development efforts. In this work, we look at how remote sensing and GIS can be used to address a variety of environmental concerns, including those related to mining, cities, the ocean, and landfills.
Keywords: Environmental studies; Satellite imagery; GPS; Global positioning system.

Introduction

In our everyday lives, the environment is something we interact with frequently. It includes the air we breathe, the water that covers most of the earth's surface, the plants and animals in our immediate vicinity, and everything else that has an impact on our ability to sustain life here on Earth. Recent years have seen intense research into humanity's environmental impacts. Researchers have discovered that human activity is a major contributor to environmental hazards such as air pollution, deforestation, acid rain, and more. When people refer to "the environment" these days, they usually mean the state of Earth as a whole [1-5].

Since the problem's scope has grown from local to regional to global with the turn of the millennium, humanity is now confronted with environmental concerns of unprecedented size. Humanity's impact on the Earth's systems continues to grow, to the point where it is now significant in virtually every sector. Unsustainable development in many regions of the world, as well as global climate change and the threat of biological and chemical warfare and terrorism, are emerging as major challenges for the survival of humanity and the planet. Human-induced changes have affected Earth's systems and environment in numerous ways, such as acidification of surface waters, loss of biotic integrity and habitat fragmentation, eutrophication of lakes and streams, and bioaccumulation of toxic substances in the food supply [6].

All across the world, people are working on a wide variety of industrial and power sector development projects. Whatever the causes of the changes, they have all contributed to a worsening of the local ecology. Environmental impact studies (EIS) with regards to every sector need to be researched in an integrated manner, giving top priority to environmental conservation, because of the lack of an appropriate data base on the pre-establishment stage, the developmental stage, and the post-developed stage. Damage to agriculture and human health from increased air pollution and dust storms. There needs to be a suitable alternative strategy to compensate for the losses caused by the clearance of forest for hydro power projects, rising urbanization, industrialization, mining, etc. Using examples from the mining environment, urban waste management, coastal, wetland, and marine environment management, this article demonstrates the use of remote sensing and GIS in these broader environmental challenges [7-15].

Remote Sensing

The term "remote sensing" refers to the study and practice of gathering data (spectral, geographical, temporal) about a target without actually touching it. In the absence of physical contact, it will be necessary to employ some method of transmitting data over great distances. Transmission of data in remote sensing is achieved by electromagnetic radiation (EMR). There are several ways in which remote sensing technologies could help with invading force detection, mapping, and monitoring. Space-based remote sensing is the gold standard for collecting both temporally-repeated (over minutes to days) and spatially-synoptic (over local to regional scales) data on the spectral behavior of objects in the environment.

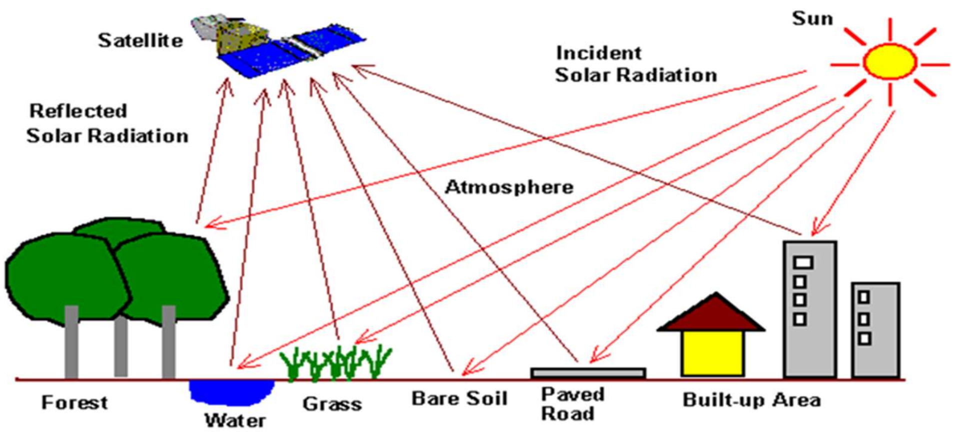

Figure 1: Principles of Remote Sensing

Changes (degradation) in the land surface, water quality, soil, and air all play a role. Many plant and animal species' ranges, as well as their ecosystems, landscapes, bio-climatic conditions, and invasion facilitators, have been mapped using integrated GIS and remote sensing. Since 1972, most of the Earth has been imaged by remote sensing satellites. Multiple satellite images taken at different times of year can be used to spot significant shifts in land cover and measure their rates of change. Landsat TM images have been analyzed and interpreted since 1987, revealing a wealth of data on the region, notably with regards to the varied land uses and the accompanying environmental problems. The field of environmental science is increasingly relying on remote sensing data. It wasn't until the 1980s that satellite photos were employed for anything more than background mapping or straightforward interpretation [16-21].

Multispectral remote sensing

The foundation of multispectral remote sensing is the simultaneous collection of picture data of the Earth's surface at a variety of wavelengths. Since different surfaces reflect light of different wavelengths with varying intensities, this can be used to our advantage. Depending on the spatial, spectral, and radiometric resolution of the employed sensor, different spectral behavior is leading to comprehensive classification of specific types of land surfaces. Acquiring images in a number of different wavelength bands is what multispectral remote sensing is all about. Materials vary in their ability to reflect and absorb light at various wavelengths. Therefore, spectral reflectance characteristics can be used to distinguish between materials in these remotely sensed images, allowing for differentiation where direct identification would otherwise be impossible.

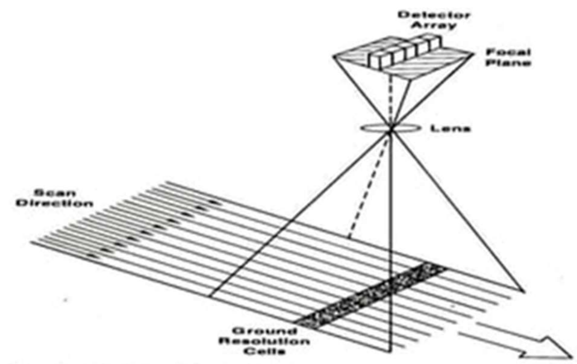

Figure 2: Multispectral remote sensing

The NASA multispectral imager Landsat is used to keep tabs on a wide variety of features at the landscape level. Before the advent of Hyperion and other aerial hyperspectral data, environmental impact feasibility mapping was often performed using multispectral remote sensing data. The use of multispectral satellite data is crucial for tracking changes over time and keeping tabs on the long-term effects of mining on the ecosystem. Synthetic Aperture Radar pictures can also be used to detect morphological changes in land use caused by mining [22-25].

Hyperspectral remote sensing

When compared to multispectral data, which often consists of hundreds of adjacent spectral bands with limited spectral coverage, hyperspectral data offers numerous benefits. Reflectance spectra and high spectral resolution make it possible to directly identify materials based on their reflectance properties. Material spectra can be measured, allowing for the high-resolution identification of minerals, rocks, soils, and plants as well as the tracking of their temporal shifts across time. Successful applications for the detection of mine waste have been reported due to its ability to resolve mineral absorption characteristics [26].

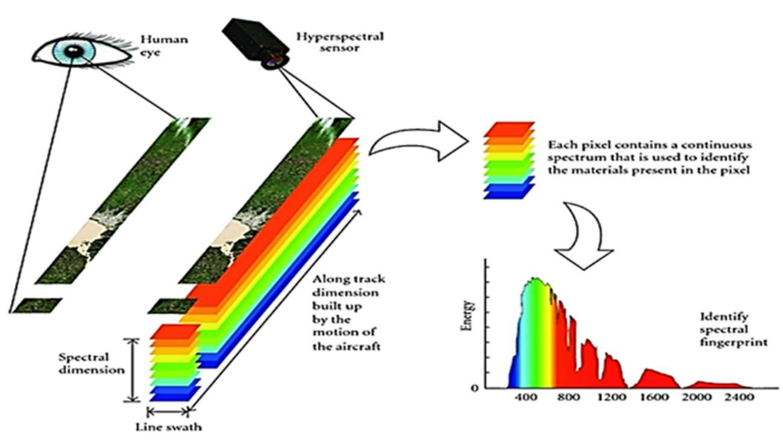

Figure 3: Hyperspectral remote sensing

Geographic Information System

Collecting, storing, analyzing, disseminating, and manipulating data that can be tied to a specific location are all tasks that can benefit from the usage of a geographic information system (GIS). Representative GIS application areas include improving the quality of both short- and long-term decision-making in regards to transportation, local government, and business, as well as addressing social and environmental issues. To collect, store, retrieve, process, and display spatial data from the real world for specific purposes, GIS is a potent set of tools, as defined by Burrough and McDonnell (1998). When it comes to environmental planning and management, GIS is making huge strides. Remote sensing and field-based analysis now have far-reaching implications thanks to Geographic Information System (GIS) technology.

Over the past two decades, GIS as a discipline and field has seen profound changes. Although GIS was once an underdog technology, it has quickly developed into a multibillion-dollar enterprise and a prominent player in the broader field of ubiquitous information technology. The utility and demands for GIS technology have grown as a result of developments in computer hardware and software, the availability of large volumes of digital data, the standardization of GIS formats and languages, the increasing interoperability of software environments, the sophistication of geo-processing functions, and the rising use of real-time analysis and mapping on the Internet. In addition, scientists, planners, and policymakers are beginning to appreciate GIS for its potential to advance environmental concerns. When used to analyze and control the effects of human activities on the environment, GIS can shed light on previously opaque processes [27-30].

Applications

An approach has been made in this research to review the applications of remote sensing and geographic information system applications to the mining environment, the management of the urban environment, the coastal and marine environment, the wasteland environment, and other environments [31].

Mining Environment

Because of its multispectral mode, synoptic view, and repeating coverage, the application of remote sensing techniques in mining environmental studies has a number of distinct features that set it apart from other approaches. Because of recent advancements in high resolution multispectral satellite data and imaging spectrometry, researchers now have access to great tools with which to investigate the environmental damages caused by mining activities. Remote sensing techniques have been successfully employed to monitor the land use changes that have occurred as a result of opencast strip mining, the influence of underground mining and subsidence, the progression of the dumping of mine wastes, and the erosion that has occurred as a result of mining activities.

Changes in the ecosystem are brought about by mining in a way that is both rapid and significant. Monitoring these kinds of environmental shifts is becoming an exceedingly challenging task due to the fact that the mining area is home to a variety of complicated difficulties and is subject to consistent alterations in its topography. Mining not only directly alters the terrain, but it also frequently makes it possible to release harmful compounds into the atmosphere. The impact of this shift might range from relatively trivial to very significant occurrences. Techniques for hyperspectral remote sensing have the potential to give essential information on a variety of environmental factors, including land use, changes in land cover, the status of vegetation, the quality of soil water, and the locations of acid mine drainage.

The field and laboratory-based radiometric approaches have been used successfully to forecast certain aspects of surface features, including water bodies, grasslands, minerals and rocks, forests, crops, and various other surface features, based on their reflectance spectra.

Environmental monitoring data collected from neighboring areas of mining region water quality, mineralogical, and gecochemical research. The problem of environmental monitoring and land-use/land cover changes over the lignite open-cast mine and power plant area was investigated using airborne remote photography along with Landsat TM and SPOT imageries in the central part of Poland by Mularz. The goal of this research was to differentiate, evaluate, and even measure these destructive phenomena. Prakash and Gupta investigated the impact of coal mining on land use by employing remote sensing techniques at the Jharia coal field. Their findings showed that coal mining had a negative impact on land usage. Open pit mining activities, such as those for lignite and other resources, are responsible for the destruction of rich agricultural land, the disappearance of surface water bodies, and the depletion of ground water in deeper aquifers.

According to Ramanathan et al. (2000), the oxidation process that takes place at the surface of dumped mining waste has the potential to produce acid water drainage. This can have an impact on the quality of both surface and groundwater. (Das and Nizamuddin, 2002) have successfully utilized the hyperspectral sensor ('Hyperion') data to map the mineral abundance, lithological mapping, and processing methodology for detecting iron and manganese mines in parts of Singhbum district, Orissa. They have also successfully utilized spectral signature and spectral mixture modeling techniques for targeting laterite and bauxite ore deposits. Levesque et al., (2001) monitored and evaluated the process of rehabilitating mine tailing sites using hyperspectral remote sensing data. Chevrel et al. (2001) used airborne hyperspectral remote sensing sensors to great effect in order to analyze the mining-related contamination and its influence on vegetation in six different mining regions across Europe and Greenland. Using hyperspectral data analysis, Ellis et al. (2004) were able to identify a variety of main granites as well as kaolinization that occurred afterward in the mining region. In their study of underground mining, Lalan Kumar et al. (2007) employed Geographical Information system to analyze a variety of factors, such as land ownership and mineral claims, exploration management production, and mine site.

Infra-red imaging with multiple time periods It was determined by Akiwumil and Butler (2007) that using Landsat pictures was the most effective method for researching environmental shifts in Sierra Leone, which is located in West Africa. According to Satish Kumar et al. (2011), there was an attempt made to identify the magnesite ore deposits in Salem by utilizing hyperspectral remote sensing data. This endeavor demonstrates the potential of employing narrow band hyperspectral data for further mapping of the impact mining has on the ecosystem. The management and controlling components of the environment that has been impacted due to mining must be implemented both during production and after the mine has been closed. For the purpose of controlling and planning the environmental management, sufficient data should be collected, and it should be processed accurately. This should be done with regard to both place and time [32-36].

Urban Environment Management

An indicator of the transition from traditional agricultural economies to contemporary industrial economies is urbanization. It refers to the gradual accumulation of people within an urban area. The global population has increased dramatically over the course of the past fifty years, and as a consequence, most urban settlements are characterized by shortages in stock housing and water supply, urban encroachments in fringe area, inadequate sewerage, traffic congestion, pollution, poverty, and social unrest, making it a difficult task for urban governance to maintain a healthy urban environment. The high rate of urban population expansion is a source for worry among urban and town planners in India for the purpose of achieving efficient urban planning. Therefore, there is an immediate need to adopt contemporary technology of remote sensing, which includes systems that are based both in the air and on satellites. This will enable us to gather a large amount of physical data very easily, quickly, and on a repeating basis, and will, in conjunction with GIS, enable us to evaluate the data in a geographical context.

Floods inflict harm to natural resources and environmental quality and indirectly contribute to increased poverty. This, in turn, further adds to the vulnerability of both natural and human systems, particularly in urban areas as compared to rural ones. Many environmental activities, such as reforestation, forest protection, upland permanent farming, and resettlement, might have been undertaken by remote sensing and geographic information systems (GIS). This linkage between the environment and floods has been identified.

GIS has seen widespread application in characterization and assessment studies, particularly those that call for a watershed-based approach to the management of water level and waste management in metropolitan settings. Digital Elevation Models (DEMs), which are easily accessible, can be used to infer the fundamental geological and hydrological features of a watershed, such as its flow routes and drainage network. When faced with challenges involving water quality and quantity as a result of natural as well as human-induced hazards (for example, droughts, hazardous material spills, floods, and urbanization), planning becomes extremely important in order to mitigate their impacts and ensure optimal utilization of the available resources.

According to Patkar (2003), remote sensing can serve as a valuable source of data for the mapping of urban land use and land cover as well as for environmental monitoring. A number of important studies were conducted for the purpose of environmental quality management. Unchecked urbanization is to blame for a variety of issues that our cities are currently confronted with. These issues include a terrible living environment, acute difficulties with drinking water, noise and air pollution, disposal of garbage, traffic congestion, and other similar issues. Technology advancement in related disciplines has to solve the difficulties generated by fast urbanization in order to mitigate the environmental degradations that are occurring in and around cities. Only then can the benefits of development trickle down to those who are the most economically disadvantaged. Together with GIS, the modern technology of remote sensing, which includes both aerial and satellite-based systems, enables us to collect physical data rather easily, quickly, and on a repetitive basis. Additionally, this technology enables us to analyze the data spatially, which offers the possibility of generating a variety of options (modeling), thereby improving the efficiency of the entire planning process.

Due to the dynamic character of the urban environment, analysis at both the macro and the micro level are required. Because of this, it is essential for those who determine policy to include remote sensing into urban planning and administration. The application of remotely sensed data in urban studies had its start with first-generation satellite sensors like Landsat MSS. A number of second-generation satellites like Landsat TM, ETM+, and SPOT gave the trend a significant boost. Excitingly, a third generation of very high spatial resolution satellite sensors with a pixel size of 5 meters or less has just recently become available. The high-resolution PAN data and the LISS III merged data have the potential to work well together for usage in urban applications. According to Rai and Kumra (2011), the data from IRS P-6 satellites with sensors on board, particularly LISS IV Mono and Multispectral (MX) with 5.8 m/pixel spatial resolution, is very helpful for in-depth research on metropolitan areas [37-39].

Coastal and Marine Environment

Coastal zones in India are constantly undergoing wide-ranging changes in shape and environment due to natural as well as human development activities. Natural processes such as waves, erosion, changes in river courses etc., cause long time effect at slower rate; but manmade activities, such as settlement, industrial activities, recreational activities, waste disposal etc., affect the coastal environment at comparatively much faster rate. Continued loss of these wetlands may lead to the collapse of coastal ecosystems. It is, therefore, necessary to monitor coastal zone changes with time. Remote sensing technology in recent years has proved to be of great importance in acquiring data for effective resources management and hence could also be applied to coastal environment monitoring and management. The high temporal resolution provided by the satellite data is found to be a major improvement in studying the behavior of suspended sediments in the coastal waters, which would help in understanding the movement of sediments and pollutants.

GIS in addition to providing efficient data storage and retrieval facilities also offers a cheaper option of monitoring forest conditions over time. Remote sensing and GIS are increasingly used in mangrove forestry worldwide to assist in gathering and analyzing images acquired from aircrafts, satellites and even balloons. The notable advantages of using GIS include the ability to update the information rapidly, to undertake comparative analytical work and making this information available as required. The area covered by mangroves in the islands of Andaman was calculated using SPOT 1993 and IRS 1D LISS III 2003 imageries. The change in mangrove area within a span of ten years has presented in the form of a table (IOM report, 2003). Twumasi and Merem (2006) assessed change within a coastal environment in the Niger delta region of Nigeria using remotely sensed satellite imagery and GIS modeling, quickened the analysis of the spatial distribution of environmental change involving land use, land cover classification, forest and hydrology and demographic issues facing the Niger Delta and successful implemented some of the strategies could lead to effective management of the coastal environment in the Niger Delta region.

Satellite based remote sensing techniques have proved successful in providing a comprehensive, reliable and up-to date information on land use/land cover in the offshore areas of east coast of Andhra Pradesh in the most cost-effective manner. Environmental Sensitivity Index (ESI) and Reach Sensitivity Index (RSI) identified through modern methods like Digital Image processing and GIS for preparedness in case of oil spill incidents in offshore areas. The combination of remote sensing and GIS technologies provides an ideal solution for understanding the spatial/temporal distribution of oil spills in the marine environment and is considered as the core of the oil spill monitoring system. The advantages of the remote sensing and GIS provides the ability to extract the oil pollution parameters such as location and spill areas including spatial and temporal information allows the users to establish the major cause and source of oil spills and then outline the risk areas to save the marine environment. One of the major advantages of GIS is the ability to extract oil pollution parameters such as location, size and spill areas. Spatial and temporal information (oil spill distribution at sea and its evolution in time) allows the users to establish the major cause and source of oil spills, and then outline the risk area. The products derived from geospatial technologies support informed decision making with respect to marine spatial planning and management [40].

Wasteland Environment

Wetlands account for only 3–6% of the Earth's land area, but they provide essential resources and functions such as floodwater retention, wildlife habitat, and soil erosion management. Wetlands are a transition zone between the terrestrial and aquatic systems; they help with flood mitigation, water quality management, wildlife habitat, and soil erosion control, among other things. Wetlands and the uplands surrounding them need to be monitored and catalogued in order to slow their decline, protect the ecology they support, and ensure that future generations can benefit from the wealth of life found there. Wetland area has been steadily declining over the past few decades as a result of human activities such wetland reclamation, population growth, water diversion, dam building, pollution, biological invasion, desertification, global warming, and poor policymaking. The qualitative and quantitative changes in land cover on Earth have been measured using remotely sensed data. Over the past two decades, many different approaches to detecting changes using remotely sensed data have been developed and evaluated.

The spatial-temporal dynamic multiplicity and distribution of wetlands can be monitored with the help of RS data and GIS. Remotely sensed data from satellites have been used extensively for wetland inventory and monitoring, and they can also reveal trends in the use of land in the area over time. Using four Landsat images from 1985 (Landsat MSS), 1999 (Landsat ETM+), 2002 (Landsat ETM+), and 2011 (Landsat ETM+), Ghobadi et al. (2012) successfully used Multi-temporal remote sensing data and GIS to map wetlands near the Karkheh River in southwestern Iran and discovered that increased agricultural activity, climate change, and construction engineering projects had reduced the wetlands' surface area. The use of satellite remote sensing offers various benefits, including the ability to keep track of wetland areas, track changes in land use, and more. Wetland classification and its spatial-temporal dynamic change are typically analyzed using Landsat MSS, TM, or SPOT data.

As satellite data may be re-visited at any time of year or any season, wetland areas can be tracked on both of these time scales. Remote sensing data can be used to classify land cover at a fraction of the expense and in a fraction of the time required by using aerial photography. In poor nations, when funds are tight and data on the wetland, such as wetland acreage, landuse, and wetland losses, are scarce, the use and application of satellite remote sensing data can be appropriate for wetland research like monitoring and inventory. As a result of its development, remote sensing has become a reliable tool for studying glaciers. GIS and GPS, two relatively new technologies, have provided a convenient framework for analyzing collected data, allowing for more precise monitoring and mapping of glaciers' temporal dynamics. Numerous glaciology investigations have benefited from the use of GPS, GIS, and remote sensing [41].

Conclusion

When planning large-scale projects that could have a negative impact on the environment and human health, it is crucial to first develop a baseline of relevant data for that project's sector. Because of this, the industrial, mining, and urban sectors must work together to develop methods of expansion that are less taxing on the environment, particularly in regards to the use of energy, power, irrigation, and other critical resources. Remote sensing and geographic information systems (GIS) offer practical resources for tracking environmental threats and figuring out how to mitigate them.

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