Natural Resource Planning Under Climate Change Issue Using Advanced Remote Sensing and GIS Technology: A Review

Pritam Das, Abhinav Kumar, Vinay Kumar Gautam, and Nirmalya Kumar Nath

Abstract Forest ecosystems are an example of a natural resource that is frequently at the focus of divisive and international discussions on biodiversity, climate change, and carbon sequestration. A large portion of human society has become interested in natural resource management as a result of a growing understanding of the role that natural resources like forests, land use, etc. play in the global carbon cycle, including the potential to decrease carbon emissions and increase carbon sequestration through forest growth processes. GIS is basically a computer-based system that manages, examines, and modifies geographic data, usually to produce visualizations (2-D or 3-D), including maps. RS stands for the use of aerial or satellite imagery to examine features on the Earth's surface. For exploration, environmental impact assessment, continuing mine management, mapping, disaster management, and civil and military intelligence, remote sensing from airborne and spaceborne systems delivers useful data to fully utilize the value of these data, the right data must be retrieved and presented in a standard manner so that it can be imported into geo-information systems and facilitate effective decision-making. Water information must be retrieved promptly and correctly for a variety of purposes, including wetland conservation, coastal alteration, flood prediction assessment, water resource study, water resource synoptic monitoring, and post-disaster analyzation. The creation of software for the analysis of complicated systems is Defines' primary goal. This paper is designed to provide an overview of some of the very broad themes in natural resource management for in-depth analyses of natural resources under climate change scenarios.

Keywords Natural resource · Climate change · GIS · Remote sensing · Impact assesment

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1 Introduction

The constraints imposed on the world's natural resources are becoming more and more of a problem as the human population approaches 7.95 billion in 2021. Disputes over carbon sequestration, climate change, and biodiversity frequently centre on natural resources like forest ecosystems. A large portion of human society has become interested in natural resource management as a result of a growing understanding of the role that natural resources like forests, land use, etc. play in the global carbon cycle, including the potential to decrease carbon emissions and increase carbon sequestration through forest growth processes. In a recent paper, the United States Climatology Program investigated management approaches for reducing the impact of climate change [1, 2].

The biggest examination of managerial adaptations to date, the paper was authored by a team of 61 scientists and managers. It focused on specific management practises for the nation's protected lands and waters, including Nature Reserves, National Forests, National Wildlife Reserves, Wild and Scenic Rivers, National Estuaries, and Marine Protected Areas. Changing management and goal-setting approaches—from a static equilibrium view of the natural world to a highly dynamic and variable approach will be necessary if considerable progress in adapting to climate change is to be made. The ideas and methods examined in this article are culled from all of the management systems examined in the report [3].

A natural resource is "any component of the natural environment, such as soil, water, rangeland, forest, wildlife, and minerals that species depend on for their welfare," according to Curlander and Cober [5]. Thus, managing natural resources means managing them for objectives of use, conservation, and preservation. Making decisions on how to use resources, including deciding to do nothing at all, is a fundamental part of management [4].

Remote sensing data is a very useful source of accurate and advanced information for environmental management and impact studies. A useful source of information for mapping, environmental monitoring, disaster management, and civil and military intelligence, remote sensing via airborne and spaceborne platforms. To fully utilise the value of these data, the right data must be retrieved and presented in a standard manner so that it can be imported into geo-information systems and facilitate effective decision-making. For the majority of remote sensing applications, the object-oriented approach can contribute to powerful automatic and semiautomatic processing. Utilizing statistical or pixel-based signal processing techniques in concert examines the rich information contents. With the aid of several models and the first object-oriented image analysis programme on the market, e-Cognition, which provides a suitable connection between remote sensing imagery and GIS, the major goals are to demonstrate real-world phenomena. Powerful signal processing methods are developed to explore the hidden information in advanced sensor data [5, 17, 22, 26, 28], e.g., for hyper spectral or high-resolution polarimetric SAR data [3, 4].

2 Importance of Advanced Remote Sensing and GIS Technology for Natural Resources Management/Planning

Advanced remote sensing and GIS technology may be used for management of natural resources like forest areas, lakes and ponds and streams, wetlands, agricultural fields and urban areas. Some of the applications of remote sensing and GIS are mentioned below: (a) Significant objects identification: River, Water body, Pool, Roads, Bridge, etc.; (b) Water resources: groundwater and surface water management: Gaps and issues to Indian water resources, Spatial and temporal variation in availability, Falling per capita availability of the country, Expanding multi-sectoral demand, Under and inefficient utilization of irrigation potential, Loss of surface storage due to reservoir sedimentation, Frequent floods severely affecting the flood prone area development, Recurring droughts, NDVI, Water resources assessment, Water resources management, Water resources development, Watershed management, Flood disaster support, Environmental impact assessment & management, Water resources information and Decision support systems, Mapping regional inundation with spaceborne L-band SAR; (c) in Glaciology: Powerful and efficient method of gathering data about glaciers, Studying glaciers usually located in remote, inaccessible and inhospitable environments, Status of snow cover during accumulation, Status of snow cover during ablation, To detect glacier features; (d) in Agriculture: Identification, area estimation and site suitability for different crops, Soil mapping, Sodic land mapping and reclamation at plot level, Crop nutrient deficiency detection and Pre-harvest crop acreage, Crop condition assessment at block level, Crop yield modelling and production forecasting, Agricultural drought assessment, Reflectance modelling; (e) Horticulture: Orchard average and Production estimation, Mapping and monitoring of extension of fruit belts, Detection, Mapping and monitoring of Insect, pest and disease infestation, discrimination of different species; (f) in soil resource: Command area development, soil conservation in catchment areas, Sustainable agriculture, Watershed management, reclamation of degraded lands, land irrigability assessment, land productivity assessment, soil erosion assessment; (g) in earth resources: land slide studies, geo-morphological studies, seismotectonic studies, engineering geological studies, mineral targeting, selection of suitable bridge, barrage and road alignment etc., lithological and structural mapping; (h) in land use planning: mapping urban sprawl, Infrastructure planning, Environmental planning etc.

3 Effect of Climate Change on Natural Resources

3.1 Agriculture

In the early phases of satellite remote sensing, the majority of researchers concentrate on the use of data for the classification of land cover types, with crop types being a primary focus among those interested in agricultural applications. Finding plant biophysical characteristics has been a recent focus of agricultural remote sensing research. Remote sensing has long been used to track and study agricultural operations. On a number of agronomic subjects, the study of agrarian canopies using remotely sensed data has yielded important data. Remote sensing has the benefit of being able to offer repeated data without affecting the crop, which can be used to supply vital data for smart agriculture applications.

The cost-effective method for gathering data across large geographic areas is remote sensing. In India, satellite remote sensing is mostly used to calculate agriculture productivity and crop acreage. The detection and characterization of agricultural output has the potential to be improved by the application of remote sensing technologies based on the functional traits of crops and/or soils. Remote sensing satellite data can be utilized for yield estimation, crop phenological information, and disturbance detection.

Together, satellite data and Spatial analysis may produce spatiotemporal fundamental informative layers which can be used for a multitude of activities, such as mapping flood plains, hydrological modelling, surface energy flow, urban development, and changes in land uses, as well as crop development monitoring and stress detection. The development of narrow band or hyperspectral sensors, as well as excellent spatial resolution aircraft or satellite based sensors, has enabled breakthroughs in the application of remote sensing systems. Additionally, hyperspectral remote sensing has contributed in more complete analyses of crop classification. For the purpose of classifying crops, hyperspectral sensors (from 400 to 2500 nm) can be thoroughly analyzed using data mining techniques such as principal components analysis, lambda-lambda models, stepwise discriminant analysis, and derivative analysis.

3.2 Vegetation Monitoring

In a variety of research projects where remote sensing is critical, aerial imagery and image analysis methods are used. However, remote sensing can decreases the quantity of field data needed and enhances estimate accuracy. Hyperspectral data can dramatically improve crop and vegetation characterization, discrimination modeling, and mapping when compared to broadband multispectral remote sensing. In order to characterises, identify, model, and map significant agricultural crops around the world as well as to examine specific biophysical and biochemical factors, this resulted in the creation of 33 ideal HNBs and an equal number of distinct two-band normalized difference HVIs.

3.3 Crop Assessment

Farmers can benefit from remote sensing by receiving timely spectral data. Information on the biophysical plant health indicator that can be utilised to make a decision. the physical modifications that occur in a person's body. Stress can cause plants to change their spectral properties. Because of the reflectance/emission characteristics, tactics for monitoring stress can be detected remotely. Crop growth is checked periodically. It is crucial to take the necessary safety precautions and to be aware of the possibility of output loss due to any stressor. A multitude of factors, including soil moisture availability, planting date, and air temperature, affect the phases of crop development and how they progress. the time of day, as well as the soil's condition These components control the environment and productive capacity of the plant [11].

3.4 Nutrient and Water Status

Two of the most crucial areas where remote sensing and GIS can be utilised in conjunction with precision farming are nutrient and water stress management. Our ability to control nutrients on a site-specific basis with remote sensing and GIS helps us reduce cultivation expenses while improving the effectiveness of fertilizer use for crops. Arid and semi-arid areas can use precision farming technologies to use water more productively. To enhance water use efficiency by reducing runoff and percolation losses, drip irrigation, for instance, can be used in conjunction with data from remote sensing data such as canopy air thermal gradient.

3.5 Crop Evapotranspiration

Crop productivity has decreased as a result of rainfall anomalies and an increase in the temperature rate, and so forth, all of which result in a decrease in Moisture in the soil Drought is an occurrence. which can be characterized as an average over a long period of time the state of the precipitation-temperature balance in a certain location, and evapotranspiration, this is also dependent on the commencement of Wilhite and monsoon, as well as their potency. Vegetation indices, in turn, CWSI, for example (Crop Water Stress Index) ST (Surface Transport), (Temperature), WDI (Water Depth Indicator), and SI (Standard Index) describe the (Stress Index). There is a link between water stress and Plants' thermal properties Sruthi et al. investigated the effects of vegetation stress.

3.6 Weed Management

Precision weed management aids in the implementation of better weed management strategies. Remote sensing in combination with Precision agriculture holds a lot of promise. Now, technology is very important. Ground, on the other hand, surveying techniques for mapping site-specific information Weed information is quite a time—consuming. demanding and time–consuming, However, Remote sensing based on images offers promising weed detection apps for site—particularly weed control. Based on the spectral differences, the differences in reflectance qualities between weeds and grasses crops, remote sensing technology offers a solution. a term used to describe the process of finding weeds in a crop taking a position and contributing to the growth of weed maps in the field to ensure site-specific and effective weed control. Herbicides that are depending on the needs of the situation can be used. Weed control is a term used to describe the process of removing weeds.

3.7 Crop Yield and Production Information

Crop forecasting has been done using remote sensing. yields are based mostly on statistical—empirical correlations between yield and indicators of vegetation. The data found on Crop output prior to harvest is important for the development of national food policies. Crop yield consistency is a crucial factor for the purpose of crop output forecasting. The crop production is influenced by a number of things such as crop type, water availability, and fertilizer levels, Weeds, pests, and disease all have an impact on the field. Infestation, weather conditions. The spectral analysis. These variables influence the response curve. The spectral response increase and declines, the crop condition is represented by a curve. performance. Using IRS P3 WiFS (Wide Format Standard), IRS-1C WiFS with LISS3 (Field Sensor).

Precision Agriculture

Remote sensing technologies are becoming more and more popular among scientists, engineers, and large-scale crop growers as an essential part of precision farming. Precision farming uses data gathered by sensors embedded in farm equipment in order to reduce cultivation expenses, enhance management, and increase resource efficiency. Variable rate technology is the most advanced aspect of precision farming (VRT). On moving farm equipment, sensors are installed. This apparatus consists of a computer that supervises the delivery of inputs based on GPS receiver data and produces input recommendation maps. The benefit of precision farming is that it can gather crop data at the spatial and temporal resolution required for management choices.

Land Use Planning

Remote sensing's key purpose in land management and planning has been to offer information about the physical qualities of the land that influence the management of particular land parcels or the allocation of lands to diverse uses. Aerial photography has already been used to evaluate these physical attributes, which are then utilized to produce resource maps and track changes in environmental conditions. These applications have been thoroughly developed in the United States and are now effectively integrated into the municipal, state, and federal planning infrastructures.

Established use cases of remote sensing

Two of the most well-known applications of remote sensing in land-use planning and management are mapping and environmental monitoring. Almost all of these applications make use of photographic photographs. When used for remote sensing, aerial photographs, also referred to as air photos, are simply images captured from an aeroplane. Utilizing air pictures has the advantage of allowing the viewer to view vast areas all at once from the unusual vantage point of being in the air. This frame of view is particularly useful when analyzing the regional distribution of ground phenomena.

Aerial photography is used to extract information by manually interpreting the things on the photographs and measuring the size and shape of the objects using photogrammetric algorithms or a visual assessment. Identifying things by connected phenomena, such as detecting a given rock type by identifying an associated flora type, is a common task for the interpreter. The interpreter must also be able to distinguish complicated items from their constituent objects, such as recognizing an industrial region based on the size and shape of the buildings. The interpreter must be skilled at problem-solving and have a solid knowledge of physical, biological, or impacts on environment in addition to their photo interpretation abilities.

Maps Mainly Obtained from Aerial Photos

Aerial photography is often used to create or combine the physical environment maps that are frequently utilised in land-use planning and management. The primary source of maps and data pertaining to the nation's physical environment has historically been the United States Geological Survey (USGS). In order to combine four earlier topographic and geologic mapping organisations, Congress passed an act in 1879 creating the United States Geological Survey (USGS). Charting the terrain of all fifty states and updating those maps is one of the USGS's most significant duties. Since this cannot be completed all at once, the states assist by determining their most urgent mapping needs and establishing cooperative programmes to aid.

Almeida et al. [1] discovered that the urban land dynamics models, powered by GIS and remote sensing data, have proven to be useful in the identification of main urban development vectors and their existing land tendencies, enabling local planning authorities to manage and reorganize (if it comes into the equation) city growth in accordance with an environmental load capacity of concerned sites and their current and anticipated infrastructure availability.

4 Environmental Conditions Monitoring

Despite the fact that applications for land have shown aerial photography to be most useful, it has also showed promise as a tool for planning and management by monitoring surface conditions. The following two examples Surface mining reclamation and other forms of it are examples of this kind of use. control over forestry Surface mines have been decontaminated. Aerial photography is used by both state and federal entities to monitor the situation. A governmental body that oversees the mining sector is the Federal Office of Surface Mining. In the western US and Appalachia, aerial photography is used to evaluate the environmental impact of mining. The Oklahoma Geological Survey uses aerial photographs to collect data. surface-mining activity in each county should be identified and located. Field investigation is used to explore the locations and classify the Unclaimed, partially reclaimed, or fully reclaimed. Monitoring surface condition by air photo interpretation is also used in forestry operations. Air photos have been used to test for the presence of agents that harm forests ever since the 1920s when the extent of damage brought on by pest damage was optically assessed from a stationary airplane. Air photographs can be used to detect trees that have been defoliated completely or partially, or that have foliage that has an aberrant hue or reflectance at non-visible wavelengths. Insects, like bark beetles, create stress-induced foliage discoloration, which can be seen in color and color infrared photography. Because the damage is first seen in the tops of trees, air images are often more accurate than ground observations in detecting the effects of defoliating insects.

5 Water Resources: Groundwater and Surface Water Management

5.1 Gaps and Issues to Indian Water Resources

Goyal and Surampalli [15] studied the trend and projections of rainfall and temperature for the Teesta River basin and upper Narmada River basin. They used GCM-simulated climatic variables for the downscaling of the precipitation and temperature for both basins and used hydrological models (SWAT and MIKE NAM) for the evaluation of the impact of climate change on the watershed hydrology and water yield. The study found that the water resources planning and management would be affected in several ways due to changes in precipitation will, including the design of hydrological structures, flood and drought management, and urban planning and development.

Rashid et al. [25] studied the implications of fast-developing urban life and its influence on water supplies in Muzaffarabad City. The data required for the study was collected by conducting 20 in-depth interviews in 2015 with representatives of the local government, political workers, and local citizens to determine how increased urbanization affects water quality in the region. The data reveal that local inhabitants were contaminating the waters of both the Jhelum and Neelum rivers, resulting in a lack of drinking water and a multitude of viral infections.

Although India has 16% of the world's population, the country possesses just 4% of the world's freshwater resources. India is water-stressed due to the changes in weather patterns and recurrent droughts. However, due to excessive groundwater pumping, an ineffective and wasteful water management system, and years of insufficient rainfall, 12% of India's population is now living in the 'Day Zero' situation. Aside from this, a number of government initiatives, particularly those relating to agriculture (minimum support price), have resulted in water overuse.

5.2 Spatial and Temporal Variation in Availability

Raj and Azeez [24] examined the spatiotemporal variation in water quality and quantity of the Bharathapuzha river basin using multivariate statistical analysis tools. The result showed that the monsoonal discharge was substantially greater in more disturbed basins than in other seasons, whereas the somewhat disturbed basin had a steady amount of flow throughout the season. They concluded that the changes in land use and the influence of dams caused spatiotemporal fluctuations in the river's surface water chemistry.

5.3 Falling Per Capita Availability of the Country

With India's growing population and overall development, water consumption is expanding at a rapid pace. Annual water availability per capita has decreased from 5,177 m^3 in 1951 to 1,508 m^3 in 2014 and is likely to reduce further to 1,235 m^3 by 2050. If it falls below 1,000–1,100 m^3, India may be classified as a water-stressed country.

6 Under and Inefficient Utilization of Irrigation Potential

The gap between irrigation potential provided by major and minor projects and actual utilization is widening, reducing agricultural production in the country. Agriculture consumes around 80% of current water consumption. Irrigated land accounts for about 48.8% of India's 140 million hectares (mha) of agricultural land. The remaining 51.2% is fueled by rain.

6.1 Water Resources Assessment

Within the boundaries of the uncertainty of the climate change projections, Gosain et al. [14] investigated the potential consequences of climate change on the water resources of Indian river systems. Water supply in river systems is evaluated using the daily weather data from PRECIS. referring to the SWAT simulation of all river basins throughout the nation.

Kumar et al. [19] presented the different difficulties and solutions for building a comprehensive strategy for sustainable development and management of the country's water resources, as well as the availability and needs for water resources in India. They also emphasised the combination of blue and green flows, as well as virtual water transfer principles, for sustainable management of water resources to fulfil current demands without jeopardising future generations' requirements. The study concluded that hydrological studies must be conducted in order to analyse water supplies under changing climatic conditions. A comprehensive general circulation model for India is required to anticipate future climatological variables on micro, meso, and macro watershed dimensions.

Remotely sensed indirect indication of groundwater may provide important data where practical alternatives are not available [8, 9]. The measurement potential, storage, and fluxes of ground water are examined in relation to satellite technology. It is claimed that satellite data can be applied if the supplementary analysis is employed to relate to surface expressions and groundwater behavior. When paired with numerical modeling, geographic information systems, and ground-based data, remotely sensed data are most beneficial [9].

6.2 Water Body Identification

The most successful and efficient way for investigating water resources, assessing flood risks, and planning for water has been water body extraction utilising remote sensing. Numerous methods, including single-band threshold, inter spectrum relation method, unsupervised classification, supervised classification, and water index method, can be used to analyse water bodies (normalised difference water index, modified normalised difference water index, and new water index) [10].

Miyun reservoir and the Miyun cit zone were chosen as the study locations by Haibo et al. [16] in order to determine the most efficient water extraction technique for various water usage scenarios across time. By applying both supervised and unsupervised classification separately, they came to the conclusion from their investigation that the area of the Miyun reservoir varied just slightly. The main distinction is caused by the disturbance of the town, the bare ground, and other features outside the reservoir. Both NDWI and MNDWI can swiftly extract water information and produce reliable water extraction results when the right threshold is used. The MDIWI model is appropriate for district background ground objects with buildings, bare terrain, or

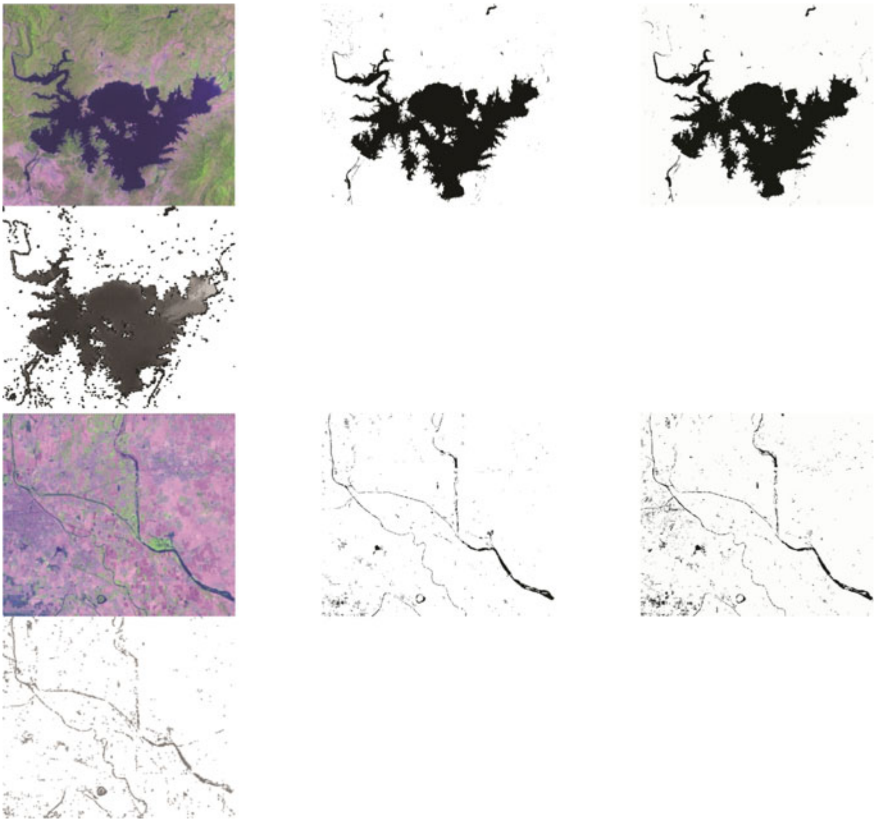

Fig. 1 Original ETM, single-band threshold approach, NDWI, and supervised classification method) Miyun reservoir and Miyun county water system (Haibo et al. [16])

urban areas, while the NDWI model is appropriate for district background ground objects with vegetation (Fig. 1).

7 Soil Resource

7.1 Soil Erosion

USLE, along with its family of soil erosion models viz. RUSLE and RUSLE based InVEST-SR/SDR models are the most extensively applied models. Although these models are recommended for small scale spatially distributed catchments, it has been established that these models estimate soil losses and sediment delivery ratios accurately in different geographical scales such as large catchment, divisional secretariat, province, and whole country scales. the different erosion modeling components (R factor, K factor, LS factor, C factor, and P factor) can be derived using many data sources and materials viz. DEM data, rainfall data, the spatial distribution of soil types data, and delineated river basin maps and some advance equations in soil erosion studies and this information can be collected by remote sensing and GIS techniques.

Piyathilake et al. [23] recommended for future soil erosion studies for Sri Lanka with USLE, RUSLE, and RUSLE based InVEST-SR/ SDR models in a GIS/RS environment. Their review clarifies how future researchers will be able to select the best method of deriving R, K, LS, C, and P factor overcoming the challenges viz. limited data availability and complexity of applying soil erosion models that are associated with running soil erosion models.

Gelagay and Minale [12] analysed the RUSLE parameter and integrated utilising raster calculator in the geo-processing tools in ArcGIS 10.1 environment to estimate and plot the yearly soil loss of the research region, Koga Watershed, Northwestern Ethiopia. The study found that the watershed's annual soil loss varies from none in the lower and mid portions to 265 t ha^{-1} $year^{-1}$ in the portion with a steeper slope, with an average yearly soil loss of 47 t ha^{-1} $year^{-1}$. The watershed saw a total annual soil loss of 255,283 tonnes, of which 181,801 (71%) tonnes covered 6691 (24%) hectares of land. The most of the places affected by soil erosion are geographically situated in the watershed's uppermost inlet, which has the sharpest slope. These are areas with higher soil nitosol and alisol content. Their study establishes that the slope gradient and length followed by soil erodibility factors were found to be the main factors of soil erosion. They concluded that sustainable soil and water conservation practices should be adopted in steepest upper part of the study area by respecting and recognizing watershed logic, people and watershed potentials (Fig. 2).

8 Soil Degradation

The physical and chemical deterioration of soil brought on by wind and water erosion is increasing at an alarming rate all over the world, yet it is still challenging to estimate and quantify the breadth and severity of these processes at the regional level. Intensive agricultural and social growth do not necessarily result in soil degradation. The majority of degradation processes and the unfavourable effects they cause can be avoided, eliminated, minimised, or at the very least regulated. The loss of land or its "productive capacity," the restriction of normal soil functions, and/or the decrease in soil fertility as a result of unfavourable changes in soil processes and, consequently, in soil properties are all common outcomes of soil degradation, which is typically a complex process.

In order to develop useful and accurate spatial information to support decision-making, advanced GIS technologies (including geostatistics and machine learning) and enough information provided by Earth Observation must be combined with trustworthy ground truth data. Although spatial inference of different land-related surface properties is made possible by digital soil and environmental mapping, it

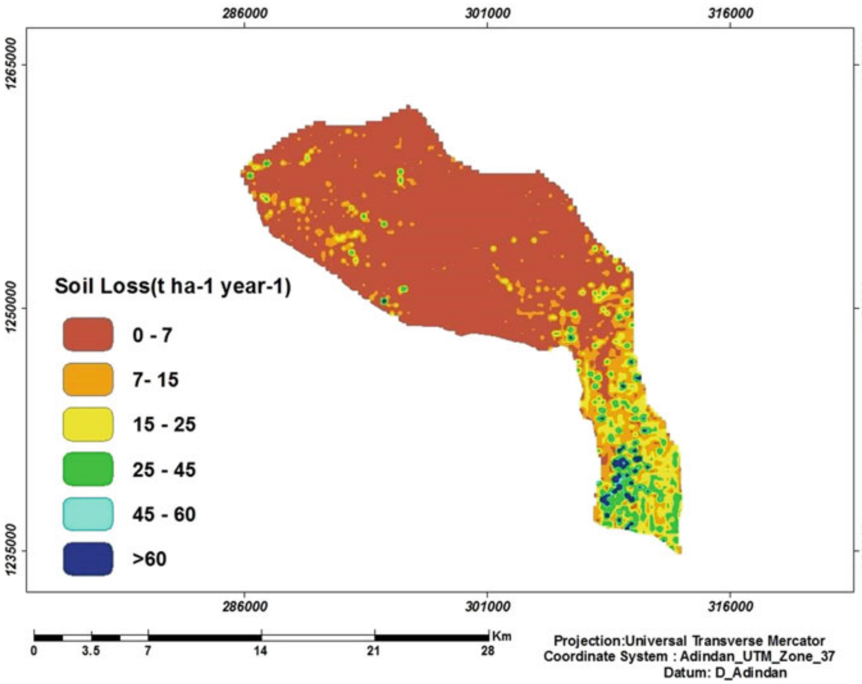

Fig. 2 Soil loss rate map (Gelagay and Minale [12])

is still difficult to assess the functions, processes, and services of soil in a spatially explicit manner. Earth observation may be very helpful in identifying various soil and land degradation processes. Remote sensing is one of the primary instruments in monitoring regional environmental processes. Although there have been many efforts to use satellite imagery to identify, map, and/or monitor various types of land degradation processes, the adoption of advanced geostatistical, data mining, machine learning, and deep learning methods in spatial and process modelling opens up new opportunities for effective assessment and mapping of soil and land degradation.

Fernández et al. [7] conducted a multitemporal examination of gully erosion in olive trees using Digital Elevation Models created using aerial photogrammetric and LiDAR data. For the analysis of the DSM of differences, they created digital surface models (DSMs) and orthophotographs using historical flights aligned in a common coordinate reference system with a recently assessed LiDAR point cloud. This allowed them to identify gullies and calculate the affected areas as well as estimate height differences and volume differences between models.

9 Landslide Susceptibility Mapping

Landslides are occurring more frequently lately on river banks and in mountainous terrain. In hilly places, the majority of these landslides happened on cut slopes or embankments alongside roads and highways. Many people experienced severe anxiety as a result of some of these landslides that happened close to apartment complexes and in residential areas. Within the past ten years, there have also been a few significant and devastating landslides. Significant harm to lives and property has been caused by these landslides. For probabilistic landslide susceptibility analysis, precise landslide location detection is crucial. In-depth and reasonably priced information about landslides can be obtained by using remote sensing techniques, such as the application of aerial and satellite photos.

10 Mining

One of the few industries that alters entire landscapes is mining, which has a number of negative effects [2, 21]. Due to the unequal distribution of mines throughout the world and their disproportionate influence on nearby communities and ecosystems, these effects are geographical in nature [27]. Modern mines can be identified from above by the presence of open cut pits, waste rock dumps, tailings dams, water storage ponds, access roads, infrastructure for milling and processing, supporting infrastructure (such as housing for workers), and in some cases, block cave areas, heap leach pads, or quarries. These characteristics are frequently suggestive of repercussions in the neighbourhood. Some of these effects, like deforestation, may be seen in aerial or satellite photos, and some typically not. As a result, different impacts call for various spatial analysis techniques. These techniques typically make use of geographic information systems (GIS) and remote sensing (RS), Two programmes that are frequently employed in geographic information science [13]. GIS is primarily a computer-based system that manages, examines, and modifies geographic data, frequently to produce visualizations (2-D or 3-D), such as maps. RS is the term that describes the investigation of surface features using aerial or satellite imagery. Major mining corporations routinely use these techniques for investigation, environmental assessment, and ongoing mine management. They have traditionally been regarded by leading mining industry organisations [20]. Software developers, such as ESRI [6] and Kim et al., have in fact designed especially GIS solutions to suit to the operational needs of mining experts [18].

11 Conclusion

Extracting water data quickly and accurately is crucial for wetland protection, coastal change, flood range assessment, and post-disaster evaluation. It also helps with water resource surveys and macro monitoring. Software development for the analysis of complex systems is Definiens' primary objective. Only by taking into consideration the complex web of interdependencies and interactions at many sizes, including context information, semantics, and hierarchical structure, can this be accomplished. With the help of Definiens' Cognition Network Technology, the foundation is now available for analysing not only photos but also texts from numerous other fields and combining data from disparate sources to assist decision-makers. While RS and GIS alone cannot withstand or forecast changes, the data gathered by RS can be fed into various models to produce results or simulations that are realistic to the real world.

References

1. Almeida CMD, Monteiro AMV, Câmara G, Soares-Filho BS, Cerqueira GC, Pennachin CL, Batty M (2005) GIS and remote sensing as tools for the simulation of urban land-use change. Int J Remote Sens 26(4):759–774
2. Bebbington A, Hinojosa L, Bebbington DH, Burneo ML, Warnaars X (2008) Contention and ambiguity: mining and the possibilities of development. Develop Change 39:887–914
3. Coulde SR, Pottier E (1996) A review of target decomposition theorems in radar polarimetry. IEEE Trans Geosci Remote Sens 34(2):498–518
4. Curlander J, Kober W (1992) Rule based system for thematic classification in SAR imagery. Proc. IGARSS. IEEE Press, New York, pp 854–856
5. Curlander JC, Kober WO (1992) Rule based system for thematic classification in synthetic aperture radar imagery. In: [Proceedings] IGARSS'92 international geoscience and remote sensing symposium, vol 2, pp 854–856. IEEE
6. ESRI (2018) The geographic advantage: GIS solutions for mining
7. Fernández T, Pérez-García JL, Gómez-López JM, Cardenal J, Calero J, Sánchez-Gómez M, Tovar-Pescador J (2020) Multitemporal analysis of gully erosion in olive groves by means of digital elevation models obtained with aerial photogrammetric and LiDAR data. ISPRS Int J Geo Inf 9(4):260
8. Gautam VK, Pande CB, Kothari M, Singh PK, Agrawal A (2023) Exploration of groundwater potential zones mapping for hard rock region in the Jakham river basin using geospatial techniques and aquifer parameters. Adv Space Res 71(6):2892–2908
9. Gautam VK, Trivedi A (2023) Decadal analysis of water level fluctuation using GIS in Jabalpur district of Madhya Pradesh. Indian J Soil Conserv 51:1–8
10. Gautam VK, Pande CB, Moharir KN, Varade AM, Rane NL, Egbueri JC, Alshehri F (2023) Prediction of sodium hazard of irrigation purpose using artificial neural network modelling. Sustain 15(9):7593
11. Gautam VK, Awasthi MK, Trivedi A (2020) Optimum allocation of water and land resource for maximizing farm income of Jabalpur District, Madhya Pradesh. Int J Environ Clim Change 10(12):224–232
12. Gelagay, HS, Minale, AS (2016) Soil loss estimation using GIS and Remote sensing techniques: a case of Koga watershed, Northwestern Ethiopia. Int Soil Water Conserv Res 4(2):126–136
13. Goodchild MF (2003) Geographic information science and systems for environmental management. Annu Rev Environ Resour 28:493–519

14. Gosain AK, Rao S, Arora A (2011) Climate change impact assessment of water resources of India. Curr Sci 356–371
15. Goyal MK, Surampalli RY (2018) Impact of climate change on water resources in India. J Environ Eng 144(7):04018054
16. Haibo Y, Zongmin W, Hongling Z, Yu G (2011) Water body extraction methods study based on RS and GIS. Procedia Environ Sci 10:2619–2624
17. Haverkamp D, Tsatsoulis C (1992) The use of expert systems in combination with active and passive microwave data to classify sea ice. In: IGARSS'92; proceedings of the 12th annual international geoscience and remote sensing symposium, Houston, TX, May 26–29, vol 2 (A93–47551 20–43). Institute of Electrical and Electronics Engineers, Inc
18. Kim S-M, Choi Y, Suh J, Oh S, Park H-D, Yoon S-H et al (2012) ArcMine: a GIS extension to support mine reclamation planning. Comput Geosci 46:84–95
19. Kumar R, Singh RD, Sharma KD (2005) Water resources of India. Curr Sci 794–811
20. Legg CA (1990) Applications of remote sensing to environmental aspects of surface mining operations in the United Kingdom. Remote sensing: an operational technology for the mining and petroleum industries. Springer, Netherlands, Dordrecht, pp 159–164
21. Mudd GM (2010) The environmental sustainability of mining in Australia: key megatrends and looming constraints. Resour Policy 35:98–115
22. Pierce E, Ulaby F, Sarabandi K, Dobson M (1994) Knowledge based classification of polarimetric SAR images. IEEE Trans Geosci Remote Sens 30(4):697–705
23. Piyathilake IDUH, Udayakumara EPN, Gunatilake SK (2021) GIS and RS based soil erosion modelling in Sri Lanka: a review
24. Raj N, Azeez PA (2009) Spatial and temporal variation in surface water chemistry of a tropical river, the river Bharathapuzha, India. Curr Sci 96(2):245–251
25. Rashid H, Manzoor MM, Mukhtar S (2018) Urbanization and its effects on water resources: an exploratory analysis. Asian J Water Environ Pollut 15(1):67–74
26. Serpico S, Roli F (1995) Classification of multi sensor remote sensing images by structured neural networks. IEEE Trans Geosci Remote Sens 33(3):562–577
27. Sonter LJ, Moran CJ, Barrett DJ, Soares-Filho BS (2014) Processes of land use change in mining regions. J. Cleaner Prod. 84:494–501
28. Tsatsoulis C (1993) Expert systems in remote sensing applications. IEEE Geosci Remote Sens Newsletter 7–15