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MONITORING OF LAND DEGRADATION AND DESERTIFICATION USING STATE-OF-THE-ART METHODS AND REMOTE SENSING DATA

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Abstract

Managing soil health is critical for sustainable agricultural growth and ecological balance, as well as for delivering many essential ecosystem services. Soils are a huge and valuable natural resource. Due to anthropogenic activity and climate change, land degradation has emerged as a significant worldwide problem that is hazardous to ecological and food security. Accurate and exact reporting of land cover changes is crucial for enhancing the study of the nature of the landscape and for reducing the consequences of desertification. Due to desertification and other related activities (such as the reduction of forests), it is challenging to identify. Due to its great efficiency and time-saving benefits, remote sensing technology is often and widely employed for researching land degradation occurrences. This article analyses contemporary advancements and technologies that have been employed in various studies at various locations to investigate land/soil degradation, including the introduction of a deep learning/AI techniques and some models to address desertification detection using Landsat imaging, etc. In order to produce findings&judge the techniques to improve&enhance the technology where improvement is required so that it could be incorporated for more efficiency&accuracy for precision in the remote sensing technologies, we conducted this study at the end we provided results of this study&some recommendations.

Keywords: Landsat imaging, desertification, soil health, land degradation, remote sensing, salinization

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Introduction

Soil bridges Earth's four spheres—lithosphere, biosphere, hydrosphere, and atmosphere—through its support of life alongside sustainable development. The natural environment achieves regulatory functions along with providing ecosystem services which together generate cultural advantages while handling worldwide threats like biodiversity loss and food and water supply assurance and climate management systems and human wellness maintenance. Earth functions become threatened because expanding land use for human needs results in soil degradation. Life and development needs, and resource conflicts require immediate sustainable soil management to receive protection[1],[2],[3],[4],[5],[6].

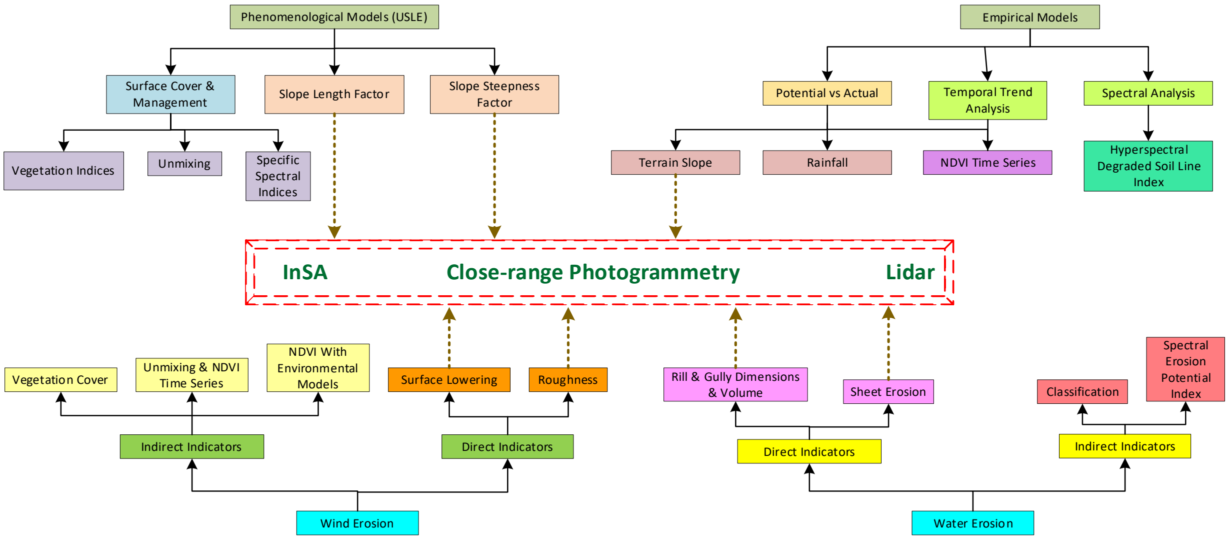

Fig. 1: Models Used for Monitoring of Soil Losses

Soil quality deterioration causes a reduced ability of the soil to generate ecosystem products alongside losing its regulatory functions. Loss of physical chemical and biological properties occurs through natural and human activities thus reducing soil ability to conduct land use operations and maintain environmental regulation. Soil degradation exists as a dynamic complex process that shows past present and future damage and serves as a vital sign for land degradation. The FAO established its definition of degradation through the GLASOD initiative and divided it into three degradation types: biological, chemical and physical processes. Erosion along with compaction and four additional issues including salinization constitutes the main signs of degradation. This occurs in combination with acidification and heavy metal pollution and depletion of nutrients. Academic institutions and governments alike focus on soil degradation solutions through proper assessment, prevention and restoration programs [7],[8],[9].The 2015 UN Sustainable Development Summit established the Sustainable Development Goals (SDGs) at this occasion. Soil management sustainability plays an essential role in accomplishing SDG1 for no poverty along with SDG2 for zero hunger as well as SDG6 for clean water and SDG13 for climate action and SDG15 for life on land. The condition of soil provides benefits for both agricultural systems that resist climate changes and aid in carbon storage and promote human welfare. Traditional field methodologies cover essential soil degradation patterns and cause analysis yet remain slow and expensive and suffer from accessibility constraints. The advancement of sustainable management strategies and soil degradation research both require modern and detailed soil data collection at improved spatial resolution. [13],[14],[15]. RS technology provides several beneficial features which outperform standard field research methods in soil degradation investigation. This methodology provides wide perspective views along with excellent efficiency along with affordable costs that enable real-time data acquisition together with repetitive surface data acquisition capabilities. Remote sensing-based data receives categorization through energy type together with site and spectral bands as well as range area definitions. The advancement of earth observation technologies together with imaging technology has led to improved accessibility of satellites with high spatial resolution and time resolution. RS investigation of soil degradation has become crucial because it offers improved spatial and temporal advantages. Computer technology and algorithm development advances have substantially improved how RS can be used to study soil degradation through monitoring processes. Scientists currently focus on developing RS-based systems to track and forecast soil deterioration because of recent technological advancements [19],[20],[21]. To evaluate the forms, contributing causes, and model techniques of soil degradation, these studies, however, mostly concentrate on a particular nation or region. Within this framework, the current review will map the worldwide landscape of soil degradation research in great detail, Explain the broad knowledge base for study on soil deterioration using remote sensing, and examine the mechanics of this field's development. Inspired, in part, by the recent and swift advancements in radio science technologies, in addition to the important benefits of modelling algorithms to comprehend soil deterioration and consequences from a number of angles, in this study, we want to give a summary of the function of RS in filling in information gaps and promoting advancements in studies on soil deterioration. This has some reference relevance for soil science investigations in different domains in addition to helping to objectively show the state of the study on soil degradation. Additionally, it provides a scientific resource for RS technology-based soil degradation study in the future.It also offers a scientific resource for future research on soil deterioration using RS technology. Next, we talk about how RS may be used to discover significant occurrences linked to soil deterioration, including erosion of soil (Section 3.1), salinization of the soil (Section 3.2), desertification of the soil(Section 3.3), and heavy metal pollution in soil (Section 3.4). Next, the section number 4 (Section 4) we have discussed result and Section 5 we have discussed some recommendations and discussions.

Characterization of Soil Characteristics by Remote Sensing

As a multi-phase substance soil possesses distinctive electromagnetic behavior through transmission and emissivity and absorbance and reflectance modes. RS technology enables the gathering of radiation and reflection data from objects which makes possible their identification and classification methods. The technology provides both temporal as well as spatial information about soil properties which allows scientists to assess soil qualities. Soil degradation occurs from physical, chemical and biological factors resulting in two types of damage: direct and indirect. Surface roughness, soil water content, organic matter content and mineral composition make up the direct indicators in addition to land cover/use and vegetation features which serve as indirect measures. The use of RS technology for soil parameters observation delivers extensive insights into the nature of soil degradation conditions along with their environmental consequences.[27],[28],[29].

Direct

Mineral Makeup of Soil

The chemical properties of soil along with its degradation patterns depend heavily on the mineral content that comes from parent materials. Primary minerals continue to show features from their natural parent materials yet secondary minerals particularly clay help demonstrate both soil fertility patterns and mineral transformation and soil development processes. Soil minerals work with organic compounds and microorganisms to influence nutrient contents together with pollution responses and total soil functioning. The visible and near-infrared (VNIR) regions (400–2500 nm) allow remote detection of spectrally active soil minerals such as clay and silicate as well as carbonate, sulphate, and iron compounds.

Remote sensing devices that include VNIR spectrometers with satellite multispectral systems and hyperspectral imaging play an essential role in studying soil mineral structure and degradation. The combination of peculiarities in hyperspectral imaging technology has enabled scientists to develop comprehensive maps showing iron concentrations alongside organic matter contents and clay measurements thus facilitating studies of soil degradation. Multiple recent advancements utilize the time series data from satellites including Landsat TM, ETM, OLI, and Sentinel-2 for precise mapping of clay content and soil degradation assessment. Scientists have proven that average spectral reflectance captured from satellite images produces accurate clay content maps ($R^2 = 0.75$ with RMSE = 188 g/kg). This technique applies an effective mechanism to monitor soil mineral properties together with degradation processes over extended time periods and geographic areas. The technique utilises globally accessible VNIR/SWIR satellite imagery to provide substantial capabilities for worldwide soil degradation assessment and sustainable soil management support. [2],[34],[35],[36],[37],[38],[39],[40].

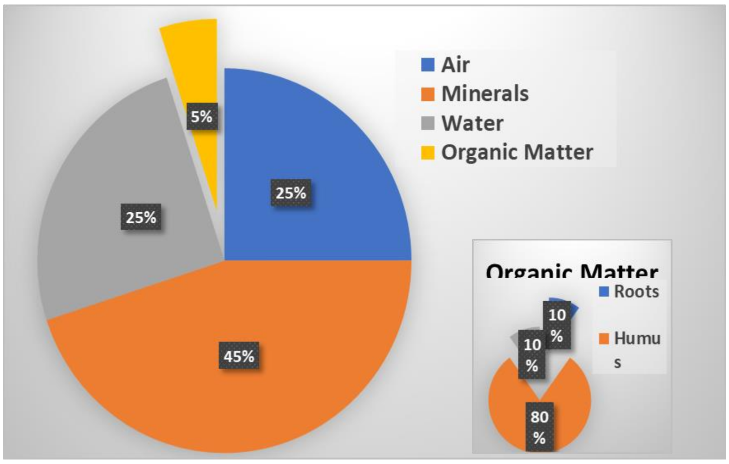

Fig. 2: Showing soil composition

Organic Matter in Soil

Soil organic matter describes all organic materials found in soil which comprise microbial substances and decaying remains of plants and animals together with microbial-produced chemicals. The presence of SOM works to sustain soil water content and physical form while ensuring climatic stability. Soil organic matter regulates CO2 uptake in the atmosphere as it simultaneously enhances water-retention ability and soil productivity alongside decreasing soil degradation. The organic matter level in soil serves as a valid meter for evaluating quality along with degradation status where increased SOM amounts appear through darker colour tones[2],[42],[15],[43],[29],[18]. The determination of soil SOM through NH, CH and CO functional group analysis needs precise monitoring by near-sensing technologies and remote sensing identification. Researchers use multispectral RS images to measure regional patterns of SOM along with its scales and types[29].SOM distributions can be successfully predicted through multispectral optical RS data acquisitions from GF-1 as well as Landsat, CBERS, ASTER, and IKONOS systems. Cloudy conditions together with low spectral resolution keep these methods from being effective. The accuracy of SOM estimations increased through researcher-developed portable VNIR spectrometers and hyperspectral RS systems[29],[45],[46],[47].The combination of Hyperion spectra and VNIR methods enables SOM content calculation to serve as a substitute for tracking soil degradation in desert areas and predicting sample soil concentration values[48], [18],[49].A global investigation of VNIR spectra conducted an analysis to predict soil properties including SOM. The spectra offer complete measurements of soil variations while also providing descriptions of worldwide VNIR spectral libraries for soil variations. Soil properties particularly SOM show spatial variation that impedes the process of spatial pattern description. The research design uses 20 g/kg SOM content as its specific threshold value [45],[50]. A combination of NIR spectroscopy and EPO has become valuable to reduce SOM

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measurement interferences so salt-affected areas can determine their soil organic matter content by minimizing both water content and iron oxide effects [51],[52].

Surface Roughness of Soil

The physical feature of soil surface roughness developed from a combination of mineral and rock fragments as well as micromorphological features and particle distribution patterns. Surface roughness plays a major role in soil erosion mechanisms because it alters flow pattern movements and hydrodynamic actions and sediment transport patterns. The Pisha sandstone region serves as an "Earth Cancer" example of erosion since it features steep slopes attached to loose rock configurations and diverse ground topography. Soil degradation studies require knowledge of surface roughness because the condition controls how fast erosion occurs and how sediments move. Research shows that higher surface roughness decreases soil erosion operations by 31% which simultaneously enhances soil quality while advancing biological systems and developing plants and animals. Remote sensors use detected soil shadows to provide essential information through optical RS reflectance readings. The Bi-directional Reflectance Distribution Function (BRDF) determines directional reflectance by using physical, semi-empirical, and empirical models. The broad investigation of surface roughness across large regions is possible with Microwave Remote Sensing which supports studies about soil degradation. Single models that analyse surface roughness serve analysts to examine soil characteristics and erosion methods while supporting preservation research by focusing on roughness measurements. [53],[54],[55],[56],[33],[57],[58], [59],[60].

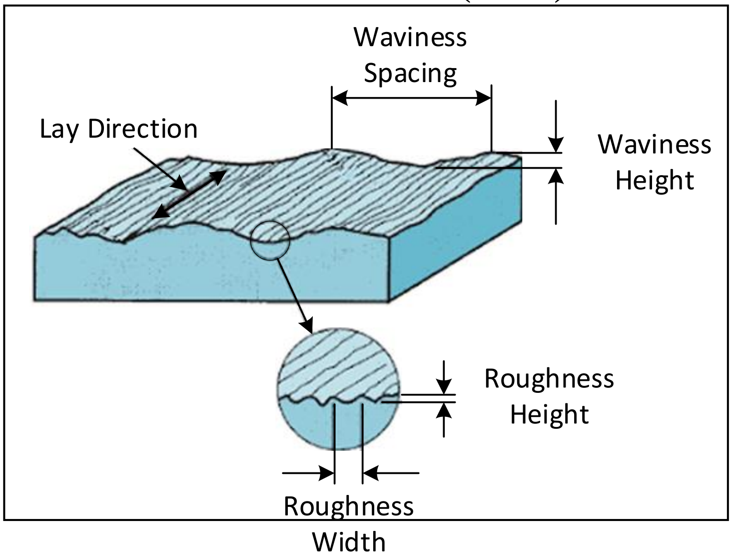

Fig. 3: Engineering Properties of Soil Surface Roughness

Moisture of Soil

Various soil qualities undergo perpetual change because of human activities and weather factors and maintain an ongoing adaptive process with regional ecosystems. Excessive dryness in the soil leads to structural degradation which diminishes biodiversity and decreases productivity and causes desertification. Soil moisture content detection from a distance would aid scientists in studying soil degradation processes. Soil moisture regulates temperature and nutrition and aeration conditions but elevated moisture decreases aeration functions while opposing effects occur from reduced soil moisture. Soil erosion becomes inevitable as both strong winds increase evaporation rates and the absence of soil water leads to destructive erosion processes [65],[66],[2],[67],[68].The vital function of Microwave remote sensing (RS) enhances macrofaunal transportation which strengthens both soil carbon cycling performance and structure-fertility characteristics. This technology provides capabilities for measuring time series and soil moisture content as well as estimating evaporation and drought status. The technique functions with specific boundaries because plants obstruct visibility and rugged land surfaces become a factor but it proves effective for broad-scale research [69],[70]. Each of the RS dataset-based techniques for retrieving soil moisture has benefits and features of its own (Table 1)[71],[72]. The analysis of soil moisture content through microwave technology employs multi-source RS data fusion-based collaborative inversion along with artificial intelligence techniques such as Convolution Neural Networks, semi-empirical and physical model improvements and inverted algo development for recently deployed sensors. Soil deterioration and drought characteristics along with multi-scale soil moisture information have been evaluated through extensive use of these models.[73],[74],[73],[52]. Additionally, a great deal of study has been done on the effectiveness of remotely sensed soil moisture products in comparing and evaluating the characteristics of drought&soil deterioration (Table 2) [75],[76].

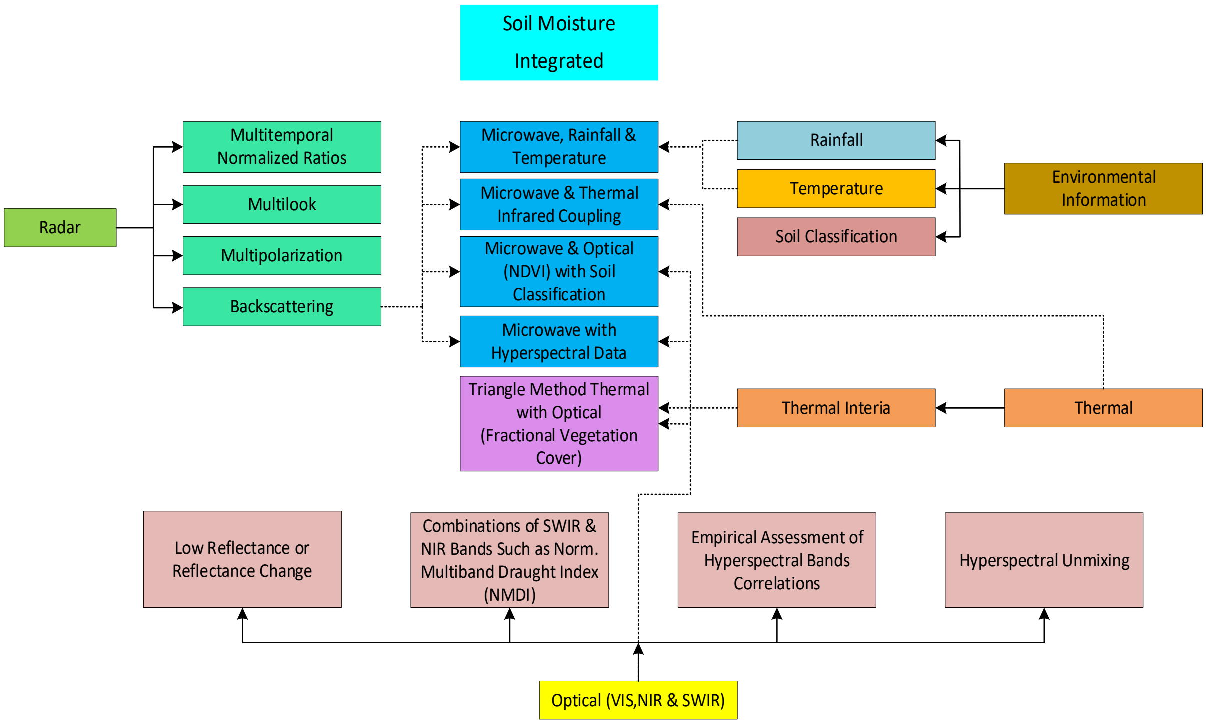

Fig. 4: The diagram illustrates the Architecture of Optical, Thermal & Radar Indicators and how they are integrated with Environmental Data to Track Soil Moisture.

Indirect

State of the Vegetation

Soil deterioration prevents itself through the protective actions of vegetation. The underground plant anatomy supports soil stabilizing properties to reduce direct scouring from runoff and the foliage protects the soil from precipitation erosion. The connection between soil quality and vegetation operates as a two-way system where the physical-chemical properties of soil directly affect vegetation health but vegetation deterioration produces negative effects on soil properties that cause reductions in biomass quantity and biodiversity together with soil porosity and infiltration rates. Soil restoration receives support from proper vegetation management since it enhances water efficiency along with fertilizer and heat utilization. Fast-wood plantation systems in dry regions worsen soil drought by producing high levels of water evaporation which reduces water supply to shallow-rooted vegetation. The evaluation of soil health usually relies on land use surveillance which focuses on monitoring changes in vegetation coverage. The decrease in tropical African vegetation cover resulted in reduced rainfall and worsened soil conditions of the region. The connection between vegetation and soil organic carbon reserves makes vegetation loss responsible for enhancing soil erosion along with carbon depletion. Programs by remote sensing involving vegetation indices (VIs) and fractional vegetation cover (FVC) along with net primary productivity (NPP) serve as key tools for tracking vegetation changes and environmental stresses. Wind erosion models require these indices to function properly while soil degradation assessment occurs indirectly through their usage. However, vegetation-based assessments have limitations. The remote sensing method does not account for litter layers although these layers play an essential role in protecting the soil surface. The effects of climate change and human activities on vegetation states create challenges when attempting to analyse particular environmental impacts. The usage of VIs as proxy elements means they cannot reveal exact details about soil degradation types or extent. The evaluation of soil degradation becomes more accurate when remote sensing combines with on-site observations while resolving its limitations[77],[78],[32],[79],[80],[81],[82],[67],[83],[84],[85],[86],[87].

Table 1: Merits and Demerits of Distinct Spectral Data to Map the Moisture Content of Soil

Electromagnetic Range	Observation Range	Advantages	Limitations
Visible and nearinfrared	Spectral reflectance	Broad sweep range&fine spatial resolution	Weak penetration, cloud cover interference,&daytime only
Thermal infrared	temperature at the land's surface	Broad sweep range, distinct physical processes,&fine spatial resolution	Weak noise penetration, cloud cover,&plant interference
Passive microwave	Dielectric characteristics & brightness temperature	robust penetration, constant&all-weather situations,&obvious physical mechanisms	Poor spatial resolution, as well as vegetation&uneven terrain
Active microwave	Backscattering coefficient&dielectric characteristics		

Land use/cover Change

Human activities drive global change causing important modifications in land use patterns across Earth (LUCC). LUCC serves as a direct connection between human impacts and Earth surface system processes which produces diverse land-use patterns that deliver reflection of human social-economic activities. A quick natural environment response serves as the fundamental method to study and combat global change[85],[88],[89],[90]. The world experiences rising demands for land resources while its population grows at the same time that land production rates decrease. The environmental change indicator called LUCC or optical remote sensing affects ecological processes while modifying both biodiversity and bio-geo-chemical cycles and sustainable resource use. The collection of optical remote sensing data has exceeded 50 years through the use of Landsat and SPOT and MODIS satellite systems in analysis. The Sentinel-2 mission joined by the Planet Dove satellite constellation delivery in 2015 enables space and time resolution enhancement which enhances modern land resource management practices[91],[89], [88],[92]. The LUCC (Land Use and Conservation) technology enables research into land degradation effects on soil. Extensive LUCC practices lead to severe soil degradation because changes in soil redistribution rates result in deteriorating soil quality. Three main factors that trigger soil degradation include alterations to the land surface combined with overuse of fertilizer and excessive animal grazing. LUCC methods allow scientists to properly study the combination of degradation impacts along with their linked soil erosion patterns [93],[94],[95],[81],[96],[85],[81].As a vital determinant of soil attributes LUCC serves as a critical factor in soil characteristics throughout riparian areas of the middle Heihe River basin. The soil moisture content depends on modifications of land cover combined with salt crust formation due to lake reduction and operations used to manage soil. A lack of nitrogen elements blocks the growth of understory plants thus reducing organic matter delivery to the soil. The accurate assessment of soil degradation proves difficult through GIS and RS technologies because remote sensing data has known limitations as well as availability constraints for RS data [68],[97].

Table-2: An Explanation of the Vegetation Indices that are Frequently Used to Measure Soil Deterioration.

Indexes	Descriptions	Refences
Conventional spectral indices		
NDVI	Normalized difference vegetation index	[98]
GNDVI	Green normalized difference vegetation index	[99]
RDVI	Renormalized difference vegetation index Linearizes relationships with surface parameters	[100]
EVI2	Two-band enhanced vegetation index	[101]
MTVI2	Modified triangular vegetation index2	[102]
Red-edge spectral indices		
NDVIre1	Red-edge normalized difference vegetation index1	[103]
NDVIre2	Red-edge normalized difference vegetation index2	
NDVIre3	Red-edge normalized difference vegetation index3	
CIre1	Chlorophyll index- Red-edge1	[104]
CIre2	Chlorophyll index- Red-edge2	
CIre3	Chlorophyll index- Red-edge1	

Evaluations of Soil Deterioration Based on Data from Remote Sensing

The analysis of soil deterioration depends heavily on remotely sensed data because these tools offer high geographical and temporal capabilities. The extraction of soil degradation data makes use of sensors including multispectral and hyperspectral and SAR alongside ground-based VNIR devices. The monitoring ability of traditional satellites remains restricted for studying soil deterioration because they operate with poor temporal resolution and available sensors are sparsely distributed. The space-time advantages of UAVs surpass satellite systems because these vehicles can release from traditional altitude limits and avoid some cloud-cover interference. Research focusing on current advancements in RS technology for modelling soil deterioration and its characterization and prediction remains systematically sparse. This paper presents an organized space-time analysis of soil deterioration research through root cause analysis (RS) by summarizing multiple techniques and indicators[31],[19],[58],[105].

Erosion of Soil

The worldwide problem of soil erosion leads to degradation through the equilibrium state of soils. The process advances methodically without major indications to degrade top soil resources of ecosystems. The state of soil and fertility depends on flood irrigation and agricultural work as well as weather conditions[106],[107],[108],[16],[108].The investigation of soil erosion together with wind erosion in Central Asia reveals the necessity to develop restoration programs. The combination of RS technology with physical models including WEQ and RWEQ through technology enables prediction of erosion rates[109],[60],[110],[111],[84],[112].Soil scientists widely adopt the RUSLE tool as a modelling system but researchers identified weaknesses to enhance its functionality. RUSLE evaluates four soil factors including rainfall, runoff erosivity and slope length and erodibility to enhance system precision and efficiency[6],[113],[23].The advancement of rainfall satellite technology now provides real-time precipitation data which solves the problem of lacking weather station observational data. The Climate Prediction Centre Morphing among other reanalysis tools including PERSIANN-CDR, TRMM, GMP, NCEP-CSFR and ERA5 underwent validation studies and comparison which may prove useful to calculate the R-factor in place of weather station observations [114],[115]. Soil structure evaluation and organic material measurement along with erodibility factors become possible through combining the RUSLE model with remote sensing and GIS. Soil erosion detection gets improved through FVC assessment together with spectral indices analysis. Scientists applied inversion models to LS factors based on RS data together with field tests which allowed for watershed area mapping [116],[113].During the last ten years both academics and society members perceived digital soil mapping (DSM) as key for evaluating soil erosion. The implementation of multi-temporal data alongside RS by researchers produced a soil deterioration assessment index which signifies DSM together with RS represents a usable approach to monitor soil deterioration from erosion processes[117],[40],[94].

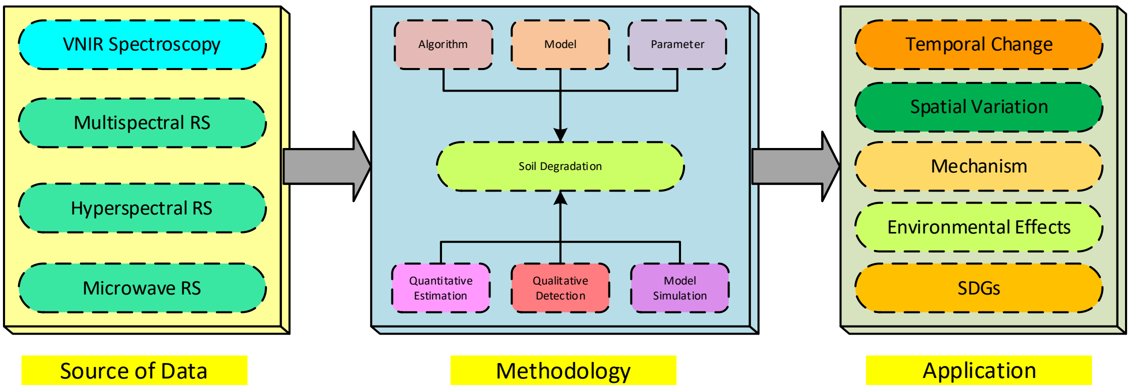

Fig. 5: Framework for Using Remote Sensing Technologies in Research of Soil Deterioration.

Soil Salinization

Soil salinization consists of two types: primary and secondary salinization which describes when salt dissolves in water. The agricultural yield suffers from primary salinization while the food security faces risks along with secondary salinization causing harm to local eco-systems and biomass production levels. The process results in desertification and leads to erosion and multiple ecological problems including degradation [118],[119],[120]. Worldwide soil salinization has exceeded 1 x 108 hectares while exceeding 100 countries in total number of affected regions. Soil salinity detection through MODIS technology depends on electromagnetic properties to interpret precise spectral reflectance patterns thus solving environmental issues [121],[122],[68]. Soil salinity monitoring relies on hyperspectral sensors as well as ground-based VNIR devices along with synthetic aperture radar (SAR). The technologies build long-term database systems to explore related processes. The current data systems have both spatial limitations and unclear resolution capabilities. The combination of land surface data and RS imagery with historical soil characteristics maps and AI algorithms enables producers to generate soil salinity maps. The combined techniques stretch research duration and enhance precision to forecast worldwide salt-induced soil changes and identify all salt-affected soil areas globally [95],[119],[21],[17],[121].

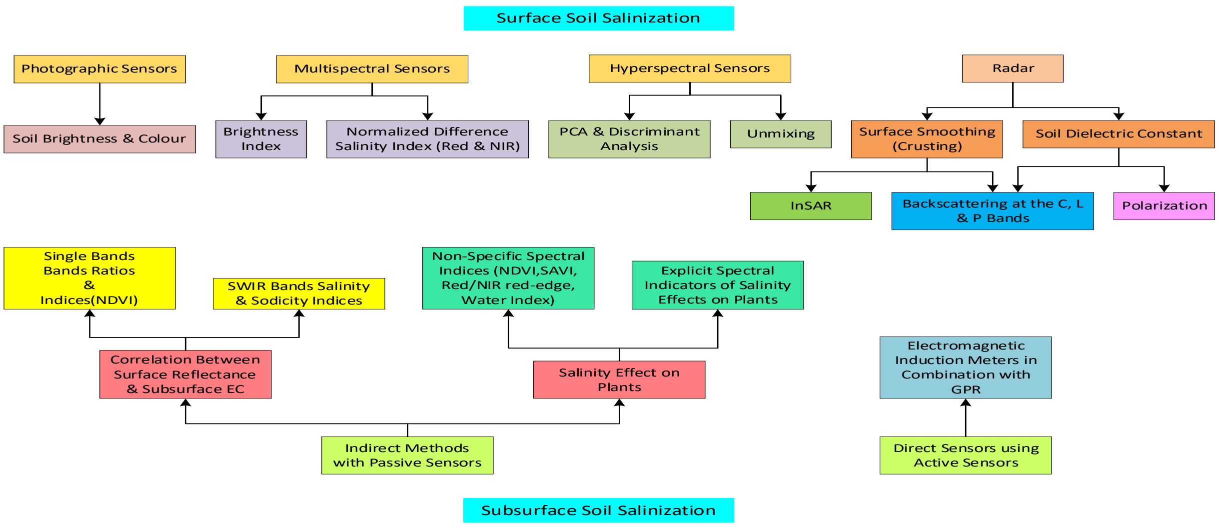

Fig. 6: Diagrammatic Topology of the Many Sensors Used to Track the Salinization of Both Surface and Subterranean Soil.

Soil Desertification

Dry subhumid regions presently experience land degradation because of human activities and environmental change which affects 1.5 billion people and destroys 2 million hectares of cultivated land each year. Soil degradation occurs as a result of human activities which disrupts environmental equilibrium while making environmental problems worse and wind erosion becomes a main contributor to these issues [123],[106],[124],[125],[126].International organizations require desertification monitoring through RS-based satellite data from Sentinel-2 and Landsat series because these platforms allow detailed local inspections. Surface data provided through SAR extends across twenty-four hours while enabling weather analysis which helps researchers study soil moisture together with surface roughness conditions. The desertification indicators of plant coverage along with biomass and soil moisture are measurable through hyperspectral remote sensing data. The degradation indicator of topsoil grain size becomes measurable through remote sensing methods based on the desertification difference index (DDI)[127],[17],[128]. Remote sensing technology should work with ground surveys to identify desertification regions along with their classification levels. Several procedures including soil identification and vegetation recognition and multi-temporal image classification processes need to be followed. A thorough evaluation of indicator biological as well as physical meanings needs to take place during the assessment process[127],[97]. The monitoring of decertified territories proves difficult because different indicator methods do not align across geographical and time-based domains. The strategic development framework allows scientists to combine field research and remote sensors for studying desertification effects in a scientific manner[131].

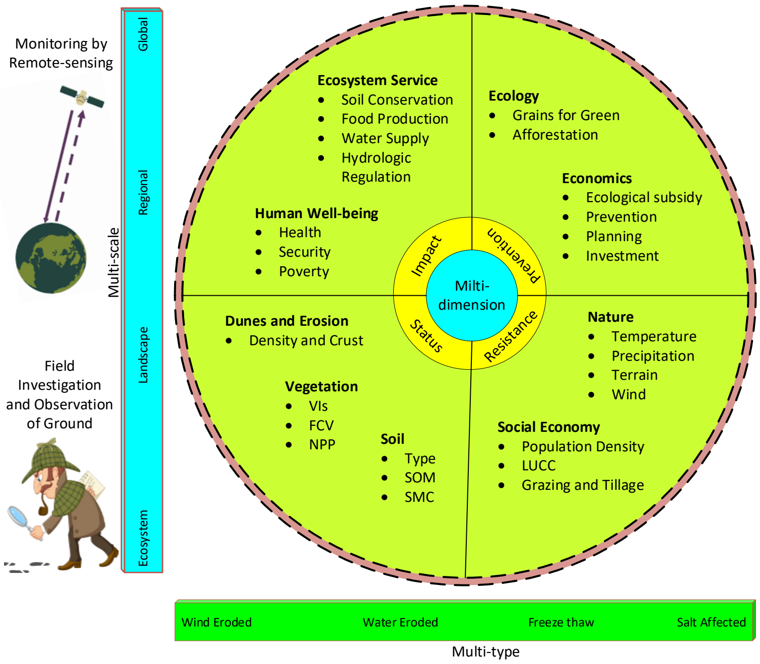

Fig. 7: The Indicator Framework for Monitoring Soil Desertification from the Perspectives of Zero Multi-Dimension (Ring Part) Multi-Scale (Y-Axis) & Multi-Type (X-Axis).

Contamination of Soil with Heavy Metals

Soil degradation occurs because of industrial operations and agricultural procedures that affect soil systems critically. Spectral analysis of soil structures represents an essential approach to identify pollutants along with their dispersion patterns which aids in resolving these problems for food security [132],[133],[134].The identification of chemical soil contaminants involves using spectroradiometers for both visible and near-infrared substances according to spectroscopy methodology. The heavy metal contents in samples can be computed through VNIR spectroscopy although researchers mainly concentrate on developing inversion methods and identifying responsive spectral parameters [137]. Soil spectroscopy stands as an essential methodology for measuring heavy metals in soil because it detects hard to identify spectral characteristics in the process. The methods benefit from improvements in pXRF instruments as well as gamma-ray machines and advanced proximal soil detection technology. [139],[133],[140]. RS technology demonstrates potential as a tool for measuring heavy metals in soil although researchers primarily use DSM technology to map hazardous metal spatial distributions in soil. Analysis of soil degradation processes along with environmental changes are currently studied from an earth systems science point of view. Sustainable development needs the combination of remotely sensed data with geographical data to understand the environment as well as human relationships due to its influence on social cohesion and economic development alongside health[135],[141],[142],[143]. AI has revolutionized current political understanding of soil degradation through its capability to analyze bio-physical, social and political factors and their combined effect.

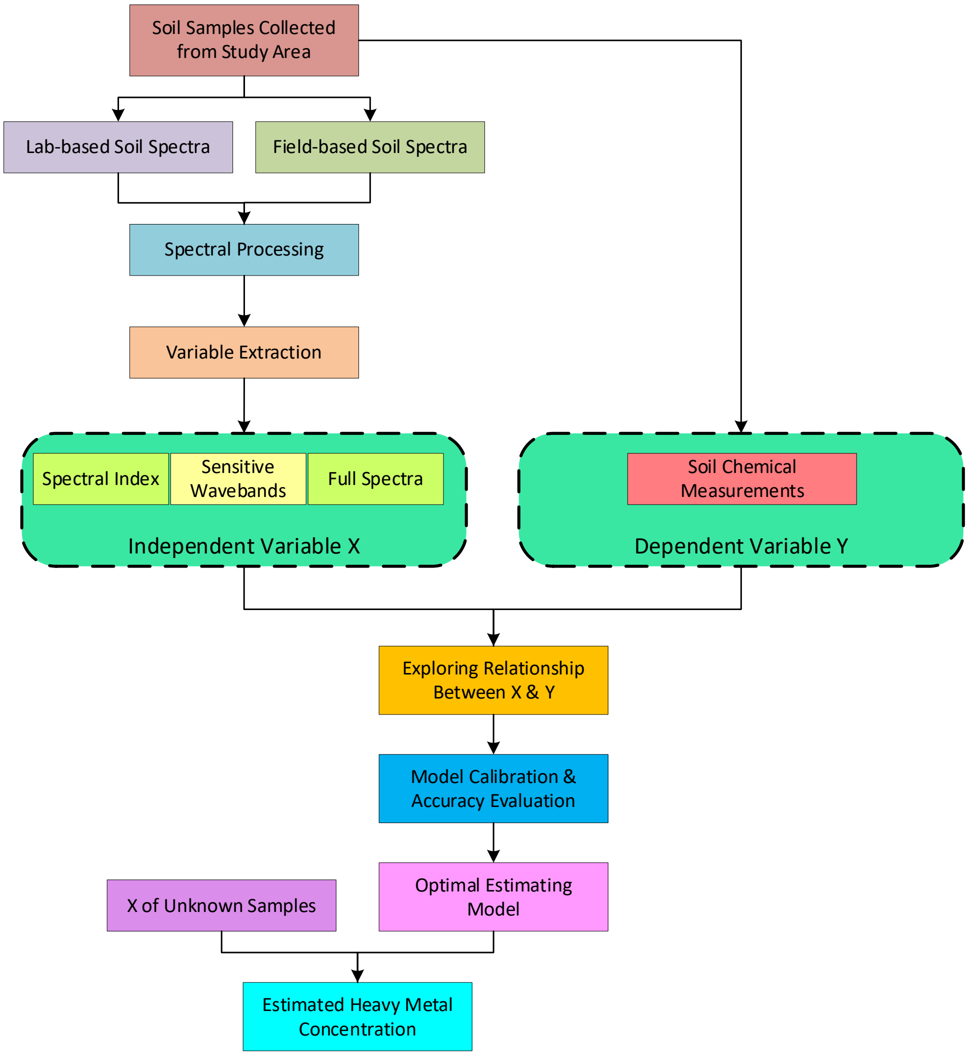

Fig. 8: Methodological Flowchart Illustrating the Primary Stages of Spectral-Based Heavy Metal Concentration Estimate

Result

Soil degradation has affected more than 30% of landmasses worldwide with special focus on dry and semi-arid regions. Determining how soil deteriorates coupled with knowledge about soil resource availability enables better prevention of worsening degradation. Soil processes are influenced by the simultaneous presence of chemical along with biological and physical characteristics[145],[8]. The application of RS systems by researchers involves using technology to restore affected land areas and monitoring environmental modifications and soil degradation while creating public awareness initiatives.[146]. The preservation of soil resources requires research about degradation alongside effective data collection and soil restoration training to support sustainable development of civilization.

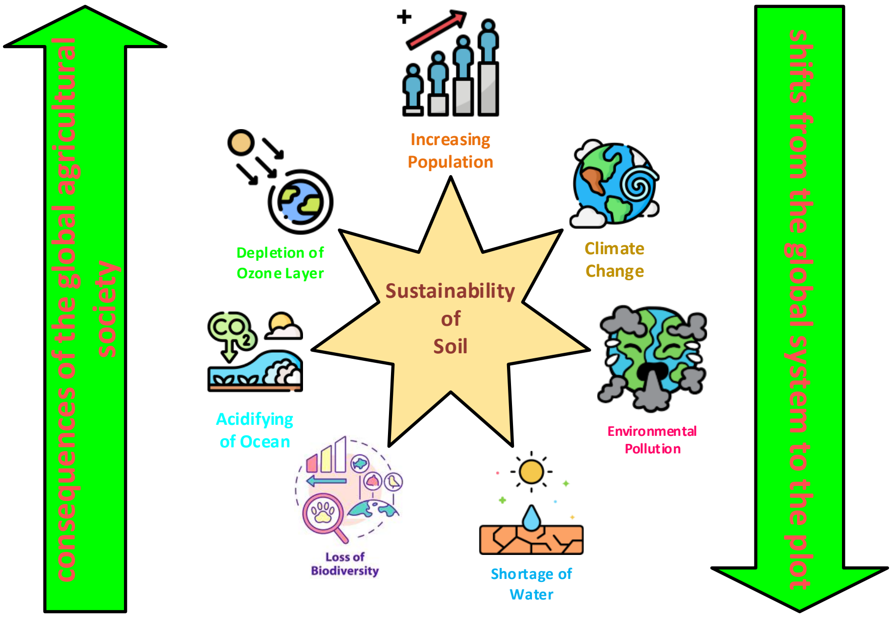

Fig. 9: Possible Connections between Variations in the Global Environment and Soil.

Conclusion

The research details about soil detergent progression presents the primary RS applications for different scenarios of soil degradation. The monitoring of soil deterioration through RS requires direct indicators combined with indirect proxies which yield crucial information for building better conceptual models and processing frameworks. Large data information spans across multiple domains including time, space and spectrum due to the emerging RS technology era. The use of independent observational data comes from devices operating in satellite mode and drone mode and from ground-based devices. Studying soil deterioration requires extensive utilization of big data information together with RS-CCP and heterogenous multisource remote sensing. A standardized worldwide method for earth observation and decision support initiatives proposes uniform datasets for quantifying soil deterioration patterns and economic implications across regions and periods. A goal exists to restore ecosystems while protecting environmental and ecological systems while blocking ongoing soil degradation processes.

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