REMOTE SENSING IN AGRICULTURE:

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Abstract:

In recent years use of remote sensing technologies increases significant growth in agriculture. It offers innovative solutions to various challenges faced by agricultural sector. Remote sensing technologies aims to provide its applications on agriculture and exploring its diverse uses and advantages. Remote sensing technologies help in capturing data from a distance using various sensors placed on satelites, drones, air craft & how it can be utilized in agriculture. Remote sensing technologies enables monitoring of crop health, growth & yield estimation. It helps in detection of pests, diseases & nutrient deficiencies. By integrating the remote sensing data with pesticides in enhanced resource efficiency & environment sustainability. Covers the integration of remote sensing in soil mapping and analysis. Soil properties like moisture content, organic matter & temperature can be assured noninvasively. It aids in making about soil health, fertility, land suitability for specific crops. It also aids in water resource management. It is helping to revolutionize agriculture making it more sustainable but adoption faces obstacles like data processing complexities, cost & user education.

Key words: Remote sensing, agriculture, crop monitoring, soil mapping, water management, sustainability, remote sensing application

Introduction:

Remote sensing is termed as the art and science of collecting data related to items or places from a distance without the need to have physical contact with items or the place being studied. A recent report by the FAO projects that an increase in world population to 9.15 billion by 2050, which may need the current food production to increase by 60%. Manyefforts are underway to increase overall production to feed the burgeoning population by increasing efficiency in production such as high intensity agriculture, efficient water use, and high yield varieties. Agricultural production follows strong seasonal patterns related to the biological lifecycle of crops. The production also depends on the physical landscape (e.g., soil type), as well as climatic driving variables and agricultural management practices. All these variables are highly variable in space and time. Moreover, as productivity can change within short time periods, due to unfavourable growing conditions, agricultural monitoring systems need to be real time for higher productivity. Therefore, use of remote sensing is indispensable in monitoring of agricultural field, crop & soil health, water management and its quality, and atmospheric conditions with emphasis to yield. During the last two decades, remote sensing techniques are applied to explore agricultural applications such as crop discrimination, crop acreage estimation, crop condition assessment, soil moisture estimation, yield estimation, precision agriculture, soil survey, agriculture water management, agro meteorological and agro advisories. The application of remote sensing in agriculture, i.e. in crops and soils is extremely complex because of highly dynamic and inherent complexity of biological materials and soils .However, remote-sensing technology provides many advantages over the traditional methods in agricultural resources survey.Overall remote sensing technologies provide real-time and historical data that revolutionize the way agriculture is practiced, making it more efficient, sustainable, and adaptive to changing environmental conditions. It empowers farmers with data-driven insights to make informed decisions, improve productivity, and contribute to global food security.

**Remote Sensing Technologies in Agriculture: A Global Perspective on Past and Present Trends**

Remote sensing technologies in agriculture have played a crucial role in transforming the way farming is practiced on a global scale. These technologies involve the use of various sensors and satellite systems to collect data and monitor agricultural landscapes from a distance. The historical evolution of remote sensing in agriculture dates back to the early use of aerial photography for crop monitoring, which eventually led to the deployment of satellite-based platforms.

**Sensors and Platform Used**

Remote sensing technologies in agriculture encompass a wide range of sensors and platforms, including visible (visual), multispectral, hyperspectral, thermal, and microwave sensors, deployed on various platforms such as satellites, manned aircraft, and unmanned aerial vehicles (UAVs) or drones. Each type of sensor and platform brings unique capabilities that contribute to a comprehensive understanding of agricultural landscapes and support informed decision-making in farming practices.

Visible (Visual) Sensors:

Visible sensors capture electromagnetic radiation within the visible light spectrum, allowing for color imaging of agricultural fields.

Multispectral Sensors:

Multispectral sensors operate in multiple narrow bands within the electromagnetic spectrum. These sensors capture data in a few distinct spectral bands, enabling the analysis of specific vegetation indices related to plant health, water content, and nutrient levels.

Hyperspectral Sensors:

Hyperspectral sensors capture data in numerous narrow and contiguous spectral bands, offering a more detailed view of the electromagnetic spectrum. This high spectral resolution allows for precise identification of different materials, minerals, and vegetation species, aiding in detecting subtle variations in crop health and identifying stress factors.

Thermal Sensors:

Thermal sensors measure the emitted or reflected thermal infrared radiation from the Earth's surface. They provide information about crop temperature, helping identify water stress, heat stress, and detecting anomalies in irrigation systems.

Microwave Sensors:

Microwave sensors operate in the microwave portion of the electromagnetic spectrum, penetrating through clouds and vegetation canopies.

**Platforms**

Satellites:

Satellites provide a global perspective, collecting data over large areas on a regular basis. They are equipped with various types of sensors and are ideal for monitoring large-scale agricultural activities and land use changes.

Manned Aircraft (Airborne or Aerial):

Manned aircraft carry remote sensing equipment and can be flown at lower altitudes, offering higher spatial resolution than satellites. They are commonly used for regional or localized agricultural monitoring and research.

Unmanned Aerial Vehicles (UAVs) or Drones:

 UAVs, commonly known as drones, are small and versatile platforms that can be deployed at low altitudes. They offer high spatial resolution and can capture data with flexibility and rapid response. UAVs are particularly useful for precision agriculture, crop health assessment, and localized monitoring.

**Temporal Trends in RS**

Temporal trends in remote sensing technologies in agriculture refer to the changes and developments that have occurred over time in the use of these technologies to monitor and manage agricultural practices. These trends involve the evolution of sensor capabilities, data acquisition frequency, and the integration of historical data to gain insights into agricultural patterns and variations over different time periods.

Early Adoption and Technological Advancements:

Temporal trends in remote sensing in agriculture showcase the early adoption of aerial photography for crop monitoring, followed by the emergence of satellite-based platforms. Over time, there have been significant technological advancements, leading to improved sensor resolutions, increased spectral bands, and enhanced data processing techniques.

Continuous Monitoring and Seasonal Patterns:

The ability of remote sensing technologies to continuously monitor agricultural areas has led to the identification of seasonal and cyclical patterns. By collecting data over extended periods, these technologies can observe crop growth, land use changes, and other agricultural dynamics that exhibit periodic trends.

Impact on Crop Yield and Management Practices:

Temporal trends in remote sensing data have played a crucial role in understanding crop yield variability and factors affecting agricultural productivity. Analyzing historical data allows farmers and researchers to make informed decisions, such as adjusting planting schedules, optimizing irrigation practices, and applying fertilizers more effectively.

Long-Term Assessments and Environmental Changes:

 Remote sensing technologies enable long-term assessments of agricultural landscapes, providing valuable data for studying changes in land use, vegetation cover, and the impact of climate change over decades. These trends help in devising sustainable agricultural strategies to mitigate environmental challenges.

Precision Agriculture and Decision Support:

Temporal trends in remote sensing data contribute to the advancement of precision agriculture. Farmers can access historical data to identify trends in soil health, crop performance, and pest infestations. This information assists in making data-driven decisions for resource management and sustainable agricultural practices.

Forecasting and Early Warning Systems:

Analyzing temporal trends in remote sensing data facilitates the development of forecasting models and early warning systems. These models help predict crop yields, monitor disease outbreaks, and forecast extreme weather events, aiding farmers in adopting proactive measures to safeguard their crops and livelihoods.

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 **Geographical Trends**

Geographical trends in remote sensing applications in agriculture reveal the distribution and adoption of these technologies across different regions of the world. Examining the geographical patterns helps to understand regional preferences, priorities, and challenges in utilizing remote sensing for agricultural purposes.

Europe emerges as a frontrunner in the adoption of remote sensing technologies in agriculture, with a substantial share of approximately 34% of the studies conducted in the region. This strong presence in Europe reflects its advanced technological infrastructure, well-established research institutions, and supportive policies for agricultural innovation.

Following Europe, the United States accounts for around 20% of the remote sensing studies in agriculture. The US's significant involvement can be attributed to its vast agricultural landscapes and its well-developed research and technology sector.

China stands as the third-largest contributor, representing approximately 11% of the studies. China's growing interest in remote sensing technologies aligns with its efforts to enhance agricultural productivity and food security, driven by a large population and limited arable land.

In contrast, regions like India, South America, and Africa have shown relatively lower percentages of remote sensing studies in agriculture. This may be due to varying factors, including limited resources, technical expertise, and infrastructure challenges in deploying and accessing remote sensing technologies.

Overall, geographical trends in remote sensing applications in agriculture indicate a global recognition of the potential benefits and efficiency gains that remote sensing offers to enhance agricultural practices. However, disparities across regions highlight the need for further investment, capacity building, and collaboration to ensure equitable access to these technologies and maximize their positive impact on agriculture and food production worldwide.

**Remote Sensing Application In Agriculture-**

Remote sensing plays a crucial role in precision by providing valuable data and insights to optimize farming practices and improve crop productivity. Remote sensing can be used to monitor the health and growth of crops by analysing spectral data obtained from satellites, airborne sensors or ground-based instruments. This information can help farmers to identify the areas of their fields. The application of remote sensing in agriculture can help the evolution of agricultural practices face different types of practices face different types of challenges by providing information related to crop status at different scales all through the season.

**Observation of Remote sensing in Agriculture -**

It involves collecting information about the Earth's surface from a distance using various sensors mounted on satellites, aircraft, drones, or ground-based systems.The most common properties of RS data are spatial, spectral and temporal resolutions, while "Spatial resolution" refers to the pixel size of an image that effects the ability to detect objects on the Earth's surface through imaginary spectral resolution. Spectral resolution refers to the number and size of spectral sampling interval that affects the ability of a sensor to resolve features in the electromagnetic regions (EMRS).

**Preseason planning-**

Topography mapping-

Topography impacts hydrological balance, which influences soil conditions. Topography mapping involves the study and representation of the Earth's surface features, including elevation, slope and aspects.

Subsurface tile drain mapping-

Subsurface tile drain mapping in agriculture using remote sensing involves the use of aerial or satellite imagery to identify and map the location of subsurface drainage system, such as tile drains in agricultural field. The drains are helping to remove excess water from the soil and improve crop productivity by preventing waterlogging and soil saturation. Currently, tile drains are a large blind spot in our understanding of water routing and nutrient exports to water resources. These tile drain networks have potentially large implications for storm hydrology and nutrient fates at the watershed scale. Without adequate information on the distribution and connectivity of tile drain systems, it is difficult to ensure that hydrologic and nutrient export models are getting the “right” answers for the “right” reasons, particularly in watersheds and basins with extensive agricultural land use.

FIELD PREPARATION :-

 Observing water conditions for precision agriculture, monitoring the soil is very much essential. Some critical parameters manage the crop management which include soil organic matter, soil texture, soil pH level. If there is a need in `growth of crops then there should be a proper emphasization in between the crop performance and soil conditions.

 Planting:-

 The most important role of remote sensing in agriculture is health and sustainability of crop. These also help in identifying affected conditions caused due to weather, insects, pests, etc. lack of deficiency in plants affects the water content, moisture.

In season crop health monitoring:-

 The crop health detoriates due to lack of nitrogen in it abiotic and biotic crop stresses more during growing season.

REMOTE SENSING FOR PRECISION AGRICULTURE: challenges, limitations and opportunities.

Remote sensing for precision agriculture is a rapidly evolving field that utilizes various technologies and sensor to gather data about agricultural practices and crop conditions from a distance. while it offers numerous opportunities to enhance farming efficiency and productivity,it also faces some challenges and limitations.

 Challenges:

1.Data interpretation and analysis: Remote sensing generates vast amounts of data,which can be challenging to interpret and analyze accurately. Advanced data processing and analysis techniques are required to derive meaningful insights from the collected information.

2.Spatial and temporal resolution: The resolution of remote sensing data might not always be sufficient for detailed and real-time monitoring of small-scale agricultural operations. Low spatial resolution can make it challenging to capture variations which a field accurately, and low temporal resolution may limit timely decision-making.

3.Weather dependence: Cloud cover and adverse weather conditions can hinder the acquisition of remote sensing data. Frequent cloud cover can reduce the frequency of data acquisition and limit the usefulness of certain sensors, such as optical satellities.

4.COST: Acquiring and processing high-quality remote sensing data can be expensive. This cost factor might limit access to some farmers, especially those in developing regions or with smaller farms.

5.DATA INTEGRATION: Integrating remote sensing data with other on-farm data sources can be complex, requiring specialized tools and software to enable seamless data sharing and analysis.

LIMITATIONS:

1.LACK OF GROUND TRUTH DATA: Remote sensing relies on accurate ground truth data for validation and calibration. Obtaining ground truth data over large areas can be time-consuming and challenging.

2.CROP TYPE AND GROWTH STAGE IDENTIFICATION: Differentiating between various crop types and accurately identifying their growth stages from remoter sensing data can be difficult, partially when crops have similar spectral signatures.

3.PESTS AND DISEASE DETECTION: While remote sensing can help detect stress in plants, it may not always be capable of directly identifying the cause, such as specific pests or diseases

4.3 OPPORTUNITIES:

1.PRECISION APPLICATION OF INPUTS: Remote sensing allows farmers to apply water, fertilizers, and pesticides more precisely, targeting specific areas in the field where they are needed. This can lead to reduced resources wastage and increased cost-effectiveness.

2.CROP MONTORING AND YIELD PREDICTION: Continuous monitoring of crops through remote sensing enables better tracking of crop health and growth. This data can be used to predict yields more accurately and optimize harvesting schedules.

3.EARLY DETECTION OF ISSUES: Remote sensing can help detect anomalies and stress in crops early on, allowing farmers to take timely action to migrate potential losses.

 4.VARIABLE RATE TECHNOLOGY(VRT): Integration of remote sensing data with VRT systems allows farmers to automatically adjust input application rates based on field variability, optimizing resources use.

5.SUSTAINABLE AGRICULTURE: Remote sensing can aid in identifying areas where land use changes or conversion efforts are needed, contributing to more sustainable agricultural practices.

**Conclusion:**

The use of remote sensing in agriculture has proven to be a transformative force, reshaping conventional farming methods and laying the groundwork for precision farming. Farmers now have access to unprecedented amounts of data and insights thanks to the integration of cutting-edge technologies like drones, satellite imagery, and advanced data analytics. The significant impact of remote sensing in agriculture was the subject of this essay, which delves into its applications, advantages, challenges, and enormous potential for farming's future.

Throughout the agricultural cycle, remote sensing has found numerous applications. From crop observing and yield forecast to illness and bug recognition, soil wellbeing evaluation, water the executives, and land use arranging, the innovation has offered priceless help to ranchers in going with informed choices. The way farmers approach agriculture has been rethought as a result of remote sensing's ability to provide data in real time and enable management driven by data.

Remote sensing has significantly benefited agriculture. Expanded crop efficiency, asset enhancement, ideal navigation, cost investment funds, and the advancement of feasible practices are only a couple of the benefits saw by ranchers around the world. Accuracy farming has considered the streamlining of asset use, prompting diminished ecological effect, worked on monetary results, and more noteworthy food security. By engaging ranchers with custom-made data on each field's particular necessities, remote detecting has introduced a time of designated intercessions and effective cultivating rehearses.

Despite the numerous advantages, there are still obstacles and restrictions. The widespread use of remote sensing has been hampered by high initial costs and limited technology access, particularly among small-scale farmers and in developing regions. Some farmers have encountered difficulties with data interpretation and the requirement for specialized knowledge, necessitating the provision of training and assistance. Furthermore, as remote sensing involves the collection and analysis of sensitive agricultural data, data privacy and security have become increasingly important. To overcome these obstacles and foster the adoption of remote sensing, governments, technology providers, and agricultural communities must work together.

Remote sensing in agriculture holds a lot of promise for the future. As innovation keeps on advancing, remote detecting devices are probably going to turn out to be more available and savvy, enabling even the littlest ranchers to profit from accuracy farming. Progressions in information handling calculations, driven by man-made reasoning and AI, will improve the precision and effectiveness of remote detecting examination. The mix of remote detecting with the Web of Things (IoT) and Huge Information investigation will make a thorough organization of horticultural information, furnishing ranchers with uncommon degrees of data for navigation.

Automation and customization are expected to have a significant impact on the future of agricultural remote sensing. Customized arrangements and robotized frameworks will empower ranchers to get customized suggestions and smooth out specific errands in light of remote detecting information. Farmers' workloads will be reduced and efficiency and productivity will rise as a result.

Sustainable farming methods are one of the most promising applications of remote sensing in agriculture. The coordination of remote detecting with reasonable practices will advance biodiversity, soil wellbeing, and water protection. Remote sensing can help with targeted interventions to reduce ecological footprints by identifying regions with high resource consumption and environmental impact. The precision with which crop health and stress levels can be monitored can result in a reduction in chemical inputs, reducing the negative effects on human health and the environment.

In conclusion, agriculture has entered a new era of precision farming as a result of a paradigm shift brought about by remote sensing. It can be used at different points in the agricultural cycle, giving farmers valuable insights and making it possible to make decisions based on data. Increased crop productivity, resource optimization, and environmentally friendly practices are just a few of the advantages of remote sensing that have the potential to transform the agricultural sector and contribute to global food security. Challenges connected with costs, information understanding, and openness can be conquered through deliberate endeavors and joint efforts.

With technological advancements anticipated to further enhance its capabilities, the future of remote sensing in agriculture appears promising. As accuracy horticulture turns out to be more open, ranchers from varying backgrounds can bridle the force of remote detecting to work on their yields, decrease expenses, and embrace reasonable practices. By embracing development and proceeding to put resources into innovative work, the rural area can completely understand the capability of remote detecting, guaranteeing a more effective, strong, and supportable future for cultivating.

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