Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 03, Issue: 03 (MAY-JUNE, 2023)
Available online at http://www.agriarticles.com

Remote Sensing and Its Use in Agriculture

(*Sunil Kumar Yadav[1], Mamta Yadav[2], Upendra Singh[1], Rizwan Ahmad[3] and Dharmendra[1])
[1]Agronomy Section, Aligarh Muslim University, Aligarh, India
[2]Horticulture Section, SKNAU, Jobner, India
[3]Department of Remote Sensing and GIS Application, AMU, Aligarh, India
*Corresponding Author's email: skyadav904072@gmail.com

Abstract

The art and science of acquiring data about items or regions at a distance without coming into direct contact with them is known as remote sensing. Remote sensing is the science and technology of drawing conclusions about physical objects without touching them from measurements taken at a distance. In addition to ground observations, remote sensing is a method for monitoring the resources of the planet. The science and technology of remote sensing involves drawing conclusions about physical objects from measurements taken at a distance without touching the object being studied. Remote sensing technology uses the visible, infrared and microwave regions of radiation to collect information about the various objects on the earth's surface. The fundamental idea behind every object that is picked up by remote sensing is its spectral signature. varied areas of the electromagnetic spectrum have varied responses from objects. The typical responses are utilized to differentiate between various features, like concert, flora, water, bare soil, and other comparable features. There are two forms of remote sensing: active and passive. Remote sensing, that is passive Seasons are used to identify the natural sources of electromagnetic radiation that are reflected or emitting. Active remote sensing: It uses the seasons to find objects' reflected responses to energy sources that are artificially generated, like radar. Platforms come in three different varieties: satellite-based, ground-based, and air-based. Crop condition monitoring, plant stress detection, vegetative indices, canopy transmission and crop stress, cropping system analysis, application on forestry, drought monitoring and its assessment, flood mapping and its assessment, ground water exploration, storm and flood warning, water availability and location of canals, wildlife inventory, and fire surveillance are just a few of the numerous applications of remote sensing in agriculture.

Keywords; Agriculture, canals, animals, and remote sensing.

Introduction

Agriculture has long been connected to the production of vital food crops. Currently, agriculture comprises forestry, dairy, fruit cultivation, poultry, beekeeping, mushroom, arbitrary, etc. in addition to farming. Today's agriculture is recognized to include the processing, marketing, and distribution of crops and livestock products. So, the production, processing, promotion, and distribution of agricultural products could be referred to as agriculture. A particular economy's entire existence depends on agriculture. The foundation of any nation's economic structure is its agriculture. A big percentage of the population has access to employment opportunities in agriculture in addition to providing food and raw materials. Producing enough food in appropriate quantities and of high quality is crucial for human welfare everywhere on the globe. Food security for a country is ensured by a stable agricultural industry. Food security is the most important prerequisite for every nation. Malnourishment, which has historically been seen as one of the main issues facing developing nations, is prevented by food security. Most nations rely on agriculture and related products.

- Only a country with a plentiful food supply can aspire to strength and independence. Using a macroeconomic model, the International Food Policy Research Institute (IFPRI), Washington, has shown that a 1% increase in agricultural production in India results in a.5% gain in industrial growth. Agriculture plants are living things that need nutrients and water to thrive. They also have a high sensitivity to diseases, pests, and harsh weather events. Data from remote sensing can be used to track and identify crops. This data becomes a crucial tool for making decisions about crops and agricultural plans when they are organized in a Geographical Information System along with other sorts of data. This data, when combined with other forms of data and organized in a Geographical Information System, serves as a crucial tool for decision-making about crops and agricultural tactics.
- Remote sensing is a scientific technique of obtaining information about objects or areas from a distance, typically from aircraft or satellites. Remote Sensing using space borne sensors is an unparalleled tool for obtaining synoptic, repetitive observations of standing crops as well as their ambient environment. Indian Space Research Organization (ISRO) and Indian Council of Agricultural Research (ICAR) jointly conducted the first multi spectral airborne Indian study in 1969.

Role of Remote Sensing in Agriculture

Remote sensing technologies offer a diagnostic instrument that can act as an early warning system, enabling the agriculture community to take immediate action to address possible issues before they spread extensively and have a detrimental influence on crop output. As a result of recent developments in sensor technologies, data management, and data analytics, the agricultural community now has access to several RS choices. Agriculture provides valuable renewable natural resources with dynamic properties. In India, the agricultural sector alone provides employment for almost 70% of the population and accounts for close to 35% of the country's gross domestic product. Since there is little room to expand the land under agriculture, enhancing agricultural production has been the focus. This necessitates the wise and effective management of both water and land resources. Therefore, detailed, and trustworthy information on land use and cover, soil types in forest areas, geological data, the size of wastelands, agricultural crops, water resources (both surface and subterranean), and the risks associated with natural disasters like drought and floods is needed. Such information is largely provided by remote sensing technologies, which can offer optical, multitemporal, and multispectral coverage of the nation. To develop methods for separating agriculturally relevant data from ground-based, airborne, and space-based data, numerous studies have been conducted. Here are a few examples of broad agricultural use areas:

Satellites & Sensors for Agriculture Application

Satellite	Sensor	Land surface reflectance	Evapotranspiration	Land surface temperature	Precipitation	Soil moisture	Vegetation Greenness	Structure
Terra	MODIS	-	-	-			-	
Aqua	MODIS	-	-	-			-	
Suomi-NPP	VIIRS	-		-			-	

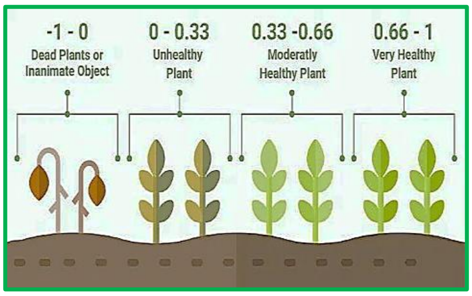
NOAA-20	VIIRS	-		-			-	
Landsat 8	OLI	-					-	
Sentinel 2	MSI	-					-	
Landsat 8 & Sentinel 2	HLS	-					-	
International Space Station	ECOSTRESS		-					
Land Data Assimilation System	Modeled output		-			-		
Global Precipitation measurement	GMI, DPR				-			
CHIRPS	Multiple				-			
Soil moisture active passive	L-band radar					-		
Sentinel 1	C-band radar							-

For remotely analysis of farmland requires parameters that focus on crop growth, soil properties, weather data and water resource.
There are some indices that are used in agriculture are as follows –

Vegetative indices

- The ratio between the infra-red region and red region: R=IR/Red
- Normalized Difference Vegetation Index (NDVI) = (IR-Red)/(IR+Red)
- Greenness =Weighted sum of radiances in the IR brand – weighted sum of irradiation in the visible band, where IR and Red refer to the radiance in red and infra-red bands.

Normalized Difference Vegetation Index (NDVI)
Among the typical spectral vegetation indices, NDVI is one of the most suitable to track crop development dynamics since it measures photosynthetically active biomass in plants.
Formula: NDVI = (NIR – RED) / (NIR + RED)
Where:
NIR – light reflected in the near-infrared spectrum.
RED – light reflected in the red range of the spectrum.
Key fact: NDVI is the **most common** vegetation index in remote sensing. It can be used throughout the whole crop production season except when vegetation cover is too scarce, so its spectral reflectance is too low.



When to use: NDVI values are the most accurate in the middle of the season at the stage of active crop growth.

Index Range

NDVI defines values from -1.0 to 1.0, where negative values are mainly formed from clouds, water and snow, and values close to zero are primarily formed from rocks and bare soil.

Indices value	Range	Possible interpretation
Very small values	- 1 to 0	Dead Plant or inanimate object
Small values	0 to 0.33	Unhealthy plant
Moderate values	0.33 to 0.66	Moderately healthy plant
High values	0.66 to 1	Very Healthy plant

Red-Edge Chlorophyll Vegetation Index (RECl)

The ReCI vegetation index is responsive to chlorophyll content in leaves that are nourished by nitrogen. ReCI shows the photosynthetic activity of the canopy cover.

Formula: ReCI = (NIR / RED) – 1

Key fact: Because chlorophyll content directly depends on nitrogen level in plants, responsible for their “greenness”, this vegetation index in remote sensing helps detect areas with yellow or shed foliage.

When to use: ReCI values are most useful at the stage of active vegetation development but are not suitable for the season of harvesting.

Soil Adjusted Vegetation Index (SAVI)

The SAVI was introduced to mitigate the impact of soil brightness. Its creator Huete added a soil adjustment factor L to the equation of NDVI to correct for soil noise effects (soil color, soil moisture, soil variability across regions, etc.), which tend to impact the results.

Formula: SAVI = ((NIR – RED) / (NIR + RED + L)) * (1 + L)

Key fact: L varies from –1 to +1, depending on the green vegetation density in the questioned area. In areas with high green vegetation L= 0, and in this case, SAVI is the same as NDVI. Conversely, L = 1 for low green vegetation zones. Most typically, L is set to 0.5 to adjust to most land cover.

When to use for analysis of young crops; for arid regions with sparse vegetation (less than 15% of total area) and exposed soil surfaces.

Visible Atmospherically Resistant Index (VARI)

The VARI index is perfect for RGB or color images since it works with the whole visible segment of the electromagnetic spectrum (comprising red, green, and blue color bands). Its specific task is to enhance vegetation under strong atmospheric impact while smoothing illumination variations. VARI can be used for the following satellite sensors: Sentinel-2, Landsat-8, GeoEye-1, Pleiades-1, Quickbird, and IKONOS.

Formula: VARI = (GREEN – RED) / (GREEN + RED – BLUE)

Key fact: Thanks to low sensitivity to atmospheric impact, the error of VARI for vegetation monitoring in conditions of different atmospheric thickness is less than 10%.

When to use crop state assessment when minimum sensitivity to atmospheric effects is required.

Normalized Difference Water Index (NDWI)

The NDWI was initially elaborated to outline open water bodies and assess their turbidity, mitigating the reflectance of soil and land vegetation cover. NDWI is retrieved with a near-infrared and visible green band combination.

Formula: NDWI = (GREEN – NIR) / (GREEN + NIR)

Key facts: The NDWI index is often confused with NDMI (Normalized Difference Moisture Index). NDWI uses SWIR (Short Wave Infrared) and NIR channels. NIR reflectance allows analyzing dry matter content in vegetation foliage and internal leaf structure, while SWIR reflectance shows the changes in plant water content and mesophyll structure. When combined, NIR and SWIR bands give a better idea of plant water content because the water in the internal leaf structure impacts the spectral reflectance in SWIR.

When to use detection of flooded agricultural lands; allocation of flooding on the field; detection irrigated farmland; allocation of wetlands.

Crop condition monitoring

The crop condition is to be passed during the crop period. This assessment will help monitoring of the crop at frequent intervals. Spacecraft based remote sensing is ideally suited for crop condition monitoring. The condition of the crop is influenced by the following kinds of stress:

- water stress brought on by a drought.
- Nutrient stress brought on by inadequate soil availability.
- Flooding
- Salinity
- Pest and disease assaults

Detection of plant stress

of the main techniques for plant stress detection in maize crop plants. Whole field sensing (VIS/NIR)

In comparison to the non-stressed crop, the water stressed crop had a greater spectral reflectance in the visible area. The NDVI, RVI, PVI, and GI vegetation indices were shown to be lower for stressed crops and higher for non-stressed crops. Estimating the soil moisture availability in the field is now possible thanks to the development of microwave remote sensing.

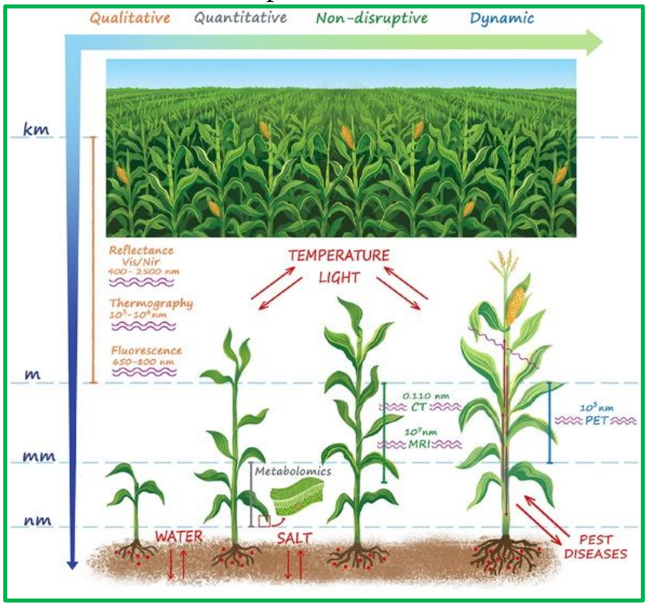


Figure - A summary (CT, MRI) provides quantitative high-resolution detection of structural damages induced by the stress (Galieni et al., 2021reflectance, Thermography, Fluorescence) is naturally attractive in the agricultural practice, but gap of the spongy mesophyll. Stressed leaves have fewer air spaces than unstressed leaves. They are less effective in reflecting infrared radiation and provide only qualitative information. At plant level morphological imaging techniques in response to visible light (0.4-0.2 mm), which they absorb, chlorophyll and other pigments react. The near infrared area is one that has substantial reflectivity that is brought on by several circumstances. This takes place in the intercellular air. The red band's reduced plant color is a result of disease attack, nutritional stress, and water stress.

Cropping system analysis

Finding agricultural areas with low to medium crop productivity where a sustainable increase in crop production can be achieved through adoption of suitable agronomic management packages, including the introduction of new crop, etc., requires knowledge about the existing cropping system in a region with respect to areal extent of crop, crop vigor/yield, and yearly crop rotation/sequence practices. By spatially integrating the temporal crop inventory data from the area's several crop seasons, remote sensing may play a significant role in cropping system analysis. The cropping system analysis was done in 1995 in the Madhur Watershed, Nizamabad district, Andhra Pradesh, using GIS to integrate multi-temporal digital satellite

(IRS-1B LISSII) data-based classification crop inventory information of the kharif season (rainy season), rabi season (winter season), and summer crop season.

Crop biophysical characterization

By providing timely spectral reflectance data that may be correlated to biophysical indices of plant health, remote sensing can play a significant role in agriculture. To determine the health or condition of a crop, quantitative methodologies can be used using spectral data collected from close range, by aircraft, or by satellite-based sensors. By offering at least the following sorts of information, technology can significantly contribute to crop management:

- percentage of plant cover
- content of chlorophyll
- the index of green leaf area, and
- additional quantifiable biophysical variables

Yield forecasting

Crop cutting experiments (CCE), carried out during harvest in the plots chosen based on a pre-designed sampling system utilizing existing ground data, are the traditional method used by the Bureau of Economic and Statistics (BES) in India to estimate crop yields (Dadhwal and Ray, 2000). Due to the significant level of unpredictability involved, crop production forecasting using remote sensing is more complicated than cropped area estimating.

Crop production depends on several factors, including soil, weather, cultivation methods, fertilizer used, irrigation, sowing date, genotype, pest, and disease pressure, etc. The entire impact of all these elements on a crop's growth may be seen in the spectral data of that crop. When using remote sensing data for yield forecasting, there are generally two different strategies. Based on the actual field data, a correlation between crop production and remote sensing observed data in the form of some type of vegetation index may be constructed. As a result, an empirical association can be found. As a result, an empirical association can be found. In the second scenario, a biophysical parameter that is generated from observations made through remote sensing, such as the leaf area index, can be used as one of the input factors in models that forecast yield, such as crop simulation models.

Precision farming

In standard cropping practices, the entire farm receives an equal amount of fertilizer, water, and other inputs. The input needed, however, could not be the same for the entire area. Precision farming aims to collect and analyze data on the spatial variability of soil and crop condition to maximize crop input efficiency based on site-specific requirements within a farm. Therefore, precision farming may be viewed as site-specific farming, which has the potential to lower costs by using agronomic inputs more efficiently and effectively. Inputs are applied where they are needed and in the necessary quantity, which also lessens the impact on the environment. We need an application map, which indicates the position, the geographical extent, and the level of input to be employed, before we can achieve the variable rate of input. For variable rate of application, precision farming necessitates the integration of several technologies, including GPS, GIS, remote sensing, and field equipment. Now that high resolution multi spectral data from the next generation satellites is available, it is possible to provide information at the field or within field level.

Forestry application

- One of the most important natural resources in the world is the forest. Many of our basic needs, like fuel wood, lumber, raw materials for paper, etc., are sourced from them. Additionally, forests are crucial for maintaining a balance in the supply and exchange of CO_2 on planet. But the rate at which our forest is vanishing is worrying. According to

FAO research, the total forest area decreased by 11.25 million hectares year between 1990 and 1995 (Russian federation omitted), or around 0.33% of the world's total forest cover. The traditional in situ monitoring of the forest area might be enhanced by remote sensing. Analyzing pictures was one of the earliest ways to get data on forests. the tones, textures, shapes, patterns, etc. in photographs. Satellite imaging is replacing conventional pictures because of the development of space-based remote sensing.

- Modelling to manage resources According to Champion and Seth (1968), a forest type is a unit of vegetation that processes (broad) traits in physiognomy and structure that are sufficiently apparent to permit its distinction from other similar units. Any region's management recommendations are based on the type of forest that is already present there. Therefore, making a distinction between different forest types is crucial for the wise management of forests. More than 60% of India's forest cover is made up of tropical moist and dry deciduous forests.

Remote Sensing Applying Areas

General application:

- Maps of agricultural land usage
- soil analysis and water resource analysis
- cropped region.
- Maps of abandoned areas
- Monitoring and evaluation of the drought

Specific application:

Crop recognition.

- Agricultural vitality and density.
- Crop maturity and crop growth rate.
- Planting and harvest dates.
- soil issues, such as salinity.
- Drought forecast.
- illnesses, insects, nematodes, and pests.
- a loss of forest
- Storm and flooding alert
- Location of canals and access to water

Application to range surveys:

- Species of fodder and their yield identification.
- Defining the many types of forests and their conditions.
- Ranges' carrying capacity.
- Fertility of the soil and soil erosion.
- Species that are toxic are identified.
- Wildlife census.

Application to livestock survey:

- Cattle, sheep, pigs, and poultry populations.
- Animal population distribution.
- Animal conduct.
- animal health.

Advantages of remote sensing:

- Coverage area: Compared to conventional techniques, satellite technology can quickly and accurately cover information from a vast region.

- Record permanence: Areal and satellite data serve as the permanent record and are used for ongoing operations.
- Spectral and spatial resolution: Any sensor's spatial resolution may be used to get images with more fineness and an increased level of object detail.
- Speed and accuracy of interpretation: By using a digital image processing system, we can quickly and accurately examine the data.
- Cost-effective and dependable: Remote sensing provides a monitoring method that is both affordable and dependable.

Limitation of remote sensing

Some of the main operational issues with our country's use of remote sensing technology for agricultural production include the following:

- a little farm with a limited crop field
- mixed crops, such as wheat and ground nut or sorghum and red gramme.
- like wheat and barley, a confusing crop.
- many cultural customs.
- a wide range of sowing dates.
- large regions with low development that are rainfed.
- Cloud cover during India's primary crop-growing season, the kharif.

References

1. Sahu, D. D. (2003). Agrometeorology and Remote Sensing: Principles and Practices. India: Agrobios (India).
2. Remote Sensing - B. Duary.
3. S.K. Bhan et al ―Use of remote sensing and GIS technology in sustainable aquaculture management and development‖, Indian Institute of Remote Sensing, NRSC, Dehradun
4. Nellis, M. Duane; Price, Kevin P.; and Rundquist, Donald, "Remote Sensing of Cropland Agriculture" (2009). Papers in Natural Resources. 217.
5. Joseph, George & Chockalingam, Jeganathan. (2017). Fundamentals of Remote Sensing. Das, D. K. and Singh, G. (1989). Estimation of evapotranspiration and scheduling irrigation using remote sensing techniques. Proc. Summer Inst. On agricultural remote sensing in monitoring crop growth and productivity, IARI, New Delhi, pp.113-17.
6. Das, S., Pardeshi, S.D. Integration of different influencing factors in GIS to delineate groundwater potential areas using IF and FR techniques: a study of Pravara basin, Maharashtra, India. *Appl Water Sci* 8, 197 (2018)
7. S. Delin B. Lindén K. Berglund (2005) Yield and protein response to fertilizer nitrogen in different parts of a cereal field: potential of site-specific fertilization *European Journal of Agronomy* 22 325–336.
8. Blackmore, Simon & Godwin, Richard & Fountas, Spyros. (2003). The Analysis of Spatial and Temporal Trends in Yield Map Data Over Six Years. Biosystems Engineering. 84. 455-466. 10.1016/S1537-5110(03)00038-2.
9. Delin, S. and Berglund, K. (2005). Management zones classified with respect to drought and waterlogging. Prec. Agric., 6: 321- 340.
10. Bramley, R.G.V. 2009. Lessons from nearly 20 years of Precision Agriculture research, development, and adoption as a guide to its appropriate application. Crop Past. Sci., 60: 197- 217.
11. Ebertseder, Th & Schmidhalter, Urs & Gutser, R & Hege, U & Jungert, S. (2005). Evaluation of mapping and on-line nitrogen fertilizer application strategies in multi-year and multi-location static field trials for increasing nitrogen use efficiency.

12. Singh, I., Srivastava, I.A., Chandna, P. and Gupta, R. (2006). Crop sensors for efficient nitrogen management in sugarcane. Potential and constraints. Sugar Technol., 8: 299-302.
13. Li, Y., Chen, D., Walker, C.N. and Angus, J.F. (2010). Estimatingthe nitrogen status of crops using a digital camera. Field Crops Res., 118: 221-227.
14. Galieni A, D'Ascenzo N, Stagnari F, Pagnani G, Xie Q and Pisante M (2021) Past and Future of Plant Stress Detection: An Overview from Remote Sensing to Positron Emission Tomography. Front. Plant Sci. 11:609155. doi: 10.3389/fpls.2020.609155
15. EOS Data Analytics: Space solutions for Earth problems. https://eos.com/make-an-analysis/ndvi/
16. EOS Data Analytics: Space solutions for Earth problems. https://eos.com/blog/vegetation-indices/#gci