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Importance and Applications of Remote Sensing in Agriculture

Vaibhav Pratap Singh[1*], Devesh Pathak[1], Sibte Sayyeda[1] and Ashish Sheera[2]

[1]Dept. of Plant Protection, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh, Uttar Pradesh (202 002), India

[2]Sher-e-Kashmir University of Agricultural Sciences & Technology (SKUAST), Jammu, Jammu and Kashmir (180 009), India

Corresponding Author

Vaibhav Pratap Singh

e-mail: vaibhavpratapsingh10392@gmail.com

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E-mail: bioticapublications@gmail.com

Abstract

With advances in ground-based, airborne, and satellite remote sensing, reflectance data are increasingly being used in agriculture. The article initiates with an overview of the need for remote sensing and main agricultural challenges. This article gives a brief description of various remote sensing applications designed to optimize the profitability of agricultural crop production and protect the environment. It also provides concise knowledge of the use of remote sensing in assessing nutritional requirements of plants, forecasting crop yield, and nutrient content in the soil, determining plant water demand, etc.

Introduction

The term 'Remote' means far away. The "American Society for Photogrammetry and Remote Sensing (ASPRS)" described photogrammetry and remote sensing as "the art, science, and technology of obtaining consistent data about physical entities and the environment, through the process of measuring, recording, and interpreting imagery and digital representations of energy patterns resulting from non-contact sensor systems."

So, it is the process of acquiring information about an object without making any physical contact. The hauler of data in remote sensing is electromagnetic radiation, which travels in a vacuum at the speed of light in the form of waves of various lengths (Figure 1). The most useful wavelengths in remote sensing cover visible light (VIS) and extend through the near-infrared (NIR), shortwave infrared (SWIR), thermal infrared (TIR), and microwave bands (Figure 2). Passive remote sensing sensors record incident radiation emitted or reflected from the objects. In contrast, active sensors emanate their own radiation, which interacts with the target to be scrutinized and returns to the measuring instrument (Atzberger, 2013).

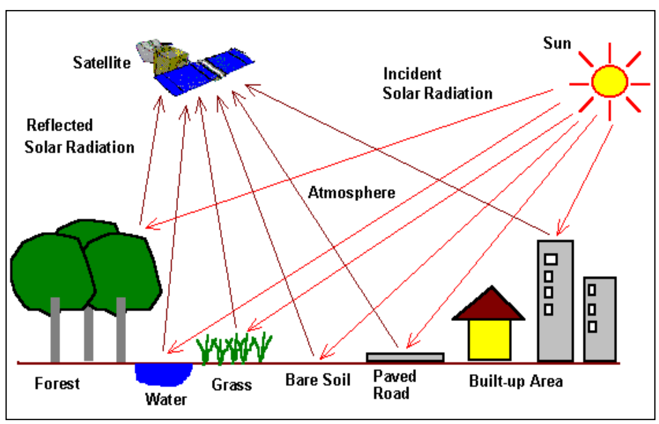

Figure 1: Processes involved in remote sensing

Table 1: Landmarks in History of Remote Sensing

Year	Milestone Achieved
1800	Discovery of Infrared (Sir W. Herchel)
1839	Beginning of Practice of Photography
1847	Infrared Spectrum (J. B. L. Foucault)
1859	Photography from balloons
1873	Theory of electromagnetic spectrum (J. C. Maxwell)
1909	Photography from airplanes
1916	World War I: Aerial reconnaissance
1935	Development of radar in Germany
1940	World War II: Application of non-visible elements of electromagnetic radiation
1950	Military research and development
1959	First space photograph of the earth (Xplorer-6)
1960	The first meteorological satellite launched
1970	Skylab remote sensing observations from space
1972	Launch LANDSAT-I and brisk advancement in digital image processing
1982	Launch od LANDSAT-4 with a new generation of sensors (TM)
1986	French commercial earth observational satellite SPOT
1986	Development of hyperspectral sensors
1990	Developing high-resolution spaceborne systems and first commercial developments in remote sensing
1998	Towards cheap one-goal satellite missions
1999	Launch EOS: NASA earth-observing mission
1999	Launch of IKONOS, extremely high spatial resolution sensor systems

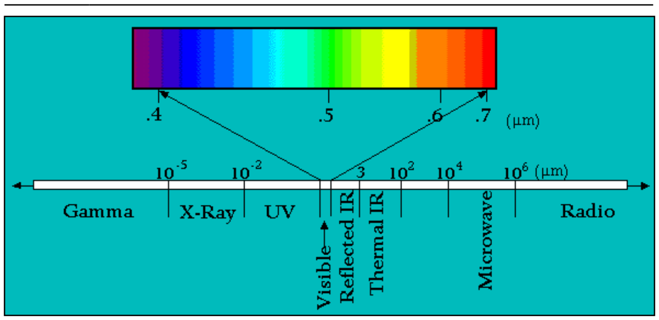

Figure 2: Range of Electromagnetic Spectrum

Need of Remote Sensing in Agriculture

Remote sensing's application has widely used in agriculture and agronomy. It is necessary as the agriculture sector deals with unique problems during monitoring, which are not common in other economic areas. According to FAO's recent report, the world's population increase to 9.15 billion by 2050, which may results in escalating the demand for current food production by 60%. Many efforts are underway to intensify the overall production to meet with future requirements of the burgeoning population by increasing its efficiency, for instance, high-intensity agriculture, high yield varieties, and efficient water use. Agricultural production follows healthy seasonal patterns related to the natural lifecycle of crops. The production also depends on the climatic driving variables, as well as the physical landscape (e.g., soil type), and agricultural management practices. All these variables are very much inconsistent in space and time. Furthermore, agrarian monitoring systems need to be real-time for higher productivity as productivity can alter within short periods due to unfavorable growing circumstances.

Consequently, employing remote sensing is requisite in scrutinizing agricultural field, water management and its quality, crop & soil health, and atmospheric conditions with importance to yield. All through the last two decades, remote sensing modus operandi has been functional in exploring agricultural applications such as soil moisture estimation, soil survey, crop discrimination, crop acreage estimation, crop condition assessment, yield estimation, agriculture water management, precision agriculture, agro-meteorological and agro advisories. The application of remote sensing in agriculture, explicitly in soils and crops, is tremendously complex because of the highly dynamic and inherent convolution of biological materials and soils (Myers, 1983). Nevertheless, remote-sensing technology provides many advantages over the traditional techniques in the agricultural resources survey. The benefits include (a) capability of synoptic view, (b) ability of repetitive coverage to detect the changes, (c) potential for the quick survey, (d) low-cost involvement, (e) use of hyperspectral data for increased information, and (f) higher accuracy.

Remote Sensing Applications in Agriculture

Remote sensing is grouped into three categories: ground-based, airborne, and satellite. When appraising a remote sensing platform, the spatial and spectral resolution must also be considered. The spatial resolution describes the pixel size of satellite or airborne images covering the earth's surface. It relates to the dimensions of the smallest object that can be acknowledged on the ground. A sensor's spectral resolution indicates the width of spectral bands in which the sensor can collect reflected radiance.

By keeping this in view, some brief description of the applications as mentioned earlier are given below:

1. Forecasting of Crop Production

Remote sensing has applied to forecast the estimated crop production and yield over a specified area and conclude how much of the crop will be harvested under certain conditions. Examiners can be able to envisage the quantity of crop in given farmland over a given period.

2. Crop Identification

By using remote sensing, we can identify the crops, especially in cases where the crop under examination shows some inexplicable characteristics. The crop data collected will be taken to labs where various aspects of the crop, including the crop culture, are examined.

3. Appraisal of Crop Progress and Crop Damage

In the event of crop progress or damage, remote sensing technology can be used to penetrate the farmland and determine the exact quantity of the given damaged crop and the growth of the remaining crop on the farm.

4. Estimation of Crop Acreage

Remote sensing plays a vital role in the estimation of previously planted farmland. This process is usually a cumbersome procedure if it is carried out manually because of estimating the large sizes of lands.

5. Crop Yield Modelling and Estimation

Remote sensing also allows experts and farmers to envisage the expected crop yield from given farmland by evaluating the quality of the crop and the farm area. This is then employed to determine the overall predicted yield of the crop.

6. Identification of Disease and Pests Infestation

Remote sensing technology also plays a crucial role in the identification of pests in farmland. It gives data on the right pests control mechanism to eliminate the pests and diseases on the farm.

7. Assessment of Soil Moisture

Soil moisture can be challenging to measure without the aid of remote sensing skills. Remote sensing provides the soil moisture data and helps in determining the quantity of moisture in the soil and enlightens the type of crop that can be cultivated in the soil.

8. Mapping of Soil

Mapping of soil is one of the most common yet most essential uses of remote sensing. Through soil mapping, farmers can tell which soils are ideal for which crops and which soil require irrigation and which ones do not. This information helps in precision agriculture.

9. Drought Monitoring

Remote sensing technology is utilized to monitor the weather pattern of a given area. The technology also monitors drought patterns of the area too. The information can be used to forecast the rainfall patterns of an area. It also tell the time difference between the current rainfall and the next rainfall, which helps to keep track of the drought.

10. Mapping of Water Resources

Remote sensing is instrumental in water resources mapping that can be used for agriculture over given farmland. Through remote sensing, farmers can tell where water resources are accessible for use over a given land and whether the resources are adequate (Wojtowicz, 2016).

Conclusion

This article demonstrates the substantial role of remote sensing within the agricultural sector. The remotely offered information is immediately needed for various decision-makers. Requests for objective information will increase in the future as a result of the expected changes in the agricultural sector (e.g., meeting food requirements and environmental restrictions). Remotely sensed information could help with identifying yield gaps and monitoring related agricultural practices. Vegetation anomalies related to local meteorological conditions (e.g., droughts) can be readily detected from space and combined with other data sources to indicate stress affected regions. This information is not only crucial for organizations dealing with food security but can also help with identifying a region's vulnerability to (drought) stress.

Highly advanced technologies used in precision agriculture require constant access to detailed information characterizing the environmental conditions under which this production takes place. Such information may be obtained from airborne and satellite images at the field scale. Data collected from satellite, airborne, and ground levels facilitate monitoring weed infestations, damages caused by pests and plant pathogens, thereby making it possible to counteract quickly. Remote sensing has also been used to assess the water needs of plants and determine the date of commencement of irrigation, making it easier to manage crop production under conditions of water stress. Combining remotely acquired data with existing crop simulation models will improve the reliability of decision support systems and will contribute to modernized agricultural production management.

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