Remote Sensing and GIS Techniques for Managing Plant Biotic and Abiotic Stresses

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OPEN ACCESS

Keywords

Farming, Nutrient, Toxicity, Spectral, Signature

How to cite this article:

Verma, S., Sankhyan, N. K. and Sharma, S. 2024. Remote Sensing and GIS Techniques for Managing Plant Biotic and Abiotic Stresses. *Vigyan Varta* 5(6): 71-75.

ABSTRACT

The environment and weather have a crucial impact on the agriculture industry. The country's established farming practices and food output to support its expanding population may be threatened by climate change. Agriculture and climate change are linked because agricultural processes frequently employ the result of climate as an input. Due to the growing impact of climate change on agriculture, these measures for mitigating its effects have received a great deal of attention in recent decades. During their growth and developmental phases, agricultural crops often go through a cycle that is extremely vulnerable to biotic and abiotic stimuli. This suggests that stress throughout any stage of development is detrimental to the growth, development, and productivity of crops during the production cycle. Any external element that causes a malfunction in an agricultural crop's life cycle is referred to as crop stress. Crop stress comes in two flavours: biotic and abiotic. Abiotic stressors include things like drought, nutrient imbalance, salinity, nutrient toxicity, insufficient or excessive water, waterlogging conditions, and physical attacks by herbivores. Biotic stressors include infections from disease pathogens. Each cropping season's crop output is severely reduced as a result of these pressures. The science and art of gathering data from a device that is not in contact with the thing being studied in order to learn more about it, as well as its surroundings, is known as remote sensing (RS). In order to

quantify and visualise the changes in plants, geographic information system (GIS) techniques are used to recognise and understand forms and patterns of remotely sensed imagery based on corresponding spectral signatures.

INTRODUCTION

Climate change is one of the biggest challenges to the world agriculture systems in present times. There is different type of challenges in crops due to climate change Abiotic and biotic stressors provide significant environmental risks that significantly lower crop productivity and yield. Plant stress is unfavourable condition which affect the plant's metabolism growth and development. Depending on what causes them, plant stress situations can be divided into two major categories. Stress, Both Abiotic and Biotic. Biotic stress is caused by other living organisms, animals, insects, plants, fungi, bacteria, pathogens etc. Abiotic stress caused by temperature, solar radiation, Drought, Flooding, Salinity, agronomic practices etc. To overcome these challenges or stress, we have to integrate the science, technology and agriculture in a sustainable way. Remote sensing and GIS techniques help in real time data monitoring and assessment of these type of stresses.

Remote sensing and GIS techniques

The technique of detecting and tracking an area's physical properties from a distance by measuring its reflected and emitted radiation is known as remote sensing (usually from satellite or aircraft). Operating in the visible, infrared, thermal infrared, and microwave regions of the electromagnetic spectrum are the majority of passive systems utilised in remote sensing applications. Typically, passive sensors are geared towards a certain electromagnetic spectrum band, such infrared light (heat radiation) or visible light. Active sensors measure energy reflected back from the earth's surface, creating its own source of illumination. Three distinct types of sensors are used in this techniques, remote sensing from the ground, distant sensing from the air, remotely sensed using satellites The classification of remote sensing might be based on wavelength areas. Remote sensing techniques include visible, infrared, thermal infrared, and microwave. An object sent into orbit around a celestial body, usually a spacecraft, is called a satellite or artificial satellite.

The area that a pixel represents is known as spatial resolution. For example, a 10 m resolution dataset represents a 10 m by 10 m square in the ground for each pixel. We are capable to examine the global area map down to a specific smaller area, like building, because of this spatial resolution.

A sensor's spectral resolution is its capacity to distinguish between smaller wavelengths. They are multispectral, with three to ten bands. Certain sensors are referred to as hyperspectral because they contain hundreds or even thousands of bands.

The term "radiometric resolution" describes a sensor's capacity to detect even the smallest variations in the energy emitted by the earth's surface.

The information available over a specific time period is referred to as temporal resolution. This is satellite's revisit time over a specific region. Temporal resolution is the number of times a satellite takes pictures of a specific region in a predetermined amount of time.

The technique of enhancing an image's quality and information content prior to processing is known as image enhancement. A device called weather radar, sometimes referred to as Doppler weather radar, uses electromagnetic energy pulses to search for precipitation, measure its velocity and intensity, and identify the kind of precipitation, such as rain, snow, or hail.

Applications of Remote Sensing in Agriculture

Crop Production Forecasting: Using remote sensing, one may predict how much crop will be harvested under particular circumstances additionally estimate predicted crop output and yield across a given area. It is helpful for researchers to forecast how much crop will grow in a specific acreage over a specific time frame.

Assessment of Crop Damage and Crop Progress: Remote sensing technology has the potential to pierce fields in the time of crop damage or progress, allowing for the precise measurement of crop damage in addition to the progress of the remaining crop.

Crop Identification: Crop identification has substantially profited from

remote sensing, particularly when the crop being observed has odd traits. The acquired agricultural data will be brought to laboratories to be evaluated in relation to multifaceted of the crop, including the crop culture.

Crop Acreage Estimation: Remote sensing has also proven very helpful in estimating the area that has been sown with crops. Because the areas being estimated are so large, doing this manually is typically a laborious process.

Crop output Modelling and Estimation: By measuring the crop's quality and the size of the farmland, remote sensing also enables farmers and specialists to forecast the anticipated crop output from a specific plot of land. The crop's entire projected yield is then calculated using this.

Identification of Pests and Disease Infestation: Remote sensing technology is a major help in identifying pests in agricultural areas and provides data on the best pest management strategies to eradicate pests and diseases from the farm.

Estimating Soil Moisture: Without the aid of remote sensing equipment, measuring soil moisture can be challenging. The amount of moisture in the soil and, consequently, the kind of crop that can be produced there are both determined by remote sensing data on soil moisture.

Soil Mapping Among the most well-liked and significant applications of remote sensing is soil mapping. Farmers may determine which soils need irrigation and which ones don't by using soil mapping to determine which soils are good for certain crops. Precision farming benefits from knowing this information.

Monitoring of Droughts: A specific area's weather pattern is observed using remote sensing equipment. Additionally, the device tracks the area's trends of drought. The data can be utilised to forecast an area's patterns of precipitation and to determine the interval between the present and the next rainfall, which aids in monitoring the drought.

Mapping of Water Resources: Over a specific farmland, the mapping of water resources that can be exploited for agriculture is made possible in large part by remote sensing. Farmers can utilise remote sensing to determine the locations and sufficiency of water resources on a specific plot of land.

Management of biotic and abiotic stresses

Using remote sensing and Geographic Information Systems (GIS) for managing biotic and abiotic stress in agriculture and environmental science has become increasingly important. These technologies offer efficient ways to monitor and assess various stress factors affecting crops and ecosystems. Here's how they can be applied:

Biotic stress management:

Pest and Disease Monitoring: Remote sensing can detect slight modifications in plant health caused by pests and diseases before they become visually apparent. Spectral signatures captured by sensors can indicate stress levels, helping farmers to intervene early.

Weed Detection: Remote sensing can differentiate between crops and weeds based on spectral characteristics. GIS can then be used to map weed distribution, aiding in targeted herbicide application (Anderson *et al.*,1976).

Crop Health Monitoring: Monitoring crop health using remote sensing allows for early detection of stress caused by biotic factors. Changes in plant vigour and chlorophyll content can be found before they become apparent to the unaided eye.

Abiotic Stress Management:

Drought Monitoring: Remote sensing data, such as multispectral and hyperspectral imagery, can detect changes in vegetation moisture content, which is indicative of drought stress. GIS can be used to map areas prone to drought and prioritize water resource allocation (Thenkabail *et al*.,2011).

Salinity and Soil Quality: Remote sensing techniques, along with GIS, can assess soil salinity and quality over large areas. This information helps in identifying regions where soil management practices need to be adjusted to mitigate stress.

Temperature and Climate Monitoring: Information can be obtained from satellite data on land surface temperature and climatic conditions and assess the vegetation dynamics of particular time period. GIS can then be used to analyze temperature patterns and their impact on crop growth, helping farmers adapt planting schedules and cultivation practices.

Integration of Remote Sensing and GIS:

Data Fusion: Collecting data from different sensors and sources (e.g., satellite imagery, weather data, ground observations) allows for a comprehensive analysis of stress factors.

Spatial Analysis: GIS provides spatial context to remote sensing data, enabling the identification of stress hotspots and spatial patterns.

Decision Support Systems: Decision support systems that use remote sensing and GIS data enable stakeholders to make well-informed choices about crop management, resource allocation, and policy creation.

Remote sensing allows for the collection of data about the Earth's surface without direct contact, using sensors mounted on satellites or aircraft. These sensors can capture various wavelengths of light, enabling the detection of biotic stresses such as pest infestations or diseases, as well as abiotic stresses like drought, salinity, or nutrient deficiencies. For example, multispectral or hyperspectral imaging can detect subtle changes in plant health and stress levels by analyzing the reflectance patterns of different wavelengths of light.

GIS, on the other hand, provides a platform for integrating, analyzing, and visualizing spatial data. By combining remote sensing data with other geographic information such as soil type, topography, and weather patterns, GIS enables the identification of areas susceptible to specific stresses and the development of targeted management strategies. (Smith *et al.*,2020)

CONCLUSION:

Remote sensing and GIS techniques hold immense potential in agriculture sector. The integration of remote sensing and GIS techniques offers a powerful framework for managing plant biotic and abiotic stresses in agricultural and natural ecosystems.

By providing real-time weather data, assessing soil health, tracking crop conditions, pre-assessment of climate extremes and assessing possible climatic hazards, enable the identification, monitoring and mitigation of stress factors and empower farmers to make informed decisions for enhancing crop productivity, ecosystem health and sustainable resource management

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