Vegetation Indices for Optimizing Crop Management

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Abstract:
Remote sensing can assist in various farming practices. A vegetation index (VIs) is essential approach in crop management, providing perceptions into plant growth, health, and stress levels. Vegetation indices (VIs), calculated from satellite and other remote sensing data are used for variety of purposes. Vegetation indices (VIs) are mathematical expressions that transform spectral imaging data to highlight vegetation properties. Vegetation indices (VIs), is allow us in agriculture to quantify vegetation cover, biomass over a given area, predict crop yields and productivity also in resource management decisions. VIs depends on several factors Such as environmental conditions, the type and growth of the crop also the camera hardware. Vegetation indices, like NDVI, are derived from satellite images. These indices are calculated using spectral reflectance data from specific bands, typically red and near-infrared (NIR), collected by remote sensing satellites. NDVI based on the relationship between red and near infrared wavelengths. NDVI is a widely-used metric for quantifying vegetation characteristics like the greenness, health, growth stage and density of vegetation using sensor data. NDVI is a simple yet powerful tool for monitoring and analysing vegetation health from space. This paper focused on the Normalized Difference Vegetation Index (NDVI).

Keywords: Remote Sensors, Vegetation indices, NDVI, Crop management.

Introduction:
Agriculture is an activity done by farmers to yield crops. Vegetation plays an important role in the global environment. Natural vegetation is a type of vegetation in which plants grow without the interference of humans. The spectrometric data is usually sourced from remote sensors, such as satellites. Remote-sensing observations offer the opportunity to monitor, quantify, and investigate large-scale changes in vegetation in response to human actions as well as climatic and environmental changes. Remote sensing is used to track the seasonal changes in vegetation. Vegetation indices like NDVI have become an essential tool in crop management and environmental monitoring. Satellite imagery comes with different temporal and spatial resolutions [1]. Our lives depend upon plants and trees. Plants are sensitive to their environment and so they serve as a good indicator whenever there is change. When the plants and trees around us change, these changes can affect our health, our environment, and our economy. For these reasons and more, scientists monitor plant life around the world. Today, scientists use NASA satellites to map the greenness of all Earth's lands. The vegetation index maps show where and how much green leaf

vegetation was growing.
Depending on the vegetation index, information on various aspects of plant growth and development can be monitored, such as chlorophyll content, leaf area, canopy structure, and water status. Vegetation indices have a crucial role in precision agriculture and crop monitoring by providing a straight forward and reliable assessment of the condition and health of crops [2].Satellite crop monitoring is the technology for observing changes in the vegetation index obtained by spectral analysis of high-resolution satellite images [3] to track the development and health of crops. A high resolution satellite data would suitably improve the land use classification. The normalized difference vegetation index technique with different threshold values has been employed for features extraction. The Vegetation analysis can be helpful in predicting the unfortunate natural disasters to provide humanitarian aid, damage assessment and furthermore to device new protection strategies [4]. Vegetation monitoring is important for many applications, e.g., agriculture, food security, or forestry. For large-scale or global monitoring, space-borne remote sensing is typically utilised, with a frequent preference for multi-spectral optical sensors because of their easy interpretability and well-established analysis techniques. A particularly common approach to vegetation monitoring is the derivation of the normalised difference vegetation index (NDVI) from the red and infrared spectral bands. The main advantage of the NDVI is the high sensitivity to vegetation photosynthesis and its wide usage in research [5]. Monitoring agricultural crops is necessary for decision-making. There are several satellites that are able to successfully monitor the development of crop phonological cycles in agricultural fields. The data derived from Sentinel 1 provided great reliability in modelling the NDVI of agricultural crops throughout their phonological cycle. The high frequency of Sentinel 1 images, along with the information it produces from the surface, means that the monitoring of agricultural crops can be continuously carried out during any weather situation. This is concluded because Sentinel 1's C-band does not have substantial influences on soil water content after the canopy closure of crops [6]. Global, regional and local natural resource survey and assessment strategies are increasingly incorporating remotely sensed imagery to monitor current and historical vegetation dynamics and often rely on the combined use of multi-sensor vegetation data. Spectral vegetation index data have been used to investigate the interactions between climate and landscape ecosystems, monitor the effects of floods, drought, fire and desertification, aid with land management and sustainability, investigate climate change and carbon sequestration, and assess natural resources, agricultural production and food aid [7]. Each remotely sensed image source has its own specifications, such as orbital altitude, spatial and spectral resolutions, wavelength band limits, relative spectral response of the sensor, etc. The information in remote sensing images is affected by the sensor type, observation angle, atmosphere and terrain conditions. Therefore, there is a huge variance in the value of the multi-source observation system products because of the different sensor observation systems and the quantitative inversion algorithms, and the value of these multi-source products is difficult to apply collaboratively [8]. Multi-sensor comparisons are sometimes used due to limited image availability and temporal coverage by a single sensor. Various factors such as the atmospheric conditions during acquisition, landscape heterogeneity, landscape changes, and sensor characteristics influence direct comparability (i.e., scaling) of VIs between different sensors. Their effects on VIs, however, are not well understood and are difficult to quantify [9]. Environmental factors such as cloud cover, atmospheric conditions, and soil moisture can impact the accuracy and reliability of vegetation-index measurements. These factors must be accounted for in data analysis to ensure that the measurements are meaningful. Calibration is also an

important consideration, as vegetation indices must be calibrated to account for differences in sensor characteristics, atmospheric conditions, and other factors that can impact the accuracy of measurements. Failure to calibrate vegetation indices properly can lead to incorrect interpretations of data and incorrect crop-management decisions. Vegetation indices provide information for various precision-agriculture practices, by providing quantitative data about crop growth and health [2]. Vegetation indices measure the amount of green vegetation over a given area and can be used to assess vegetation health. NDVI values range from -1 to 1, and represent the difference between near-infrared (NIR) and red reflectance divided by their sum. Low values of NDVI generally correspond to barren areas of rock, sand, exposed soils, or snow, while higher NDVI values indicate greener vegetation, including forests, croplands, and wetlands[10]. The Vegetation index is a single number and is computed using several spectral bands that are sensitive to plant biomass and Vigor for each pixel in a remote sensing image [11]. Vegetation index is a mathematical combination of satellite multispectral data used to measure the Strength and health of vegetation. These indices exploit the unique ways in which plants reflect light in different parts of the electromagnetic spectrum [1].

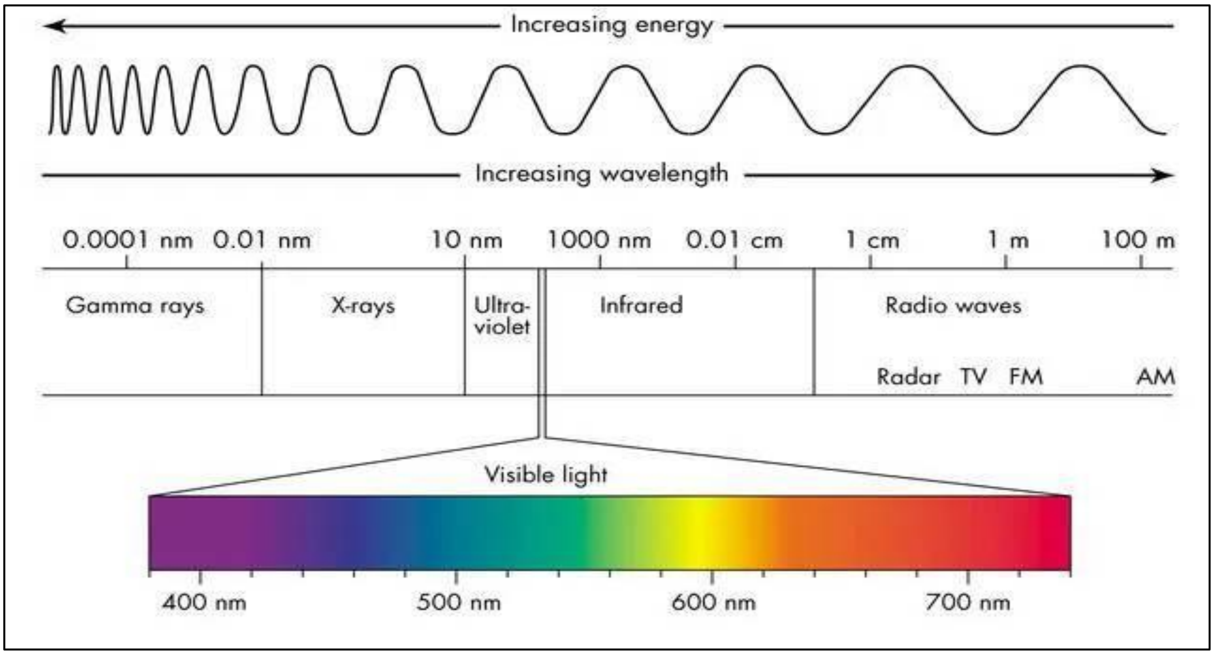

Figure. 1. Electromagnetic spectrum

When sunlight shines on objects, certain wavelengths are absorbed and other wavelengths are reflected. Scientists exploit this knowledge of plants interactions with light to map the density of green vegetation across Earth's landscapes by designing satellite sensors to measure the wavelengths of red and near-infrared light that is absorbed and reflected by plants all over the world.

Scientists routinely produce global NDVI maps to help them monitor and investigate shifts in plant growth patterns that occur in response to climate changes, environmental changes, and changes caused by humans. Reflected red energy decreases with plant development due to chlorophyll absorption within actively photosynthetic leaves. Reflected near-infrared energy, on the other hand, will increase with plant development through scattering processes (reflection and transmission) in healthy, turgid leaves. Dark green areas show where there was a lot of green leaf growth; light greens show where there was some green leaf growth; and tan areas show little or no growth. Black means no data [12, 13].

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to analyse remote sensing measurements and assess whether the target being observed contains live green vegetation or not. NDVI has found a wide application in vegetative studies as it has been used to estimate crop yields, pasture performance, and rangeland carrying capacities among others. It is often directly related to other ground parameters such as percent of ground cover, photosynthetic activity of the plant, surface water, leaf area index and the amount of biomass [14].
This review aims to provide an overview of remote sensing applications for vegetation monitoring and reveal the potential of Vegetation indices in crop management.

Data Acquisition and Methods:-
The spectrometric data is usually sourced from remote sensors, such as satellites. The following are methods typically employed in research on the analysis of vegetation changes using satellite imagery and NDVI

1. Data Acquisition: Satellite Imagery, Temporal Resolution.
2. Pre-processing: Image Correction, Geometric Correction, Mosaicking.
3. Band Selection, Calculation of NDVI and Stack NDVI images.
4. Change Detection: Thresholding, Supervised or unsupervised methods for Classification in vegetation cover.
5. Spatial Analysis
6. Temporal Analysis
7. Validation
8. Interpretation and Reporting [15].

Normalized difference vegetation index (NDVI):-
NDVI is the most common vegetation index in agriculture characterizes the density of vegetation and allows farmers to assess germination, growth, the presence of weeds or diseases, as well as to predict the productivity of the fields. NDVI is more commonly used and sensitive to a wider range of vegetation conditions. NDVI metric is popular because of its accuracy. Normalized Difference Vegetation Index (NDVI) is calculated from spectrometric data at two specific bands: red and near-infrared. NDVI maps used to monitor the health of croplands and forests. So, these maps are useful both for scientific research as well as social benefit. In addition, for agricultural and vegetation condition monitoring, clouds are partially screened from NDVI images by producing Maximum Value Composites (MVC) over 10-day, 16-day, or 1-month periods, where the highest NDVI pixel value within the time period is retained under the assumption it represents the maximum vegetation greenness during the period[16]. NDVI compares the reflectance values of the red and near-infrared regions of the electromagnetic spectrum using the formula, Subtracting plants reflectance of red light from near-infrared light and then dividing that difference by the addition of the red and near-infrared light reflected produces a resulting value called Normalized Difference Vegetation Index (NDVI).

$$\mathbf{NDVI} = \frac{(\mathbf{NIR}-\mathbf{RED})}{(\mathbf{NIR}+\mathbf{RED})} \qquad 1)$$

Where: NIR = reflectance in the near-infrared band.
= the near infrared portion of the electromagnetic spectrum (0.75-1.5 μm) and
Red = reflectance in the red band

= the red portion of the electromagnetic spectrum (0.6-0.7 μm)
The NDVI index is easy to interpret. The NDVI values, which ranges from -1.0 to 1.0 for each pixel in an image, helps to identify areas of varying levels of plant biomass. NDVI will increase in proportion to vegetation growth. An area with dense, healthy vegetation will have NDVI Values of one. Values close to +1(0.8 to 0.9) indicates the highest possible density of green leaves or dense, healthy vegetation. Values around 0.2 to 0.5 suggest thin vegetation. An area with nothing growing in it will have an NDVI of zero. Negative values to 0 mean no green leaves or Values close to 0 typically represent bare soil. NDVI values less than 0 suggest a lack of dry land. Negative values often indicate water, snow, or clouds.[3,17,18]
NDVI values can be used as predictors in determination of the type of land cover in a particular area. NDVI value is directly proportional to the green land cover and also to the rainfall. Higher the value of NDVI higher will be the chances of green land cover in particular area, and if the area is having green land cover it implies that the rainfall in that area will be more. Also, the NDVI value is inversely proportional to the soil erosion. Soil erosion is more in barren land and NDVI value for barren land is less as compared to the green land or forest land. Therefore, lesser will be the value of NDVI more chances of barren land will be there and more will be the soil erosion on such type of land [19]. By analysing NDVI data over time, we can detect early signs of crop disease, nutrient deficiencies or stress. This allows farmers, decision-makers and agricultural professionals for farming practices, Prediction of resource management and to take quick action for saving crops. The data empowers, sustainable and responsible for various precision-agriculture practices and food production.

Result and Discussion:
Satellite sensors in space measure the wavelengths of light absorbed and reflected by green plants. Vegetation indices like NDVI have become essential tool in Remote Sensing, Precision Agriculture and environmental monitoring. Vegetation indices are an excellent source of spectral signature data for NDVI analysis. The Normalized Difference Vegetation Index (NDVI) is uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to investigate remote sensing measurements and evaluate whether the target being observed contains live green vegetation or not. Normalized difference vegetation index (NDVI) for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1); No green leaves give a value close to zero. A zero means no vegetation and High NDVI Values, +1 indicates healthy vegetation; a Low NDVI value, -1 indicates less or no vegetation. NDVI has found a wide application in vegetative studies. Incorporation of vegetation indices with NDVI data into precision agriculture has upgraded farming practices.

Conclusion:
Satellites and sensors can be used to monitor the seasonal variations in vegetation. Vegetation indices Enhances green vegetation so that plants appear distinct from other image features. Reflectance of light spectra from plants changes with plant type, water content within tissues, and other intrinsic factors. The NDVI index detects and quantifies the presence of living green vegetation using the reflected light in the visible and near-infrared bands. NDVI maps are also used for a wide variety of land applications, including agriculture, natural resource management, Early Warning Systems and optimize agricultural practices.

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