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Application of Remote Sensing in Agriculture

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Remote sensing has several advantages in the field of agricultural production. Remote sensing plays a significant role in crop classification, crop monitoring and yield assessment. Remote sensing is an important tool in timely monitoring and giving an accurate picture of the agricultural sector with high revisit frequency and high accuracy.

The remote sensing along with the other advanced techniques such as global positioning systems and geographical information systems are playing a major role in the assessment and management of the agricultural activities. These technologies have many applications in the field of agriculture such as crop acreage estimation, crop growth monitoring, soil moisture estimation, assessing nutritional requirements of plants,soil fertility evaluation, crop stress detection, detection of diseases and pest infestation, weed management, drought and flood condition monitoring, yield estimation, weather forecasting, precision agriculture for maintaining the sustainability of the agricultural systems and improving the economic growth of the country.

The unprecedented availability of high resolution (spatial, spectral and temporal) satellite images has promoted the use of remote sensing in many precision agriculture applications.

Introduction

Remote sensing is the process of obtaining information about objects without coming into direct contact with the object. The carrier of information in remote sensing is electromagnetic radiation, which travels in vacuum at the speed of light in the form of waves of different lengths. The most useful wavelengths in remote sensing cover visible light (VIS) and extends through the near (NIR) and shortwave (SWIR) infrared, to thermal infrared (TIR) and microwave bands.

Passive remote sensing sensors record incident radiation reflected or emitted from the objects while active sensors emit their own radiation, which interacts with the target to be investigated and returns to the measuring instrument.

Vegetation Indices

The most commonly used index is the Normalized Difference Vegetation Index (NDVI), proposed by Rouse *et al*. (1974) and calculated as aquotient of the difference and sum of the reflectance in NIR and red regions. Green parts of plants reflect intensively in the NIR region due to scattering in the leaf mesophyll and strongly absorb red and blue light via chlorophyll (Ayala-Silva and Beyl 2005).

Examples of vegetation indices which are used specifically in agricultural purpose are listed in the Table 1.

Table 1: Some important vegetation indices for remote sensing application in agriculture

Index	Definition/ Equation	Application
Normalized difference vegetation index (NDVI)	$\frac{R_{NIR}-R_{Red}}{R_{NIR}+R_{Red}}$	Biomass, Yield, disease, N-management, soil moisture, water stress
Green NDVI (GNDVI)	$\frac{R_{NIR}-R_{Green}}{R_{NIR}+R_{Green}}$	Water stress; yield; Biomass, disease
Soil adjusted vegetation index (SAVI)	$\frac{(R_{NIR} - R_{Red})(1+L)}{R_{NIR} + R_{Red} + L}$ L-soil conditioning index	Yield, disease, N-concentration and Uptake, water stress
Modified soil adjusted vegetation index (MSAVI)	$\frac{2R_{NIR}+1-\sqrt{(2R_{NIR}+1)^2-8(R_{NIR}-R_{red})}}{2}$	Biomass, crop yield, N-uptake, chlorophyll content
Chlorophyll vegetation index (CVI)	$\frac{R_{NIR} R_{Red}}{R_{Green} \times R_{Green}}$	Crop yield, crop growth-chlorophyll content, yield
Chlorophyll index (CI)	$\frac{R_{NIR} 1}{R_{Red\ edge}}$	Chlorophyll and N-content
Normalized Difference Water Index	$\frac{R_{NIR1}\ R_{NIR2}}{R_{NIR1}\ R_{NIR2}}$	Estimation of plant water content

Types of Remote Sensing

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

Ground-Based Remote Sensing: According to Jackson (1986) hand held remote sensing instruments are very useful for small-scale operational field monitoring of biotic and abiotic stress agents. Ground-based remote sensing has better temporal, spectral, and spatial resolutions in comparison to airborne and satellite remote sensing. Forecasting yield, nutritional requirements of plants, detection of pest damage, water demands and weed control are the most commonly undertaken problems in studies making use of opportunities of field spectrometers in agriculture.

Airborne Remote Sensing: Up to date, airborne remote sensing is mainly realized with the use of piloted aircrafts. However, in recent years they are more often replaced by Unmanned AerialVehicles (UAVs), which are aircraft remotely piloted from a ground station. UAVs are typically low cost, light weight and low airspeed aircrafts that are well suited for remotely sensed data gathering.

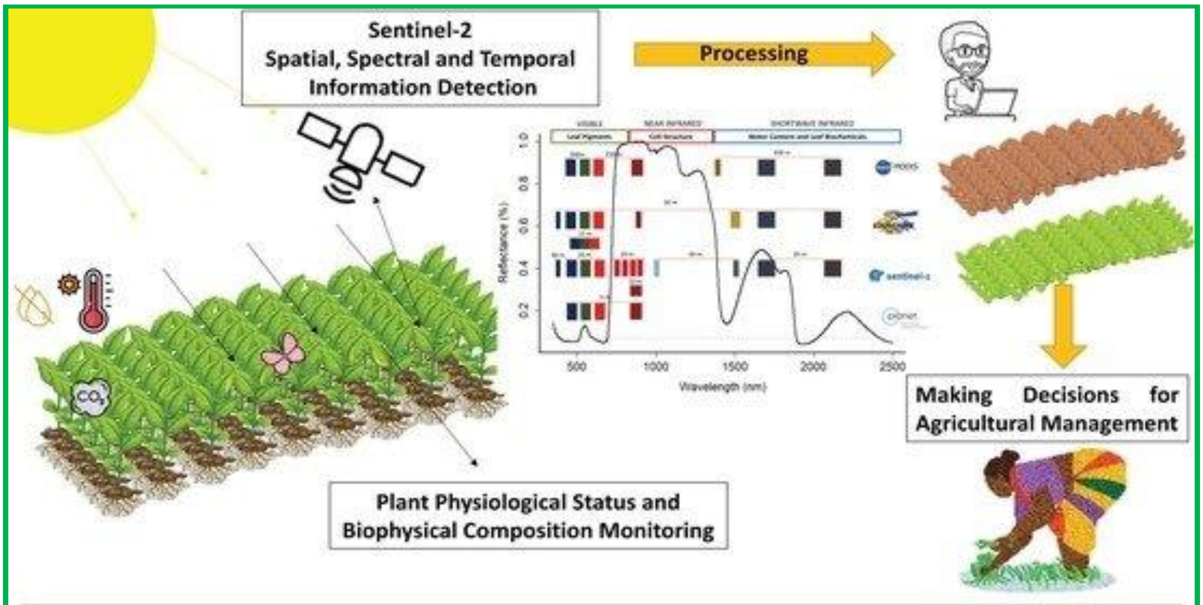
UAVs with a typical spatial resolution of 1–20 cm could fill the resolution gap between piloted aircraft (resolution of 0.2–2 m) and ground-based platforms (< 1 cm). Providing a swath width of 50–500 m and a spatial resolution of 1- 20 cm, UAV platforms may be able to provide high resolution inputs necessary for site-specific crop management. UAVs with a very high resolution might also be used in agronomical research, management of specialty crops and studies of the within-field variability.

Satellite Imagery: Satellite imagery has been used for crop type mapping, general crop condition assessment and crop acreage estimation. Typically, these applications were used over large areas due to the limited spatial resolution of sensors. Finer resolutions of more recent satellite sensors, however, are now enabling within field assessment of problems such as drought stress, flooding and hail damage. Lamb and Brown (2001) indicated that the low-resolution satellite images beneficial only for large-scale studies and may not be appropriate for the small-scale farms. Additionally, satellites providing higher-resolution images, e.g., Quick Bird (2.4 m in VNIR) and ASTER (15 m), havelong revisit times (1-3.5 and 16 days respectively), making them of limited utility for any application that might require frequent images. To reduce the revisit time,satellites are often deployed in constellations consisting of a few synchronizedsatellites, which are coordinated and overlap in ground coverage.

Applicationsof Remote Sensing in Agriculture

1. Crop condition assessment: Cropmonitoring at regular intervals of crop growthis necessary to take appropriate measures andalso to know the probable loss of productiondue to any stress factor. The crop growthstages and its development are influenced by different factors such as available soilmoisture, date of planting, air temperature,day length, and soil condition. These factorsare responsible for the plant conditions andtheir productivity.

2. Nutrient Management: Detecting nutrient stresses by using remotesensing and GIS helps us in site specificnutrient management through which we canreduce the cost of cultivation as well asincrease the fertilizer use efficiency for thecrops.



Remote sensing for agriculture monitoring: Sentinel-2 features and precision agriculture

3. Irrigation Management: In semi-arid and arid regions judicioususe of water can be made possible through theapplication of precision farming technologies.For example, drip irrigation coupled withinformation from remotely sensed data such ascanopy air temperature difference can be used to increase the water use efficiency byreducing the runoff and percolation losses. The spectralreflectance in the visible region was higher inwater stressed crop than the non-stressed. Thevegetation indices like NDVI, RVI, PVI and GI were found lower for stressed and higherfor non-stressed crop.

4. Weed identification and Management: Based on the difference in the spectralreflectance properties between weeds andcrop, remote sensing technology provides amean for identifying the weeds in the cropstand and further helps in the development ofweed maps in the field so that site specific andneed based herbicide can be applied for themanagement of weeds. Kaur *et al.*, (2013)reported higher radiance ratio and NDVI values in solid stand or pure wheat and minimum under solid weed plots. It was observed that by using radiance ratio and NDVI, pure wheat can be distinguished from pure populations of *Rumex spinosus*beyond 30 DAS. Different levels of Rumex populations could be discriminated amongst themselves from 60 DAS onwards.

5. Pest and disease infestation: Riedell *et al.*, (2004)reported remote sensing technology as aneffective and inexpensive method to identifypest infested and diseased plants. They usedremote sensing techniques to detect specificinsect pests and to distinguish between insectand disease damage on oat. They suggested that canopy characteristics and spectralreflectance differences between insectinfestation damage and disease infectiondamage can be measured in oat crop canopiesby remote sensing. Mirik*et al.*, (2012)reported that the Landsat 5 TM image can beused to accurately detect and quantify diseasefor site-specific Wheat Streak Mosaic diseasemanagement in the wheat crop.

6. Crop yield and production forecasting: Remote sensing has been used to forecast crop yields based primarily uponstatistical–empirical relationships between yield and vegetation indices (Thenkabail*et al.* 2002, Casa and Jones 2005).The crop yield is dependent on many factorssuch as crop variety, water and nutrient statusof field, influence by weeds, pest and diseaseinfestation, weather parameters. The spectralresponse curve is dependent on these factors.

Conclusion

Data collected from satellite, airborne and ground levels facilitate monitoringweed infestations, damages caused by pests and plant pathogens, thereby making itpossible to counteract quickly. Accurate determination of thenutritional requirements of plants at critical stages during the field season helps tooptimize fertilization as well as reduce potential adverse impacts associated withoffsite transport of agrochemicals. Remote sensing has also been used to assess thewater 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 willimprove reliability of decision support systems and will contribute to modernizedagricultural production management.

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