Remote Sensing in Agriculture

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Abstract— *Remote sensing is defined as the art and science of gathering information about objects or areas from a distance without having physical contact with objects/areas being investigated. Remote sensing is the science and technology of making inferences about material objects from measurement made at a distance without coming into physical contact with the object under study. Remote sensing is a tool to monitor the earth's resources using space technology in addition to ground observations. Remote sensing is the science and technology of making inferences about material objects from measurement made at a distance without coming into physical contact with the object under study. Spectral signature of any object that detect by remote sensing is the main principle. Remote sensing technology uses the visible, infrared and microwave regions of radiation to collect information about the various objects on the earth surface. The responses of the objects of different regions of the electromagnetic spectrum are different. The typical responses are used to distinguish object such as vegetation, water, bare soil, concert and other similar features. Remote sensing is two types viz, active and passive remote sensing. Passive remote sensing: It makes use of seasons that detects the reflected/emitted electromagnetic radiation natural sources. Active remote sensing: It makes the use of seasons that detects reflected responses from object that are irradiated from artificially generated energy sources, such as radar. There are three types of platforms-air based, ground based and satellite based. The various applications of remote sensing in agriculture are- crop condition monitoring, detection of plant stress, 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 etc.*

Keywords—Remote Sensing, Agriculture, canals, wildlife.

I. INTRODUCTION

For decades, agriculture has been associated with production of essential food crops. At present, agriculture above and beyond farming includes forestry, dairy, fruit cultivation, poultry, bee keeping, mushroom, arbitrary, etc. Now-a-days processing, marketing and distribution of crops and livestock products are all acknowledged as part of current agriculture. Thus, agriculture could be referred to as the production, processing, promotion and distribution of agricultural products. Agriculture plays a critical role in the entire life of a given economy. Agriculture is the backbone of economic system of a given country. In addition to providing food and raw material, agriculture also provides employment opportunities to very large percentage of population. Producing food of sufficient quantity and quality is essential for the well-being of the people anywhere in the world. A stable agricultural sector ensures a nation of food security. The main requirement of any country is food security. Food security prevents malnourishment that has traditionally been believed to be one of the major problems faced by the developing countries. Most countries rely on agricultural products as well as associated industries for their main source of income (1). Only a nation, which has abundant food supply, can dream to become strong and self-reliant. International food policy research institute (1FPRI), Washington, using a macro economic model has estimated that a one percent increase in agricultural production in India generates half percent increase in industrial growth. Agricultural plants, as living organisms, require water and nutrients in order to grow and are sensitive to extreme weather phenomena, diseases and pests. Remote sensing can provide data that help identify and monitor crops. When these data are organised in a Geographical Information System along with other types of data, they become an important tool that helps in making decisions about crops and agricultural strategies. The National goverments can use remote sensing data, in order to make important decisions about the policies they will adopt, or how to tackle national issues regarding agriculture. Individual farmers can also receive useful information from remote sensing images, when dealing with their individual crops, about their health status and how to deal with any problem (2). 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 Organisation (ISRO) and Indian Council of Agricultural Research (ICAR) jointly conducted the first multi spectral airborne Indian study in 1969.

II. DEFINITION OF REMOTE SENSING

The term remote sensing was coined by Fischer in 1960 A.D. Remote sensing is defined as the art and science of gathering information about objects or areas from a distance without having physical contact with objects/areas being investigated. Remote sensing is the science and technology of making inferences about material objects from measurement made at a distance without coming into physical contact with the object under study. Remote sensing is a tool to monitor the earth's resources using space technology in addition to ground observations.

It can be used in soil mapping, land use pattern, forest mapping, geological and hydrological purpose, drought & flood monitoring in addition to crop coverage crop output estimates. Remote sensing techniques are used in agriculture & allied fields. This involves collection of basic data, monitoring of crop growth, soil moisture condition irrigation drainage & outbreak of pest & disease infestation.

Spectral reflectance:

Remote sensing technology uses the visible, infrared and microwave regions of radiation to collect information about the various objects on the earth surface. The responses of the objects of different regions of the electromagnetic spectrum are different. The typical responses are used to distinguish object such as vegetation, water, bare soil, concert and other similar features.

Concept of remote sensing:

The concept of remote sensing involves six stages-

- Source of electromagnetic energy (EME), sun or transmitter is the source of energy.
- Transmission of the energy from the sources to the surface of the earth (as well as absorption & scattering by the atmosphere).
- Interaction of the energy with the objects on the surface of the earth
- Transmission of the energy to the remote sensing sensors.
- Generation of the data in pictorial &/or digital form.
- Analysis, interpretation & use of data.

Principal of remote sensing:

Every material on the earth absorbs and reflects the solar energy. In addition they emit certain amount of internal energy. The absorbed, reflected and emitted energy is detected by remote sensing instruments. The instrument or sensors carried in aircraft or satellites. The detections are made by characteristic terms called 'spectral signature' and 'images'. Remote sensing systems in common use record radiation in the form of electromagnetic spectrum, i.e., visible range (0.4-0.7um), near infrared (0.7-1000um) and microwaves (1mm-0.8m). artificial sources of illumination such as radars are also used in some seasons.

Types of remote sensing:

1. Passive remote sensing: It makes use of seasons that detects the reflected/emitted electromagnetic radiation natural sources.
2. Active remote sensing: It makes the use of seasons that detects reflected responses from object that are irradiated from artificially generated energy sources, such as radar.

Remote sensing platforms:

1. Ground based: Infrared thermometer, spectral radiometer, pilot balloons, & radars are some of the ground based remote sensing tools.
2. Air based: Aircrafts are air based remote sensing tools.
3. Satellite based: Satellite technology has become handy for wider application of remote sensing techniques. The satellites are subdivided into two classes. These are-
   i. Polar orbiting satellites-These satellites operate at an altitude between 550 &1600 km along an inclined circular place over t5he poles. LANDSAT (USA), SPOT (France), & IRS (India) series are some of the remote sensing satellite.
   ii. Geostationary satellites- These have orbit around the equator at an altitude of 36000 km & move with the same speed as the earth, so as to view the same area on the earth continuously. The INSAT series satellites are launched from India for the above purpose.

Sensors used in remote sensing:

1. Photography: Photographic system is the most commonly used sensing systems. The film records the energy reaching in at the time in the visible and near infrared ranges of the spectrum. The range of any individual system is governed by a particular film characteristics and use of films.
2. Line scan and related system: Line scan system uses the visible and near infrared portion of the

spectrum. In this system a mirror is rotated parallel to the direction of the movement of the aircraft or satellite. The mirror reflects the radiation received on to a detector and the data are recorded.

3. Microwave system: Microwave radiation is emitted from the earth's surface is very small quantities. These microwaves are used by microwave sensors in a wavelength of about 1 mm to 1000 mm. the sensors record the microwave radiation through complex antennae. These are used in weather satellites.

III. ROLE OF REMOTE SENSING IN AGRICULTURE

Agricultural resources are important renewable dynamics natural resources. In India, the agricultural sector alone sustains the livelihood of around of 70% of the population and contributes nearly 35% of the net national product. Increasing agricultural productivity has been the main concern, since the scope for increasing area under agriculture is rather limited. This demands judicious and optimal management of both land and water resources. Hence comprehensive and reliable information on land use and cover, forest area soils, geological information, extent of wastelands, agricultural crops, water resources (both surface and underground) and hazards of natural calamities like drought and floods are required. Remote sensing systems, having capability of providing regular, synoptic multi temporal and multi spectral coverage of the country, play an important role in providing such information. A large number of experiments have been carried out in developing techniques for extracting agricultural related information from ground borne, air borne and space borne data. Some of the broad agricultural application areas are:

1) Crop condition monitoring: The crop condition is to be assed 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:
   i. Moisture stress due to drought
   ii. Nutrient stress due to insufficient availability in the soil
   iii. Flooding
   iv. Salinity and
   v. Disease and pest attacks
2) Detection of plant stress: The chlorophyll and other pigments react to the visible radiation (0.4-0.2 mm). Near infra red region is a region of high reflectance caused by multiple seatting. This takes place between inter cellular air space of spongy mesophyll. The stressed leaves have fewer air spaces than non stressed leaves. They are less reflective to infra red radiation. Water stress, nutrient stress, and disease attack lead to reduction in plant pigment in red band. The reflectance measured in the visible and near infra red bands can be taken as indicator of plant health.
3) Vegetative indices:
   a. The ratio between the infra red region and red region: R=IR/Red
   b. Normalised Difference Vegetation Index (NDVI) = (IR-Red)/(IR+Red)
   c. Greenness =Weighted sum of radiances in the IR brand – weighted sum of irradiation in the visible band,
   where IR and Red refers to the radiance in red and infra red bands.
4) Canopy transpiration and crop stress: The thermal infra red region (8-14 micrometre) is made use an indicator of plant canopy temperature. Where the crop has sufficient moisture. It will transpire freely and the leaf temperature will be lower than that of air temperature. Thus the difference between the crop canopy and the air temperature will be a useful parameter for monitoring the crop water conditions.
5) Cropping system analysis: Information on existing cropping system in a region with respect to areal extent of crop, crop vigour/ yield and yearly crop rotation/ sequence practices is important for finding out the with agricultural areas with low to medium crop productivity where sustainable increase in crop production can be achieved by adoption of suitable agronomic management packages including introduction of new crop etc. Remote sensing can play a vital role in cropping system analysis of an area by spatial integrating temporal crop inventory information of various crop seasons of that area.The cropping system analysis was carried out by GIS aided integration of 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 in 1995 in Madnur Watershed, Nizamadad

district, Andhra Pradesh. The result of the study is summarised in the table 1-

Table.1: Major cropping system and their areal distribution in the watershed

Cropping system	% of watershed area	Agricultural productivity
Single crop season (rice/sorghum/rainfed crop)	52.0	Low
Two season crop (rice, sunflower, rainfed crop)	6.0	Medium
Three season crop (sugarcane cotton rainfed crop)	4.0	High
Non- agriculture (watershed, forest, water bodies)	38.0	------

Source: Use of remote sensing and GIS technology and sustainable agriculture management and development- S. K. Bhan *et al.*

The result indicates that 52.0% of the study area has low agricultural productivity with one season under crop (rice/sorghum/ rainfed crop) out of every three cropping season. Only 10% of the area have medium to high agricultural productivity or under almost perennial sugarcane. Most of the watershed does not have irrigation facilities and hence rainfed single crop grown once out of three crop season in a year in the major system of farming in the area.

6. Crop biophysical characterization:

Remote sensing can play an important role in agriculture by providing timely spectral reflectance information that can be linked to biophysical indicators of plant health.
Quantitative techniques can be applied to the spectral data, whether acquired from
close-range or by aircraft or satellite-based sensors, in order to estimate crop
status/condition. The technology is capable of playing an important role in crop
management by providing at least the following types of information:

1. fraction of vegetative cover,
2. chlorophyll content,
3. green leaf area index, and,
4. other measurable biophysical parameters

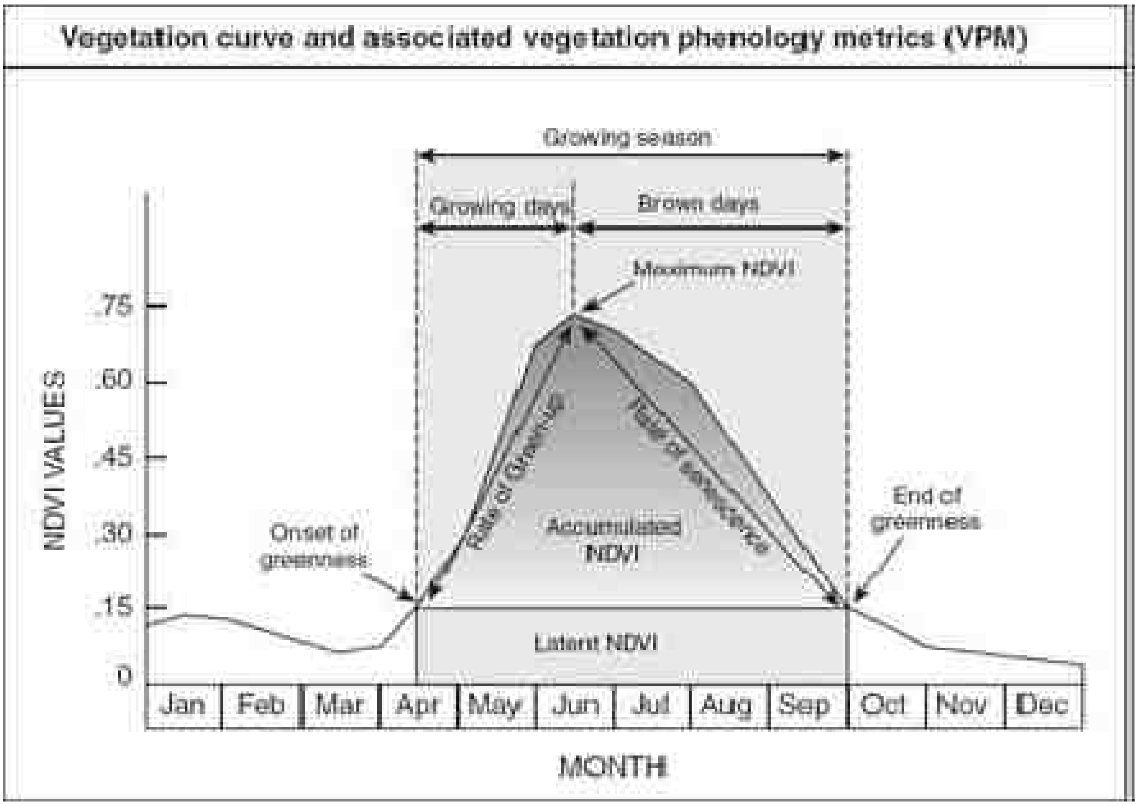

Fig.1: A twelve month, hypothetical NDVI temporal response curve for

Vegetation. Additionally, the vegetation metrics are displayed to show their relation to
both NDVI values and time (after Reed et al. 1994).

7. Yield forecasting: The conventional procedure for crop yield estimation by the Bureau of Economic and Statistics (BES) in India involves crop cutting experiments (CCE) conducted during harvesting in the plots selected based on pre-designed sampling scheme using available ground data (Dadhwal and Ray, 2000).

Crop yield forecasting using remote sensing is more complex than cropped area estimation, because of the high variability involved. Crop yield is a function of various parameters like soil, weather, cultivation practice, fertilizer used, irrigation, date of sowing, genotype, pest and diseases, etc. spectral data of a crop is a manifestation of the overall effect of all these factors on its growth. There can be two broad approaches for the use of remote sensing data in the yield forecasting. Remote sensing observed data in the form of some kind of vegetation index can be correlated with crop yield, based on the actual field data. Thus an empirical relationship can be established. In the second case, some biophysical parameter which is derived based on remote sensing observation (say leaf area index) can be one of the input parameters in yield prediction models (e.g., crop simulation model).

8. Precision farming: In conventional cropping practice a similar dose of fertiliser, water and other inputs are applied to the whole farm. However the input requirement may not be the same in the total area. The goal of precision farming is to gather and analyse the information about the spatial variability of soil and crop condition in order to optimise the efficiency of crop input based on site specific needs within a farm. Thus precision farming can be considered as site specific farming, which has a potential to reduce cost through more efficient and effective application of agronomic inputs. This also reduce environmental impacts, since inputs are applied where they are needed and at the required quantity. To realise variable rate of input, we should first have an application map, which gives the location and spatial extend and level of input to be used. Precision farming requires an integration of various technologies such as remote sensing, GPS, GIS, and field equipments for variable rate of application. With the next generation satellites providing high resolution multi spectral data, it is now possible to give information at field/ within field level.

9. Forestry application: Forest are one of the most valuable ecological resource of global interest. They are t6he source for many of our essential requirements such as fuel wood, timber, raw material for paper etc. In addition forest play an important role in balancing the earth's CO_2 supply and exchange. But our forest is continuously disappearing at an alarming rate. A study of FAO shows that the overall forest area is decreasing at a rate of 11.25 million ha/year for the period 1990-1995 (Russian federation excluded), which is about 0.33% of the global forest cover. Remote sensing provides potential to improve upon the conventional *in situ* monitoring of the forest area. Early methods used to compile information about forest are from interpreting photographs. The photographic characteristics of tone, texture, shape, pattern, etc. With the advent of space based remote sensing, traditional photographs are being replaced by satellite imagery. Both visual and digital interpretations have been used. The broad areas for forestry for which remote sensing techniques can be used are:

i. Mapping/statistics generation of forest cover
ii. Change detection and
iii. Modelling for resource management

Forest type is defined as a unit of vegetation, which processes (broad) characteristics in physiognomy and structure sufficiently pronounced to permit its differentiation from other such units (Champion and Seth, 1968). Management prescriptions is any region are based upon the existing forest type in that region. Hence distinguishing different forest type is very essential for judicious management of forest. Tropical dry deciduous and tropical moist deciduous forest amount for more than 60% of the forest cover of India. The forest type in India and their area are given in the following table:

Table.2: Principal forest type of India

Forest type	Area (million ha)
Tropical dry deciduous forest	29.7
Tropical moist deciduous forest	22.4
Tropical thorn forest	5.2
Tropical wet evergreen forest	4.1
Subtropical pine forest	3.7
Himalayan moist temperate forest	2.7
Tropical semi evergreen forest	2.4
Mountain wet temperate forest	1.6

Source: Siyag P.R., Director, Forest Training Institute, Jaipur (www.envindia.com/paper.htm)

IV. REMOTE SENSING APPLYING AREAS

1. General application:
    - i. Agricultural land use mapping
    - ii. Agricultural population distribution
    - iii. Soil survey and water resource survey
    - iv. Cropped area
    - v. Crop production forecasting
    - vi. Mapping of wasteland
    - vii. Drought monitoring and its assessment
    - viii. Flood mapping and damage assessment
    - ix. Monitoring of surface water bodies
    - x. Ground water exploration
2. Specific application:
    - i. Crop identification.
    - ii. Crop acreage vigour and density.
    - iii. Crop growth rate and crop maturity.
    - iv. Date of planting and harvesting.
    - v. Soil problem like salinity.
    - vi. Drought prediction.
    - vii. Disease, pest, nematodes, insect and diseases.
    - viii. Forest damage
    - ix. Storm and flood warning
    - x. Water availability and location of canals
3. Application to range surveys:
    - i. Identification of forage species and their yield.
    - ii. Delineation of forest types and condition of range.
    - iii. Carrying capacity of ranges
    - iv. Soil fertility and soil erosion.
    - v. Identification of poisonous species
    - vi. Wildlife inventory.
    - vii. Fire surveillance.
4. Application to livestock survey:
    - i. Population of cattle, sheep, pig and poultry.
    - ii. Distribution of animals.
    - iii. Animal behaviour.
    - iv. Health of animal.

Advantages of remote sensing:

- i. Extent of coverage: By using satellite technology information from a large area can be covered with short time much accuracy as compared to traditional methods.
- ii. Permanence of record: Areal and satellite data are the permanent record, these are use in future purpose.
- iii. Spectral and spatial resolution: Greater fineness of the image and the details of the object can be obtained by using spatial resolution of any sensor.
- iv. Speed and consistency of interpretation: With the use of digital image processing system we can analyse the data consistently and speedily.
- v. Cost effective and reliable: Remote sensing offers cost effective and reliable monitoring system.

Limitation of remote sensing:

The following are some of the major operation problems in using remote sensing techniques for crop production in our country:

- i. Small land holding with small crop field
- ii. Mixed crops like sorghum + red gram, wheat +groundnut.
- iii. Confusing crop, like wheat and barley.
- iv. Different cultural practices.
- v. Large variation in sowing dates.
- vi. Large areas under rainfed condition with poor growth.
- vii. Cloud cover during *kharif* season- the major crop growing season in India.

REFERENCES

[1] Agrometeorology and Remote sensing, Principles and Practices- D.D.Sahu
[2] Remote Sensing-B. Duary
[3] Use of remote sensing and GIS technology in sustainable agriculture management and development- S.K.Bhan et al
[4] Remote Sensing of Cropland Agriculture- M. Duane Nellis, Kevin P. Price, and Donald Rundquist.
[5] Fundamentals of remote sensing- George Joseph.