Remote Sensing and Its Application in Agriculture

Kalpana Gairola[1], Sanjarambam Nirupama Chanu*[2], Angam Raleng[3], Thaneridus B. Marak[4] and Johnson Chingsubam[5]

[1]Assistant Professor, School of Agricultural Sciences, Shri Guru Ram Rai University, Dehradun, India.
[2]Subject Matter Specialist (Agricultural Engineering), CAU-KVK, East Garo Hills, Megagre, Meghalaya.
[3]Assistant Professor, College of Agricultural Engineering and PHT, Ranipool, Gangtok, East Sikkim.
[4]Research Scholar, Department of Agricultural Engineering, Assam University, Silchar, Assam-788011.
[5] Extension worker, Department of Agriculture, Govt. of Manipur, Manipur-795010
*Corresponding Author: linthoich@gmail.com

Remote sensing is the art of obtaining information about an object from a distance without actual physical contact with the object. Remote sensing works on the principle that electromagnetic radiation emitted from an item is measured in sensors and converted into data about the object and processes about the object as shown in fig. 1. Different objects on earths reflect/emit the electromagnetic radiation from the sun at different amounts of energy in wide bands of the electromagnetic spectrum. The properties of both the object and the incident energy (incidence angle, wavelength and intensity) affect the degree of energy reflected or emitted and accordingly different objects are identified.

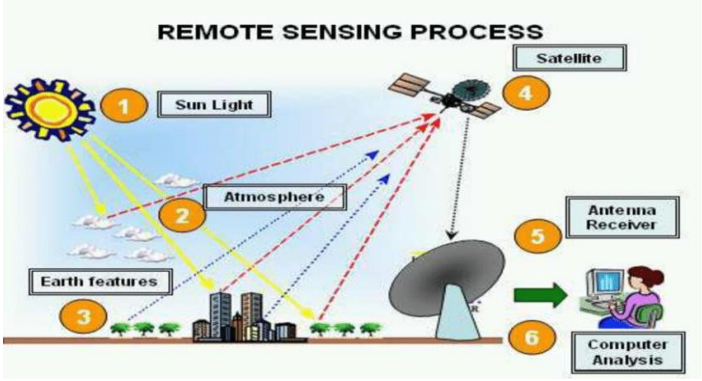

Fig. 1 Process of remote sensing

The energy emitted from the sun is known as electromagnetic energy and it travels in waves and consist spans of broad spectrum called electromagnetic spectrum (Figure 2) ranging from very short gamma rays to very long radio waves. Out of this broad spectrum, the wavelengths that are used for agricultural applications cover a small amount and some of the useful electromagnetic radiation from remote sensing point of views includes visible light, infra-red (both near, shortwave, thermal infrared) and microwave bands. Based on the source of the light, remote sensing has two types i.e. active and passive remote sensing. In passive remote sensing, the sensor uses either reflected solar energy as its source of energy to store the information about an object while in active remote sensing; sensors emit their own radiation to record the incoming energy after hitting back to the target object.

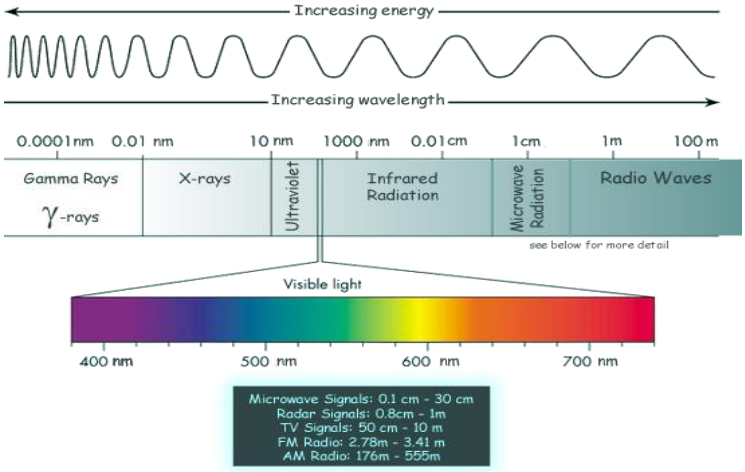

Fig. 2 Electromagnetic spectrum

Agricultural application

Agriculture provides food and raw materials for survival of humanity and plays a vital role in the economy of a country. Fulfilling the demand of food production within climate change and environmental sustainability to meet the requirement of expanding population is a pressure and challenging task in agriculture system. Computer-based technologies like remote sensing and geographical information systems (GIS) can help farmers with a novel platform to grow crops sustainably assessing the crop growth stages, crop health, soil conditions, water uptake, nutrient status, and stress level. These tools are also helpful in land use planning, mapping, water resources, data collection, pests and disease monitoring and also provide agro meteorological applications such as forecasting of crop yields by use of remote sensing inputs, and crop simulation models. If we see the Indian condition with diverse climatic conditions, it is possible to grow a large number of crops however, maintaining sustainability and environmental effects are the main concerns. Thus, growing a large number of crops coupled with uncertainties of climatic conditions requires information at the spatial and temporal levels. Thus, use of advance techniques like remote sensing for collection crop data is imperative

which we cannot rely on old the traditional data collection methods to meet the demands of food production. The application of remote sensing in agriculture can help in facing the challenges and providing information related to crop status at different scales all through the season.

Remote sensing techniques are recently applied in many fields to explore agricultural applications such as crop discrimination, crop acreage estimation, crop condition assessment, plant crop growth monitoring (plant populations, nutrient deficiencies, diseases, water deficiency or surplus, weed infestations, insect & herbicide damage), yield estimation, soil moisture estimation, reliable information on land use\cover, precision agriculture, soil survey, agriculture water management, forest area, geological information, water resources (both surface and underground), hazard\natural calamities like drought and flood, wind and hail damage etc. agro meteorological and agro advisories.

Remote sensing provides data for crop cover classification for the farmers to grow the major crops in the field. Classification of crop canopies based on imaging techniques is one of the milestones in the agriculture field. Remote sensing in the field provides repeated information without rigorous samplings. Remote sensing provides an alternative for data collection in large geographical areas to traditional methods (De-Beurs and Townsend, 2008). Yield estimation can be done (Bernardes et al., 2012). Crop phenological data can be estimated (Sakamoto et al., 2005). Based on the bio-physiological attributes of crops/soil, remote sensing has the potential to revolutionize agricultural productivity. As mentioned above, remote sensing has many applications in the agricultural sector. Summary of these applications is highlighted below.

Crop Acreage Estimation

Estimation of crop acreage is a cumbersome procedure if we carry out manually and with the help of remote sensing it is become very easier to estimate the size of farm land in which crop has to be planted. This technique helps in reducing the labor cost, saves time and improves agriculture production.

Crop condition assessment

Assess plant health through timely spectral information assessing the bio-physical indicators of plant health. Monitor crop growth at regular intervals to take appropriate action. A variety of factors affect the crop growth stages and development, such as soil condition, water, nutrients, temperature, date of planting, and photo-period. The physiological changes that occur in a plant due to stress will be visible as change in the spectral reflectance/ emission characteristics resulting in the detection of stress.

Nutrient and water status

Remote sensing and GIS are applicable to nutrient and water stress management. Utilizing remote sensing and GIS to detect nutrient stress helps us reduce cultivation costs and increase fertilizer efficiency for crops through site-specific nutrient management. Remote sensing technologies are used to judiciously use water in arid regions. Soil moisture can be estimated using microwave remote sensing in the field. Remote sensing data can allow us to obtain information on crop water demand, water use, crop growth stages, soil moisture condition, and nutrient status.

Crop evapotranspiration

Various approaches to calculating evapotranspiration from remotely sensed data such as correlations between remote sensed data and evapotranspiration and some combine different types of remotely sensed data. Water management in agricultural systems is largely dependent on remote sensing and it can be further enhanced by integrating hyperspectral sensors with remote sensing data with other spatial data.

Weed identification and management

Remote sensing has a great potential in detecting the weed infestation in an area and can be also be used towards site specific management of weeds infested. It not only helps in identifying the weed species but also helps to apply the appropriate amount of herbicide to control. The remote sensing technology will identify the weeds in crops and develop weed maps in the field allows site-specific and need-based herbicides based on the difference in spectral reflectance properties between weeds and crops. Farmers are advised to take preventive measures based on weed prescription maps that can be prepared with a Geographic Information System (GIS).

Pest and disease infestation

Stress caused by biotic and abiotic factors is monitored and quantified with a remote sensing technique. Remote sensing is used to measure canopy characteristics and spectral reflectance differences in crop canopies to assess insect infestation and disease infection damage.

Crop yield and production forecasting

Information about crop production before harvest is essential for the economy of the country. Forecasting crop production requires certain crop

yields. Several factors affect crop yields, such as crop variety, cultivation practices, nutrient status, weed infestation, insect pest damage, disease damage, and environmental factors. The spectral response curve is dependent on all these factors. Spectral response curves show the crop's condition based on its growth and decay.

Precision agriculture

Precision farming aims to reduce the cost of cultivation, improve control, and improve resource utilization efficiency with the help of sensor-based technologies. Variable rate technology (VRT) is one of the most advanced applications of precision farming. The moving farm machines contain computer-based sensors to recommend the information based on GPS-based inputs. Remote sensing makes management decisions based on information acquired at frequent intervals and high spatial resolutions.

Atmospheric dynamics

The use of remote sensing in meteorological satellites in weather forecasting is one of the other applications. Meteorological satellites measure cloud cover, moisture, wind, temperature, and wind speed. It is possible to determine whether the field is equipped with enough or adequate water or not based on variations in canopy temperature. The use of remote sensing data plays an important role in drought assessment in the agriculture field. Drought monitoring using satellite data has been accepted and the vegetation condition index (VCI) and normalized difference vegetation index (NDVI) are widely used to identify drought in different conditions.

Land use and soil mapping

Remote sensing allows accurate mapping of agricultural land use land cover changes and the identification of different soil types. This information is helpful for land use planning, resource allocation, assessing changes in land cover over time and ideal soil for different types of crops and also in irrigation scheduling. It supports policymakers, researchers, and farmers in making informed choices regarding for proper land management with change in time and sustainable agricultural practices.

Water resource mapping

Remote sensing is emerged as an instrumental tool for collecting data as well as the mapping of water resources of a given area. It has its applicability in assessing water availability, monitoring water quality, detecting water pollution, mapping watershed boundaries, measuring surface water flow, flood monitoring and forecasting, drought assessment and prediction, groundwater exploration, irrigation management, wetland mapping and monitoring, soil erosion mapping etc. Thus, remote sensing provides valuable data for sustainable water resource management.

Conclusion

Remote sensing application in agriculture will continue to grow and with this advances it has brought many benefits in agriculture with higher precision, efficiency and sustainability and provides the farmers techniques and methods that are more environment friendly, optimize resource usage and availability of valuable real time data in many fields. With the advancement in technologies, farmers are also necessary to adapt with the modern techniques to capture maximum benefits so that agricultural production can be maximized in a sustainable manner.

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