

POTENTIAL APPLICATION OF REMOTE SENSING IN MANAGEMENT OF AGRICULTURAL RESOURCES IN NORTH EASTERN REGION

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INTRODUCTION

Agriculture resources are among the most important renewable, dynamic natural resources. Comprehensive, reliable and timely information on agricultural resources is very much necessary for a country like India whose mainstay of the economy is agriculture. Agriculture surveys are presently conducted throughout the country in order to gather information and associated statistics on crops, rangeland, livestock and other related agricultural resources. These information of data are important for the implementation of effective management decisions at local, panchayat and district levels. In fact, agricultural survey is a backbone of planning and allocation of the limited resources to different sectors of the economy.

North Eastern region of India, comprising eight states namely, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim, has vast physiographical variations, which represent six agro-climatic zones. The major problems for agriculture in this region are undulating topography, high rainfall, natural calamities, frost, drought, occurrence of diseases and pests, etc. With increasing population pressure in whole NE region and the concomitant need for increased agricultural production (food and fiber crops as well as livestock), there is a definite need for improved management of agricultural resources. In order to accomplish this, it is first necessary to obtain reliable data on not only the types, but also the quality, quantity and location of these resources. Thus, awareness and information of remote sensing technology can play a significant role for proper planning and management of agricultural resources in this region.

REMOTE SENSING AND ITS IMPORTANCE IN AGRICULTURAL SURVEY

Remote sensing is the science and art of acquiring information (spectral, spatial, temporal) about material objects, area or phenomenon without coming into physical contact with the objects, or area, or phenomenon under investigation. Without direct contact, some means of transferring information through space must be utilized. In remote sensing, information transfer is accomplished by use of electromagnetic radiation (EMR).

In agriculture, possible applications are in the management of soil resource inventory, estimation of cropped area and production, detection of many agronomic stresses like water, nutrients, salinity, etc., scheduling of irrigation and estimation of ET apart from modeling crop growth and yield using sensing inputs. Remote sensing is quite economical, exhaustive, simple and fast. Use of remote sensing for early warning system against possible threats from natural calamities makes it more meaningful and convincing to this region.

MEASUREMENTS

Agricultural remote sensing is commonly done in the visible, near-infrared and thermal infrared portions of the spectrum; however, new applications in the microwave area are under development. The given wavelengths are employed in agricultural survey through Electromagnetic radiation by using remote sensor system.

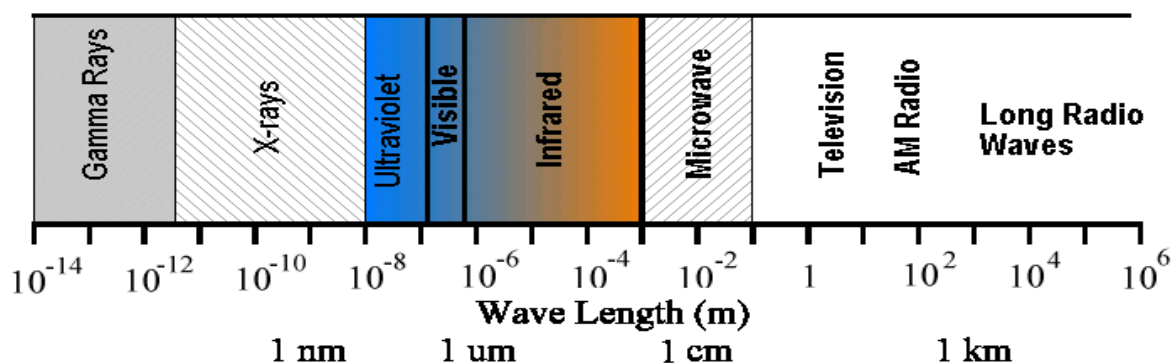


Table 1. Use of wavelength region for agricultural survey.

Area of agricultural phenomena	Wavelength employed
Plant diseases and insect infestation	0.4-0.9 mm and 6-10 mm
Natural vegetation, types of crop and fresh inventories	0.4-0.9 mm and 6-10 mm
Soil moisture content (radar)	0.4-0.8 mm and 3-100 mm
Study of arable and non-arable land	0.4-0.9 mm
Assessment of plant growth and rigour for forecasting crop yield	0.4-0.9 mm
Soil type and characteristics	0.4-1.0 mm
Flood control and water management	0.4-1.0 mm and 6-12mm
Surface water inventories and water quality	0.4-1.0 mm and 6-12 mm
Soil and rock type and conditions favorable for hidden mineral deposits.	0.4-1.0 mm and 7-12 mm

APPLICATIONS IN AGRICULTURE

- Estimation of crop acreage:** An accurate and timely forecasting system of crop production is an essential element in ensuring a country’s food security and proper distribution. In this, remote sensing is of paramount importance in identifying areas under cultivation. It is for this reason that the reflectance characteristics of a green leaf must be studied. Pre-harvest estimations of acreage for major crops like cotton, paddy, sorghum, soybean, sugarcane, wheat, etc. are now based on remote sensing and the methodology is now well established.
- Pest detection:** Brown and Steckler (1995) developed a method to use digitized color-infrared photographs to classify weeds in a no-till corn field. The classified data were placed in a GIS and a decision support system was then used to determine the appropriate herbicide and amount to apply. Penuelas *et al.* (1995) used reflectance measurements to assess mite effects on apple trees. Powdery mildew has also shown to be detectable with reflectance measurements in the visible portion of the spectrum (Lorenzen and Jensen, 1989). The ability to detect and map insect damage with remotely sensed imagery implies that methods can be developed to focus pesticide applications in the areas of fields most infected, thus decreasing the damage to beneficial insects.
- Crop stress:** Crop stress includes anything occurring in the field different than what was planned. Some of the common crop stresses that can be measured are drought, weed patches, soil erosion, nutrient deficiency and similar conditions. When trying to identify these types of stress using remote sensing, one can utilize some of the computer-aided methods or simply use visual methods to discriminate. The ratio of the red to blue to the near-IR scene reflectance can indicate plant stress before it becomes evident on the ground. A vegetation index (brightness or greenness) is a reduction of several spectral bands into one “index” number. Emissions in the thermal IR band also can indicate plant health conditions. Other methods of detection may include change detection (subtraction

of one image from an earlier image to see where the vegetation changed) and supervised or unsupervised vegetation classification (algorithms are used to select certain coloured pixels and assign to a group). Identifying crop stress due to frost damage with the aid of Landsat TM images shows promise with the development of a modified NDVI (Jurgens, 1997). Methods have been developed to utilize color-infrared images to classify weeds in no-till cornfields (Brown and Steckler, 1995) and have been established to identify water stress in plants with the difference of remotely sensed surface temperatures and the measurement of ground based air temperatures (Jackson *et al.*, 1981)

- **Water stress:** The difference between remotely sensed surface temperature and ground-based measurement of air temperature has been established as a method to detect water stress in plants (Jackson *et al.*, 1981). More recently, methods to integrate spectral vegetation indices with temperature have been used to improve remotely-sensed estimates of evapotranspiration (Carlson *et al.*, 1995; Moran *et al.*, 1994). Moran *et al.* (1994) defined a Water Deficit Index, which uses the response of a vegetation index to account for partial canopy conditions, so that false indications of water stress due to high soil background temperatures were minimized. Spectral indices have also been used to determine "real-time" crop coefficients to improve irrigation scheduling (Bausch, 1995).
- **Soil properties or soil inventory:** Soil investigations, surveys and mapping are three types of applications using remote sensing information. They include three different approaches: the effects of soil properties on reflectance or image response, the influence of soil surface conditions on the response, and the use of imagery in mapping soil patterns. Satellite images such as Landsat Thematic Mapper (TM) data can be used in soil surveys for a broad range of applications. Soil spectral image responses are related to soil organic matter content, i.e., dark soils (higher organic matter) contrast to lighter soils (lower organic matter). The vegetation spectral response can also be used to infer various soil conditions. Yang and Anderson (1996) used these vegetation responses to define management zones within fields. The management zones are an aid to soil sampling as they define logical boundaries for obtaining samples. Remotely sensed images are also being used in "directed soil sampling" where one can map "soil management zones", which would be sampled as separate units. The management zones would become the basis for adjusting nutrient application rates using variable rate technologies
- **Predicting crop yield:** Remote sensing data are used to estimate some of the crop biometrics parameters such as Leaf Area Index (LAI) and crop cover, which in turns are parameters required to predict crop yield. Crop yield is influenced by a large number of biotic factors. The data through remote sensing gives an integrated picture of the effects of all these factors on its growth. Several approaches adopted for predicting crop yield using remote sensing data or derived parameters (Spectral Vegetation Index: SVI) have proved to be of immense use to policy makers.
- **Nutrient detection:** Using remote sensing information to detect field nutrient situations requires a thorough knowledge of what effects nutrient variations can have on the plant and on soils. Soil characteristics, such as colour, relate to organic matter content from which one can predict nitrogen (N) release to the plant. Other soil properties such as pH, texture and nutrients such as phosphorus (P) and potassium (K) are difficult to detect. Leaf greenness is related to chlorophyll content, which is directly related to plant N concentration. Discoloration such as leaf chlorosis of the margins of leaves is correlated to K deficiency while purplish leaves are correlated with P deficiency. Most of the nutrient work in remote sensing have focused on N. There have been some encouraging results. For instance, leaf color measurements made at ground level have correlated well with corn plant N status (Blackmer *et al.*, 1996).
- **Vegetation change:** Images from the green and near infrared bands highlight the amount of vegetation and give an indication of plant vigor. Some companies have been providing "crop vigor" maps to farmers to assist them in seeing where vegetative growth is

occurring and to determine areas within the field where vegetation is not progressing, as it should. Change detection can be accomplished by overlaying images from two flight dates and showing the vegetation change occurring between the two dates.

- **Detection of crop injury:** Hail and wind damage is a common occurrence in many parts of the country. Information about the amount of damage is useful to crop management and accuracy of insurance payments. For corn and soybeans, the greatest yield effects from hail or wind are usually related to leaf loss, stand loss, or lodging. In each case, the amount or orientation of leaves and stalks is altered and can be measured by remote sensing. Direct damage to the ears, pods or seeds is another component that is difficult to detect and measure directly. Images from non-damaged adjacent areas or before-storm condition would aid in the accuracy assessment. These images normally are colour or colour infrared. The use of color infrared film assists in the detection of damage areas. Colour infrared gives a good indication of the amount or volume of vegetation or biomass present; therefore, lower values of red reflectance reveal vegetation damage or loss.

THRUST AREA

The specific application of remote sensing techniques can be used for i) detection ii) identification iii) measurement and iv) monitoring of agricultural phenomena.

a) Applicable to crop survey

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|------------------------|----------------------------|
| 1. Crop identification | 10. Effects of fertilizers |
| 2. Crop acreage | 11. Soil toxicity |
| 3. Crop vigour | 12. Soil moisture |
| 4. Crop density | 13. Water quality |
| 5. Crop maturity | 14. Irrigation requirement |
| 6. Growth rates | 15. Insect infestations |
| 7. Yield forecasting | 16. Disease infestations |
| 8. Actual yield | 17. Water availability |
| 9. Soil fertility | 18. Location of canals |

b) Applicable to range survey

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|--------------------------------|-------------------------|
| 1. Delineation of forest types | 7. Water quality |
| 2. Condition of range | 8. Soil fertility |
| 3. Carrying capacity | 9. Soil moisture |
| 4. Forage | 10. Insect infestations |
| 5. Time of seasonal change | 11. Wildlife inventory |
| 6. Location of water | |

c) Applicable to livestock survey

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|-------------------------|----------------------------|
| 1. Cattle population | 6. Distribution of animals |
| 2. Sheep population | 7. Animal behaviour |
| 3. Pig population | 8. Disease identification |
| 4. Poultry population | 9. Types of farm buildings |
| 5. Age sex distribution | |

SUMMARY

The remote sensing techniques will continue to be very important factor in the improvement of present system of acquiring agricultural data in this region. The remote sensing provides various platforms for agricultural survey in NE region. Satellite imagery has unique ability to provide the actual synoptic views of large area at a time, which is not possible for conventional survey methods and also the process of data acquisition and analysis are very fast through GIS (Geographic Information System) as compared to the conventional methods. The different features of agriculture are acquired by characteristic, spectral reflectance, spectral signature of agriculture and associated phenomena through EMR.

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