GEOSPATIAL WORLD FORUM

Study of IRS 1C-LISS III Image and Identification of land cover features based on Spectral Responses

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Abstract— Satellite Remote sensing with repetitive and pan viewing and multispectral capabilities, is a powerful tool for mapping and monitoring the ecological changes. Analysis of the remote sensing data is faced with a number of challenges ranging from type of sensors, number of sensors, spectral responses of satellite sensors, resolutions in different domains and qualitative and quantitative interpretation. Any analysis of satellite imagery directly depends on the uniqueness of above features. The multispectral image from IRS LISS-III sensor has been used as the primary data to produce land cover classification. This paper reports on the study of LISS III image, with emphasis on spectral responses of satellite sensors. The aim of the study was to know all the relative details of the data as the primary requirement for any study. Indian Remote Sensing IC Linear Integrated self-scanning (IRS IC-LISS III) imagery data set specifications and its use for land cover classification were also discussed. This study can be used as a primary literature for analysis of IRS LISS III Image.

Index Terms— Spectral signature, Spectral response, Resolution and IRS-1C LISS III image.

I. INTRODUCTION

Remote sensing [1] is the science of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information[2]. Identification, discrimination and classification of earth surface features using remotely sensed data are based on the basic premise that different objects have unique reflectance/emittance properties in different parts of the electromagnetic spectrum [3]. The term “Signature” is defined as any set of observable characteristics, which directly or indirectly leads to the identification of an object and/or its condition. Signatures are statistical in nature with a certain mean value and some dispersion around it. Spectral variations: Spectral variations are the changes in the reflectance or emittance of objects as a function of wavelength. Spatial variations: Spatial arrangements of terrain features, providing attributes such as shape, size, and texture of objects which lead to the identification of objects are termed as spatial variations. Temporal variations: Temporal variations are the changes of reflectivity or emissivity with time. They can be diurnal and/or seasonal. Polarization variations: Polarization variations relate to the changes in the polarization of the radiation reflected or emitted by an object. These variations help to distinguish vegetation and non-vegetation features. Distinguishing the object from others is possible. All matter with a certain temperature radiates electromagnetic waves of various wavelengths. The total range of wavelengths is commonly referred to as the electromagnetic spectrum (Fig. 1). It extends from gamma rays to radio waves [4] . This study helps to have a clear picture of spectroscopy of LISS III sensors.

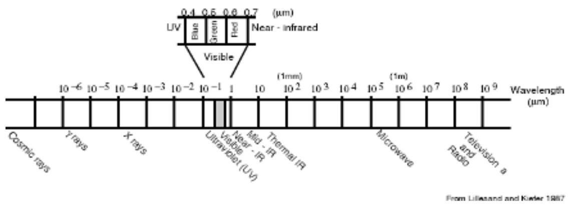

Fig. 1. The electromagnetic spectrum

Common wavelengths of what we perceive as particular colors from the visible portion of the spectrum are listed below. Violet: 0.4 - 0.446 µm, Blue: 0.446 - 0.500 µm, Green: 0.500 - 0.578 µm, Yellow: 0.578 - 0.592 µm, Orange: 0.592 - 0.620 µm and Red: 0.620 - 0.7 µm. Remote sensing operates in several regions of the electromagnetic spectrum. Comprehensive description of classification of electromagnetic radiation is given below [5]:

Visual Blue 0.45—0.52 µm: Because water increasingly absorbs electromagnetic (EM) radiation at longer wavelengths, provides the best data for mapping depth-detail of water-covered areas. It is also used for soil-vegetation discrimination, forest mapping, and distinguishing cultural features.

Visual Green 0.50—0.60 µm: The blue-green region of the spectrum corresponds to the chlorophyll absorption of healthy vegetation and is useful for mapping detail such as depth or sediment in water bodies. Cultural features such as roads and buildings also show up well in this band.

Visual Red 0.60—0.70 µm: Chlorophyll absorbs these wavelengths in healthy vegetation. Hence, this band is useful for distinguishing plant species, as well as soil and geologic boundaries. Near-IR 0.70—0.80 µm: The near-IR corresponds to the region of the EM spectrum, which is especially sensitive to varying vegetation biomass. It also emphasizes soil-crop and land-water boundaries. Near-IR 0.80—1.10 µm: The second near-IR band is used for vegetation discrimination, penetrating haze, and water-land boundaries. Mid-IR 1.55—1.74 µm This region is sensitive to plant water content, which is a useful measure in studies of vegetation health. This band is also used for distinguishing clouds, snow, and ice. Mid-IR 2.08—2.35 µm This region is used for mapping geologic formations and soil boundaries [6]. It is also responsive to plant and soil moisture content. Mid-IR 3.55—3.93 µm A thermal band which detects both reflected sunlight and earth--emitted radiation and is useful for snow-ice discrimination and forest fire detection.

II. SPECTRAL RESPONSE OF SOME EARTH FEATURES

A basic assumption in remote sensing is that spectral reflectance is unique and different from one object to an unlike object. There are three basic problems in spectral analyses that need our attention, namely: (1) measurement of wavelengths, (2) measurement of intensities, and (3) interpretation. Earth surface features like vegetation, soil water and snow have unique reflectance (Fig. 2). Vegetation has a very high reflectance in the near infrared region, though there are three low minima due to absorption and may reflect up to 50%. The soil has rather higher values for almost all spectral regions and may reflect up to 30-40%. Water has almost no reflectance in the infrared region and reflects at the most 10% of the incoming radiation [2], [7]. The following figure shows the concept of imaging spectroscopy[8].

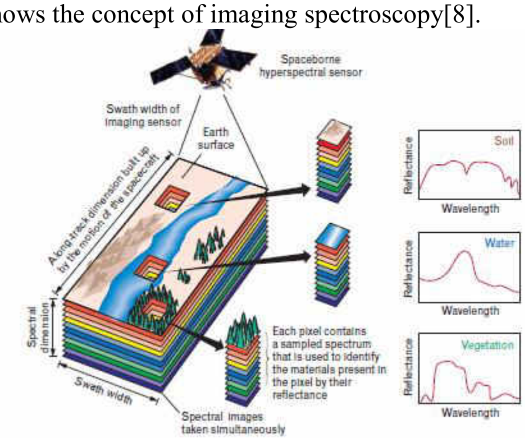

Fig. 2. Comparison of Reflectance spectra

Vegetation: Plant pigments, leaf structure and total water content are the three important factors, which influence the spectrum in the visible, near infrared (IR) and middle IR wavelength regions, respectively. Low reflectance in the blue and red regions corresponds to two chlorophyll absorption bands centered at 0.45 and 0.65 micrometer respectively. A relative lack of absorption in the green region allows normal vegetation to look green to one’s eye. In the near infrared (NIR), there is high (45 per cent) reflectance, the transmittance of similar magnitude and absorbance of only about five per cent. Total incident solar radiation absorbed in NIR region is directly proportional to the total leaf water content. Soil: Typical soil reflectance curve shows a generally increasing trend with wavelength in the visible and near-IR regions. As the moisture content of the soil increases, the reflectance decreases. Soil having more moisture content [9], [10] has lower reflectance.

Increasing particle diameter results in decreased soil reflectance. Structure of the soil is another parameter, which has an important influence on its reflectance. Soils without much of a structure reflect 15 to 20% more than the soils, which have well-defined structures. Fine textured soil has low reflectance compared to those soils having a sandy texture. The organic matter content increases, soil reflectance decreases. In a thermal IR image moist soils look darker compared to the dry soils[2]. Water: Water [11] absorbs most of the radiation in the near-IR and middle IR regions. This property enables easy delineation of even small water bodies. In the visible region, the reflectance depends on the reflectance that occurs from the water surface, bottom material and other suspended materials present in the water column. Turbidity in water generally leads to increase in its reflectance and the reflectance peak shifts towards longer wavelength [2]. The highest reflectance is given by turbid (silt loaded) water and water containing plants with a chlorophyll reflection peak at the green wavelength.Snow and Clouds: Snow has very high reflectance, up to 0.8 µm and then decreases rapidly afterwards. In case of clouds, there is non-selective scattering and they appear uniformly bright throughout the range 0.3 to 3 µm [2].

III. RESOLUTION

Four distinct types of resolution must be considered. These four domains contain separate information that can be extracted from the raw data [2].

A. Spectral Resolution: Earth surface data as seen by the sensors [12] in different wavelengths (reflected, scattered and/or emitted) is radiometrically and geometrically corrected before extraction of spectral information [13]. Wide intervals in the electromagnetic spectrum are referred to as coarse spectral resolution, and narrow intervals are referred to as fine spectral resolution. Table 1 shows different spectral bands of IRS LISS III Image and their application areas.

Table I. Spectral band of LISS III Image and relative applications.

Band	Wavelength (Micrometer)	Nominal Spectral location	Principal Applications
1	0.45-0.52	Blue	Designed for water body penetration, making it useful for coastal water mapping. Also useful for soil/vegetation discrimination, forest type mapping, and cultural feature identification.
2	0.52-0.60	Green	Designed to measure green reflectance peak of vegetation for vegetation discrimination and vigor assessment. Also useful for cultural feature identification.
3	0.63-0.69	Red	Designed to sense in a chlorophyll absorption region aiding in plant species differentiation. Also useful for cultural feature identification.
4	0.76-0.90	Short wave Infrared(SWIR)	Useful for determining vegetation types, biomass content, for delineating water bodies and for soil moisture discrimination.

An important concept for analysis of LISS III imagery is Color and False Color. The human eye can only distinguish about 16 shades of grey in an image; however the computer is able to distinguish between millions of different colors. A true color image (photographic image) is one for which the colors have been assigned to DN (Digital Numbers) values that represent the actual spectral range of the colors used in the image (red band on red, green band on green, blue band on blue).

The display color assignment for any band of a multispectral image can be done in an entirely arbitrary manner. In this case, the color of a target in the displayed image does not have any resemblance to its actual color. The resulting product is known as a false color composite image (many channel data, much not comparable to RGB (visible)). One of the most widely used data format for information extraction about the land-use and land-cover is the infrared False Color Composite (FCC) image [14]. Basically, the visual interpretation of the remote sensing data is based on the FCCs (NIR band on red, red band on green, green band on blue)(Fig. 3).

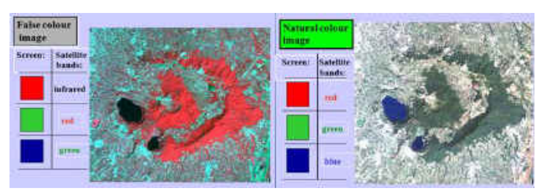

Fig. 3. False color image (left) and Natural color image (right).

B. Spatial Resolution: Spatial resolution is a measure of the smallest object that can be resolved by the sensor, or the area on the ground represented by each pixel. The finer the resolution, lower the number. For instance, a spatial resolution of 79 meters is coarser than a spatial resolution of 10 meters. The extraction of urban information from remotely sensed data requires higher spatial resolution. The spatial resolution of LISS III image is 23.5 mts. *C. Radiometric Resolution*: Radiometric resolution refers to the dynamic range, or number of possible data files values in each band. This is referred to by the number of bits into which the recorded energy is divided. For instance, in 8-bit data, the data file values range from 0 to 255 for each pixel, but in 7-bit data, the data file values for each pixel range from 0 to 128.*D. Temporal Resolution:* Temporal resolution refers to how often a sensor obtains imagery of a particular area. For e.g., the IRS satellite can view the same area of the globe once in every 24 days.

IV. INTERPRETATION

Interpretation of satellite image is region and resolution specific. Quantitative analysis: Pixels with like attributes are often counted to give area estimates. Photo-interpretation: This approach involves a human analyst/interpreter extracting information by visual inspection of an image composed of the image data. Photo interpretation is good for spatial assessment but poor in quantitative accuracy. By contrast, quantitative analysis, requiring little human interaction [15], has poor spatial ability but high quantitative accuracy [16]. LISS-III data were interpreted based on the image elements such as tone, texture, association, etc [17]. LISS III imagery can be used to generate a database, including floral, soil, microbial, hydro, socio-economic and geological fields and can be used to address queries of the user organization pertaining to area statistics, location, water potential, soil suitability, agricultural suitability according to the prevailing ecological conditions, etc [18]. Land cover is a discrete label based on classification of the Earth's surface as it is represented in imagery [19], [20]. IRS 1C-LISS III image is shown in Fig. 4.

Fig. 4. IRS-1C LISS III Image acquired on 02nd March 2009.

Improvement in classification accuracy can be achieved by applying the intensity, hue, and saturation transformation, to the LISS-III data followed by replacing the intensity (I) component by the PAN data, restoring subsequently to the RGB components, and linearly stretching the resultant digital data Image and finally segmented into four segments based on its Geo technical elements and pixel intensities as shown in figure 5(a, b, c, d). Field study was made to compare the results for decision of feature type. First image in figure 5 shows settlements in urban area, second image shows vegetation, third image shows fallow/plain lands, last image shows water bodies.

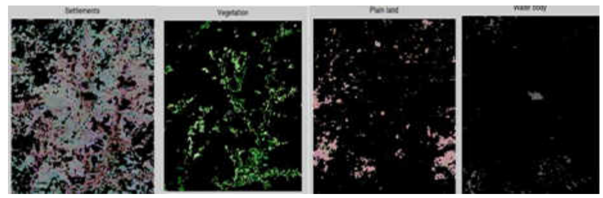

Fig. 5(a b c d): a. Settlements, b. Vegetation, c. Plain land, d. Water bodies

The extraction of information from such images about ground reality is done by image interpretation [21]. The mapping and monitoring of the land use/land cover requires a land use classification system (as shown in Table 2).

Table II. Characteristics of land cover classes.

Land Cover Classes	**Description**	**Characteristics on LISS-III data**
Dense Forest	Tall dense trees	Dark red with rough texture
Sparse Vegetation	Low vegetation density with exposed ground surface	Dull red to pinkish
Agriculture	Crops on hill terraces as step cultivation	Dull red and smooth appearance
Fallow Land	Agriculture fields without crops	Bluish/greenish gray with smooth texture
Barren Land	Exposed rocks without vegetation	Yellowish
Settlements	Town and villages; block like appearance	Bluish
Fresh sediments	fresh landslides debris and river sediments on the blank	Cyan
Water bodies	Rivers and lakes	Cyan blue to blue according to the depth of water and sediment content
Snow	Snow covered areas on high altitude mountains	Very bright white

To improve the accuracy of wastelands delineation, analysis of cropping season LISS-III images can be done by mapping wastelands, with limited field checks [22]. IRS LISS-III data can be used for agricultural, land cover classification [23] and forestry monitoring also.

CONCLUSION

Interpretation of satellite image is region and resolution specific. Prior knowledge of the responses of the data set is very essential before starting any analysis for a specific application. This study aims to identify the spectral responses based interpretations of IRS-1C LISS III image. This literature can be referred for monitoring and analysis of different features. It also helps in extraction, identification and changes detection in the landscape. This can help researchers for quick reference of spectral responses and satellite imagery characteristics. IRS LISS-III data can be used for water, soil, agricultural and forestry monitoring. IRS LISS-III imagery is best suited for land cover classification of Earth surface.

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