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Chlorophyll concentration and biomass percentage of vegetation helps to identify vegetation of satellite image: A case study on plantation crops of the Kasaragod district of Kerala*

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Abstract

Mapping of land use with the help of remote sensing techniques often provides valuable information for environmental planning and land development. In this paper, attempts have been made to map the plantation crops of Kasaragod District of Kerala with the help of FCC imagery, chlorophyll and carotene concentration of the leaves and leaf bio-mass of different vegetation. The results revealed that these bio-physical parameters have highly significant correlation with the Normalized Difference Vegetation Index (NDVI) ratio and the prediction based on these parameters done in the laboratory were of high degree of agreement with land truth.

Key words: FCC imagery (False colour composite imagery), plantation crops, chlorophyll, bio-mass, Normalized Difference Vegetation Index (NDVI)

Introduction

The detection and quantitative assessment of green vegetation is one of the major applications of remote sensing and is very useful for mapping of vegetation because of the synoptic coverage of satellite data. The remote sensing techniques are of immense value for preparing accurate land use / land cover map and monitoring changes at periodic intervals (Gautam,1995)

Satellite imagery is largely concerned with the measurement of electromagnetic energy from the sun which is reflected, scattered or emitted by the objects on the surface of the earth. Detection and measurements, of these response and spectral signature enable identification of surface objects on the satellite imagery. The reflection intensity of the different vegetation varies depending on the component of the leaf canopy (Gupta *et al.*, 2000).The chlorophyll concentration of the leaves of different vegetation and the biomass are the two important aspects which focus on the vegetation signature. The aim of the present study is to standardise the identification of image signature of different vegetation with the help of chlorophyll concentration and biomass percentage.

Chlorophyll is an important ingredient of green leaf. It helps in the production of carbohydrate for the plant (food for the plant) in presence of sunlight. It is essential to understand the chlorophyll percentage of the leaf to study the satellite image as it helps in absorbing the sun's energy or the red light. The leaf greenness depends on the chlorophyll percentage of the leaf. Healthy canopies of green vegetation have a very distinctive interaction with energy in the visible and near infrared regions of the electromagnetic spectrum. In the visible regions, plant pigments (most notably chlorophyll) cause strong absorption of energy, primarily for the purpose of photosynthesis. The absorption peaks in the red and blue areas of the visible spectrum leading to the characteristic green appearance of most leaves. In the near infrared,

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however, a very different interaction occurs. Energy in this region is not used in photosynthesis and it is mostly scattered by the internal structure of the leaves, which leads to a very high apparent reflectance in the near infra red.

Biomass of leaf means the dry cell mass of leaves without any water content. Reflection of light depends on the leaf area or the leaf structure. When the bio-mass is more either the leaf area is more or the thickness is more. Therefore, the reflection back to the satellite camera is more resulting in brighter signature.

Kasaragod district of Kerala (India) is a district of plantation crops where coconut, rubber and cashew cover an area of 77.87% of the net sown area which is 59% of the total land area of the district. It is important to assess the overall setting of these plantation crops along with the forest and settlements of the coastal district.

Materials and Methods

The satellite imagery of IRS LISS III FCC of Kasaragod district was collected from the National Remote Sensing Agency (NRSA), Hyderabad. The leaf samples of the main vegetations of the district were collected for chlorophyll analysis and biomass study.

Chlorophyll extraction (Singh, 1982)

Fresh tissue (1.0 g) was ground with 40 ml of 80% acetone to a fine pulp. The resulting green liquid was transferred to a Buchner funnel lined with Whatman no.1 filter paper. The grinding of the pulp was repeated several times. The extracts were pooled. The volume of the filtrate was made up to 100 ml with 80% acetone.

Chlorophyll determination

The optical density (OD) of the chlorophyll extract was taken with a spectrophotometer set at 652 nm for total chlorophyll, 645 nm for chlorophyll a and 663 nm for chlorophyll b using 80% acetone solvent as blank. The amount of chlorophyll present (in mg/g of tissue) in the extract was calculated according to the following equation:

Total chlorophyll = (OD value at 652 nm x 1000/ 34.5) x (V/ 1000 x W)

Where,

OD = Optical density

V = The final volume of the 80% acetone chlorophyll extract

W = Fresh weight in grams of the tissue extracted.

34.5 is a constant

Extraction of carotenes (Singh, 1982)

The same extract was used to take optical densit carotene . The OD values were taken at 480 nm and nm and the carotene concentration was calculated a

7.6 (OD value at 480 nm – 1.49 x OD at 510 nm) x (V/ 1000 x W)

Leaf biomass calculation (Singh, 1982)

Biomass of leaf means the dry cell mass of le without any water content. Fresh leaf tissue (5g) wrapped in a piece of ordinary filter paper and ke oven at 55°C for drying. After every three days, weight of the tissue was taken and the same continued till there was no further reduction in wei This gave the dry weight of 5 g fresh tissue. The weight/ g tissue was then calculated, which is the bion of the tissue taken.

Vegetation indices

Healthy canopies of green vegetation have a v distinctive interaction with energy in the visible and n infrared regions of the electromagnetic spectru Chlorophyll absorbs light (red) for photosynthesis. very less amount of light is reflected back to the satel camera from the visible region (400nm-700nm) of spectrum. However, in the near infrared region a v different interaction occurs. Energy in this region is used in photosynthesis and it is mostly scattered by internal structure of the leaves, leading to a very h apparent reflectance in the near infra red region. Taki this into view, most particularly the amount of reflec energy in the red and near infra red (NIR) regions of t electromagnetic spectrum, a quantitative index w developed and it has been found that it has a dir correlation with the internal structure or the biomass the leaf.

This index is called Normalized Difference Vegetati Index calculated as:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

The Reflectance value of a canopy in the NIR (70 1100nm) region and the reflectance value of the sar canopy in the RED (600-700nm) were calculated wi the help of ERDAS software.

Results and Discussion

Satellite imagery is mainly based on the principle reflection of the radiated sun light. So the structure, colo and the physical set up of the reflected surface is ve important, and these things could be understood with the help of biochemical parameters like chlorophyll content, water content and carotene content of the leaf tissues.

Results of the biochemical analysis of the vegetation of Kasaragod district is given in Table 1. In the visible region (400 nm-700 nm), the plant pigments, the physiological structures of the canopy and the water content influence reflectance. The absorption peaks in the red and blue areas of the visible spectrum leading to the characteristic green appearance of most of the leaves is shown as a green peak (Fig 1) in the curve (green reflects back). Actually in spectrophotometer, absorbance wavelength for carotene is 580 nm, which means at 580 nm, the plant having carotene will absorb blue and green and will reflect back red.

Table 1. Results of the biochemical analysis of vegetation in Kasaragod district

Name of sample	Total chlorophyll mg/g	Carotene mg/g	% of bio-mass/g leaf tissue
Acacia	1.410	0.196	75
Cashew type small leaves (unknown forest bush)	1.080	0.109	55
Cashew type big Leaves (unknown forest tree)	0.927	0.144	52
Small glossy bush	0.402	0.006	39
Mixed bush	1.290	0.118	31
Gulmohur	1.938	0.048	40
Mango	1.040	0.130	49
Casuarina	0.930	0.320	50
Cashew	1.660	0.220	65
Rubber	2.610	0.359	50
Coconut	0.994	0.150	50
Bamboo	1.170	0.490	71

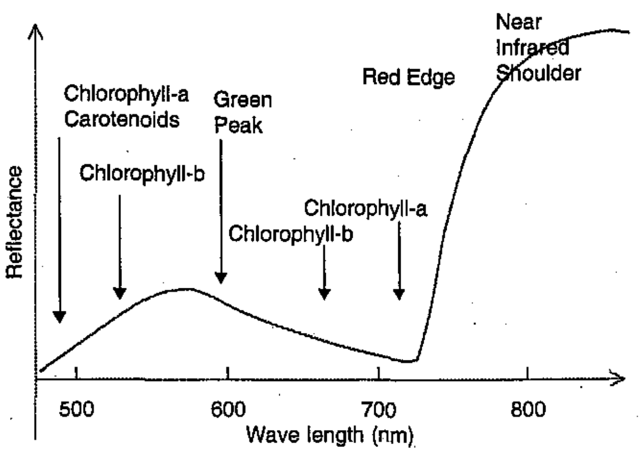

Fig. 1. Spectral reflection curve of a plant canopy with principal absorption features indicated

Again in spectrophotometer, the absorbance wavelength used for total chlorophyll is 652 nm, which means that at that channel red and blue are being absorbed and the green reflected back. So where chlorophyll content is more, more green is reflected back to the satellite camera and afterwards the superimposed image of green and red (infra-red region reflection) gives a darker impression to the image. Where red is reflected back instead of green, brighter red impression occurs on the image. In the false colour composite (FCC), the vegetation appears red, pink and dark red depending on the leaf greenness (as blue colour has been assigned to green band, the green to red band and red to INR band). The reason is in visible region, the red light is used in photosynthesis whereas near infra red, the band of light is reflected back very effectively as it is of no use to the plants. Therefore, the reflection from vegetation in the INR and in the visible range of the spectrum varies considerably. As these decision rules are based solely on the spectral radiance observed in the data, the classification process is termed as 'spectral pattern recognition' (Gautam,1995).

Biomass means the solid particles of the canopy or in other words the cell concentration. When the bio-mass is more, it means the number of cells is more, hence the reflection substratum is more and incidence as well as reflectance of light is more and brighter is the colour in the image.

Actually using this criterion, the prediction on the satellite image was done and confirmed with the survey. It was found that the prediction of the types of vegetation was exactly correct.

NDVI and physiological parameter

In the near infrared, however, a very different interaction occurs. Energy in this region is not used in photosynthesis and it is mostly scattered by the internal structure of most of the leaves, leading to a very high apparent reflectance in the near- infra- red channel. In the infrared region, the biomass of the leaves works more prominently. It is found that the radiances in the middle infrared region are more sensitive to total biomass of the plant (Horler and Ahern, 1986). Where the number of cells is more, the number of incident rays is more and as a result the number of reflected rays is also more. Hence, more reflection in the red region gives a brighter impression in the image.

The NDVI ratio, biomass, chlorophyll percentage and carotene percentage of the main vegetation of the district were grouped into four classes (Table 2). The vegetation like cashew and rubber have more biomass as well as chlorophyll than coconut and NDVI ratio is also more whereas mango and some bush type plants have less biomass and less NDVI values.

Table 2. Vegetation of Kasaragod grouped with the calculated values of NDVI, biomass, chlorophyll concentration and carotene concentration

Name of vegetation	NDVI ratio	Bio-mass %	Chlorophyll mg/g	Carotene mg/g
Mango, Small bush type plants, Gulmohur	Below 0.50	40-49	0.5-1.05	0.1-0.
Coconut	0.5-0.55	50-55	0.85-0.99	0.12-0.15
Cashew, Cashew type small leaves, Acacia, Bamboo	0.56-0.65	56-65	1.1-1.66	0.11-0.22
Rubber	0.65 & above	65-70	1.75-2.5	0.3-0.35

In this study, the relation among all the physiological factors and NDVI was also determined by correlation analysis (Snedecor *et al.,* 1979).

The co-efficient of determination found was 89.2% (Table 3) indicating that the three characters strongly influence NDVI to a tune of 89 % ($R^2 = 0.892$). All the three characters showed very high correlation with NDVI as well amongst themselves.

Table 3. Correlation between NDVI and physiological parameters

Characters	Biomass	Chlorophyll	Carotene
Chlorophyll	0.840	-	-
Carotene	0.770	0.943	-
NDVI	0.943	0.799	0.752

$R^2 = 0.892$

The present study confirms the earlier report that satellite remote sensing is a valuable technique to map and monitor land use or land cover of a large area rapidly and economically (Parthasarathy *et al.,* 2004). This provides more consistent and accurate base line information than many of the conventional surveys employed for such task.

Similar work was done by Menon (1990) for Attappady region of Kerala. According to him, remote sensing can help in building up an ideal database for vegetation. Present discussion shows that the physiological characters of the different vegetati definitely give an impression on the image. Imagi spectrometry could also provide detailed biochemi information (Bisun, 2000). In this study, the decisio made with the help of biochemical values and the satell imagery were found totally in agreement with the fie truth. According to Tamaluddin and Kamaruzam (2001) leaf biomass for most of the crops is high correlated with the leaf area and the chlorophyll conte and NDVI ratio is also positively related with le biomass.

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