OPPORTUNITY FOR APPLICATION OF REMOTE SENSING AND GIS APPROACH FOR SUGARCANE PRODUCTION ESTIMATE IN THAILAND

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ABSTRACT: Thailand ranks the second exporter of sugar after Brazil. Crop monitoring and early yield assessment of cane production are important for agriculture planning and policy making at regional and national scales of cane production. Remote sensing offers an efficient and reliable means of collecting the information required in order to map crop type acreage and condition. The study area comprised of four provinces viz., Khon Kean, Chaiyaphum, Nong Bue Lum Phu and Mahasarakham in Northeastern of Thailand. Landsat5 TM digital data (Dec, 2011) was evaluated for the potential utility of remote sensing derived normalized difference vegetation index (NDVI) for sugarcane production estimation. Sum of NDVI of individual sampling fields were correlated with the actual production (ton/ha). NDVI which describes the healthiness of crop is one of the factors of yield variability. The result showed correlation 0.75 for sum NDVI image and sugarcane production. The other factors which influence variations are color leaf and age of cane. Further study progress to integrate with other variables to improve the accuracy.

Introduction

Crop monitoring and early yield assessment are important for agriculture planning and policy making at regional and national scales. Remote sensing technology is widely used in environmental and agricultural research. The normalized difference vegetation index (NDVI), one of the most well-known vegetation indices derived from optical remote sensing imageries has been used to identify the sugarcane area and its condition assessment. Ratio image are often useful for discriminating subtle differences in spectral variation in a scene that is masked by brightness variations. For identifying the area and condition of dense crop like sugarcane (Rejaur et al., 2004), mapping seasonal patterns and crop rotations (Martinez- Casasnovas et al., 2005; Panigrahy & Sharma, 1997), for many other topics, as shown in papers collected in (Bruzzone & Smits, 2002; Smits& Bruzzone, 2004). For estimate crop growth under irrigation and assessing the yield gaps arising in the local environmental and prevailing socio- economic context (Wim G.M. and Samia Ali., 2003). analyze the spatial scale dependencies of NDVI and to analyze the relationship between NDVI and fractional vegetation cover at different resolutions based on linear spectral mixing models (Zhangyan et al., 2006) Using the NDVI to monitor vegetation and plant responses to environmental change (Nathalie et al., 2005) Time series of optical satellite images acquired at high spatial resolution is a potentially useful source of information for monitoring agricultural practices. Integrating SPOT-5 time series, crop growth modeling and expert knowledge for monitoring agricultural practices the case of sugarcane harvest on Reunion Island (Mahmoud El Hajj et al., 2009)

Remote sensing techniques for acreage estimation yield prediction and production forecasting of sugarcane. Studied the effect of different sampling schemes on the accuracy of sugarcane acreage estimation using IRS LISS-I data of October 1989. Normalized difference vegetation index relationships with rainfall patterns and yield in small plantings of rain-fed sugarcane (Wuttichai et al., 2011) Used different sizes of sample segments and classified the data using maximum likelihood supervised classification. Among all the sample segments tried, 7.5 per cent sampling fraction resulted in sugarcane acreage estimates with relative deviation of less than 4 per cent (Vyas et al., 1990). Investigated on the use of time spot4 satellite imagery to monitor sugarcane areas harvested by smallholder growers in a selected area within the Umfolozi mill supply area.This was achieved by manipulation of the four satellite-measured spectral bands and subsequent classification of sugarcane into harvested and non-harvested areas. Mixed results indicate that the satellite imagery classifications are able to clearly distinguish between standing sugarcane and harvested plots. Stressed cane was difficult to discriminate from harvested plots (Gers et al., 2001). Use of remote sensing techniques for yield forecasting.

Monitored the development of sugarcane in Buttala area of Monaragala district, Sri Lanka from 1983 to 1994 using aerial photographs and IRS images. He also made an attempt to estimate the sugarcane harvest by selecting few farm plots within study area and actual yield data for few consecutive years. He concluded that by separating the vegetative stages of sugarcane from the mature stages and combining this information with few field investigations, it is possible to predict the harvest within agreeable limits (Guruge et al.,1996). Finally can site-specific management the application of information technology to crop production (Richard E. Plant, 2001)

Remote sensing techniques can play quite an important role in land cover survey and as a source of information relating to land resource condition. The main objective of the study is to identify the extent of sugarcane area and mapping, using remotely sensed data and NDVI algorithm to assess the condition of crop health from NDVI value.

Study Area - An Overview

The study area cover on area 55,062 hectares Khon Kean, Chaiyaphum, NongBueLhumPhu and Mahasarakham Provinces in Northeastern Thailand. (Fig1). Sampling size for NDVI study is 109 fields cover area 145 hectares. This was select from difference AEZ which was determined base on soil type and rainfall pattern. The yield (ton/ha) was estimated from 3 sampling plots with 3 replication selected at random each farmer's field. Six sugarcane stalks randomly chosen from each replication in early on December were cut, subsequently weighed in the field.

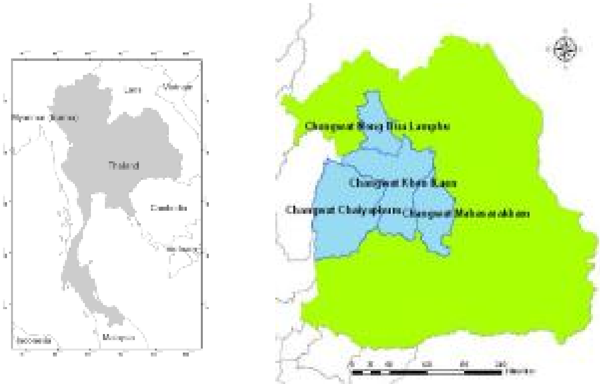

Figure 1 Boundary for this research. The large blue points four provinces.

Sugarcane – Physiological Aspect

Spectral Reflectance, Vegetation and Normalized Difference Vegetation Index (NDVI)

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to analyze remote sensing measurements and assess whether the target being observed contains live green vegetation or not. NDVI has found a wide application in vegetative studies as it has been used to estimate crop yields, pasture performance, and rangeland carrying capacities among others. It is often directly related to other ground parameters such as percent of ground cover, photosynthetic activity of the plant, surface water, leaf area index and the amount of biomass. NDVI was first used in 1973 by Rouse et al. from the Remote Sensing Centre of Texas A&M University.

Generally, healthy vegetation will absorb most of the visible light that falls on it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. Bare soils on the other hand reflect moderately in both the red and infrared portion of the electromagnetic spectrum (Holme *et al* 1987). Since we know the behavior of plants across the electromagnetic spectrum, we can derive NDVI information by focusing on the satellite bands that are most sensitive to vegetation information (near-infrared and red). The bigger the difference therefore between the near-infrared and the red reflectance, the more vegetation there has to be.

The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it by the sum of near-infrared and red bands.

$$\mathbf{NDVI = (NIR - RED) / (NIR + RED)}$$

This formulation allows us to cope with the fact that two identical patches of vegetation could have different values if one were, for example in bright sunshine, and another under a cloudy sky. The bright pixels would all have larger values, and therefore a
larger absolute difference between the bands. This is avoided by dividing by the sum of the reflectances.

Theoretically, NDVI values are represented as a ratio ranging in value from -1 to 1 but in practice extreme negative values represent water, values around zero represent bare soil and values over 0.6 represent dense green vegetation.

OBJECTIVES

1. The main objective of the study is to identify the extent of sugarcane area and mapping using remotely sensing data and NDVI algorithm.
2. To assess the condition of crop health from NDVI value.

MATERIALS

Remote Sensing Data:
Satellite digital data: Landsat5 TM
Bands: 3, 4, 5
Data acquisition: December 2011
Spatial resolution: 30 m.

METHODOLOGY

In accordance with the objectives of the study satellite image of Landsat7 ETM+ (4 Bands) has been collected for December, 2011 and field observation. On the other hand, for digital data processing, analysis and integration of spatial and non-spatial data PC based raster with Erdas imagine 9.1 and Arcgis 9.1 software has been used in this study. Two bands (NIR and RED) of the Landsat5 TM have been geo-referenced using sufficient number of ground control points and pixel size defined as 30 m. Then, using NDVI algorithm NDVI image has been generated and the study area extracted from the NDVI image. For feature recognition especially for crop mapping, NDVI value of band 4 (infrared) and band 3 (red) of Landsat7 TM digital data have been used. For classifying the NDVI image cluster and knowledge based classification methods have been applied. According to the signature, pattern and color of NDVI image and ground truth and observation, range of NDVI values has been selected for each of the classes (Fig-2). For ground truth/observation some training sample/site have been selected in the NDVI image and verified those sample site in the respective ground or field.

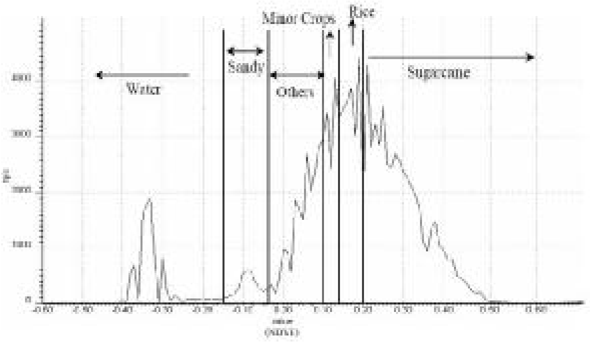

Figure 2: Histogram of NDVI image and range of NDVI value for each of the classes.

After the NDVI data and farmers' fields were assigned the same projection system, the average NDVI value within each farmer's field boundary was calculated from spatial analysis tool using ArcGIS 9.1 software. Although sufficient information on the relationships between sugarcane production and NDVI statistic is unavailable for Thailand, correlation analysis (Spearman's rank correlation coefficient, or rs) between sugarcane production and NDVI statistic was conducted using SPSS statistical software (version 17). Simple linear regression analysis was carried out to quantify the strength of the relationship between rainfall and yield with NDVI to Estimate production cane with equation from relationship.

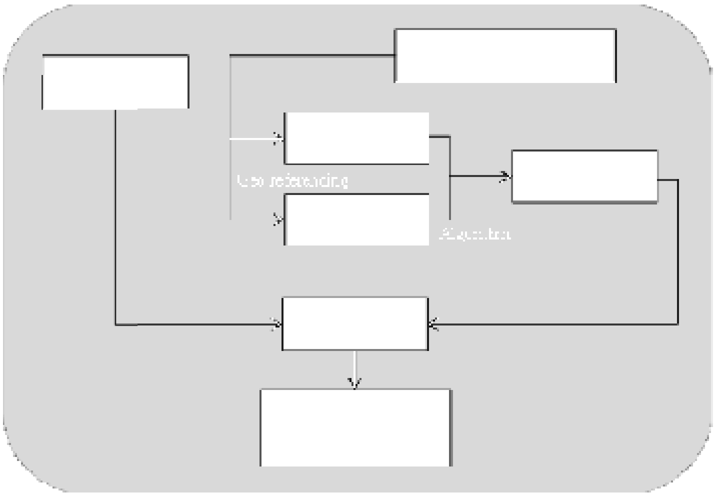

Figure 3: Show methodology for sugarcane area identification and condition assessment.

Geo referencing

RESULTS AND DISCUSSION

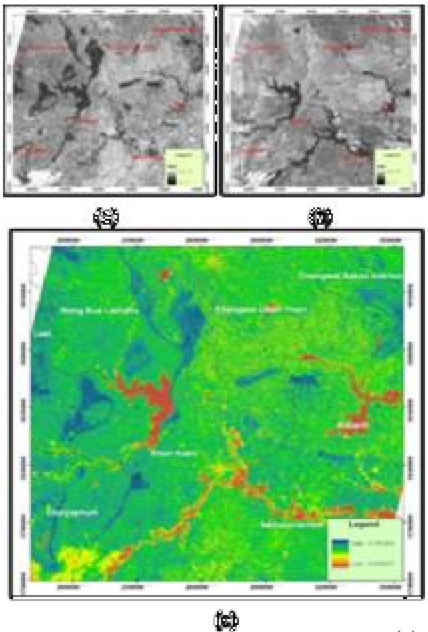

Figure 3: Sattellite Image Band 3 (a), Band 4 (b) and NDVI mapping (c)

The NDVI values derived from averaging data from all sugarcane fields reasonably corresponded to the regional temporal rainfall pattern. The rainy season in this region occurs from April to late November while highest rainfall is usually recorded in August to September. Thereafter. The cold season generally starts in November and end in March (Sakurathani et al., 2002). Corresponding to the age of cane and rainfall pattern peak vegetation observed in December.

In the NDVI map, the bright areas are vegetated while the non-vegetation area are generally dark. Using NDVI value, has been classified for identification of different crop areas (figure 3.) Table 1 show crop condition of sugarcane sampling in area study. Overall sugarcane condition was good in area, because more 67.34% of total sugarcane area under "good" and "very good" condition. Only 7.6% of the total sugarcane area falls under "poor" condition. The correlation between sugarcane area (Hectares) and sugarcane production (tons) with sampling time. This is shown in figure 4.

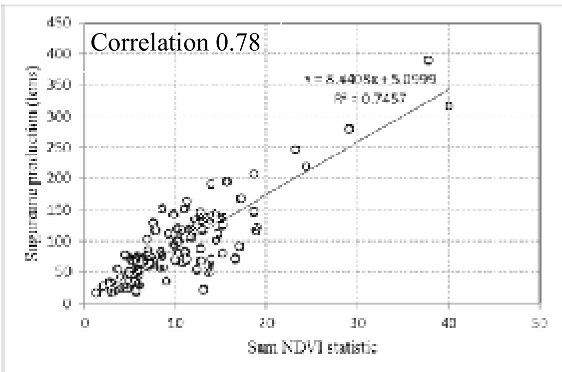

Figure 4: Correlation between sugarcane area (Hectares) and sugarcane production (tons)

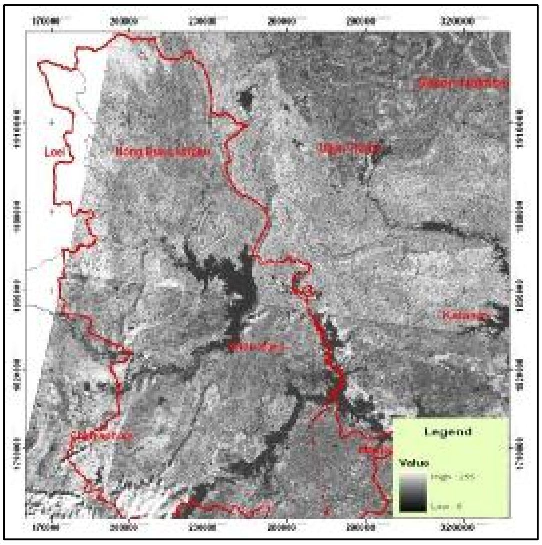

Figure 5: NDVI mapping within sugarcane area of Mitr Phu Vieng Mill

Table 1: Crop condition of sugarcane sampling in study area.

Crop condition	Sum pixel	Area (hectares)	% of total
Poor	71	11.00	7.61
Moderate	271	36.19	25.04
Good	321	43.25	29.93
Very good	433	54.06	37.41
Total	1,096	144.50	100.00

Y = 8.44X + 5.09

Y= yield in tons

X= sum of NDVI the zonal

This is equation from relationship between sum NDVI statistic and cane production. Actual cane production

CONCLUSION & RECOMMENDATIONS

The results of the investigation on other factors which influence variations are color leaf and age of cane. Further study progress to integrated with other variables to improve the accuracy.

The correlation co-efficient is $R^2 = 0.78$. There are other variability which influence on the cane production apart from vegetation index. Age of the cane is area of the primary factors, the other is variety difference which need to be considered. Thus, an integrated approach need to be studied to increase accuracy.

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