EXTENDED ABSTRACT

MULTI SPECTRALSATELLITE IMAGES AS A TOOL FOR DETECTING HEALTHY TEA PLANTATION

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(Published 15 October 2021)

Abstract

Sri Lanka is well known for its rich tea cultivation. Diseases are always injurious to the tea plant's health which in turn severely affect its growth, yield and quality. So it is always advisable to continuously monitor its growth to ensure minimal losses of tea plant. This study proposes a solution of tea leaf disease detection approach that is simple, time efficient and generic, which can be utilized to assess and monitor tea plantations. In this study, an attempt has been made with the help of Remote Sensing and GIS techniques to monitor the tea plant health by using the spectral responses in the visible and Near Infrared (NIR) regions of the Electromagnetic Spectrum using Landsat-8 OLI\TIRS images. Spectral profiles for the tea patches were generated from the classified images obtained after atmospheric correction. Grey Level Co-occurrence Matrix (GLCM) based texture variations and Normalized Difference Vegetation Index (NDVI) analysis have been used to verify the results.

Keywords: NDVI, texture, GLCM, healthy and unhealthy, plant spectral profile, regression analysis, GIS

1. Introduction

In ancient Sri Lanka agriculture had been the main living hood. In 1867 tea was recognized as a possible alternative crop as a result of economic breakdown due to coffee leaf rust disease. In modern times, the tea industry is the backbone of Sri Lanka. Sri Lanka is recognized as the 3rd top country which produces tea. Further, it contributes to the 1.2% for Gross Domestic Production (GDP) and 14% share of net foreign exchange as well as 70% total foreign exchange of agriculture (ThasfihaM et al., 2020)The Sri Lankan tea industry earns approximately 1.5 billion USD. It generates approximately 2.5 million employment opportunities for Sri Lankans. Majority of tea small holders and their families (70%) depend on tea cultivation. Therefore, tea plantation is the most important sector where more research works have to be done to enhance the economy of the nation. Many researches have been conducted regarding the application of GIS and Remote Sensing in the field of tea plantation. (Ghosh and Roy, 2004, Rajapakse, Tripathi and Honda, 2002)

2. Study area

According to the elevation, tea growing areas in Sri Lanka are clustered in to three major regions. They are low country teas which are grown at an elevation from sea level to 610m, mid country

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teas which are from 610m to 1,220m and upcountry regions which are grown at an elevation above 1,220m (Tea Exporters Association, n.d.). The taste, flavor, aroma of teas and production of high quality tea from each region are influenced by the conditions particular to those regions (Sai, Chaturvedula and Prakash, 2011).

Since mid-19th, NuwaraEliya has been the capital of tea industry (Super User, 2018). Perfect climate combine with the rolling terrain NuwaraEliya produce he finest tea. So this study was carried out for NuwaraEliya lies between latitude of 6°580N and longitude of 80°460E (Figure 1).

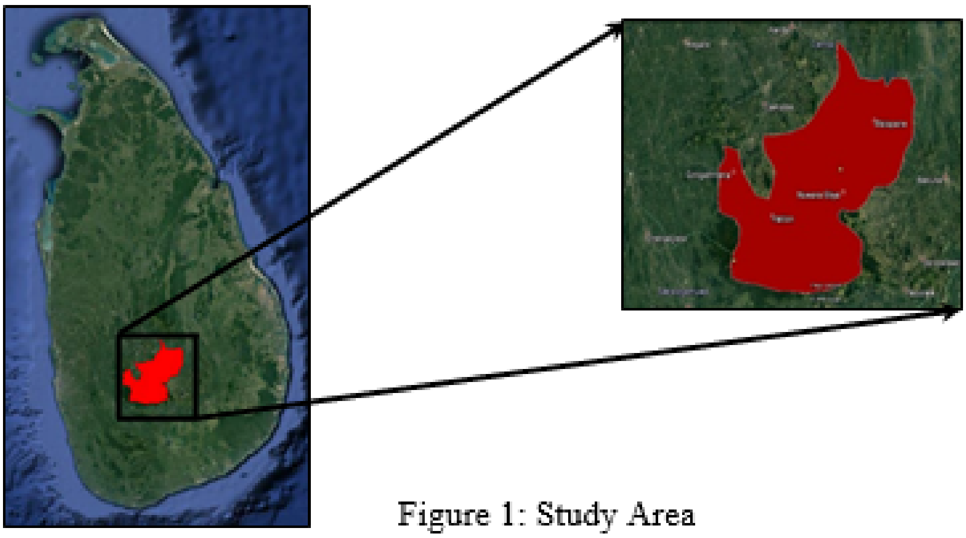


Figure 1: Study Area

3. Data

This study used multi-temporal series of Landsat-8 OLIdata of January, February, March, and September, 2016. Bands from 1 to 9 were taken as the input for this study. The first 7 bands and band 9 of multi spectral data have 30m resolution. Band 8 which is the panchromatic band has spatial resolution of 15m.

FLAASH (Fast Line-of-sight Atmospheric Analysis of Hypercube) atmospheric correction was performed for all satellite images in order to reduce the effect of atmosphere which gives the precise reflectance values of the surface being studies because energy captured by the sensor goes through the series of interactions with atmosphere (Katkovsky et al., 2018).

4. Methodology

In order to accomplish the main objective of deriving a Spectral profile of Tea, firstly the study aimed to propose a method to identify tea cultivated lands in Nuwaraeliya (Figure 2).

4.1 Atmospheric Correction

There are distortions and degradations in the raw remote sensing images due to the sensors, platform and atmospheric condition when images were taken; called as image pre-processing which includes geometric correction and atmospheric corrections. For this study FLAASH algorithm was used to correct the images atmospherically.

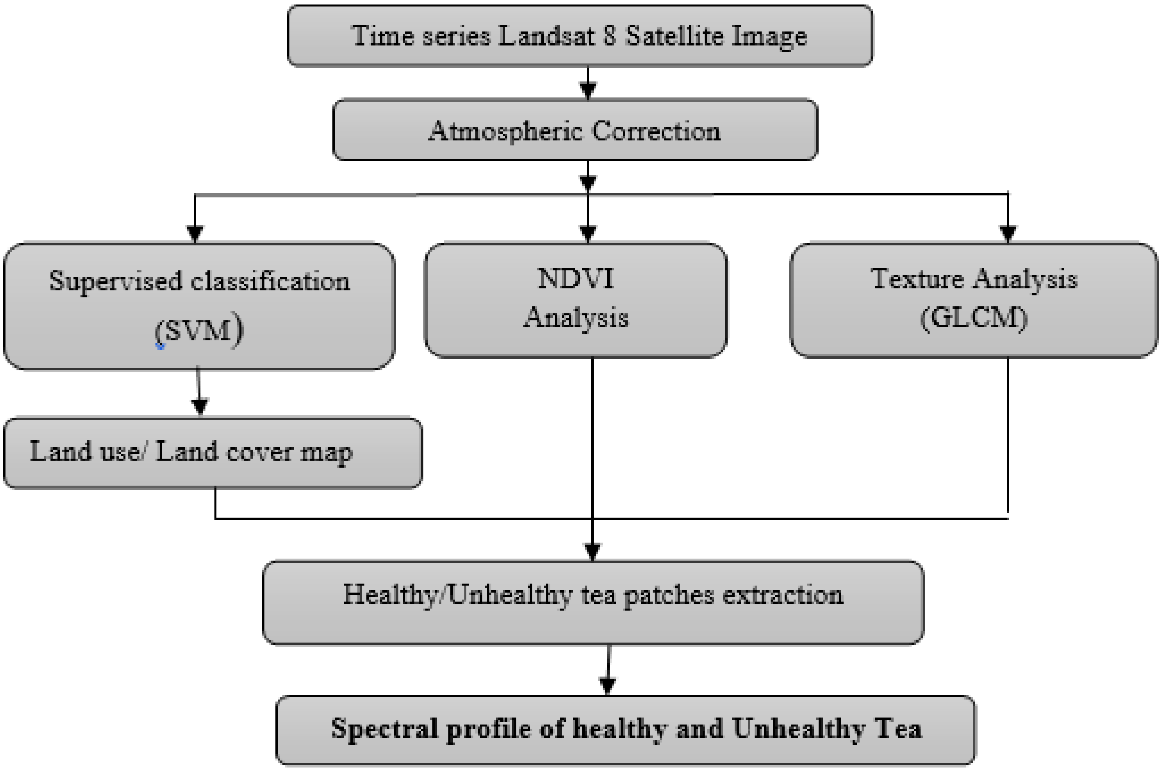


Figure 2: Methodology Adopted

4.2 Supervised Classification

Low chlorophyll measurements can be a strong indicator of inadequate nitrogen levels that ultimately affect the growth and yield of the crops (Haider et al., 2021). However, low chlorophyll measurements can also be a result of sparse vegetation cover. So in order to discriminate the sparse vegetation cover and tea patches supervised classification was performed using Support Vector Machine (SVM) classifier to classify the image into 7 land cover classes namely tea, water, forest, urban, scrub, other vegetation and land. Training samples for the supervised classification were obtained from Google Earth and 1:50 000 topo map sheet.

4.3 Support Vector Machine (SVM)

Support vector machine classification method derived from statistical learning theory, constructs a hyper plane or set of hyper planes in a high- or infinite-dimensional space, which can be used for classification, regression, or other tasks.

4.4 Texture Analysis

To extract the texture features Grey Level Co-occurrence matrix method was used for each atmospherically calibrated image. Texture features are scale dependent. So window size should be chosen carefully. If the window size is too small relative to the texture structure, the extracted texture feature will not accurately reflect the real texture property. It was found that only 3*3 window shows a strong texture representation with proper clarity, meanwhile other window size gave blurred texture images. In addition to that to obtain a better result proper texture feature should be employed. Dissimilarity, Variance and Contrast images can be used to clearly identify the boundaries of the tea patches. At the same time Mean texture image provides the better variation for healthy and unhealthy tea patches. Result of supervised classification technique was used to identify the tea patches. Then

DN values of mean texture image were compared within the tea patches in order to discriminate the health and stress tea patches.

5. Result and discussion

According to the result of classified images (Figure 3) from end of the February to September tea cultivated areas reduced and amount of land increased. This is because during that period amount of rain fall decreased (Metrological Department). So the amount & distribution of rainfall are most important to productivity of tea. False color composite (Band5, Band4, and Band3) images of mean texture was generated to identify the Land cover classes because false color combination gives the better result to discriminate the green vegetation patches among other classes. Texture values be greater than 16 to healthy tea bush and less than 16 to unhealthy (Figure 4 and Figure5). Further in texture image tea bushes have appeared in reddish color. The healthy tea bush appears in bright red color due to the higher reflectance. The unhealthy or stressed bush appears in dark brown color.

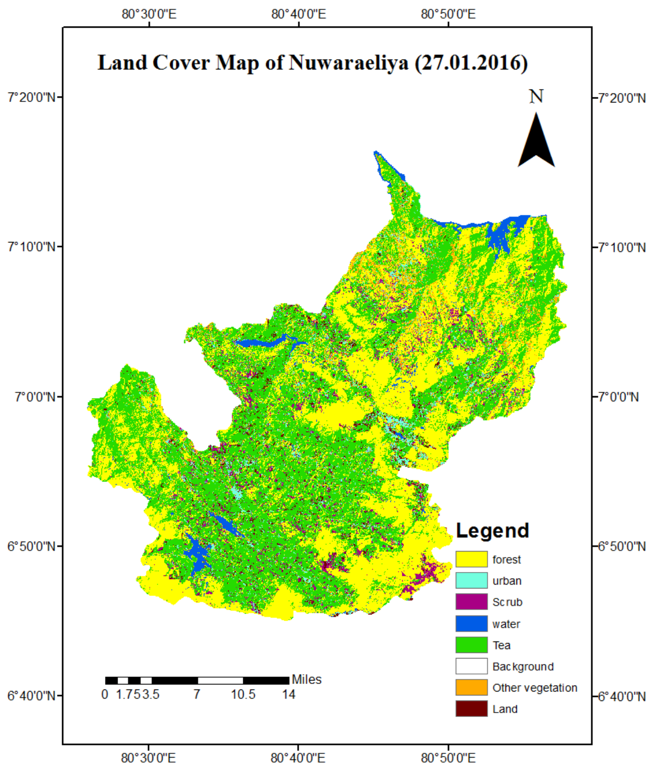
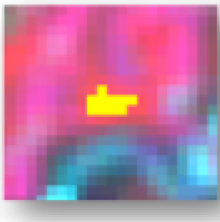


Figure 3: Land Cover Map (27.01.2016)

5.1 NDVI

Empirical relationships between spectral indices and chlorophyll content measurements have been exploited for estimating leaf chlorophyll content (Dou et al., 2018). So the normalized difference vegetation index (NDVI) was retrieved from spectral reflectance of red and near infrared light using Landsat data.

Then texture aided NDVI analysis was carried out to identify the tea patches as healthy and diseased tea. It is noticed healthy tea patches have high NDVI values (greater than 0.76) while stress tea patches have low NDVI values less than 0.76) (Figure 4 and Figure 5).



Sample of healthy tea patch

	3881	3882	3883	3884	3885
4956	0.751308	0.746863	0.72241	0.738325	0.710606
4957	0.797764	0.789940	0795521	0.785337	0.755510
4958	0.802039	0.799241	0.801008	0.794034	0.785857
4959	0.795454	0.799216	0.820631	0.800198	0.783848

NDVI value of tea patch

	3881	3882	3883	3884	3885
4956	17.3333	17.4444	17.2222	17.0000	16.7778
4957	18.1111	18.5556	18.2222	18.1111	17.6667
4958	18.6667	19.7778	19.7778	19.5556	18.6667
4959	18.6667	19.3333	19.3333	18.8889	18.2222

Texture value of tea patch

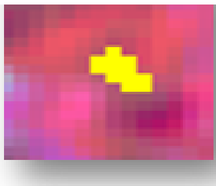
Figure 4: Pixel Values of healthy vegetation

5.2 SPECTRAL PROFILE

The dependence of spectra on leaf biochemical properties provides the physical bases for remote detection of vegetation stresses through monitoring the change of chlorophyll content (Xue and Su, 2017).

Spectral signature analysis was performed for representing the reflectance variability between land cover classes and for evaluating spectral responses within land cover classes. The reflectance curves for all 9 bands were generated for studying the pattern of spectral responses of each land cover classes. Healthy tea present high spectral responses in the green peak and along the NIR due to changes in pigment levels. Contrast healthy tea patches present low spectral response in blue and red regions. According to the result Near-infrared reflectance is one of the most powerful ways to classify healthy tea plant (Graph 1).

Further, pattern of spectral responses of other land cover classes also generated. According to the result it is notices forest has a minimum RED band due to absorption of chlorophyll. When we compare the reflectance values between tea patches and forest, it is relatively low for forest. Forest is not a homogenous surface, it causes multiple scattering. Therefore, multiple scattering cause reduction in reflectance value. At the same time tea bush have homogenous surface and reflectance values also high. The reflectance value of healthy and unhealthy or stressed tea bush, as well as separatability of tea from other vegetation can be identify through the peaks in the NIR band. According to the spectral responses these forest areas can be recognized as dense forest areas. In



Sample of Unhealthy tea patch

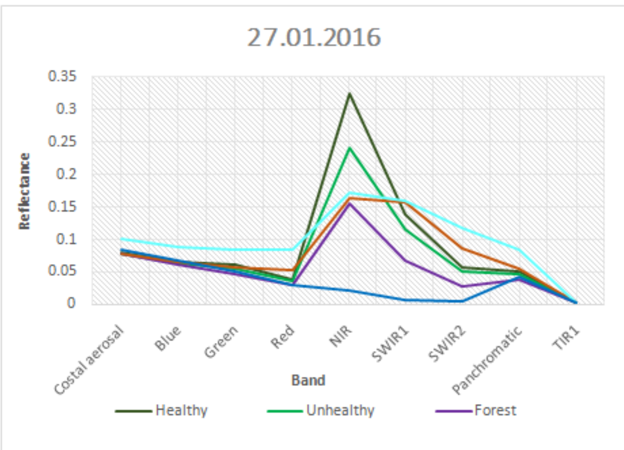
	3654	3655	3656	3657	3658
5384	0.767433	0.747850	0.733780	0.762896	0.783509
5385	0.730651	0.722795	0.741056	0.770947	0.786332
5386	0.719682	0.689116	0.716943	0.758421	0.784984
5387	0.715422	0.733817	0.704805	0.754361	0.780345
5388	0.718056	0.755453	0.739909	0.718882	0.748473
5389	0.717189	0760228	0.731007	0.726396	0.724515
5390	0.789031	0.726188	0.737028	0.735712	0.695594

NDVI value of Unhealthy tea

	3655	3656	3657	3658
5384	15.6667	15.0000	15.5556	16.4444
5385	15.1111	14.6667	15.4444	16.5556
5386	14.7778	14.5556	15.3333	16.5556
5387	14.6667	14.3333	14.8889	15.8889
5388	15.0000	14.3333	14.4444	15.0000
5389	15.8889	14.6667	14.2222	14.2222
5390	16.3333	14.6667	13.8889	13.6667

Texture value of Unhealthy tea patch

Figure 5: Pixel values of unhealthy tea patch



Graph 1: Spectral profile (27.01.2016)

Landsat-8 imagery vegetation can be easily distinguished by its distinctive spectral signature.

5.3 SCATTER PLOT

Scatterplots shows a variation of measurements with respect to a range and could be used for regression and correlation analysis also. RED, NIR, SWIR1 are the bands which are high sensitive to tea bush reflectance than other bands. In this case of study those band of 2016 images were compared with 2017 January image's bands. It gives the correlation of same two bands of different months.

Scatter plots show high correlation between the bands. It implies that health of tea bush all over the year seems good. But through the drought seasons it spread little bit. In RED band SWIR band reflectance value is low than NIR band. Scatter plot also shows that reflectance in NIR band is high than other 2 bands.

6. Conclusion

It is possible to observe the affected tea patches using the optical remotely sensed data. It will help to identify the exact location of the affected or infected area instead of surveying the whole field. Images provide an opportunity for the planters to identify the pattern of epidemiological spread which will lead them towards sustainable solutions.

7. Recommendation

The results can be further improved by analyzing a particular tea estate only, as health level of plantation varies with tea species and plantation height which may affect the spectral profile. A broad and continuous spectral profile can be derived by using Hyper-spectral imageries instead of Multispectral imageries.

Prior knowledge of the study area is very essential to get good classification results. Knowledge based and object based classification should be carried out so that the results can be compared with the texture based classification. Performing LAI analysis and finding relationship between NDVI and LAI with the usage of spectrophotometry will lead for further findings.

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