Estimation of fractional vegetation cover in Dak Lak Province using Landsat 8 OLI satellite images

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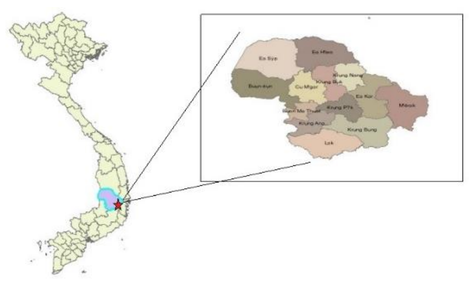
Abstract: *The proportion of plant canopy occupation in a given ground area in vertical projection is known as fractional vegetation cover. With an average altitude of 400-800 meters above sea level, Dak Lak is Vietnam's fourth biggest province, located in the heart of the Central Highlands. The province's overall forest and forestry land area is more than 720,000 hectares as of 2017. There are more than 526,000 acres of wooded land (including rubber trees) in this area, accounting for more than 39.3% of the total land area. As a result, research on fractional vegetation cover is critical. Landsat 8 OLI pictures were used in this investigation, which were taken on two occasions: October 8, 2018 and February 2020. The rainy season (October-2018) accounts for 80 percent to 90 percent of Dak Lak Province's yearly rainfall, with humidity ranging from 82.9 to 84.6 percent. This might explain why vegetation is growing at a rapid rate, resulting in a high FVC. In the dry season (2-2020), on the other hand, rainfall amounts for just 10-20% of annual rainfall, and the lowest humidity is 73.5-74.7 percent.*

Keywords— NDVI, FVC, Landsat 8 OLI image, Dak Lak Province

Introduction

Fractional vegetation cover (FVC) is defined as the percentage of occupation of vegetation canopy (leaves, branches and stems) in a given ground area in vertical projection [1]. FVC, representing the level of vegetation cover on the Earth's surface, plays an important role in ecological environment research such as studying the pattern of vegetation distribution on the Earth's surface and its affecting factors, analyzing and evaluating the ecological environment, monitoring accurately and timely the change of vegetation cover and analyzing vegetation growth trend to maintain ecological balance [2].



Dak Lak is the the fourth larges province of Vietnam located in the center of the Central Highlands (Fig. 1), with an average altitude of 400-800 meters above sea level. As of 2017, the total area of forest and forestry land in the province is more than 720,000 hectares. In which, the forested land area (including rubber trees) is more than 526,000 ha, covering more than 39.3% of land area

Data and research methods

A. *Data*

This study employs Landsat 8 OLI images of 30m resolution obtained from the website https://earthexplorer.usgs.gov/, at Path/Row of 124/51 and cloud cover at 5.64 and 4.59. The images were taken on two occasions, the 8th October, 2018 (rainy season) and the 16th February, 2020 (dry season).

A. *Research methods*

Linear Spectral Mixture Model (LSMM), was generalized by Van de Meer by the following equation [4]:

$R_k = \sum_{i=1}^{n} f_i r_{i,k} + e_k$ (1)

In which, R_k is the mixed reflectance spectrum of each pixel in the k band

n is number of spectral components or end-members together causing the observed mixed spectral signature of the pixel

f_i is the fraction of its end-member i in the mixed spectral signature of the pixel

$r_{i,k}$ is the reflectance spectrum of end-member i at k band in the mixed spectral signature of the pixel

e_k is the residual error

$\sum_{i=1}^{n} f_i = 1$ (2)

In this research, given that components of a mixed pixel are only water, vegetation and soil then spectrum signature of the pixel is contributed by these 3 components. The ratio of each pure components (water, vegetation and soil) in an area represented by a pixel is considered the weight. In which the percentage of vegetation component in a pixel is actually the vegetation cover of this pixel.

Then the relationship between vegetation cover and NDVI is a linear regression:

NDVI= f* $NDVI_v$+ (1-f)* $NDVI_s$ (3)

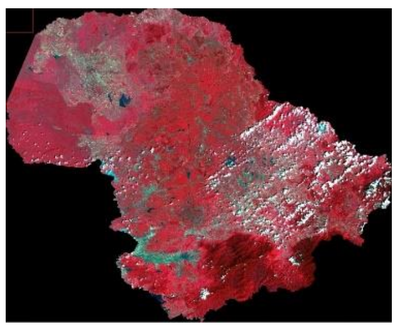
Vegetation cover is determined by following formula:

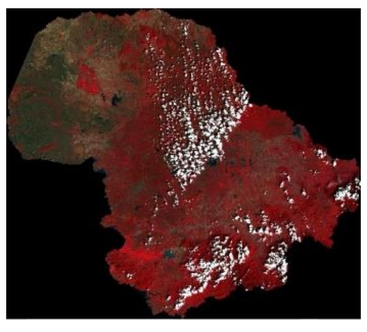
$$f = \frac{NDVI - NDVI_s}{NDVI_v - NDVI_s} \quad (4);$$

in which: f is the fraction of vegetation in a mixed pixel, thereby is vegetation cover;
NDVI is NDVI of mixed pixel and defined by formula (5);
$NDVI_s$ is NDVI of bare soil;
$NDVI_v$ is NDVI of dense vegetation.

$$NDVI = \frac{P_{NIR} - P_{RED}}{P_{NIR} + P_{RED}} \quad (5);$$

in which, P_{NIR} , P_{RED} is reflection value at near-infrared light and visible red light.





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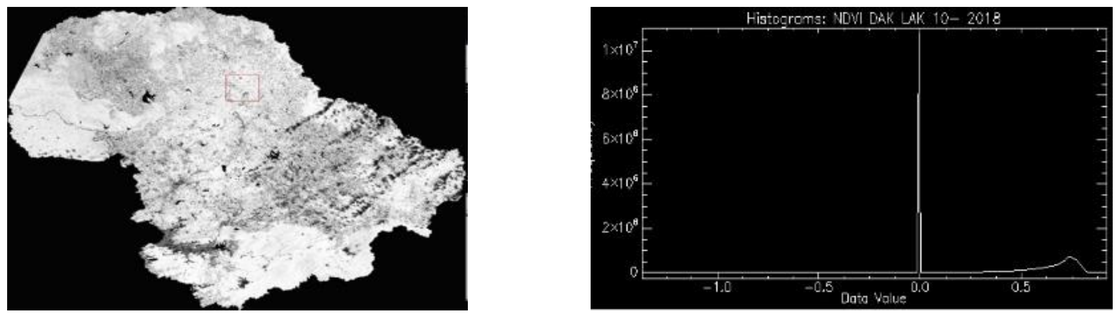
Landsat 8 OLI images

Determining $NDVI_v$ and $NDVI_s$ is difficult, and there are many uncertainties as they are influenced by soil types, different types of vegetation, chlorophyll content and other factors. In this study, $NDVI_v$ and $NDVI_s$ were determined from Sobrino's research [7, 8]. If NDVI > 0.5, then that pixel is considered to be completely covered by vegetation (plant object), vegetation cover is 1. If NDVI ≤ 0.2, then that pixel is considered to be completely covered by soil (subject of barren land), vegetation cover is 0. If 0.2 < NDVI ≤ 0.5, the vegetation cover is determined according to formula (1).

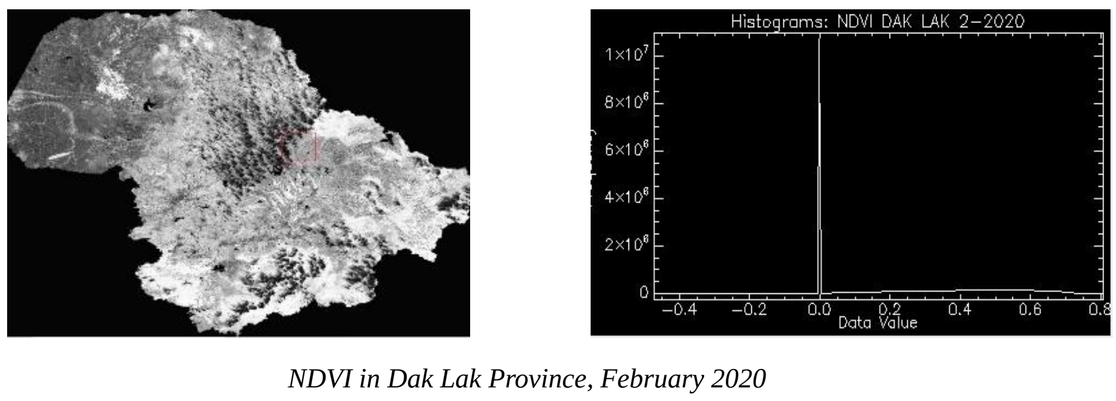
Results and discussion

1. NDVI

NDVI of Dak Lak Province was calculated from Landsat 8 OLI images taken at 2 occasions: October 8, 2018 and February 16, 2020. The result is shown at Fig. 3.1 and 3.2. NDVI distribution and result are illustrated in Table 3.1 and 3.2 while Fig. 3.3 and 3.4 show the histogram of value distribution.



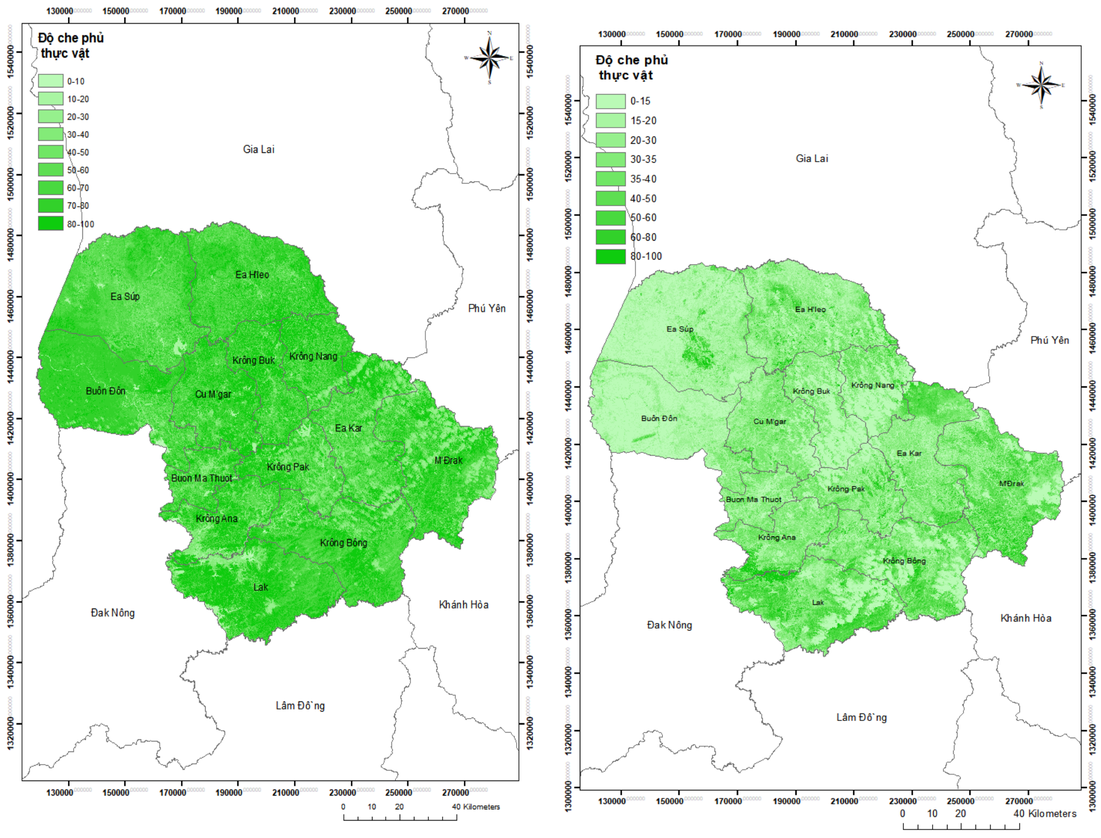
NDVI in Dak Lak Province, February 2018



NDVI in Dak Lak Province, February 2020

2. Fractional vegetation cover (FVC)

Research results show that in the rainy season (October-2018), land with less than 10% plant cover (FVC) accounting for at least 39.90 km² accounting for 0.30% of the area, sparse FVC (10 - 40%) accounted for 9.22%. Area with medium coverage (60 - 80%) accounts for 6,700.39 km² (48%) while area with dense coverage (80 - 90%) occupies an area of 2,310.12 (17.56%) (Fig. 5).



During the dry season (February-2020), FVC of less than 10% covers an area of 2,910.83 km², accounting for 22.13%, sparse FVC (15 - 40%) accounts for 60.81% while FVC of less than 50%, reaching 11,924.81 km² (accounting for 90.67%). The area with medium coverage (60 - 80%) has an area of 394.87 km², accounting for 3%. The area with dense coverage (80 - 90%) covers an area of 124.37 km², accounting for 0.95% (Fig. 6).

CONCLUSIONS

The research results show that the FVC of Dak Lak Province in October 2018 is higher than that in February 2020. This can be explained by climate of Dak Lak Province with two different seasons: dry season and rainy season. In the dry season, the leaves in forest fall, resulting in the lower vegetation cover than in the rainy season.

The application of LSMM has processed the mixed pixels from Landsat 8 OLI satellite image quite well in determining the vegetation cover. In addition, the application of satellite images helps to determine the vegetation cover quickly, effectively and especially, more cost-effectively than other methods such as surveying and measuring in the field.