SocioBrains
ISSN 2367-5721, JOURNAL HOMEPAGE: WWW.SOCIOBRAINS.COM
INTERNATIONAL SCIENTIFIC REFEREED ONLINE JOURNAL WITH IMPACT FACTOR
ISSUE 60, AUGUST 2019

VEGETATION COVER DYNAMICS WITHIN THE SATOVCHA MUNICIPALITY (SOUTHWESTERN BULGARIA)

Abstract: Vegetation cover is one of the most important components of natural ecosystems. Its condition is an indicator of whether local ecosystems are developing sustainably or are in a degradation phase. The purpose of the present study is to analyze the vegetation cover dynamics within the small bulgarian municipality of Satovcha (41°72'-41°75' N; 23°89'-24°11' E) in the last one year. For this purpose, based on the Normalized Difference Vegetation Index (NDVI), the territory of the study area is classified according to the quantity of vegetation cover. Four vegetation classes are separated – sparse, light, medium and heavy one. The study include data from 2 satellite imagery obtained from Landsat 8 missions for the period of time July 1, 2018 - July 4, 2019. The results obtained in the course of the study show negative changes in the vegetation cover, which affect the ancient forests located on the territory of the municipality.

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Keywords:
Satovcha, NDVI, vegetation cover, Rhodopes, Landsat 8, monitoring, Bulgaria

INTRODUCTION

Vegetation is one of the landscape elements that has received the most attention in the field of image analysis. Vegetation coverage is important related to their role within maintenance land condition and ecosystem balance. Detection of vegetation dense can be used as a tool for monitoring of ecosystem dynamics. Therefore, there are many parameters that can be used to obtain information on vegetation from remote sensing imagery (Alonso et al., 2017). The analysis of vegetation cover is performed by the use of several vegetation indices. The most commonly applied of them is Normalised Difference Vegetation Index (NDVI). It can be used to objectively measure of important aspects of complex vegetation patterns and to describe the underlying dynamics which give rise to these patterns (Hastings and Sugihara, 1993). NDVI is related to vegetation canopy characteristics such as biomass and percentage of vegetation cover and is representative of plant photosynthetic efficiency, and fluctuations due to changes in meteorological and environmental parameters (Gross, 2005). The areas covered with dense vegetation have high values of this index, while the territories with sparse vegetation are characterized by a low NDVI values. The NDVI images have been proven to be a powerful tool to monitor biomass growth (Minamiguchi, 2005).

The main objective of the present study is to analyze the density of the vegetation cover within the small Rhodopean municipality of Satovcha. For this purpuse four vegetation classes are separated – sparse, light, medium and heavy one.The results obtained give a quantitative assessment of the state of the environment in the region within the last one year.

STUDY AREA, DATA AND METHODS

Study area

The object of present study is the small mountainous municipality of Satovcha (41°72'-41°75' N; 23°89'-24°11' E). Satovcha municipality is located in Southwestern Bulgaria. In administrative terms, it is an integral part of the Blagoevgrad District (Fig.1). It occupies parts of the southwestern slopes of the Dabrash Ridge within the Western Rhodope Mountains. The total area of the municipality is 334, 245 km^2 and the total population is 14 263 people (*NSI, 31.12.2018). It comprises 14 villages, as the administrative center is the village with the same name – Satovcha (approx. 1900 inhabitants). The topography is mountainous (average 1000 m above sea level), with a variation from 407 m to 1731 m (Boichevi skali peak).

The forest fund of the municipality is rich in coniferous (white pine, spruce, etc.) and to a lesser extent of deciduous (beech, oak, birch, etc.) tree species. In the northern part of the municipality is situated the nature reserve "Konski Dol", which preserves ancient beech and spruce forests. The shrub vegetation is represented predominantly by the species *Chamaecytisus absinthioides* and *Genista rumelika* (Geography of Bulgaria, 2002). There are many meadows and pastures on the territory of the study area.

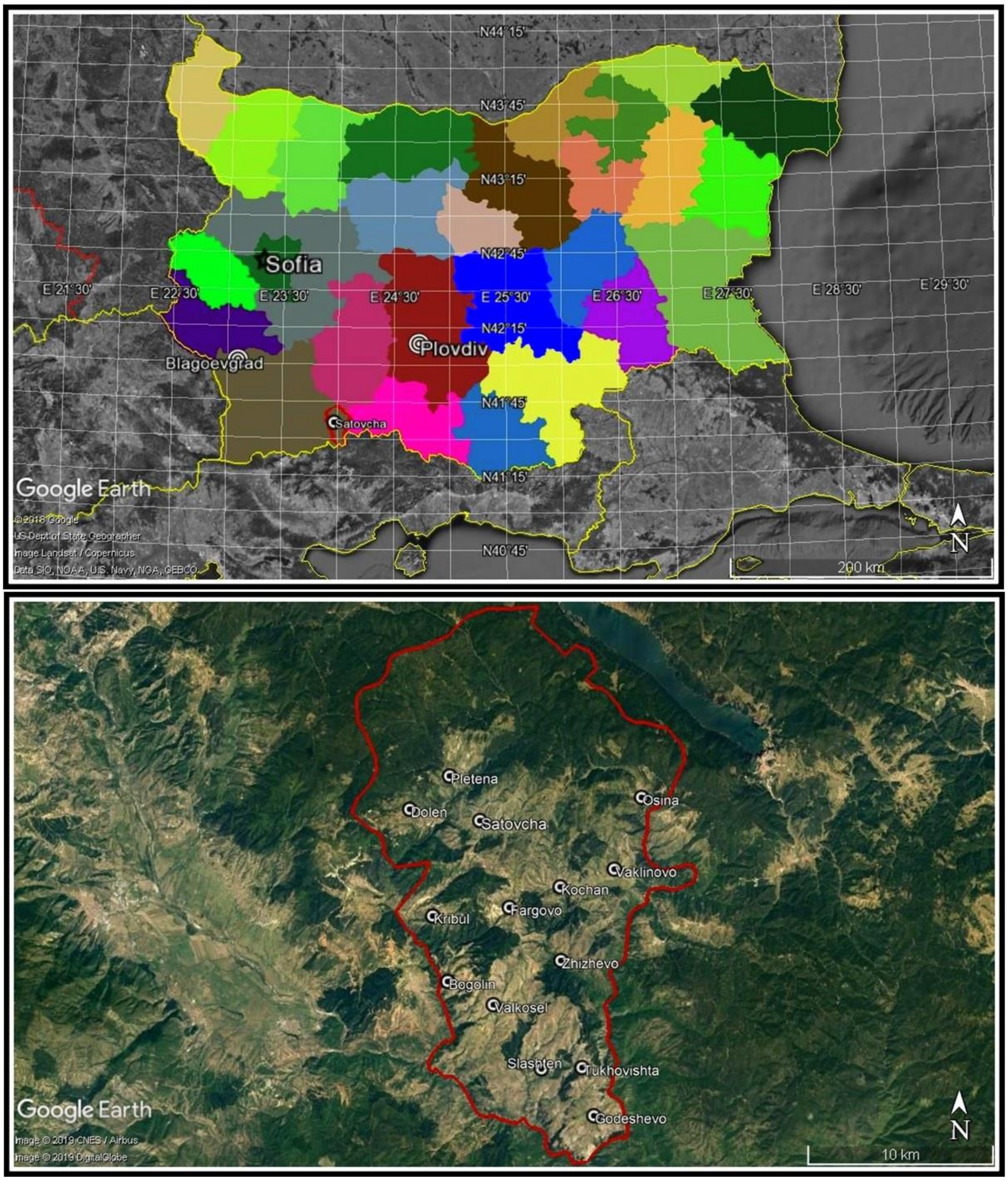

Fig.1 Geographical location of the study area (Mapping tool: GoogleEarthPro)

Normalized Difference Vegetation Index (NDVI)

The Normalized Difference Vegetation Index (NDVI), initially proposed by Rouse et al. (1973), is closely correlated with green biomass and leaf area, and thus is one of the most widely used vegetation indices. The NDVI is calculated as a ratio between the red (R) (wavelength of 0.630 to 0.680 µm) and near infrared (NIR) (wavelength of 0.845 to 0.885 µm) values in traditional fashion. The NDVI can be defined by following formula (Rouse et al., 1973):

$$\mathrm{NDVI} = \frac{\rho_{\mathrm{nir}} - \rho_{\mathrm{r}}}{\rho_{\mathrm{nir}} + \rho_{\mathrm{r}}} \quad (1)$$

where NDVI is Normalized Difference Vegetation Index, nir is the pixel value in the near-infrared band and r the pixel value in the red band. In Landsat 8 imagery data, the NDVI = (Band 5 – Band 4) / (Band 5 + Band 4). The values of this index are within the range (-1,+1) and their positive values are sensitive to the proportion of soil and vegetation in each pixel (Carlson and Ripley, 1997). For the purposes of the study, the values of the NDVI pixels are classified into four vegetation cover classes (Gross, 2005) (Table 1): sparse, light, medium and heavy one.

Table 1 NDVI Land Cover classification using in the study (based on Gross (2005))

Type of Land Cover	NDVI values
Heavy vegetation	0,5<
Medium vegetation	0,3-0,5
Light vegetation	0,2-0,3
Sparse vegetation	0,1-0,2
Bare soil	-0,1-0,1

Data and Software

The imagery data for the present study were acquired from Landsat 8 satellite using the United States Geological Survey (USGS) online interface, Earth Explorer (online available at https://earthexplorer.usgs.gov/). The imageries are generated at 30x30 m spatial resolution on a Universal Transverse Mercator (UTM) mapping grid. The satellite data were acquired as zipped Georeferenced Tagged Image File Format (GeoTIFF) representing systematically terrain corrected data (L1T) for period of time July 1, 2018 - July 4, 2019.

The software used for processing and information extraction of imagery data are ArcGIS 10.1 and SAGA-GIS (Conrad et al., 2015).

RESULTS AND DISCUSSION

The results obtained in the course of the analysis of vegetation cover changes within the Satovcha Municipality are summarized in Table 2 and 3. The main conclusions and interpretations are discussed below.

Table 2 NDVI values for the period of time 01 July 2018- 04 July 2019

	NDVI values (01.07.2018)	NDVI values (04.07.2019)
NDVI min	0,043	0,043
NDVI max	0,637	0,627
NDVI mean	0,340	0,335
Standart Deviation (SD)	0,174	0,171

Table 3 NDVI Land Cover for the period of time 01 July 2018- 04 July 2019

NDVI Land Cover (01.07.2018)	Area (km^2)	Area (ha)	Relative share of total area (%)	NDVI Land Cover (04.07.2019)	Area (km^2)	Area (ha)	Relative share of total area (%)
Bare soil	0,1	10	0,03	**Bare soil**	0,1	10	0,03
Sparse vegetation	1,10	110	0,33	**Sparse vegetation**	1,03	103	0,31
Light vegetation	19,05	1905	5,76	**Light vegetation**	19,49	1948	5,89
Medium vegetation	265,50	26550	80,23	**Medium vegetation**	271,27	27127	81,95
Heavy vegetation	45,18	4518	13,65	**Heavy vegetation**	39,10	3910	11,82

The monitoring of the vegetation cover density for the period of time 01.07.2018-04.07.2019 shows a decrease in the absolute values of the NDVI (Table 2). This is an indicator that the variation in index values has decreased in favor of lower NDVI values.

The consecutive results in the Table 3 clearly show a reduction in the total area of the heavy vegetation class by about 13,5% compared to the previous year. This is a significant reduction on an annual basis and is probably due to all of anthropogenic factors such as intensive logging. Compared to the previous period in a medium vegetation class, an increase in the total area is observed (+2,1%). The total area of sparse vegetation cover decreased by 6,36%, while the total area of light vegetation cover increased by 2,26%.

An interesting picture is obtained in the analysis of the NDVI Land Cover spatial changes. The attached map (Fig.2) shows that the most negative changes in the density of the vegetation cover are observed in the central and eastern parts of the municipality. The most affected areas are located between the villages of Satovcha and Fargovo and between the villages of Kochan and Osina. Positive changes are present mainly in the northwestern part of the municipality- in the areas of Dolen village and "Konski dol" reserve (in the area of which, however, there are also negative changes). Restoration of the vegetation cover there is also to the southeast - in the area eastern of Zhizhevo village. In general, however, negative changes are more pronounced than positive ones (Table 4). Overall, the total area of the positive changes is 11 km^2 (1100 ha), and of the negative ones is 17 km^2 (1700 ha) respectively.

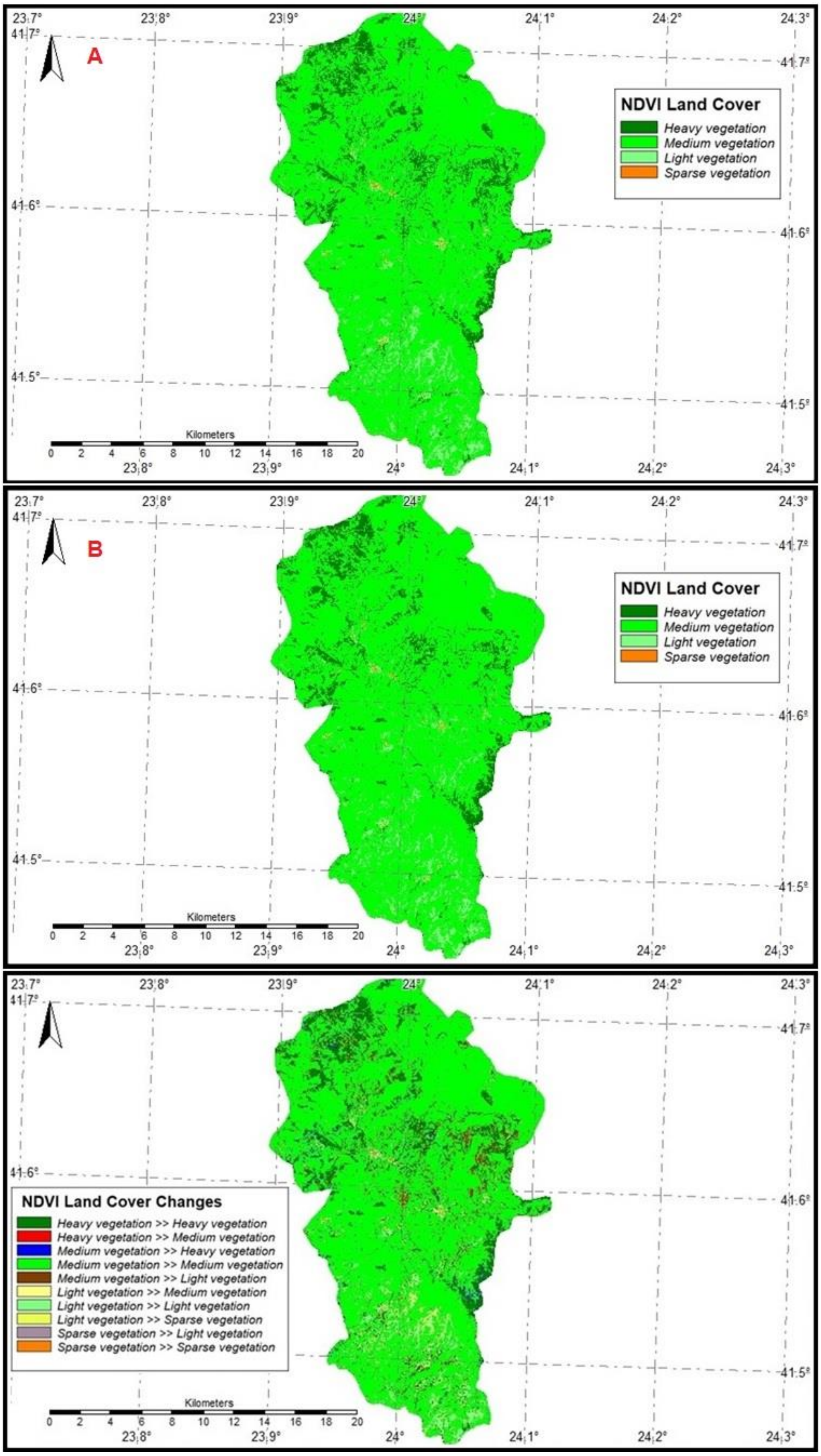

Fig.2 Spatial analysis of the NDVI Land Cover changes between 01 July 2018 (A) and 04 July 2019 (B)

Table 4 NDVI Land Cover types changes for the period of time 01 July 2018- 04 July 2019

NDVI Land Cover transition	Area (km^2)	Area (ha)
Sparse vegetation >> Light vegetation	0,40	40
Light vegetation >> Sparse vegetation	0,26	26
Light vegetation >> Medium vegetation	5,51	551
Medium vegetation >> Light vegetation	5,80	580
Medium vegetation >> Heavy vegetation	5,03	503
Heavy vegetation >> Medium vegetation	11,12	1112

CONCLUSION

In the course of this study, adverse annual changes in the vegetation cover of the municipality of Satovcha were found. Reducing the areas of heavy vegetation cover in favor of the medium vegetation cover is an indicator of negative changes within the local ecosystem. These negative changes primarily affect those areas of the surveyed area occupied by the unique ancient forests. This is not a good prerequisite for the municipality, as the forests located on its territory are its most valuable natural resource. Much of the local population feeds through the wood processing industry, and this fact will further aggravate the poor socio-economic situation in the area. In the medium and long term, this requires a more reasonable attitude towards the environment and a more rigorous observance of the rules and norms laid down in the legislation.

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