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GEMI – A POSSIBLE TOOL FOR IDENTIFICATION OF DISTURBANCES IN CONFIREROUS FORESTS IN PERNIK POVINCE (WESTERN BULGARIA)

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A b s t r a c t

The Global Environmental Monitoring Index (GEMI) represents a vegetation index that allows for making analysis. The index is not that sensitive to atmospheric effects. GEMI has been applied for the investigation of disruptions in the coniferous forests in Pernik Province, which is situated in the western parts of Bulgaria. The basic data comes from Landsat 8 and Corine Land Cover. The results of the study show that the index performs well in the distinguishment of broad-leaved vegetation from the coniferous one. At the same time the index doesn't always provide satisfying results when it comes to deforestation. In conclusion GEMI provides good results, yet it's use should be controlled and supported by other vegetation indices.

Keywords: remote sensing, forestry, deforestation

1. INTRODUCTION

Forests provide a number of essential ecosystem goods and services and their condition should be constantly monitored in order to have their health guaranteed. Coniferous forests in Bulgaria with anthropogenic origin have been experiencing a number of problems in the recent decades, leading to a deterioration of their condition and they are fading in many areas. At the same time planted forests are

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being invaded more easily by non-native species such as *Robinia pseuodacacia, Ailanthus altissima*, etc. Native broad-leaved species are mixing with them too. Human interference is represented also by an array of deforestation activities.
Remote sensing plays a key role in forest monitoring nowadays due to the huge potential of satellite images. They provide data that can be acquired by the use of vegetation indices. The present research deals with the Global Environmental Monitoring Index (GEMI). It is a pilot study for Bulgaria, regarding the application of this index, to the best knowledge of the author. The index makes a calculation from a multiband raster object and produces index values. GEMI resembles NDVI, while being less sensitive to atmospheric effects [9].
The index has been used by a number of authors [1], [2], [3], [4], [5], [6].
The aim of the current study is to identify disturbances in coniferous forests, using GEMI.

2. MATERIALS AND METHODS

The study area that has been chosen for the application of the GEMI is Pernik Province. It is situated in the western parts of Bulgaria, neighboring the Republic of Serbia to the west, Kyustendil Province to the south, Sofia Province and Sofia City Province to the north and east. Climate is temperate or mesothermal Cfb according to Köppen classification.
The GEMI has been calculated, basing on the use of a Landsat 8 data from 29.09.2019. The latter has been downloaded from USGS EarthExplorer [8]. In order to calculate the GEMI, first "eta" should be summed up, following the following formula:

$$eta = (2 * (NIR^2 - Red^2) + 1.5 * NIR + 0.5 * Red) / (NIR + Red + 0.5)$$

When "eta" has been calculated, then the index is next on the line:

$$GEMI = eta * (1-0.25 * eta) – ((Red – 0.125) / (1 – Red))$$

CORINE Land Cover data from 2018 has also been incorporated in the research [7]. It has been used to export data, regarding the coniferous forests in Pernik Province.

3. RESULTS

The results, concerning the possibility of the application of GEMI as a tool for identification of changes in coniferous forests, are providing interesting data. They are following some of the patterns of other studies [2], [4], [5]. All coniferous

forests in Pernik Province cover 117.75 km^2, following CLC 2018 data [7] (Fig. 1). They are fragmented and unequally dispersed throughout the territory. They are mainly of anthropogenic origin and they have been planted mainly for erosion regulation.

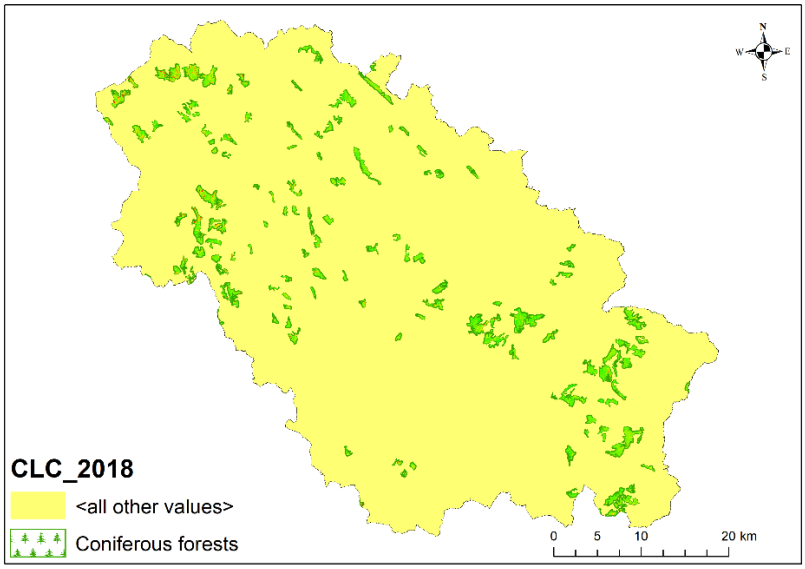

Fig. 1. The coniferous forests in Pernik Province (source CLC 2018[7])

Figure 2 displays data about the results, following the calculation of the GEMI. These forests possess mainly high values, with a few spots i n the polygons to the northwest and west where lower values can be observed.

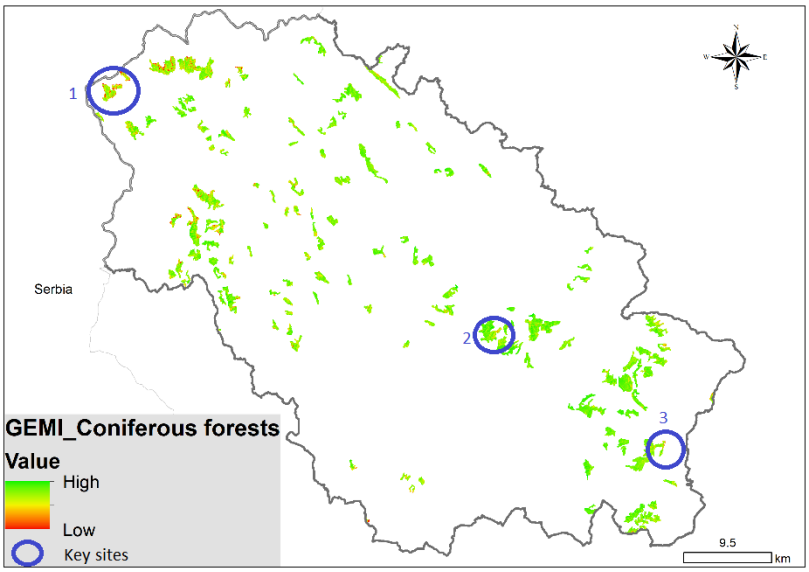

Fig. 2. GEMI for the coniferous forests in Pernik Province

Several patterns have been observed when a more detailed investigation of the map has been undertaken. These patterns have been summarized with the use of three key sites (Fig. 2, Fig. 3, Fig. 4 and Fig. 5) and each one has revealed strengths and weaknesses of the index. Figure 3 presents data about key site number 1. GEMI is presented to the left and a base map of the same site, but without the index, can be seen to the right. Spots with green are displaying parts of the forest that contain undisturbed coniferous species. Areas, shown in yellow, orange and red correspond with sections that include broad-leaved species. CLC database is known to be generalized so, a possible application of the GEMI is to find sections with species, different from coniferous ones (Strength). A more detailed look at key site 1 reveals that there are sections with roads and deforestation patterns (shrublands, pastures and meadows), which are not traceable to the best extend with the index (Weakness).

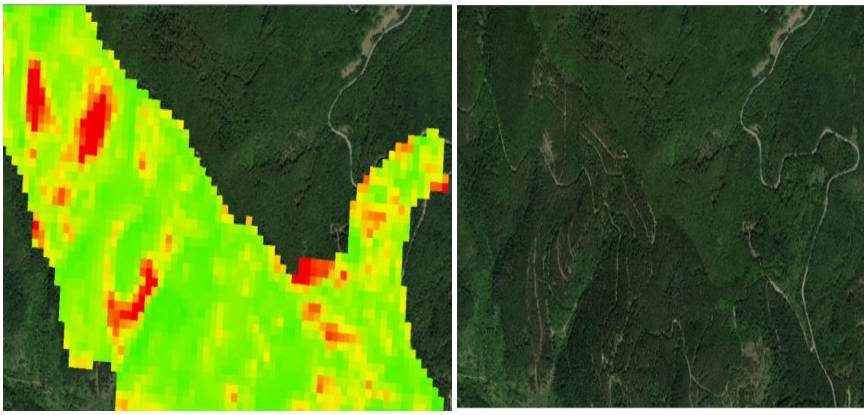

Fig. 3. Key site 1

Figure 4 deals with data, regarding key site 2. The "v-shaped" form presented by the GEMI accounts for a territory that has been turned to other land cover type and now is not a coniferous forest (Strength). Terrain research can provide the best answer of this question, but judging only by this remote sensing image, it can be deducted that this territory has changed into shrubland. At the same time GEMI does not provide enough data for the intensity of this event here (Weakness).

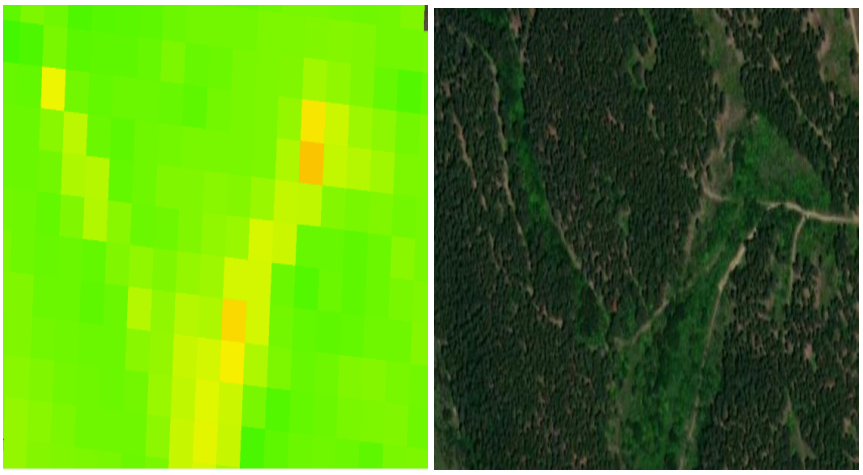

Fig. 4. Key site 2.

The most perplexing of the above-mentioned summarized patterns has been presented in Figure 5. Luckily this occurrence is valid only for a few sections of the coniferous forests in Pernik Province, yet it deserves our attention. Figure 5 represents the most zoomed in image from the three key sites. Several sections are

in the green spectra, meaning high values. However most of the sections are colored with other nuances that mean lower values of the index (orange, yellow and red). Any closer look to the base map image to the right does not necessarily provide sufficient data about the reason for the previously mentioned pattern. A possible interpretation may be that this part of the so-called coniferous forest does not include coniferous species, as it was discussed in the analysis of key site number one. The issue is that the closer look into the image is not fully convincing and only terrain research can approve or disapprove this hypothesis and here arises the important question: Can remote sensing data totally outcompete information, gathered during terrain work? Another explanation may provide insight about a technical problem, but this option may have to be omitted. It is clear that GEMI does not provide enough quality data that can easily be addressed in this case (weakness). The use of another vegetation index or indices may be necessary in the quest to reveal all secrets of this and similar territories.

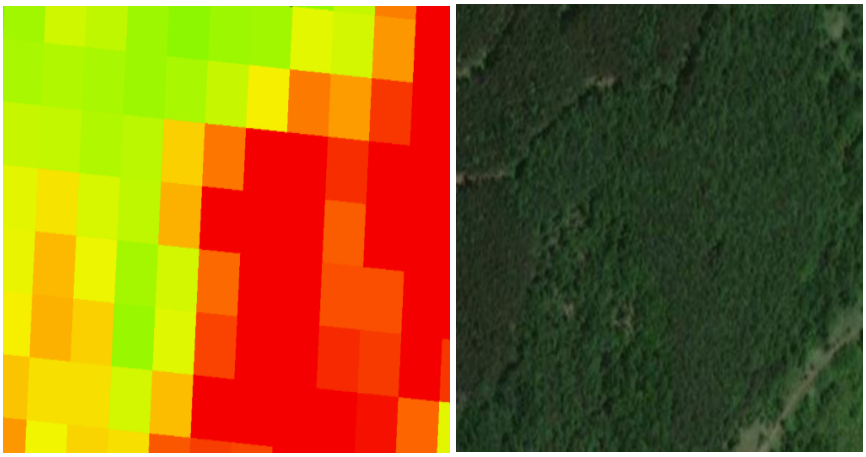

Fig. 5. Key site 3

4. CONCLUSIONS

The present investigation deals with the application of the Global Environmental Monitoring Index (GEMI) and its appropriateness to reveal changes in the state of the coniferous forests of Pernik Province. Landsat 8 and Corine Land Cover 2018 data are at the basis of the research. Their analysis has led to the creation of a GEMI map. Three key sites, summarizing the observed processes, have been chosen. The analysis of the results has given way to the following conclusions, regarding the investigation in Pernik Province:

- GEMI is an option when a researcher needs to differentiate changes in coniferous forests that has led to the appearance of broad-leaved species within them;

- GEMI provides data about a change of the land cover type (a turn into a shrubland, pastures and meadows) in some cases, but in other does not, so this should be carefully observed;
- GEMI may have to be used along with other vegetation indices, as a supporting tool in some cases;
- Vegetation indices, such as GEMI provide sufficient data for analysis, yet it always has to be backed up by terrain research.

REFERENCES

1. Gitelson, A, Kaufman, Y and Merzlyak, M 1996. Use of a Green Channel in Remote Sensing of Global Vegetation from EOS-MODIS. *Remote Sensing of Environment*, **58**, 289-298. http://dx.doi.org/10.1016/S0034-4257(96)00072-7
2. McDonald, A, Gemmell, F, Lewis, P 1998. Investigation of the Utility of Spectral Vegetation Indices for Determining Information on Coniferous Forests. *Remote Sensing of Environment*, **66 (3)**, 250-272. https://doi.org/10.1016/S0034-4257(98)00057-1.
3. Muhd-Ekhzarizal, M et al 2018. Estimation of aboveground biomass in mangrove forests using vegetation indices from SPOT-5 image. *Journal of Tropical Forest Science*, **30 (2)**, 224–33. http://www.jstor.org/stable/26409971.
4. Peddle, D, Brunke, S, Hall, F 2001. A Comparison of Spectral Mixture Analysis and Ten Vegetation Indices for Estimating Boreal Forest Biophysical Information from Airborne Data. *Canadian Journal of Remote Sensing*, **27 (6)**, 627-635. DOI: 10.1080/07038992.2001.10854903
5. Pereira, J 1999. A comparative evaluation of NOAA/AVHRR vegetation indexes for burned surface detection and mapping. *IEEE Transactions on Geoscience and Remote Sensing*, **37 (1)**, 217-226. doi: 10.1109/36.739156.
6. Soltanikazemi, MS, Minaei, H, Shafizadeh-Moghadam, A, Mahdavian, 2022. Field-scale estimation of sugarcane leaf nitrogen content using vegetation indices and spectral bands of Sentinel-2: Application of random forest and support vector regression. *Computers and Electronics in Agriculture*, **200**, 107130. https://doi.org/10.1016/j.compag.2022.107130.
7. CLC 2018 - https://land.copernicus.eu/pan-european/corine-land-cover/clc2018
8. USGS EarthExplorer - https://earthexplorer.usgs.gov/
9. https://pro.arcgis.com/en/pro-app/latest/arcpy/image-analyst/gemi.htm

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