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Vegetation Stress Detection Using GIS Techniques in East of Lake Tana, Ethiopia

Temesgen Gashaw[1*], Bogale Teferi[2], Wondie Mebrat[3]

[1]Center for Environmental Science, College of Natural Sciences, Addis Abeba University, Ethiopia
[2]Department of Geography and Environmental Studies, Dilla University, Ethiopia
[3]Department of Biology, Adigrat University, Ethiopia
**gashaw.temesgene@yahoo.com/gtemesgen114@gmail.com*

Abstract: *The study was conducted to detect vegetation stress changes using GIS techniques in East of Lake Tana, Ethiopia. It was conducted using Landsat 5 TM 1985 and Landsat 7 ETM$^+$ 2011 images. Global positioning system and topographical maps of scale 1:50,000 were used for ground verification. Normalized Difference Vegetation Index was calculated from the two images in order to recognize the vegetation stress changes. For this purpose, ERDAS Imagine 9.1 for calculating NDVI values and ArcGIS 9.3 for NDVI mapping was used. The result showed that there has been a reduction of vegetation biomass coverage from 1985 to 2011. Taking the maximum value, it decreases from 0.96 in 1985 to 0.68 in 2011. To this effect, the standard deviation value decreases in 2011 image as compared to 1985. Overall, there was an increase in the size of land cover class classified as severely stressed area.*

Keywords: *Vegetation stress detection, GIS, NDVI*

1. INTRODUCTION

Geographic information system (GIS) is a computer based system that deals with spatial data collection, storage, management, retrieval, conversion/changing, analysis, modeling, and display information about the features that make up the Earth's surface (Abbas et al., 2010). It provided the potential for mapping and monitoring the spatial extent of the built environment and the associated land use/ land cover changes (Tahir et al., 2013). It is also important for land degradation assessment, soil erosion modeling and vegetation change detection to mention few of them (Temesgen et al., 2014b). Similarly, Berhan (2010) acknowledged that geoinformatics tools such as remote sensing and GIS techniques gives a vital contribution in providing information like the spatial extent and patterns of forest cover change over years and this information is decisive for environmental planning, monitoring and management strategies. In fact, there are numerous studies which apply GIS techniques for vegetation change detections (Temesgen et al., 2014a, b; Kiage et al., 2007 and Ochego, 2003). In the same way, this study aims to detect vegetation stress changes using GIS techniques in East of Lake Tana, Ethiopia.

2. MATERIALS AND METHODS

2.1. Study Area

This study was conducted in East of Lake Tana, Ethiopia particularly in Tana Mitsili *Kebele*. It is located between 13° 02' - 13° 14' N and 33° 60' - 35° 10' E, and its topography varies from 1779m to 1846m above sea level. The study area comprises mixed farming zones where crops are grown for food (mainly cereal and pulse crops) and for cash (mainly oil crops), and livestock are kept for complementary purpose, as a means of security during food shortage, and to meet farmers' cash needs. The main soil types of the study area are Nitosols, Vertisols, Gleysols, Luvisols and Cambisols. The dominant vegetation type includes: *Eucalyptus* species, *Croton macrostachyus*, *Cordia africana* and *Ficus vasta*.

2.2. Data Collection

The study was conducted using Landsat 5 TM 1985 and Landsat 7 ETM$^+$ 2011. Global Positioning System (GPS) and topographical maps of scale 1:50,000 were used for ground verification (Table 1).

Table1. *Types of landsat and toposheet used in the study*

Image	Path	Row	Sensor	Resolution or Scale	No of Bands	Date of acquisition	Source
Landsat5	169	52	TM	30 X 30	7	25/12/1985	GLCF
Landsat7	169	52	ETM +	30 X 30	8	12/1/2011	GLCF
Toposheet				1:50,000			EMA

2.3. Methods of Vegetation Stress Detection

In order to recognize the vegetation stress change, TM imagery of 1985 and ETM$^+$ of 2011 were used to calculate Normalized Difference Vegetation Index (NDVI). NDVI is an empirical formula designed to separate green vegetation from other surfaces based on the vegetation reflectance properties of the area. The result of NDVI value will be between -1 and 1. NDVI values greater than zero indicate the presence of vegetation. The higher the vegetation index value, the higher the probability that the corresponding area on the ground has a dense coverage of green vegetation. While, negative values indicate no vegetation and corresponds to water bodies (Kiage et al., 2007). The final NDVI maps were categorized into four parts. That is water bodies (NDVI value < 0), highly stressed (0 < NDVI value ≤ 0.2), moderately stressed (NDVI value 0.2 < NDVI value ≤ 0.4) and low stressed areas (NDVI value > 0.4). To do so, ArcGIS 9.3 for satellite image processing and NDVI mapping and ERDAS Imagine 9.1 for calculating NDVI values were used.

2.4. Data Analysis

By using the NDVI result of 1985 and 2011images vegetation changes were detected which is calculated (Temesgen et al., 2014a) as: NDVI= (NIR-RED)/ (NIR+RED)

Where NIR is the near infrared band response for a given pixel and RED is the red response

3. RESULTS AND DISCUSSION

The statistics and visual observation of the NDVI images over the subsequent periods show those decrements in vegetation biomass. As it can be visually compared the amount of green vegetation is falling. Taking the maximum value, it dramatically decreases from 0.96 in 1985 to 0.68 in 2011. To this effect, the standard deviation value decreases in certain amount in 2011 image as compared to 1985.

Table2. *NDVI statistics of the study area*

Statistics	1985	2011
Minimum	-0.96	-0.47
Maximum	0.96	0.68
Mean	0.128	0.085
Standard Deviation	0.157	0.119

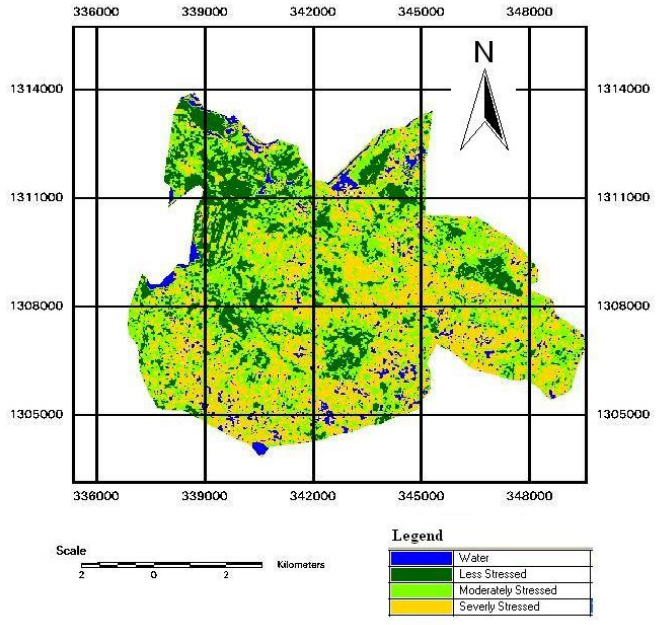

Figure1. *NDVI, 1985*

These showed how vegetation biomass cover has degraded severely (Table 2). Generally, there was an overall increase in the size of land cover class classified as severely stressed area (Figure 1 and 2). The result of this study is similar with a study conducted by Temesgen et al. (2014a) in Dera District, Ethiopia, Temesgen et al. (2014b) in Northern Ethiopia, Berhan (2010) in Dendi district case study, Ethiopia, Kiage et al. (2007) the Lake Baringo catchment, Kenya and Ochego (2003) in Aberdares (Kenya), who reported that the decline of total vegetation biomass cover in the study periods.

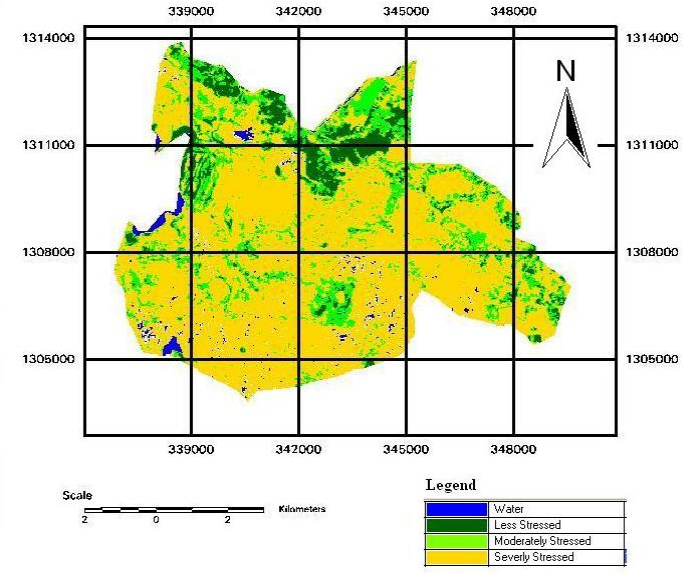

Figure2. *NDVI map, 2011*

4. CONCLUSION

GIS is an important tool to detect vegetation stress changes. Using this tool, the result of this study showed that there was an overall increase in the size of land cover class classified as severely stressed area. Thus, afforestation and reafforestation of trees are recommended.

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