Indo - African Journal for Resource Management and Planning
(An International Peer Reviewed Research Journal)

ISSN 2347-1786.
VOL 1. NO. 01
September 15, 2013

Article info
Received on February 17, 2013
Published on September 17, 2013

India

Vegetation classification and quantification by satellite image processing. A case study of Debub, Eritrea

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Abstract

In this paper vegetation change from November 24, 1984 to November 24, 1999 was calculated in Debub region. Calculations and classifications of the normalized difference vegetation index (NDVI) of aforesaid region have been done by satellite images of TM and ETM + sensors (1984 and 1999) of Landsat programme. As a result a map was developed showing change in vegetation in the same period.

Keywords: GIS, NDVI, Debub.

Abbreviation: GIS = Geographical Information Systems; NDVI = Normalized Difference Vegetation Index.

Introduction

Vegetation estimation has been made, in recent years, by a range of methods, from remote sensed data to field measurements, while GIS-based modelling approaches have been used with auxiliary data for spatially vegetation estimation (Wulder et al., 2008).

Remote sensed imagery with moderate spatial resolution as Landsat TM (28.5 x 28.5m), IRS 1C - LISS III (23.5 x 23.5m) are commonly used sources of remotely sensed imagery (e.g. Muukkonen *et al* 2007; Zhenga *et al* 2007; Meng *et al* 2007; Kumar *et al* 2010).

The spectral information recorded by remote sensing has a good correlation with vegetation biomass (Zhenga *et al* 2007; Meng *et al* 2007) reason why the recent estimation processes are applying, increasingly, methodologies where vegetation indices are used as an effective tool.

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to analyze remote sensing measurements and assess whether the target being observed contains live green vegetation or not. NDVI has found a wide application in vegetative studies as it has been used to estimate crop yields, pasture performance, and rangeland carrying capacities among others. It is often directly related to other ground parameters such as percent of ground cover, photosynthetic activity of the plant, surface water, leaf area index and the amount of biomass. NDVI was first used in 1973 by Rouse et al (Rouse *et al* 1973) from the Remote Sensing Centre of Texas A&M University.

Generally, healthy vegetation will absorb most of the visible light that falls on it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. Bare soils on the other hand reflect moderately in both the red and infrared portion of the electromagnetic spectrum (Holme *et al* 1987).

Since we know the behavior of plants across the electromagnetic spectrum, we can derive NDVI information by focusing on the satellite bands that are most sensitive to vegetation information (near-infrared and red). The bigger the difference therefore between the near-infrared and the red reflectance, the more vegetation there has to be.

Site description

Debub is located between 14°25'7.536” to 15°16'43.667" of northern latitude and 38°15'27.597" to 39°39'27.62" of eastern longitude.

This state is a part of south region of Eritrea and bounded to the south by the northern border of Ethiopia. Most of the part lies in central highland region of Eritrea, which is relatively moist to other five states of the nation.Figure1

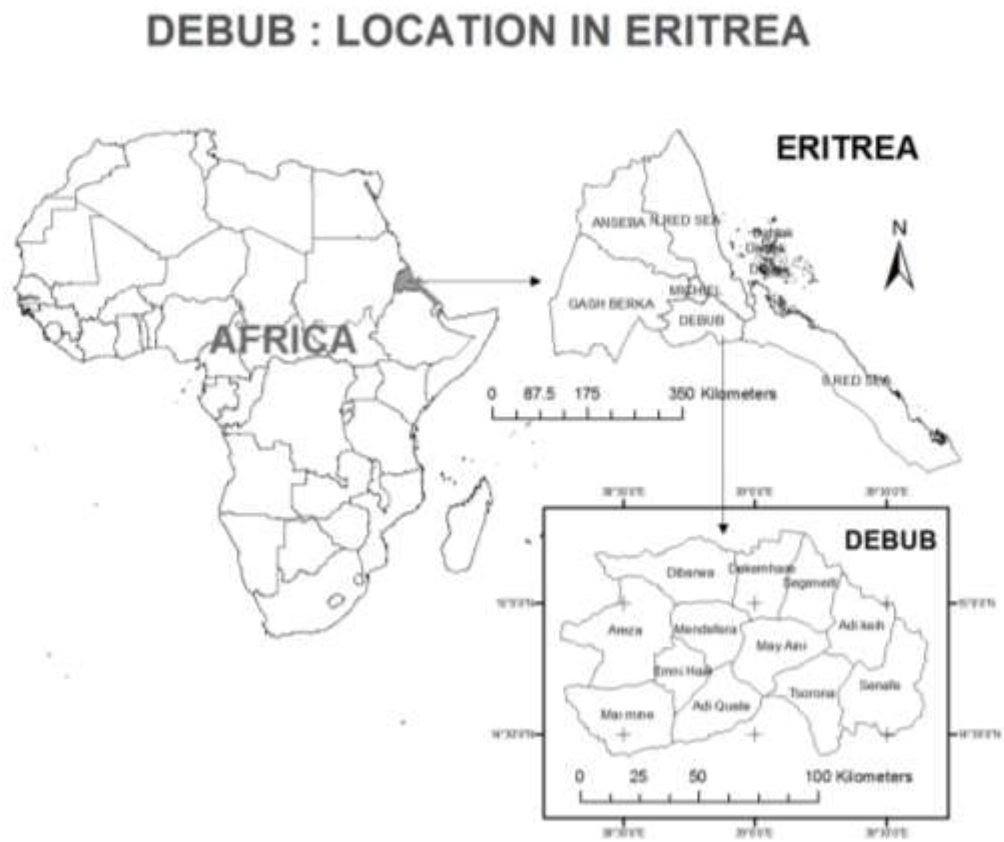


Figure 1

Materials and methods

Material

This research was carried out using software Erdas 11 & ArcGis 9.3; a vector based Geographical Information System. Erdas 11 was used for image preprocessing moreover ArcGis 9.3 was used for classification and mapping.

Methodology

Data collection

To derive this research Landsat TM image from 24 November 1984 & Landsat ETM+ image from 24 November 1999 were used.

Image processing and classification

Atmospheric calibration

It is important to remove atmospheric effects, especially for scene matching and change detection analysis. The dark pixel subtraction technique was used for the same, it assumes that the pixel of lowest DN in each band should really be zero, and hence its radiometric value (DN) is the result of atmosphere-induced additive errors (**Crane, 1971**; **Chavez et al, 1977**).

Measurement of vegetation distribution

NDVI index has been applied for measurement of vegetation distribution and density in this research.

The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it by the sum of near-infrared and red bands (Eq. 1):

NDVI= (NIR-RED) / (NIR+RED)………….. (Eq. 1)

Where

NIR is the 3rd band image
RED is the 4th band image

Calculations of NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1); however, no green leaves gives a value close to zero. A zero means no vegetation and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves. (Frantzova, 2010). Study area's results are converted into 0-255 for an easier calculation and classifications of the regions. Considering this value system, the calculated and normalized NDVI index for each pixel of the satellite images of regions were categorized in four groups which indicate the different ranges of the vegetation density (Table 1).

Table 1. Numerical range of NDVI

Numerical range of NDVI		**Vegetation Density**
Old values	**New values**	
-1 to - 0.242092	0-100	No Vegetation
- 0.242092 to 0.089243	100-150	Low to Medium
0.089243 to 0.486845	150-210	Medium to High
0.486845 to 1	210-255	Too High

For change detection each pixel value of the image showing NDVI with ETM+ sensor was subtracted from the image showing NDVI with TM sensor. Figure 4

Vegetation change was also calculated at district level by averaging positive and negative values of the source image of figure 4 zonal statistics tool. As a result values ranged from 7.6 to 13.17. These values were grouped in three categories as 7.6 to 8.59, 8.59 to 10.99 & 10.99 to 13.17 for respectively low, medium & high change. Finally thematic map was prepared to show vegetation change at district level.

Results and discussion

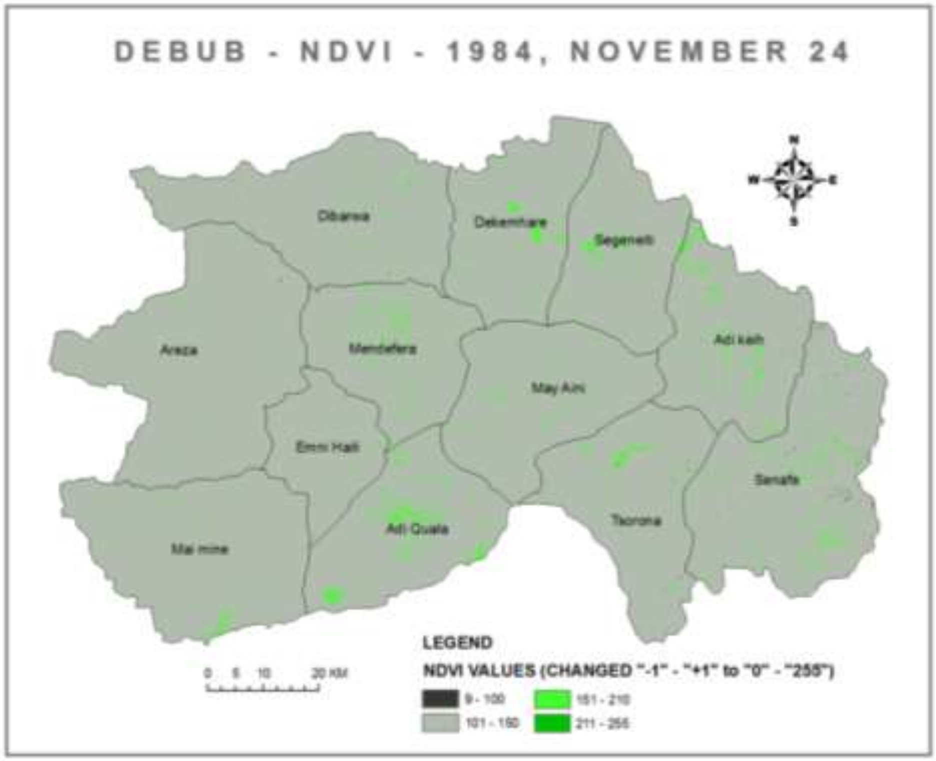


Figure 2

The areal distribution of vegetation classes in Debub during 1984, November 24 and 1999, November 24 area shown in figure 2 & 3.
Figure 2, which is developed from the images of TM sensor acquired in 1984, November 24. So, the four classes of NDVI values, which are shown in Figure 2, belong to the same period. First class represents the areas of nil vegetation. Such areas were covering 7.36 km^2 of land in Debub. Most part of this class is shown in District Senafe, western part of Debub (fig.2). Second class represents the areas of low to medium vegetation, 97.843 % of the land in Debub was covered with this class. Third class represents the areas of medium to high vegetation, 201.49 km^2 of the land (2.077 %) in Debub was covered with this class. Fourth class represents the areas of high vegetation, which was spread only in 0.37 km^2 (0.004%) of land in Debub. Figure 3, which is developed from the images of ETM+ sensor acquired in 1999, November 24. So, the classes of NDVI values, which are exposed in Figure 3, belong to the same period. Table 2 showing the change of NDVI classes in fifteen years of spell discloses the fact that First class got shrink to 2.7933 km^2.
Second class was also compressed to 7663.53km^2; it is the major and positive change, which Debub experienced. Consequently third class got expended to 2033.41 km^2 (20.958 %) earlier it was only 2.077%. Fourth class was also somewhat improved from 0.004% to 0.026 %.(Table 2)

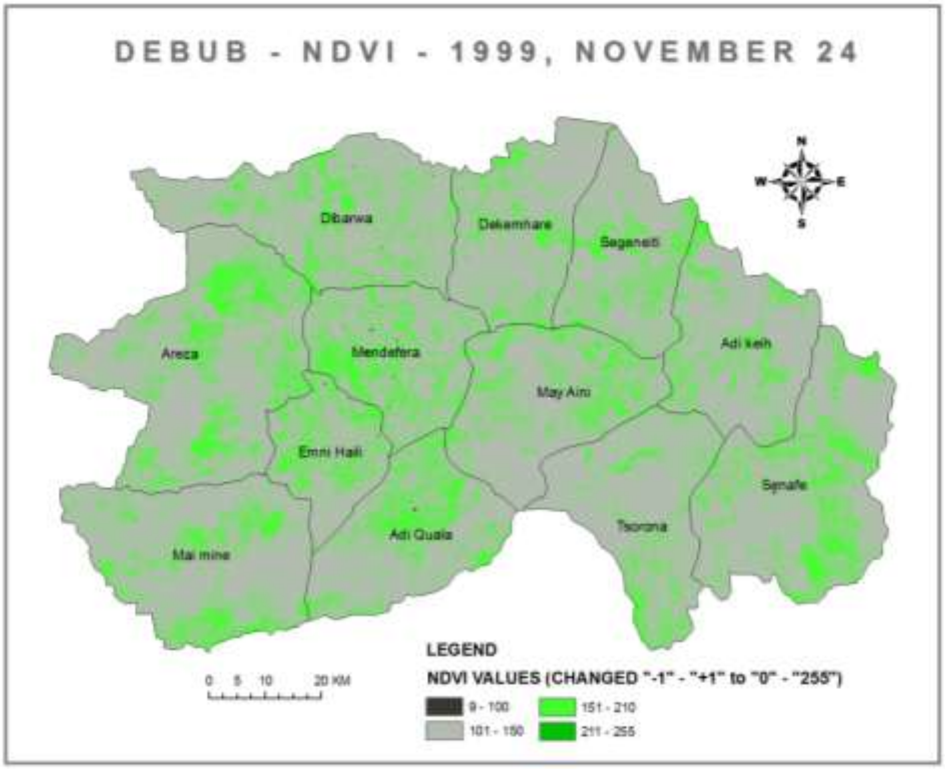


Figure 3

Table 2 shows areal distribution and change of NDVI classes from 1984, November 24 to 1999, November 1999 as following:

Table 2. Areal distribution and change of NDVI Classes in Debub

NDVI Classes	TM SENSOR 1984, November 24			ETM+ SENSOR 1999, November 24			Change
	Pixel count	Area – km^2	% of total area	Pixel count	Area – km^2	% of total area	
0-100	9060	7.36	0.076	3439	2.79333	0.029	-0.047
101-150	11687314	9493.02	97.843	9434939	7663.53	78.987	-18.856
151-210	248070	201.49	2.077	2503431	2033.41	20.958	18.881
211-255	459	0.37	0.004	3094	2.5131	0.026	0.022
Total	11944903	9702.25	100	11944903	9702.25	100	

Figure 4 is showing the NDVI change, shades of red color are showing negative change, while shades of green color are exposing the positive change. More green color highlights the positive change. In Debub as a whole 18.856 percent of area changed from second class to third class or from "low to medium" to "medium to high" type of vegetation.

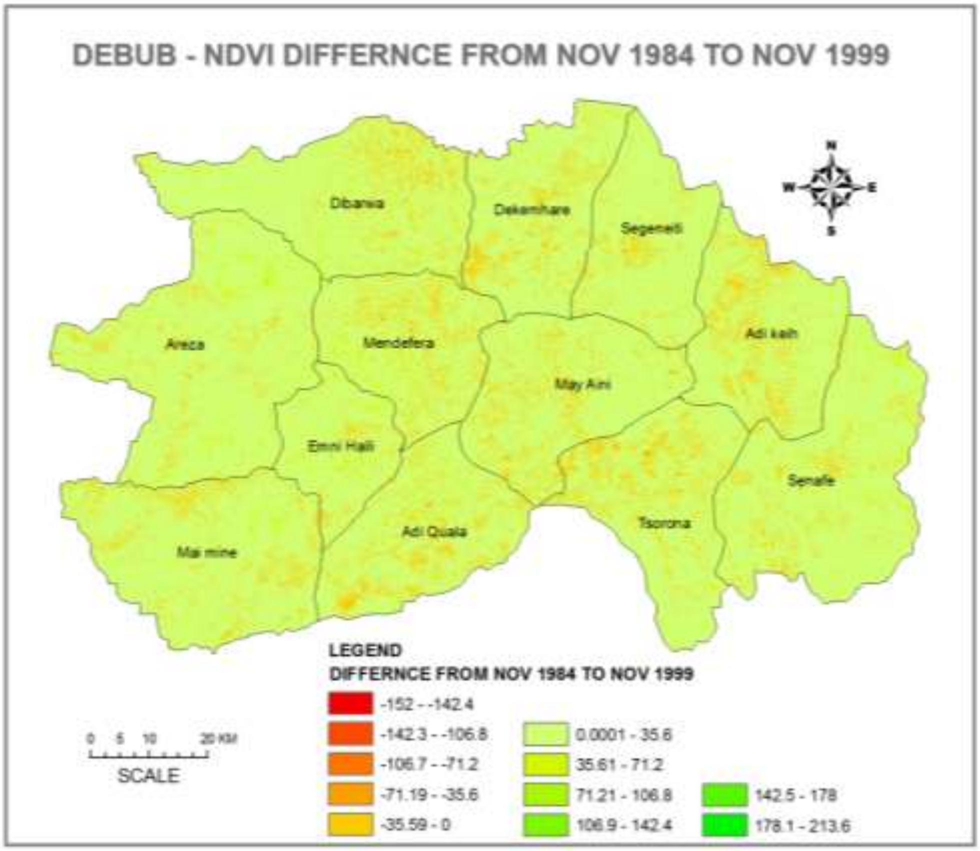
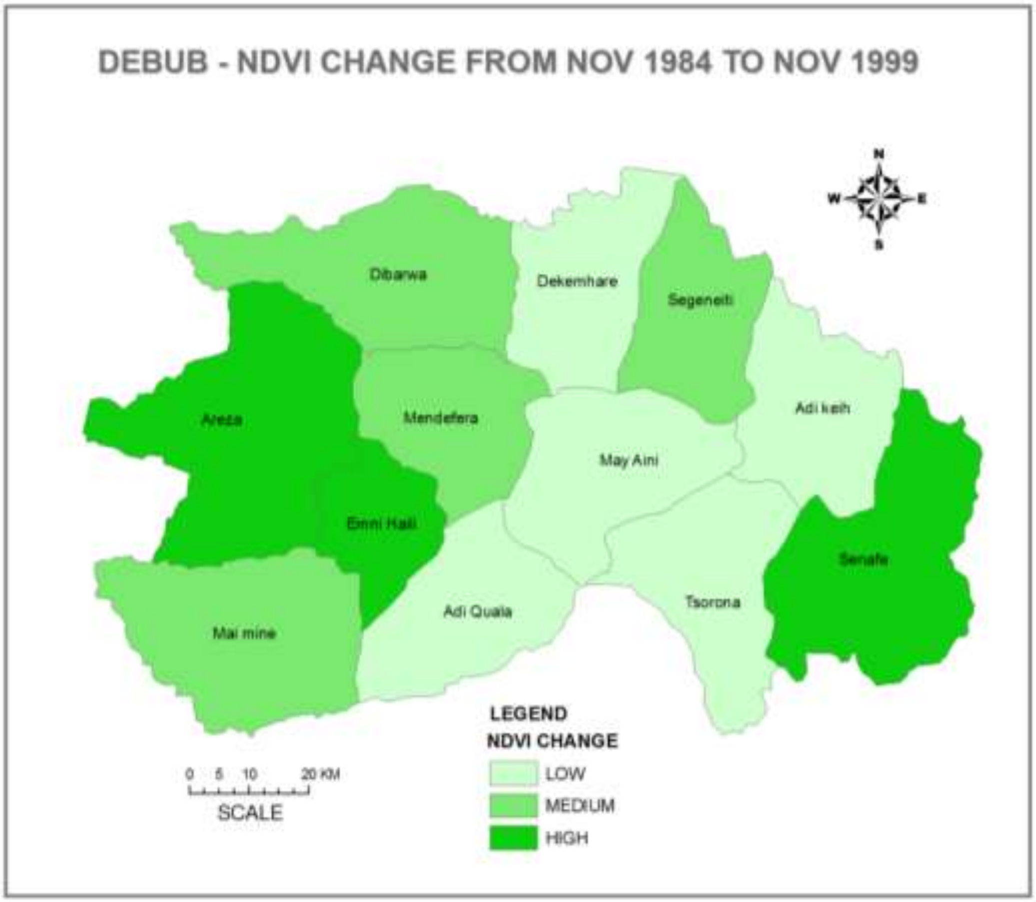


Figure 4

Figure 5 is displaying district wise vegetation change; there are three groups of the levels of NDVI change as low, medium and high. Three districts named as Areza, EmniHaili and Senafe are in high category. This is because during 1984 as per the images of TM sensor these districts were accounted under worst category of vegetation cover, so from the view point of change they are on the top.

Since the images of both the sensor's belong to the month of November and this is the period of winter crops as wheat, sorghum and some pulses, so NDVI change may be because of change in cultivable land.



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