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Appling Change Vector Analysis to Detect Vegetation Regeneration and Deforestation in Edd Al Fursan locality, South Darfur, Sudan

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1. Introduction

Agricultural expansion (that is, the conversion of forest land to large scale cultivated area), and wood exploitation have been identified as the most dominant causes of deforestation in Southern Darfur State. This is due to rapid increase in human population since the drought of 1985, as the result of natural increase and immigration from North Darfur and Chad (Fuller, 1985). For instance, South Darfur State is recorded to have population growth rate of (4.15 %) per year, the estimated number for year 2008 is about 4.093,000 persons (Darfur Relief and Documentation Centre, 2010).

The analysis of vegetation is one of the most fundamental applications of remotely sensed satellite imagery (Lawrence and Ripple, 1999). Monitoring change in vegetation between two time periods can assess the vegetation growth and regrowth following a cataclysmic event, or quantify forest loss caused by deforestation and timber harvesting (Lawrence and Ripple, 1999). Classifying these types of changes can be effectively performed using Change Vector Analysis.

The main aim of this paper is to assess the dynamic of the change of the natural vegetation cover during the period 1972- 2008 in Edd Al Furssan locality by applying Change Vector Analysis (CVA) technique.

2. Material and Methods

2.1. Research site

Edd AL Furssan locality is located in the south-western part of south Darfur State, Sudan. It covers an area between longitude 24° 00′ to 24° 30′ E and latitude 11 ° 30′ to 12° 00′ N. of approximately 11,000 km² (Fig. 1). The climate consists of a rainy season lasting approximately from June to September, and a dry season covering the rest of the year. 90 % of the annual rainfall falls during the period of June to September, while only 10% falls in May and October.

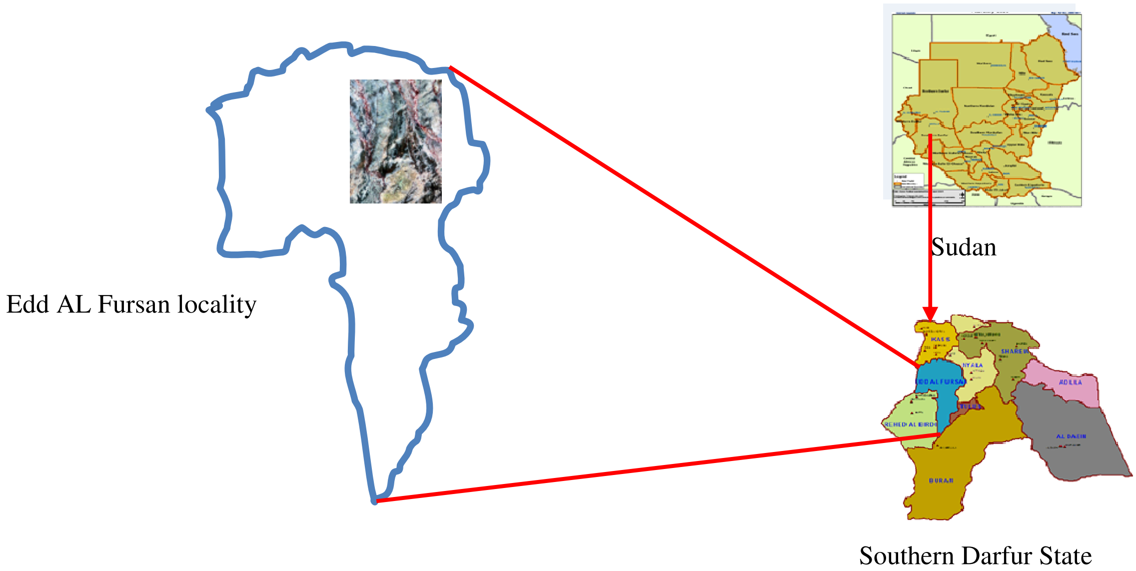

Figure 1: Study area

2.2. Satellite data

Multi-spectral cloud-free Landsat MSS (Dec. 1972), TM (Nov.1984 and 1989), ETM Nov. 1999 and Aster 2008 imagery, acquired from the United Stat Geology Survey (USGS), has been utilized for analyzing an area covering Edd Al Fursan locality. A subscene covering approximately 1.207.553 square km was extracted as area of interest.

2.3. Image pre-processing

For the geometric correction, the 2008 scene was co-registered to the Landsat scene, which had been acquired in UTM projection and used as the base image. Using the Nearest Neighbor method the images were re-sampled to a pixel size of 30 m × 30 m. Radiometric correction was necessary to reduce or eliminate differences due to atmospheric or sensor variation between the two dates, the atmospheric correction was conducted using ENVI software, Dark Object Subtraction (DOS) method.

2.4. Change vector analysis calculation

Change vector analysis has been variously applied and advanced since its application by Malila (1980) to characterize change magnitude and direction in spectral space from a first to a second date. Change direction is measured as the angle of the change vector from a pixel measurement at time 1 to the corresponding pixel measurement at time 2 (Figure 2). Angles measured between 90° and 180° indicate an increase in greenness and a decrease in brightness. Lorena et al. (2002) designated this change direction to represent regeneration of vegetation. Angles measured between 270° and 360° indicate a decrease in greenness and an increase in brightness. They designated this change direction to represent deforestation. Angles measured between 0° and 90° and 180° and 270° indicate either increases or decreases in both bands of greenness and brightness. They designated this change to persistence, which is representative of neither an increase nor decrease in vegetation upon the landscape.

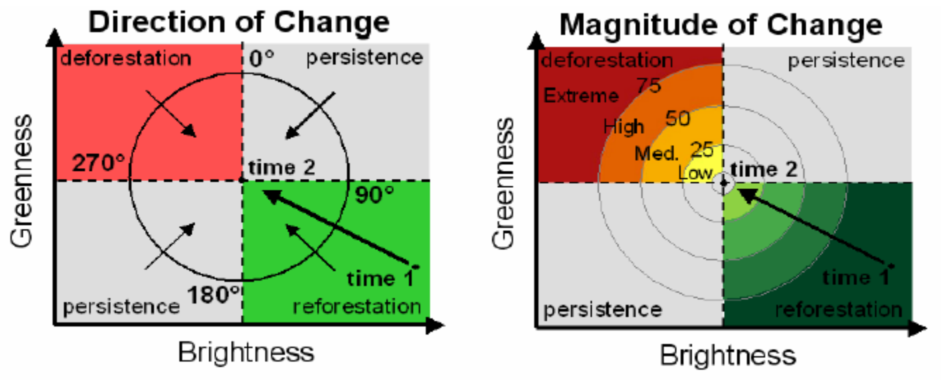

Figure 2: The process for detecting the direction of change (a) and the magnitude of change (b) within change vector analysis.
Source: (Kuzera et al, 2005)

For this study the change vector analysis technique was performed using a designed tool imported to IDL ENVI. The first step of the CVA method was to apply a tasseled cap transformation which generates components of greenness and brightness and defines the new coordinate system on which the CVA is based (Table 1). Thus, as a pixel undergoes change during a certain time-interval, its position in the defined coordinate system will change. (Kauth & Thomas, 1976).

With this method, two images are computed: one image for the vector intensity and another for the vector direction.

Table 1. Possible change direction classes from brightness and greenness component and related types of change

Classes	Brightness	Greenness
Bare soil expansion	+	+
Deforestation	+	−
Persistence	+ −	+ −
Reforestation	−	+

3. Results and Discussion

According to the field survey, visual comparison of the original images and author’s background knowledge, maximum likelihood classification has been carried out to show a quantitative analysis for the above mentioned classes (Figure 3 & 4).

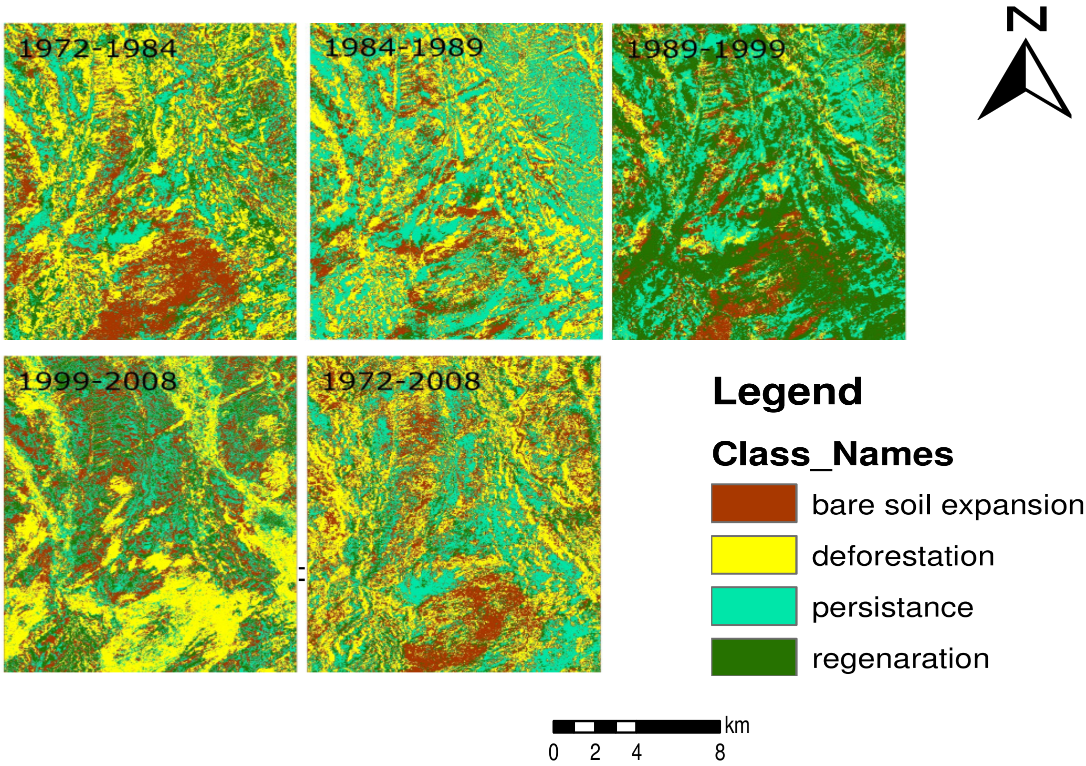

Figure 3: Maximum likelihood classification showing CVA classes during 1972- 2008

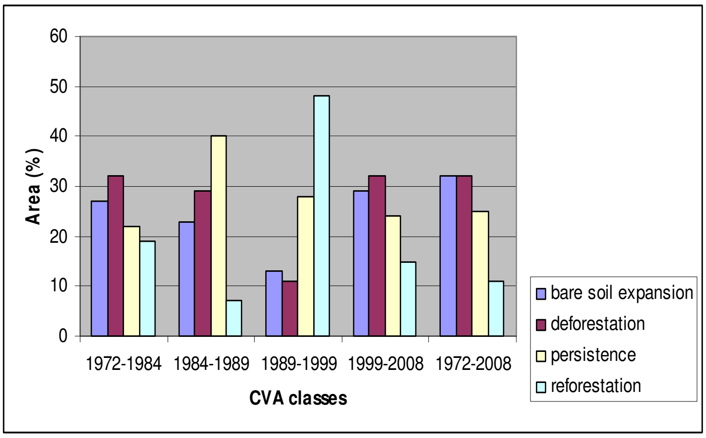

Figure 4: Area percentage of the CVA classes during the period 1972- 2008

3.1. Interpretation of the results

The change image of 1972 and 1984 shows an intensive and dynamic rate of deforestation and bare soil expansion which constitute about 27 % and 32 % respectively, this period is characterized by drought condition that let many farmers to encroach the forest either for agricultural purpose or selling the harvested wood at local market as fire wood and/or building materials. The period between 1984-1989 was an extension of drought conditions in the area, the rate of deforestation was remain high representing 29 %, while bare land decreased to 23 % compared to the above period; this is because the persistence class remain high about (40 %). In contrast, the years 1989-1999 were characterized by high rate of reforestation which represents 48 %; this indicates that the environment recovered from drought. As reported by the State Ministry of Agriculture together with respondents in the area there was good rainfall during this period. The change image of 1999 and 2008 shows rapid increase in deforestation rate of 32 % combined with bare soil expansion of 29 %, this due to rapid increase in human and animal population as well as environmental crises, conflict and war in recent years. Moreover, during 1972-2008 there was intensive change in land use resulting from high clearance of forest by local people and overgrazing. The rate of deforestation as well as the bare soil expansion represents the same percent (32 %). This period was characterized by agricultural expansion, which most of the forest land were cleared and converted to agricultural land.

Conclusions

Generally one may conclude that CVA technique demonstrate the capacity to detect and stratify different types of changes in terms of vegetation reforestation deforestation and in Southern Darfur.

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