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Impact of climate change on natural resources at EL-Damazine and AT -Tamadon localities Blue Nile state

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This study was carried out to estimate the effect climatic changes of natural vegetation at the Blue Nile state, focusing on two selected localities El-Damazine and Al-Tamadon during the years 2010 - 2011. Remote sensing techniques were used for detection of changes for the years (from 1972 to 2011). The data analysis adopted the descriptive Statistical Package for Social Science (SPSS, version 16). The results obtained showed that fluctuations in rainfall through the years (from 1972 to 2011) depicted a general declining pattern while that of temperature tended to increase. This was confirmed by secondary data obtained from meteorological authority. Higher fluctuations in areas of vegetation cover could be detected for the years (from 1973 to 2011). However, rock and bare lands showed small changes. The increase in vegetation cover in most recent years was correlated with the appearance and disappearance of some species. Deterioration of tree cover was due to indiscriminate cut wood around the city and due the horizontal expansion of mechanized agriculture It could be concluded that rain fed agriculture is inherently sensitive to climate conditions and is one of the most vulnerable sectors to the risks and impact of climate change mainly determined by rainfall and warming of air temperatures. Impact of climate change showed shift in the ecosystem causing appearance and disappearance of plant species, other land types (bare and rock lands) were not significantly affected.

Key words: Natural resources, cove vegetation, climate change, Sudan.

INTRODUCTION

During the last decade there has been a virtual explosion of interest in climate change which is now considered as one of the most serious problems facing most of the regions in Sudan. Moreover, a World Bank (2009) study assessed Sudan to be the country most at risk from the effects of climate change on agriculture. The largest operation of world food programmes is currently involved in providing aid to11 million people over the vast country that encompasses the full range of metrological diversity semi-arid in the north, savannah in the central regions (UN, 2009).

There is ample evidence that climate has recorded a clear change during the last three decades of the twentieth century throughout the country, including areas with the highest rainfall (UN, 2008) including reduction of rainfall (Walsh et al., 1988; Eldredge et al., 1988;), warming of air temperatures (Elagib and Mansell, 2000a; Elagib, 2010a, Elagib and Elhag, 2011), solar dimming, increasing reference evapotranspiration and intensifying aridity (Elagib and Mansell, 2000b). Moreover, Elagib and Mansell (2000a) found that trends of warmth and dryness have a strong association. As many other Sahelian African countries, Sudan is a drought prone area, findings indicate that drought has become more recurrent in recent decades, of which those of the early to mid-1970s, mid-1980s; early 1990s and early 2000s can be noted as common drought years and were among the driest 10 years in the central region of Sudan (Elagib, 2009).

These droughts emphasized the vulnerability of the country to desertification and were socially and economically damaging (Abu Sin, 1986; Walsh et al., 1988; Webb et al., 1991; Olsson, 1993; Larsson, 1996; Ayoub, 1999). The present study aimed to detect climatic changes of natural vegetation at the Blue Nile state.

MATERIAL AND METHODS

Study area

The Blue Nile State is located in central east Sudan (lat 9^o 30' and 12^o 30' N and long 33^o 5' and 35^o 3' E). Focusing on two selected localities (El-Damazine and Al-Tamadon; lat 11^o 55' and 12^o 45'N, Long 33^o 45'E) during the years 2010 - 2011. It lies in the fertile woodland savannah belt of eastern Sudan, and receives significant rainfall through much of the year. It is characterized by vast clay plains, the Ingessana Mountains and the Blue Nile River flowing northwest from the Ethiopian highlands. There is a huge land for cultivation in both mechanized and traditional rain fed sectors, huge potential for fishing grounds, seasonal streams traversing the state fertile land along the banks of Blue Nile River which are suitable for vegetable and fruit production and great number of livestock (Practicalaction, 2007).

Three systems of agriculture can be identified which depends on machinery: mechanized farming is done by large companies and commercial farmers which are very common in the state, Zero-tillage cultivation system, which applies integrated technology packages and mechanization.

Non-mechanized traditional farming system is undertaken by small scale farmers. Farms plots are located around villages at a distance of approximately 1 to 2 km. Although the area used for cropping varies from 3 -5 for each household. Farmers would extend cultivated areas at the expense of rangelands as their lands become more and more degradable.

Remote sensing data

Change detection

Land-cover and land-use change is only one component of global environmental changes currently underway, and is superseded by fossil fuel consumption in regard to atmospheric warming (Steffen *et al*., 2004). Energy use, however, is tightly linked to population and its standards of consumption, and this linkage interacts with socio-political and cultural structures to create pressure on land users to produce more goods and services to meet human demands. The sources of this demand and the location of production to meet it are not necessarily spatially congruent, and large regional differences in access to land and land-based resources exist different method was used to assessment the changing on vegetation cover during the period time.

Data preparation

Remote sensed data produced by Land sat Thematic Map (TM) images and I konos data were visually interpreted using the facilities of image interpretation of the laboratory of the Remote Sensing Authority (RSA). Changes in land cover, land use, drainage system and soil pattern had been detected and different maps were generated.

Statistical analysis

The data analyzes adopted the descriptive Statistical Package for Social Science (SPSS, 1999) (version 14). Regression analysis was used to assess the effects of climatic variations on crop production; paired t-test was used to compare production between the beginning and end of the season (Mead and Curnow, 1983).

RESULTS

Temperature and rainfall

Both temperature (Figure 1) and rainfall (Figure 2) fluctuated through the years 1972 – 2011 at El-Damazine area. There was a general trend for temperature to increase through these years, whereas rainfall showed a declining pattern. The same observations were obtained for the individual month's rainfall through the years 1972 – 2006 (Figure 3). An estimation of mean annual rainfall in mm by locality (for 1971-2000) is adapted from SIFSIA/FAO (2008) it confirms that the southern part of the state receives more rain fall than its northern neighboring localities.

Vegetation

According to Harrison and Jackson (1958), the Blue Nile state area falls, within the broad belt of low rainfall woodland savannah (600-800 mm rainfall) of dominant tree species: *Acacia seyal and Balanites aegyptiaca*. Two main vegetation patterns are observed:

i) In depression areas within the plain the species are *Acacia seyal*, *A. fistula*, *Balanites aegyptiaca* and *Zizyphus spinachristi*. Depression areas near Jebel pediments had in addition *Anogeissus shimperi.* Dominant grasses included *Hyperthermia pseudo cymbaria, Sporobolus helveolus* and *Aristida spp*.

ii) In the flat to rolling plain the main vegetation association consisted of *A. seyal* (dominant) and variable densities of *Balanites aegypiaca* and *A*. *senegal.* In the significantly complex and better drained parts of the clay plain, *Combretumhart manianum*, predominates. Main grasses are *Hyperthermia pseudo cymbaria, Cymbopogon nervatus, Aristida spp* and in slightly low lying areas *Sporobolus helveolus* and the herb "Um

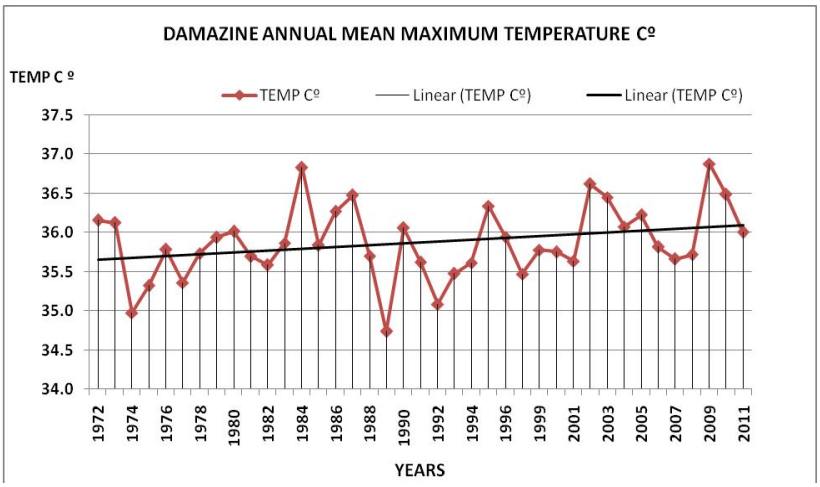

Figure 1. El-Damaanzine annual mean maximum temperatures (^{o}C).

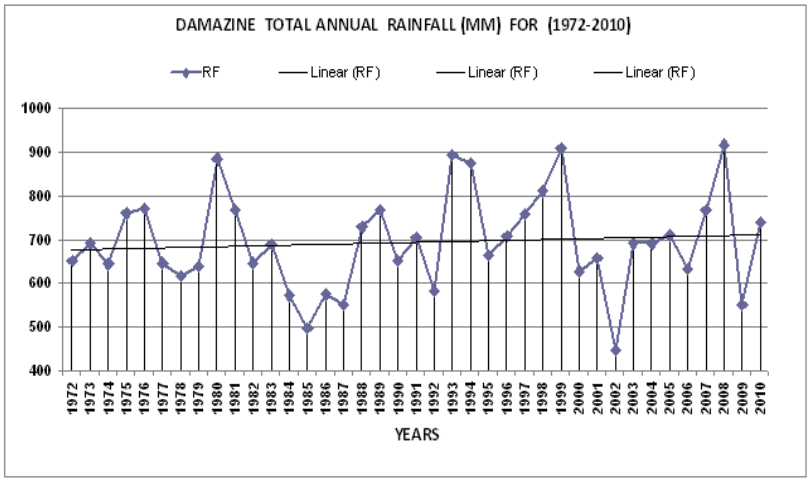

Figure 2. El-Damazine total annual rainfalls (mm) for (1972-2010).

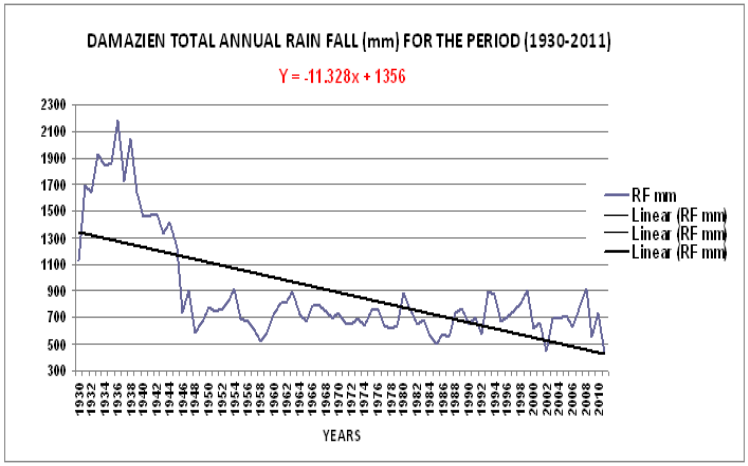

Figure 3. Fluctuation of the rain fall during (1930-2011).

Table 1. Area of different land use classes agriculture vegetation, rock land, bare land, urban areas and water pointes (km²).

Year / Classes	1973	1987	1999	2000	2008	2011	2012
Agriculture	1751.47	6139.34	5078.81	2424.11	7202.18	75722.66	3537.92
Vegetations	8064.17	3781.49	4829.83	2121.65	2671.98	132.48	6407.52
Rock Land	75.65	71.93	73.52	0	87.67	0	35.60
Urban Area	11.87	25.38	40.10	37.85	53.24	71.49	36.47
Bare Area	121.34	0	0	0	0	0.95	0
Water	26.45	26.70	33.63	29.35	31.43	35.21	46.35

Table 2. Percent area of different land use classes agriculture vegetation, rock land, bare land, urban areas and water pointes (km²).

Year / classes	1973	1987	1999	2000	2008	2011	2012
Agriculture	17.64	61.12	50.51	50.51	71.69	86.01	35.16
Vegetations	81.22	37.65	48.03	48.03	26.6	12.63	63.67
Rock Land	0.76	0.72	0.73	0.73	1.87	0.17	0.35
Urban Area	0.12	0.25	0.40	0.40	1.53	0.80	0.36
Water	17.64	61.12	50.51	50.51	71.69	86.01	35.16

Kiweisat". Rich savannah trees and shrubs dominate the vegetation cover of the Blue Nile state and woodland/forests occupy about 26% of the state area, making the state one of the richest forests and grazing lands. The woodlands in the state are characterized by a large presence of *Acacia seyal* and *Balanites aegyptica* tree species.

Impact of climate change on land pattern trend

Detection of land use pattern change during the years 1973 – 2011 for Al-Tadamon and El-dmazine localities showed different changes in areas (km^2/%) sharp increase during years 1987, 2008 and 2011(~61 – 86%) but dropped to a very low level during the year 2012 (~35%). Vegetation cover decreased sharply from 1973 to 1987 (~81 – 37%), maintained similar levels through 1999 – 2011 then increased to ~63% in 2012. Rock and bare lands showed small areas through the years with slight increases. Water areas showed a sharp increase from 1973 to 1987 (~ 17 – 61%), reaching a peak at 2011 (~86%) then declined sharply at 2012 (~ 35%) (Tables 1, Figures 4 and 5).

Impact of climate change on vegetation cover

Fluctuations in rainfall resulted in disappearance of some grass species and appearance of new ones. For tree species most have disappeared and only two new appeared (*CalotropisProcera*, and *Acacia nobica*). For the grasses *Striga hermonthica*, considered as parasitic to sorghum crop (Table 3).

DISCUSSION

The Blue Nile state have witnessed increases in ambient temperature with declining trend in rainfall as were illustrated by Figures 1 and 2 through the past years (1972 - 2011). There was even a sharp decline that could be shown through the years 1932 – 2011 with fluctuations in month to month during the period of the study (2010 – 2011).

Similarly, it was speculated by the fourth assessment report of the IPCC (2007) that there had been a 0.2 to 1^oC increase in the Sahel from 1970 to 2004. They also stated that rainfall levels have declined in Sudan during the past three decades where mean annual rainfall declined by 6.7 % between 1960-1969 and 1970-79 and by 17.7% between 1970-70 as well as between 1980-1986 with year to year fluctuation seemed to have increased, especially in arid and semi-arid zones.

For example, coefficients of variation increased, on average, from 16 %in the 1960s to 21%in the 1970s and 32%in the 1980 in western Sudan (Zaki, 1988). The decrease in rainfall with rising temperature would have negatively impacted ground water availability, vegetation cover and crop production.

Vegetation cover in the study area is subject to continuous changes over space and time in response to environmental factors. There was a sharp decline through the years 1973 to 2010, then there was an increase, this could be related to appearance of new plant species for example the appearance *Acacia nubica* (lao'at) which

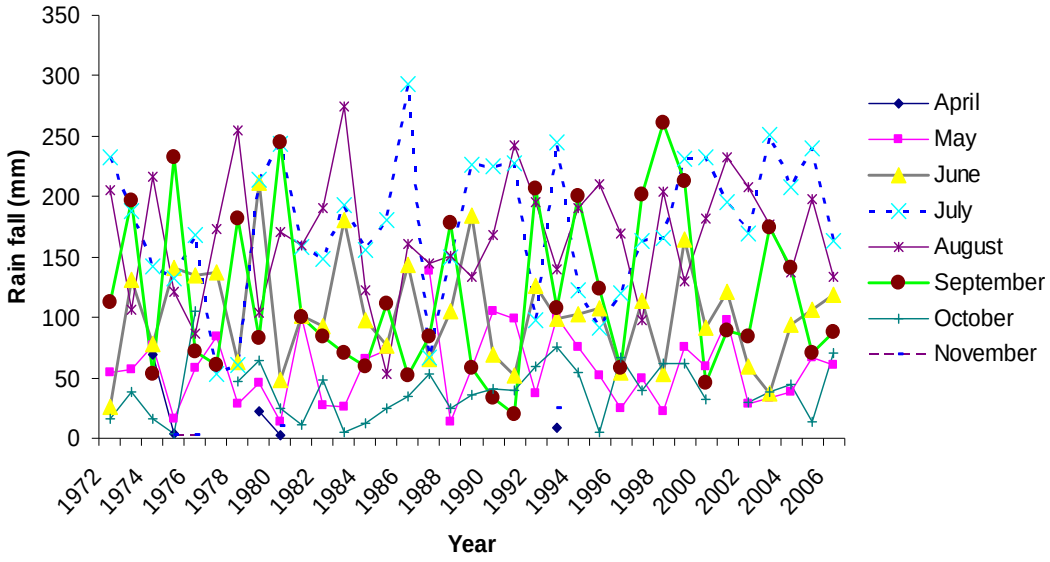

Figure 4. Fluctuations in rainfall during the years 1972-2010 from (April to November in the study area. Source : Sudan meteorological authority 2011.

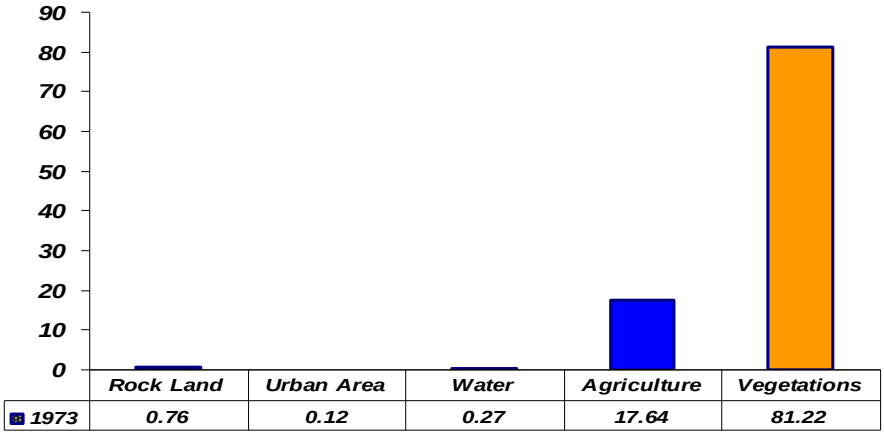

Figure 5. Percentage area of different land classes (agriculture vegetation rock land urban water sources at 1973).

indicated decline in soil fertility and excessive grazing. Nutritious grasses e.g *Aristida pallida* (gao) have disappeared replaced by unpalatable species e.g. *Accicia nubica* and *Ziziphus spinachiristi* because these vegetation types are quick maturing species. Also the area witnessed wide invasion of the plant parasite (*Striga hermonthica*).

As was shown by the investment map, the creation of Roseires dam led to the removal of vast forests of *Hyphaene ihebacia* and *Adansonia digitata* (tabeldi) usually used by the communities for fiber and as medicinal. At AD-Damazin indiscriminate cut wood around the city was used for carpentry work. Also the horizontal expansion of mechanized agriculture in Agadi in the seventies resulted in the removal of large areas of *Acacia seyal* trees and *Acacia sengal* (Hashab) and *Balanites aegyptica* (heglig).

Furthermore the creation of public investment, which began in the distribution of agricultural projects thousand acres, led to entrepreneurs to take advantage of the logging to produce charcoal. In addition local inhabitants use tree stems and strong branches for fuels and for keeping straw materials in addition to local uses. These led to the deterioration of tree cover where more than 5 million acres were removed resulting in the migration of wild animals and exposure of soil to erosion.

Table 3. Change in vegetation (1972-2010).

Types of Vegetation cover (1972 -2010) Scientific name (Vernacular Name)	**Appearance of new Vegetation (2010) Scientific name (Vernacular Name)**
Vegetation cover (grasses)	New vegetation (grasses)
*Sorghum purpureosericeum (*Anees)	*Striga hermonthica* (Boda)
-*Brachicaria spp* (um-kweat)	*Desmodium dichotomum* (Abu Arida)
-*Rottboellia spp*(um-bleelaa)	*Dinebra retroflexa* (Um Mamleha)
Brachiaria obtusifolia (Um Girr)	*Sorghum arundinaceum* (Adar)
-*Dactlyocteniem spp* (Abo asabea)	*Cymbopogon nervatus* (Nal*)*
-*Pennisetumpolystachion*(Umm-khameeria)	*Trilulusterrestris* (Il-deresah)
-*Ennisetum vamsum* (Il-baashowm)	*Aristida Mutalilis* (Al-goeo)
-*Ischaemum afrum* (Ankoug)	*Ipomoea cordofana* (Taber)
Vegetation cover (trees)	
Acacia mellifera(Kiter)	-*Acssia-occedentalisc*(Il-sowreab)
Balanites aegyptiaca (Hegleg)	-*Blepharis edulis* (Al-seeh)
Acacia seyal var. *seyal* (Taleh)	*Aristida adscensionis* Dembalab
Acacia senegal (Hashab)	
-*Acacia seyal var .fistula*(Il-Affar)	*Aristida hordeacea* (Daneb Elkades)
-*Anogesus leiocarpus* (Al-Sahab)	
Tamarindus indica Aradeb	*Veronica sp.* (Abu Morowa)
-loncharpus laxifloris (Al-khasash)	**New vegetation(trees)**
Dalbergia melanoxylon Abanos	
-*Cordia Africana* (Al-Enderrab)	-*CalotropisProcera* (Ar-ushar)
Diospyros mespiliformis Gogan	-*Acacia nobica* (Laaot)
-*Podocapus leucans* (Il-Tarah)	
-*Boswellia papyfifera* (Gafel)	
-*Hyphaene ihebacia* (Il-Doom)	
-*Adansonia digitata* (Il-Tabeldi)	
-*Pseudocedrela rotchyi* (Il-Drobah)	
- *Slercula setigera* (Il-Tirtir)	
-*Boswellia papyrifea* (Al –Terag treg)	
-*Oxytenanthera abyssinca* (Al-ganah)	
-*Acacia nilotica* (Sunut)	
Ziziphus spina-christi (Sidir)	
-*Crewia tonoy* (Guddeim)	
-*Salyudora persica* (Araak)	

Conclusion

Increases in ambient temperature with decrease in rainfall would have negatively impacted ground water availability, vegetation cover and crop production especially in arid and semi-arid zones. Also the vegetation cover in the study area is subject to continuous changes over space and time in response to environmental factors.

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