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Spatial Biodiversity's Change sin Khor Abuhabil Area- Sudan (1972-2013)

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ABSTRACT

This article focuses on the study of biodiversity' changes in Khor Abuhabil area. The intentions of the article are to study the change in biodiversity, and distinguish its main indicators and causes. Data were collected from primary and secondary sources together with Geographical Information Systems and Remote Sensing to track the changes in biodiversity through different periods. The descriptive and statistical analytical methods; density index, ARC MAP 10 and ERDAS 8.5 are used for the data analysis. The study points out that changes in biodiversity is a wide spread phenomena in Khor Abuhabil area as indicated by 98.4% of the respondents, the analysis of the satellites images and index of density. The forest and grass area decreased from 3708 km² to 819 km² and from 9817 km² to 4578 km² during the period 1972 to 2013 respectively, and concurrently, the cultivated area increased by 40% during the same period, at the expense of biodiversity. The changes in biodiversity represented by change in vegetation cover including the dominance of *Calotrpis procera*, *Maerua crassifolia*, *Boscia angustifolis*, *Guiera senegalensis* trees and decreased in *Acacia senegal*, *Acacia mellifera* and *Dalbergia melanoxylon*. The study also indicates the decreased and disappearance of palatable grass species like *Triumpettaf lavesscens*, *Ischamum brachyatherum*, *Eragrostis pilosa* and appearances of unpalatable grass species like *Triumpetta flavesscens*. The study also showed that many wildlife animals like *Panther atigris*, *Crocuta crocuta*, *Viverra civetta* and *Gazella dorcas* disappeared whereas birds like *Bubulcus ibis*, *Ploceus galbula* and *Apus apus have* become very abundant. The study concluded that the main causes stand behind the phenomena of change in biodiversity represented in frequent drought years 1973, 1984, 1991 and 2003, fluctuation of rainfall, overgrazing and misuse of trees and over hunting ($P \leq 0.001$).

Introduction

The study of biodiversity requires knowledge on the relationship between plant and animal groups, human and natural factors affecting the growth, reproduction, spread and distribution of both plants and animals. Animals and plants are the most important renewable natural resources. They are the major source of food, clothing, medicinal and other needs of living. The loss and disappearance of part of these varieties have negative effects on human source of livelihood and well-being (Díaz et.al. 2006).

At the global level, human activities have caused and will continue to cause a loss in biodiversity through, land-use and land-cover change (Intergovernmental Panel on Climate Change 2002). Some studies for example Chapin et al. (2000) attributed changes in biodiversity to human activities which has triggered the sixth major extinction of life and caused widespread changes in the global distribution of organism.

In Sudan, biodiversity has witnessed major changes and Sudan has been classified as one of the most destructive forest country (Abdul Majid 2001). In Sudan biodiversity has been subjected to extinction because of abuse, and a long list of animals threatened with extinction include *Oryx Leucoryx*, *Gazella dorcas*, and *Ceratotherium simum burchell* (Nimer, 1989). On the other hand, exotic or invasive plants such as *Prosopis chilensis* and *Eichhorina crassip* threat to biodiversity in many parts of Sudan (Gamie 2010). Some studies for example (Abdel-Mejid.2001) and (Hamed 2002) have pointed out that semi-desert region of

Sudan has deteriorated by 80%, the savannah regions deteriorated by 60% and clay plains by 11%. Various studies conducted by the Arab Organization for Agricultural Development (2001), Zakieldeen et al., (2013) concluded that changes in biodiversity have occurred not only at the level of the study area but also in the Sudan at large. This includes change in the ecosystem and species level which is intended to differentiate species in the area and the various dynamics causes which affect species richness and relative abundance leads to the spread of new species that have the ability of widespread, drought resistance (Abdel Mahmoud 2009). The study area has witnessed significant changes in biodiversity as a result of their exposure to climate change represented in fluctuation of rainfall, prolonged drought and advances of sand dunes coupled with overexploitation of wildlife, trees and expansion of agricultural land at the expense of pasture and grazing. The continuous decreases in *Acacia Senegal* in Khor Abuhabil area can be attributed to human factors including overgrazing and cutting of trees for different purposes (Khogali 2012).

The marked increase in the numbers of the animals and human population has accentuated the losses of biodiversity. Per se, the objective of this paper is to study the changes that

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have occurred in the biodiversity of Khor Abuhabil and investigate the reasons behind such changes.

Materials and Methods

This part outlines and describes the materials and methods used in this study. The first section spotlights on the geographical and environmental accounts of the study area, while section two focuses on the methods of data collection and analysis.

Khor Abuhabil Area: Geographical and Environmental explanation

The study area is located between latitudes 12^0 $14^/$ – 13^0 $43^/$N and longitudes 30^0 $21^/$ – 32^0 $22^/$E as shown in Fig. 1. Khor Abuhabil is one of the biggest seasonal water courses in Sudan as the water flows during July to October crossing a distance of 150km with a total discharge of 140 million cubic meters per year. It has a wide alluvial Delta with heavy clay deposits. The area has been struck by frequent drought years (1973, 1984, 1991 and 2003), and fluctuation of rainfall where denotes the coefficient of variation (CV = 0.3) in Kosti and (CV= 0.3) in Elobied as the nearest meteorological stations during the period 1970-2013.

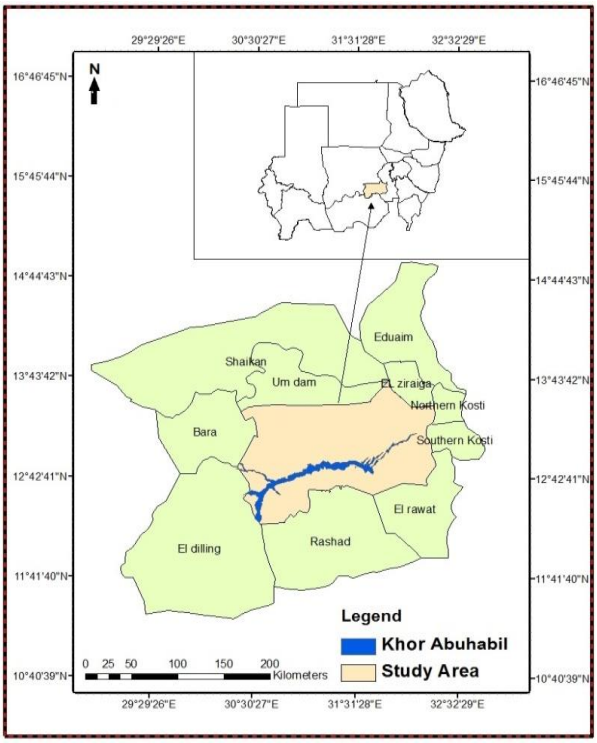

Figure 1. Location of the study area

Methods of Data Collection and Analysis

To study the changes in biodiversity especially flora and fauna of Khor Abu Habil, several ways and methods of collecting and analyzing data and information were used. These methods include the primary and secondary sources, such as interviews, questionnaires, survey, satellite images as well as field measurements which are illustrated below:

Satellite Images as a Source of Data

In order to follow up and to track the changes in vegetation cover, the satellite images of the years 1972, 1984, 1994, 2000 and 2013 are used as shown in Fig.2A-2E. These images provided data on the size and density of vegetation cover, human activities and its expansions as well as land cover in general.

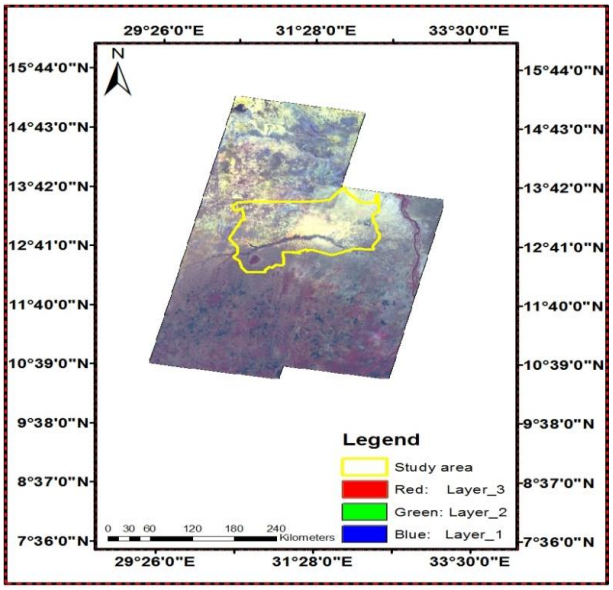

Figure 2A. Satellite image of Khor Abuhabil 1972 Source: Landsat MSS 1

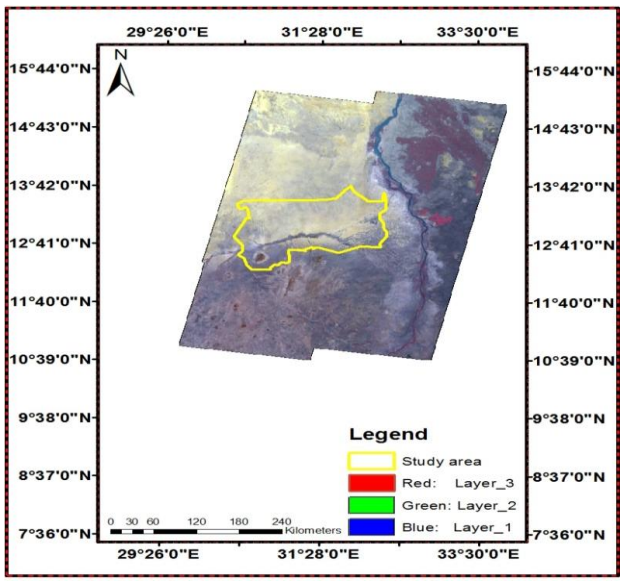

Figure 2B. Satellite image of Khor Abuhabil 1984 Source- Landsat 5-MSS.

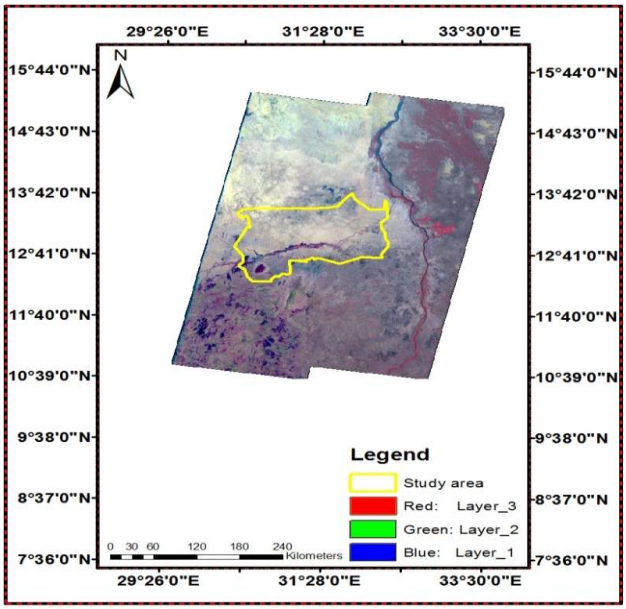

Figure 2C. Satellite image of Khor Abuhabil 1994 Source: Landsat 5, ETM.

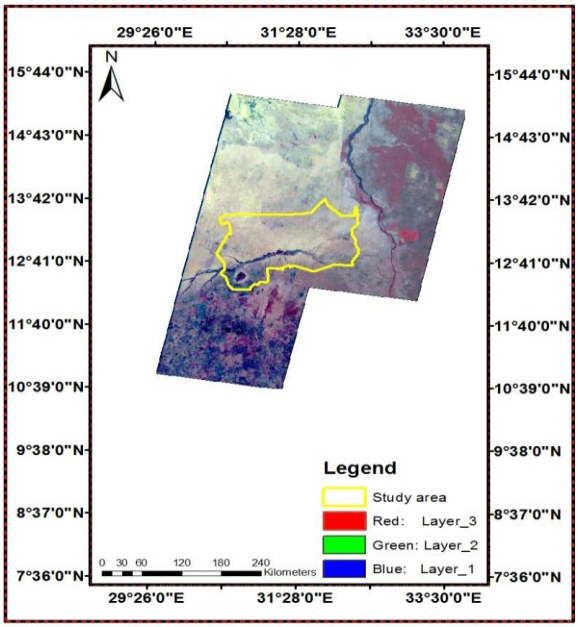

Figure 2D. Satellite image of Khor Abuhabil 2000
Source: Landsat 7, ETM +

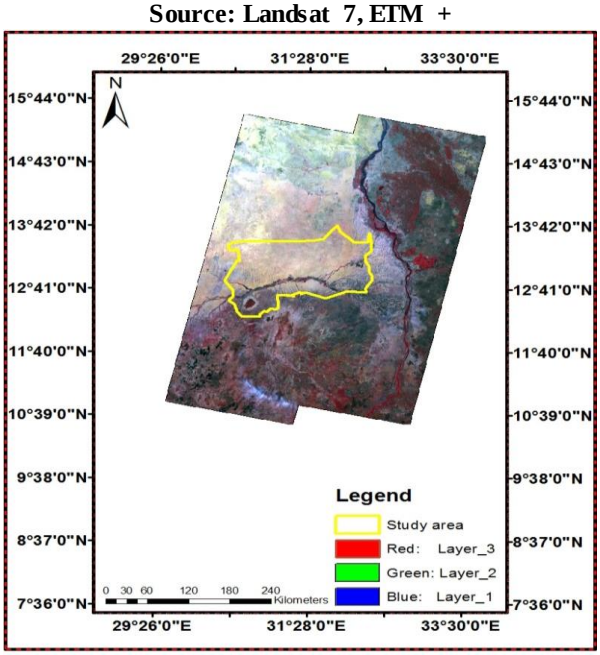

Figure 2E. Satellite image of Khor Abuhabil 2013
Source: Landsat 8, OLI.

Sample Site and Size

Ten sample sites were deliberately selected on the left and right banks of Khor Abu Habil (Table 1 and Fig. 3). These sites are selected because they are most populated, represent centers for other small villages, located at the vicinity of the Khor Abuhabil and the majority of the social services are available at them. In these settlements, chiefs (Sheikhs) and village committees play paramount roles in impacting human livelihoods and biodiversity. The tribal chiefs and peoples committees run day to day- today activities at the village level, secure funds and donations from villagers to establish some services infrastructure like education, health, water supply and the like. It is imperative to note that these bodies in the selected villages impact aspects like forestry, agriculture, animal husbandry, water supply and market places to greater extent and hence they have a very close relationship with biodiversity issues. A total of (250) headed household were randomly selected and has been proportionally distributed among the sample sites based on the headed household at each site.

Table 1. Sample Size.

Name of village	population	Percent population	No. of respondents
Abu hamra	256	7%	17
Gedaideem	350	10%	25
Wad ashana	457	12%	30
Abu kamdla	228	6%	15
Shirkaila	704	19%	48
Alla kareem	593	16%	40
Guz boshara	279	8%	20
Andraya el tahir	214	6%	15
Um banona	203	6%	15
Dabara	367	10%	25

Source: Central Bureau of Statistics, 2014- Manipulated by the researcher

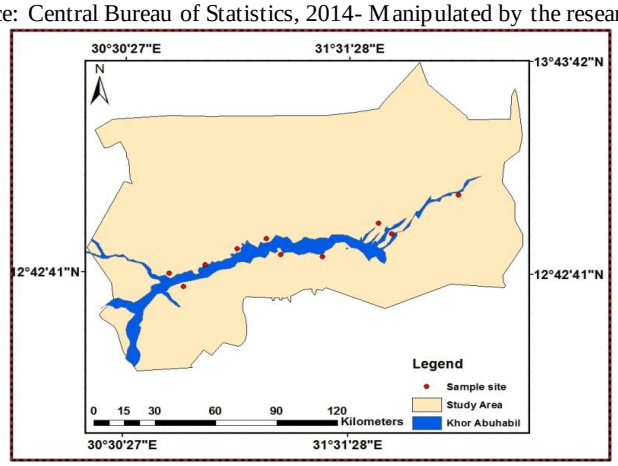

Figure 3. Sample sites

Field Measurements

The study area has been divided into three sectors using Global Positioning System (GPS). Thirty sample points (each point has an area of 10000 m^2) were determined and chosen to measure species richness and density as an indicator of biodiversity. The species richness is a descriptive analysis present in each sector while the Species Density (SD) is a number of species divided by the area.

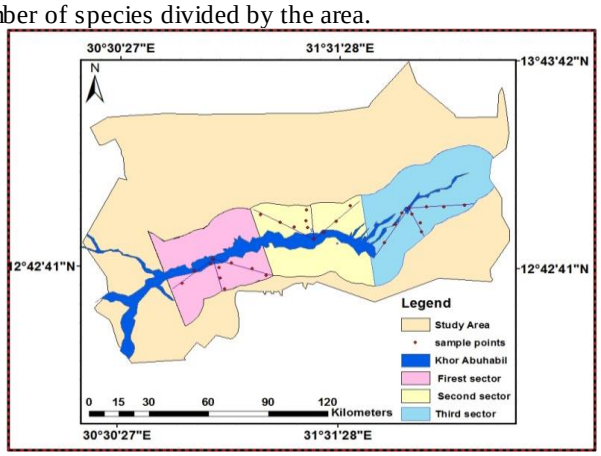

Figure 4. Sectors and Points of the Field Measurements.

Data Analysis

For the analysis of the satellite images, unsupervised classification has been used, where each image has been classified into five major units (forest, grass, agricultural land, seasonal water courses and bare land). The Erdas imagine 8.5 and Arch GIS are the software used in the data analysis. The overall accuracy assessments have been counted which ranged between 80-86%.

For the analysis of the questionnaires and interviews data, the nonparametric statistics are used in the data examination and the Statistical Packages for Social Sciences (SPSS) is the software used in the analysis.

For the analysis of the species density i.e. measure the relative presence of the species in an area is equally conducted. Such a descriptive analysis measures the numbers of individuals in the sample rather than the species is used.

Results and Discussions

Data on demographic characteristics can be depicted by Table 2. Taking the age structure of the respondents, it is found that only 5.2% of them are less than 40 years while the majority of the respondents are within the age bracket 51-60 years and those of more than 60 years of age constitute about 29.2% of the total population.

As for the economic activities prevailing in the area; farmers are taking the lead with 82.4% of the total respondents. Those with activities other than farming and animal husbandry constitute about 12.4%.In taking migration to the study area, about 66% of the respondents came here 70 years before. Recent migration to the study area is equally prevalent as about 6.8% of the respondents came during the period 1981-2000.

As for education, Khalwa (Quranic School) is taking the lead scoring about 35% of the respondents, followed by primary, secondary and university education with 29.2%, 16% and 17.2% respectively. The study area is attracting tribes from all corners of the Sudan with Bedaireya as a majority of 74% of the whole ethnic composition.

Table 2. Demographic characteristics of the respondents (N= 250).

Characteristics	Detailed Demographic Data	Frequency	%
Age	Less than 40 years	**13**	**5.2**
	Between 41-50 years old	**77**	**30.8**
	Between 51- 60 years old	**87**	**34.8**
	More than 60 years Total	**73**	**29.2**
Jobs	Farmer	**206**	**82.4**
	Pastoralist	**13**	**5.2**
	Dealer	**31**	**12.4**
Date of living in the area	Before 1970	**165**	**66.0**
	Between 1970- 1980	**64**	**25.6**
	between 1981 – 2000	**17**	**6.8**
education	Illiterate	**4**	**1.6**
	Khalwa	**88**	**35.2**
	Primary	**43**	**29.2**
	Secondary	**73**	**17.2**
	University education	**40**	**16.0**
tribes	Jawamah	**46**	**2.4**
	Bedaireya	**185**	**74**
	Jaleyein	**12**	**4.8**
	Others	**15**	**6.0**
		38	**15.6**

Source: field work, 2015.

Change in Trees and Grass Species as Indicated by the Respondents

The vital change in biodiversity is presented by changes in trees and grass type and density. Such changes are observed by the respondents regardless of their demographic characteristics. The field survey reported (98.4%) of respondents, officials and elderly noticed a change in the density and type of trees and grasses as presented in Tables 3 and 4.The Tables show that the That study area is covered by perennial and short annual grass with sparse trees cover which indicates that the changes in biodiversity resulted in large scale changes in trees, grass cover and pasture quality that reflects serious range and forage plants deterioriation. The changes in trees and grass species can be illustrated as follows:

- There is an increase in some major trees species like *Acacia nilotica, Acacia tortilis, Cordia monoica* and *Boscia angustifolis*. Those type of trees have some economic values as they can be utilized as furniture and as flanks for railway.
- *Balanites aegyptiaca* and *Zizyphus spina- christi*. Are also augmented and they are very useful as medicial plants.
- A major type of tree which had decreased in number is *Adansonia digitata* (used for water conservation)
- Some trees like *Prosopis chilensis*, and *Rhynchosia ferruginea* are newly appeared in the study area.
- Some trees species are completely disappeared such as *acacia tortilis* and *Terminalha brownie*.
- Some grass and herbs have equally increased in number such as *Brachiaria comate* and *Cenchrus catharticus* as shown in Table 4.
- Some grass species like *Schoene feldlagracilis, Dipterygium glaucum, Ctenium elegans, Ctenium elegans* and *Sorghum arundinaceum* disappeared from the study area.
- The *Requienia obcordata, Cymbopogon proximus* and *c.pilosa* have decreased and become very rare.

Table 3. Changes in trees type as indicated by the respondents.

Scientific name	***Status and conditions of the trees***		
	Decreased	***Disappeared***	***Increased***
Acacia Senegal			√
Acacia mellifera			√
Acacia seyal			√
Acacia nilotica	√		
Acacia tortilis	√		
Acacia albida			√
acacia tortilis		√	
Acacia nobica			√
Acacia seyal			√
Balanites aegyptiaca	√		
Boswellia papyrifera		√	
Zizyphus spina- christi.	√		
Dobera glabra		√	
Leptadenia			√
Calotrpis procera	√		
terminalha brownie		√	
Cappris decidua			√
Azadinachya	√		
Maerua crassifolia			√
Cordia monoica	√		
Adansonia digitata			√
Bauhinia reticulate		√	
Acacia etbaica		√	
Combretum glutinosum			√
Tamarindus indica		√	
Guiera senegalensis	√		
Sclerocarya birrea		√	
Terminalia brownie		√	
Anogeissus leiocarpus		√	
Boscia angustifolis	√		
Dalbergia melanoxylon		√	

Source: fieldwork 2015

Table 4. Changes in grass type as indicated by the Respondents.

Scientific name	Status and conditions of the grass		
	Increase	Disappeared	Rar
Aristida funiculate	√		√
Cenchrus catharticus	√		
Triumpetta flavesscens	√		
Eragrostis pilosa	√		
Schoene feldlagracilis		√	
Ischamum brachyather		√	
Dipterygium glaucum		√	
Andropogon gayanus		√	
Ctenium elegans		√	
Setaria pallid-fusca		√	
Pennisetum pedicellatu	√	√	
Sorghum arundinaceu	√		
Requienia obcordata			√
Panicum turgidum	√	√	
Zornia glochidiata			
Cymbopogon proximus	√		√
Tribulus pentrandus	√		
Pennisetum ovale	√	√	
Commicarpus verticill			
c.pilosa	√		√
C.prieurii	√		
Brachiaria comate	√		

Source: fieldwork, 2015

Changes in Vegetation Cover as Indicated by the Satellites Images

Land cover has been quantified based on interpretation of remote sensing images and field survey. Six main categories are identified as shown in Fig.5A to 5E. The results showed that grass and forest covered 62.7% and the seasonal water courses covered 8% of the study area in the year 1972. The situation has been drastically changed in the year 1984 where grass and forest covered only 4.3% and seasonal water courses cover only 3.4% from the total area i.e. change in the land cover of more than 50% and this variation in land cover is fluctuating rather than continuous. The statistical results are presented in Table 5.

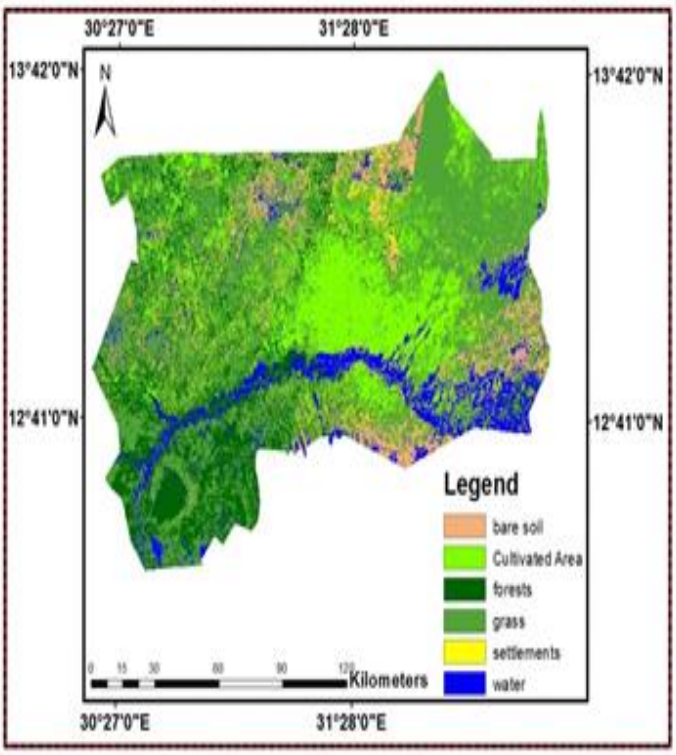

Figure 5A. Measured parameters of the study Area, 1972.

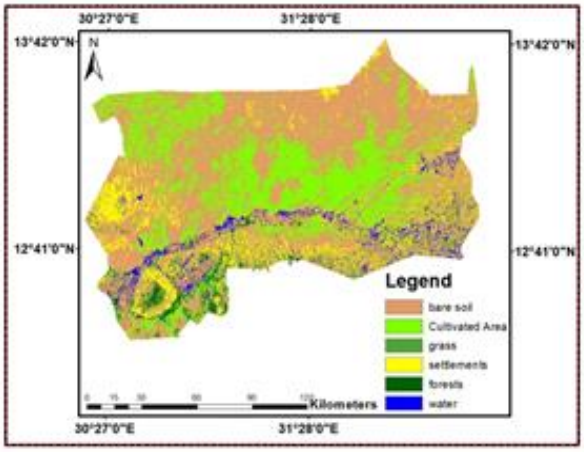

Figure 5B. Measured parameters of the study Area, 1984.

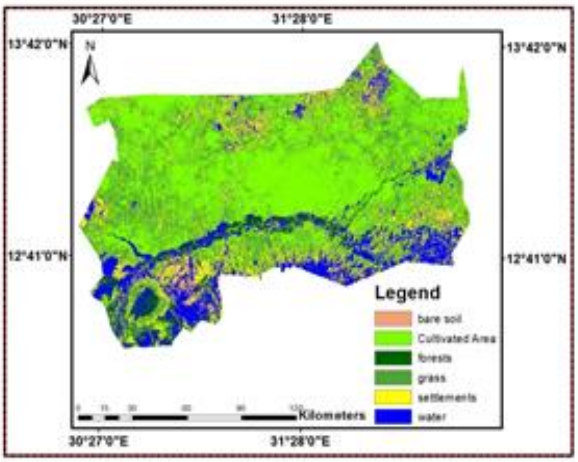

Figure 5C. Measured parameters of the study Area, 1994.

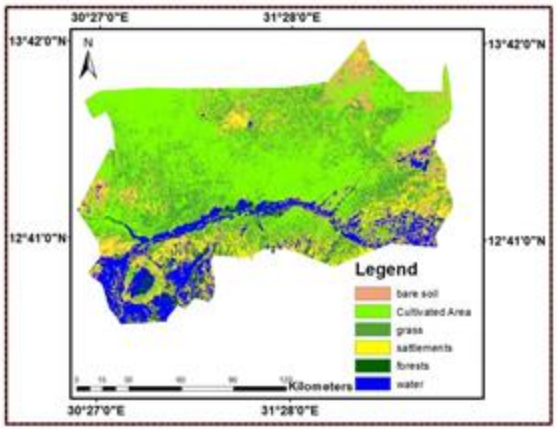

Figure 5D. Measured parameters of the study Area, 2000.

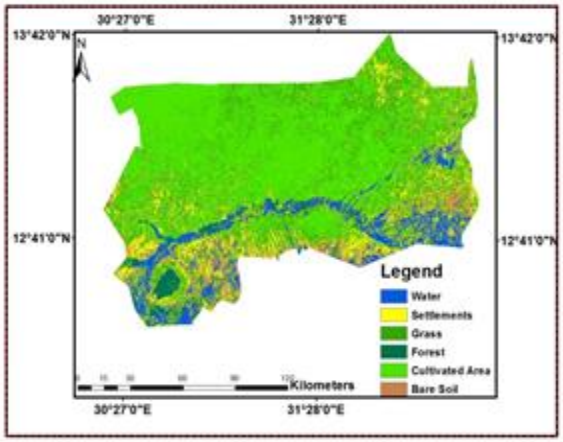

Figure 5E. Measured parametersof the study Area, 2013.

Table 5. Land cover dynamic changes indicators in the study area 1972-2013.

Year	Measured Variables					
	Settlement	Cultivated area	Bare soil	Grass area	Forest area	water courses
1972	731	3733	1863	9871	3708	1735
1984	2099	5597	12313	463	476	714
1994	2196	8614	960	6229	911	2740
2000	2483	9251	1965	5235	346	2369
2013	2974	10188	1425	4578	819	1665

Source: Calculated from Satellite images (Fig 2A-2E)

The Table shows that there is a decrease in forest and grass area and increase in cultivated and settlement areas. The forest area covered 17.1% from the total area in the year 1972 and decreased to 2.2% in the year 1984 and then increased in 1994 to 4.2%, due to good rainy season during that period and then decreased to 1.6% in 2000 and once again increased to 3.8 which indicate changes in the area and density of biodiversity.

Changes in Biodiversity as Indicated by Field Measurements

The field measurements indicated that the relative existence of the original species varies from sector to another, but they generally decreased and the invading tress such as Cassia angustifolia , Calotrpis procera and Rhynchosia ferruginea represent relatively high density (Table 6). These trees are unplatable trees for animals and have less forage. Simultaneously, it has low economic value. On the other hand, some grass species present high density in all sectors as shown in Table 7. This grass includes Cenchrus catharticus and Commicarpus verticillatus.

Table 6. Trees density in different sectors of the study area.

scientific name	Sector 1	Sector 2	Sector 3
	Relative density	Relative density	Relative density
Acacia Senegal	2	2.6	1.9
Acacia seyal	3.1	-	2
Acacia nilotica	-	-	6.2
Acacia tortilis	1.1	-	-
Acacia nobica	1.2	-	1.8
Fadherbia albida	-	1	-
Balanites aegyptiaca	2.4	3	1.9
cassia angustifolia	-	-	26.3
Zizyphus spina- christi.	4.4	2	2.2
Leptadenia pyrotechnica	2	6	-
Calotrpis procera	7.2	13.2	11.6
Boscia sesnegalensis	-	9.9	-
Adansonia digitata	-	0.5	-
Compretum glutinosum	-	0.4	-
Guiera senegalensis	7.2	5.4	-
Terminalia brownii	0.2	-	-
Boscia angustifolis	12.3	11	-
Prosopis chilensis	-	-	6.1
Rhynchosia ferruginea	-	-	29.3

Source: Field work 2015

Change in Wild life and Birds as Indicated by the Respondents

The study shows that 64% of the respondents (160 head of households) authenticated that around 55% of the listed animals in Table 8 disappeared from the area, such as Panther pardus, Crocuta crocuta and Viverra civetta and 34% of Lepus cuniculus, Bubulcus ibis and Felis catus have equally decreased which reflects changes in animals' habitat and biodiversity in broad-spectrum. Meanwhile, no changes have been observed in the number of Neophron perconopterus, Ploceus galbula and Apus apus.

Table 7. Grass density in different sectors of the study area.

scientific name	Sector 1	Sector 2	Sector 3
	Relative density	Relative density	Relative density
Aristida funiculate	-	19.6	-
Cenchrus catharticus	21.7	33.8	40
Zornia glochidiata	10	40	3.3
Eragrostis pilosa	16.7	1.6	-
Pennisetum pedicellatu	-	-	-
Sorghum arundinaceum	1.6	3.4	-
Requienia obcordata	9.3	11	-
Commicarpus verticilla	10	12.4	35
Echino chllia coloruain	3.3	5.6	10
Dacty locternium	5	3.3	-
Sesamumalatum	16.7	15.6	-
Ipemea cardiospepala	-	6.4	-
Waltheria indica	4.3	4	16.7
Solanum aethiopicum	-	1.2	3
Tribulus pentrandus	-	-	5
Bergia suffruticosa	-	-	10
Aristida hordeacea	6.7	-	16.7

Table 8. Trees density in different sectors of the study area.

scientific name	Status and condition of wildlife		
	Disappeared	Decreased	No change
Panthera tigris	√		
anther leo	√		
Hippotigris granti	√		
Panther pardus	√		
Gazella dorcas	√		
Crocuta crocuta	√		
Viverra civetta	√		
Cercopithecus aethiop	√		
Lepus cuniculus		√	
Addax nasomaculatus	√		
Felis catus		√	
Numida meleagris		√	
Struthioncamelus	√		
Falco peregrines		√	
Corvus albus		√	
Milvus migrans	√		
Ciconia ciconia	√		
Bubulcus ibis		√	
Neophron perconopte			√
Pterocles exustus	√		
Ploceus galbula			√
Coracias garrulous		√	
Pelecanus onocrotalus	√		
Apus apus			√
Streptopelia roseogris		√	
Grus grus	√		
Chlamydotis undulate	√		
Lamprotornis chalyba		√	
Anserinae		√	

Source: Field work 2015

Causes of Changes in Biodiversity

Several controversial factors are found in the literature to explain the causes of changes in biodiversity. These factors include both natural and human causes. In this study, lack of rainfall, unpredictable and irregular precipitation are the main natural factors related to changes in biodiversity as indicated by 51.6% of the respondents ($P \leq 0.001$) shown in Table 9. This perception and subjective responses of the individuals are coinciding with rainfall records and reality of this semi-arid land of Sudan. However, cutting of trees, overgrazing and agricultural expansion have a significant role in changing biodiversity. These human factors indicate the prevailing of traditional and subsistence economy which is internally oriented

to produce for the local market. This orientation deprives the local communities from the excess food which goes to the urban centers at cheap price and reflects the economic marginalization of the local communities at the national level. Accordingly, more land is utilized and more resources are used and exploited in the already fragile environment which causes momentous changes in biodiversity. Equally important factor as indicated by 5% of the respondents is the weak role played by local authorities and government institutions to monitor and protect the forests and grasslands from cutting and overgrazing has accentuated the problem.

Table 9. The causes behind changes in biodiversity.

Cause of changes in biodiversity	Observed Frequency	Expected frequency	Residual
Lack of rain	105	50	55
Irregular rainfall	24	50	-26
Cutting of trees and over grazing	91	50	41
Agricultural expansi	17	50	-33
Local authorities, government institutio	13	50	-37
Total	250		

Chi square 156.8 df = 4, ($P \leq 0.001$)

Source: fieldwork 2015

Conclusion

The biodiversity of the study area was formerly very rich. Recently it has undergone drastic changes and disturbance. The changes in biodiversity have become a wide spread phenomenon where some species have disappeared from the habitat and other inferior species which were not belonging to the area have appeared. These changes being the result of lack and irregular rainfall, prolonged droughts and the existing land use pattern. This is exemplified by cutting trees for different purposes, exhaustion of soil due to excessive use and opening up more land for cultivation at the expense of vegetation cover and grazing area.

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