

Assessing and Analyzing Natural Land Cover Degradation in North Kordofan State Using GIS and RS

Ibrahim Mohamed Eltom

Faculty of Geographical & Environmental Sciences || University of Khartoum || Sudan

Amna M. Bashir Maryoud

Faculty of Education || Alzaeim Elazhari University || Sudan

Abstract: The modern land environmental degradation in Sudan was started prominently after the severe drought in 1984, when all socioeconomic sectors and environmental settings were affected by severe drought. The main objective of this paper is to assess the most observed and measured types of degradation over the North Kordofan State in Western Sudan using different spatial analysis techniques and remote sensed data. Data used are from different sources include satellite imageries, Google Earth and field-based observation and meetings methods. The data analyzed using ArcGIS 10.4 and Erdas Imagine 2014 softwares for processing the data. NDVI spectral index has been used for assessing the land cover greenings. The results presented by maps showed the severe degradation surrounding villages and towns. The results quantification showed that the study area exposed to severe degradation since 1984, and the most affected areas are surrounding towns that 100% of the deforestation was depicted surrounding EIObeid city. Village deforestation was evaluated to be more than 45% of the sampled villages using buffer analysis estimation. During drought seasons in 1984 and 1990, NDVI results showed negative values that indicated about 89% of land were degraded seasonally (less greenings cover) used to assess situ land degradation in the study area.

Keywords: Environmental degradation, land degradation, NDVI satellite imageries.

تقييم وتحليل تدهور الغطاء الأرضي الطبيعي ولاية شمال كردفان باستخدام نظم المعلومات الجغرافية والاستشعار عن بعد

إبراهيم محمد التوم

كلية علوم الجغرافيا والبيئة || جامعة الخرطوم || السودان

أمينة محمد بشير مريود

كلية التربية || جامعة الزعيم الأزهرى || السودان

المستخلص: بدأ التدهور البيئي الحديث للأراضي في السودان بشكل بارز بعد الجفاف الشديد في عام 1984، عندما تأثرت جميع القطاعات الاجتماعية والاقتصادية والبيئية بنتائجه. الهدف الرئيسي من هذه الورقة البحثية هو تقييم أكثر أنواع التدهور البيئي التي حدثت ويمكن ملاحظتها وقياسها في ولاية شمال كردفان في غرب السودان باستخدام تقنيات التحليل المكاني المختلفة وبيانات الاستشعار عن بعد. تم الاستعانة بمصادر مختلفة من البيانات شملت صور الأقمار الصناعية وجوجل إيرث والملاحظة والمقابلات وفق أساليب العمل الميداني. تم تحليل ومعالجة البيانات باستخدام برنامج ArcGIS 10.4 و Erdas Imagine 2014. تم استخدام تطبيق المؤشرات الطيفية لقياس مستوى التغطية الأرضية السنوي. أظهرت نتائج مخرجات تقنيات التحليل المتمثلة في الخرائط التدهور الشديد في المناطق المحيطة بالقرى والمدن. وأظهر التقدير الكمي أن منطقة الدراسة تعرضت لتدهور شديد منذ عام 1984، وأن أكثر المناطق

تدهوراً هي الغابات المحيطة بالمدن حيث تم كشف أن 100% من الغابات المحيطة بمدينة الأبيض تم إحلالها بامتدادات سكنية حديثة. تقييم إزالة الغابات حول القرى التي تم مسحها وتحليلها من جوجل إيرث، أظهرت أن أكثر من 75% منها تم إزالة غاباتها وذلك باستخدام طريقة تحليل تقدير الحرمة المحيط بها. خلال مواسم الجفاف في عامي 1984 و1990، دلت نتائج NDVI قيمًا سلبية أشارت إلى تدهور حوالي 89% من الأراضي موسميًا (غطاء أقل إخصراً) كطريقة لتقييم تدهور التغطية الأرضية في منطقة الدراسة.

الكلمات المفتاحية: التدهور البيئي - تدهور الأراضي - مؤشر الاخضرار الطيفي - المرثبات الفضائية.

1- Introduction.

The links between the environment and the economy have risen on policy and academic agendas through various initiatives (e.g. the Economics of Ecosystems and Biodiversity (TEEB), the Green Economy Coalition) (Jouanjean, et al.,2014). Land degradation is a serious problem for many communities across the world, particularly smallholders in tropical regions, and it has constituted a prominent field on the environmental research agenda for quite some time (Andersson, et al; 2011). The Sudan has been classified as 92% dry country, mostly dominated by hyper arid, arid and semi-arid regions (Ayoub, 1998). Drylands are susceptible to environmental changes and degradation. The term “degradation”, has involves many concepts. In this paper, by “degradation”, we refer to the land cover changes and to some extent represents by deforestation. Also, it defined as a negative trend in land condition, caused by direct or indirect human-induced processes. Climate change, expressed as long-term reduction or loss of at least one of the biological, productivity, or ecological integrity (IPCC SRCCL, 2019). Land Degradation of arid and semi-arid areas (often referred to as desertification) remains a significant global problem because they host 38 % of the world’s population (Reynolds et al. 2007). Land degradation has been stated in the global agenda for sustainable development from 2015 to 2030 (Salehi et al, 2017).

More than 150 countries of the world are facing the problems of desertification includes most of the Arab countries, where about one-third of desert lands worldwide are located. Land resource degradation and the consequent impacts upon livelihoods have long been recognized, but not as a problematic issue. Recently, as the spatial technology of resource monitoring advanced, the demand for scientific assessment is at the priorities of the decision makers. The assessment is to understand the impacts of climate change on natural and human systems that governed the current conditions.

Sustainable and efficient environmental conservation and management of the available resources are perceived to be an essential condition for pushing strategic efforts in the degraded areas of the western Sudan. Applicable research guidance that has contributed to the resources analysis of such degradation involves guidance to analyze its cost benefits all over the productive sectors. Before the spatial analysis techniques, environmental degradation analysis and predictions have typically been carried out for a limited area using traditional methods of surveying that accompanied by some errors that decline its accuracy.

Although the general understanding of the importance of environmental problems is recently growing among the Sudanese societies and within the decision makers, still there are considerable gaps need to be managed as a national strategy. The framework of the environmental degradation considers eco-political approach as part of the solutions. So, the role of the government is to be involved in what has been going on the national collapse of the environment.

2- Current status of the Problem:

For all of history the lands bordering deserts have been prone to drought, their inhabitants frequently threatened with starvation (Morris,1995). Over 250 million people are directly affected by desertification. In addition, some one billion people in over 100 countries are at risk. These people include many of the world's poorest, most marginalized, and politically weak citizens (WMO,2005). Land degradation associated with reduced land capability and productivity remains a serious problem in the western part of the Sudan. Vegetation, water and soil are continuously experienced heavy changes in the marginal areas of the Sudan. Based on UNEP's reports, since 1980s, western Sudan includes the study area, witnessed different levels of land degradation. Land degradation is considered one of the major threats to the people in North Kordofan State. People of this State suffer from continuous decrease in productivity of the food crops, which leads to infrequent famines and food shortage (Dafalla,2006). Globally, 2 billion ha of land are degraded annually and as a result 6 million ha area goes out of cultivation each year (ICRISAT,2015). Over the Sudan, the forest lands were declined by 11.6 percent since 1990 or approximately 8.8 million hectares. At the regional level, two-thirds of the forests in north, central and eastern Sudan disappeared between 1972 and 2001. According to Ayoub (1998), out of the agricultural land, pasture and forest and woodland (170 million ha in total), nearly 75 million ha (45%) have been degraded severely to very severely by human factors in recent history. The consequences of the environmental disturbances were related to population mobility from rural areas to urban centers (millions of people were displaced); mass death of livestock; a massive scale of deforestation; aggressive expansion of shifting cultivation and occurrence of climate variability.

3- Previous related studies:

In literature most of the environmental land degradation studies are related to the analysis of the factors causes, consequences and approaches. The 1970s and 1980s studies were focused on these main elements, while contemporary publications have approaching some recent methodologies that include the spatial techniques to evaluate land degradation from spatial and temporal perspectives using remote sensing satellites data. **Abu Hammad and other in 2010**, published a research about the land degradation: socio-economic and environmental causes and consequences in the eastern Mediterranean. They linked between the industrial and current environmental settings. **Andersson et al, (2011)** add methodological study about the political ecology of land degradation. They justified the need for the

political ecology approach for the better policy. **Zaman et al (2011)** wrote a paper about the impact of population on environmental degradation in south Asia: application of seemingly unrelated regression equation model. The main object of the researchers is to undertake an empirical study for interrelation between population and environmental degradation. In 2012 **Saodat Olinova and Muzaffar Olimov** has their contributed part in the International Organization for Migration Development Fund. They wrote about the environmental degradation, migration, internal displacement and rural vulnerabilities in Tajikistan. **Jouanjem, et al (2012)** finished a paper about understanding the effects of resource degradation on socio-economic outcomes in developing countries. They addressed four key elements in their paper, which are; biophysical change, potential socio-economic impacts, resilience of socio-economic system and the actual socio-economic impacts resulting from the other three elements. In (2013) **Joachim and Gatzweiler** published an open access book. The chapter of land degradation, poverty and marginality emphasizes the complexity of the types and magnitudes of communal relationships between poverty and environmental degradation. **Pani and Carling (2012)** published a paper about land degradation and spatial vulnerabilities: a study of inter-village differences in Chambal Valley, India. The study used multi-disciplinary approach that integrated multiple data sources and methodologies to study the implications of land degradation in semi-arid India. **Abu Sayaed in 2014** studied the causes and consequences of land degradation in Bangladesh. His case study was about agricultural land. He discussed the changes that agricultural sector facing and the conversion of agricultural land in non- agricultural uses. **Rajiv Chopra (2016)** wrote a paper about environmental degradation in Indi, causes and consequences. He discussed the causes of environmental degradation as categorized into social, economic and institutional factors. Each group of factor was explained by him in its sub elements. At the level of countries, **United Republic of Tanzania in (2016)** finished a detailed design project about reversing land degradation trends and increasing food security in degraded ecosystem of semi-arid areas of Tanzania. Also, one of the value online book about the economics of land degradation and improvement, a Global Assessment for Sustainable Development published by Springer Open. The editors contributed are; **NKanya et al., (2016)**. The book provides with valuable knowledge and information at globally regional and national levels on the cost of land degradation and benefits of taking actions against land degradation. **Prince et al, 2018** were finished the IPBES assessment report on land degradation and restoration. The report involves many intensive topics that concern land degradation. The main issues covered are process and degradation impacts in response to human drivers. In (2019), **Lernant Olsson and Humberto Barbosa** as coordinating lead authors finished a satisfied chapter about land degradation in the IPCC final government distribution report. The chapter includes many aspects of land degradation such as the human dimensions of land degradation, forest degradation, climate change and land degradation, process of land degradation, drivers of land degradation and approaches to assessing land degradation.

4- Study area:

The study area is one of the Western Sudan States named North Kordofan. It consists of six localities. Two localities (Shiekan and Bara) had been chosen for this study. The study area located between lat. $12^{\circ} 14'$ and $16^{\circ} 36' N$, and long. $32^{\circ} 21'$ and $26^{\circ} 56' E$ fig (1). The climate of the study area is of semi-arid type. Mean rainfall is of 356 mm per year, with the rainiest months from July to end of September. The area characterizes by a long dry season from the end of December to May. The most dominant soils in the study area are sandy soils derived from Quz formations, and alluvial soils associated with the seasonal water bodies such as Wadis and Khors. The study area as part of the Sudan which has a desert region of about 725,800 square kilometers, while the area of the semi-desert region is approximately 491,000 square kilometers (Badi, 1989). According to Harrison and Jackson the North Kordofan distinguished by (i) Desert Zone that receives an annual rainfall of zero to 75 mm (ii) Semi-Desert Zone where annual rainfall varies from 75-300 mm. The study area has more than 80 per cent of its population lives in rural areas, depending on the traditional activities such as shifting cultivation and open grazing. From environmental perspectives, land resources in the study area are multi benefits range from arable, grazing, wildlife and forest lands. All resources are main economic generators via traditional open practices. Drought, desertification and biodiversity loss, are accelerating as the human traditional activities intensified to extend that low land productivity becomes significant problem over the study area.

5- Methodology.

5-1 Data used:

The data methods implemented in this paper for data preparation are from different scenarios. The data used was based on the analysis formulated to evaluate land degradation in terms of its spatial extent. Data brought from satellite imageries and Google earth have been utilized as a primary data, while institutional and literature documents were secondary data. Satellite imageries for the years 1984 and 1990 were downloaded for the two sampled localities (Bara and Sheikan) with a specifications required for the various processes. Google earth digitizing data were used for analyzing the degradation surrounding village settlements and the eight villages selected for this study presented in table (1).

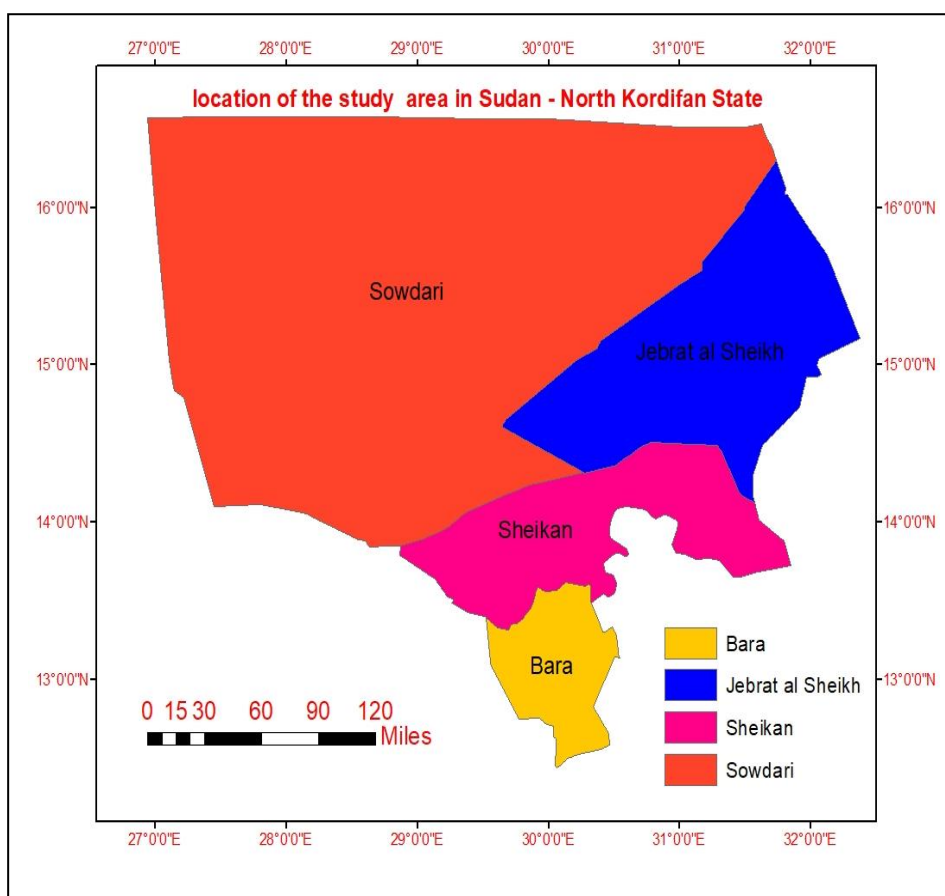


Fig (1) Location of the Study Area – North Kordofan State -Sudan

Source: Sudan Shape file GIS-based processing

Table (1): The geographical locations of the villages used for degradation assessment

Village name	Coordinates		Google date
	longitude	latitude	
Farj Alla	30 16 12.11	13 19 55.36	3/26/2020
Abu Khores	30 13 00.06	13 17 00.33	12/4/2018
Al-Waeb	30 19 12.75	13 10 14.05	3/26/2020
Zungaha	30 19 43.93	13 18 46.07	3/26/2020
Um Galhe	30 19 51.33	13 33 03.64	3/26/2020
N.W.Bara	30 21 57.46	13 41 59.18	3/26/2020
El-Tawil	30 13 20.02	13 43 45.69	3/26/2020
Al-Bashiri	30 11 30.00	13 51 26.39	3/15/2020

5-2 Analysis methods:

Different localities have been selected for the different analysis. Bara and Sheikan were used for NDVI as drought indicators, while Gabrat El Sheikh and Sodary were used for general degradation assessment as the most example of severe degradation. In this paper the google earth is used to extract village maps and satellite images were used for mapping and analyzing the land degradation. The Normalized Difference Vegetation Index (NDVI) and buffering geoprocessing were used to assess and delineate degradation around settlements.

4- Results and discussion:

Land degradation level of severity varies over the study area and associated with the human activities that caused the natural disturbances. Drought frequency is aggravated the condition of land degradation and in its extreme level caused desertification. As depicted from the field observations and google earth visualization, the most significant changes and the major land cover transformations were observed in association to deserted areas (barren and Nagгаа) in between the farming lands. This explained the destruction of the forest that has been seriously occurred since mid-1980s. The results are based on the field survey, google mapper, remotes sensing satellite imageries and statistical records.

6.1 Overview of Environmental Degradation:

As we mention degradation we mean land degradation (LD) that includes land cover change (LCC). Degradation of Vegetation cover indicates the reduction in the number as well as quality of species with regards to the vegetation composition, which can be measured using vegetation indices. The problem is that the environmental problems related to wood fuel and timber consumption are under estimated because there are no updating statistical reports. Based on the GLASOD project about the worldwide assessment of degradation problems produced by (GLASOD-ISRIC, 1991). Table (2) shows some characteristics of land degradation in the Sudan as assessed by the project. Of all factors causing or contributing to deforestation or even tending to disturb the natural conditions in forests, man has been the most powerful and persistent (Badi, 1989). In study area many factors have been combined by the local societies in rural areas are behind severe deforestation. These are: over cutting as all people use the trees as building materials and for daily fuel wood. In addition to the industrial of brick-making that uses tree species selectively. UNEP estimates that fuel wood requirements for 2006 were around 27 to 30 million cubic meters. Deforestation led to a loss of about 11% of Sudan's forest cover between 1990 and 2005. Other factors are; over-cultivation (shifting cultivation and modern agriculture), over-grazing and fire effects.

Table (2): Some characteristics of land degradation in the Sudan as assessed by the GLASOD project

Degradation causes	Code used	%	Remarks
Total degraded lands	C.2	23	% Of the total land
Lightly degraded land	C.3	7	c.3+c.4+c.5= c.2
Moderately degraded land	C.4	14	% Of the total land
Strongly degraded land	C.5	1	% Of the total land
Degradation by water erosion	C.6	31	c.6+ c.7+c.8+c.9= 100%
Degradation by Wind erosion	C.7	40	
Degradation by Chemicals	C.8	25	
Degradation by Physical degradation	C.9	5	
Degradation by Deforestation	C.10	10	c.10+c.11+c.12= 100%
Degradation by Overgrazing	C.11	55	
Degradation by Agricultural activities	C.12	35	

Sources: GLASOD (1991)

From table (2), the most relevant assessment for this study are the total degraded land in Sudan which determined by 23% of the total land, if the estimation by states to be evaluated, we can classify the western Sudan regions as the top of this degraded percent of the total Sudan's land. The degradation caused by the wind and water erosion presents 71% attributed to the increasing dryness seasons. Deforestation is type of land degradation that was accounted 10% and involves 55% of degradation caused by overgrazing and 35% by over cultivation. This realizes the local people views about the cause of deforestation as they said that the over cultivation is above overgrazing in its impacts upon forests and both are direct causes of deforestation in rural areas of the study area.

In fact, there are no official annual statistical reports that give some previous indicators about the rates of deforestation in the study area. This was attributed to the lack of reliable time-sequence land use monitoring, inadequate ground truth surveys, forest institutions mismanagement to cope with the forest strategies in the study area.

The assessment of land degradation in North Kordofan State is based on the Sudan's land degradation assessment that classified the country into five classes from none to very severe degradation. Maps used are modified from Sudan's environmental degradation map used by Egemi (2014). Degradation by localities had been created by researchers using ArcGIS 10.2 software. Fig. (2) shows the land degradation of the North Kordofan State and the most two very severe degraded localities.

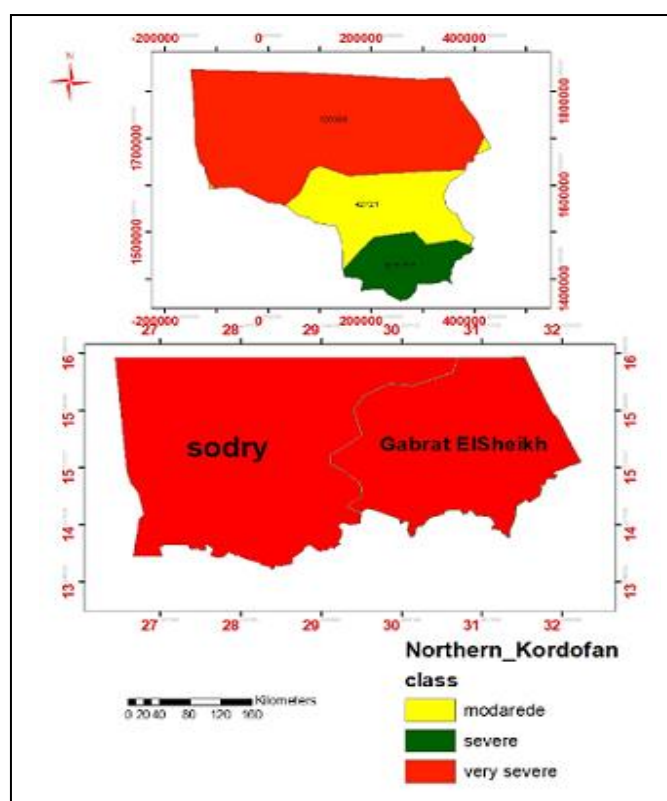


Fig (2): The most degraded localities in North Kordofan State

Source: modified after Egemi (2014)

Table (3) shows the overall main characteristics of land degradation assessment over the study area based on google mapper visualization and field survey. The scale used consists of three indicators; high, medium and low. Deforestation phenomenon is in the top ranking followed by overgrazing and over cultivation. Water and wind erosions are exclusively the consequences of the deforestation and over cultivation. Deforestation always confined to the settlements and water points, while the water erosion observed along the Wadis and Khors. The accelerated wind erosion is associated to the barren land where the overgrazing is transformed the land into vast barren lands directly exposed to sand creep encroachment.

Table (3): Overall characteristics of land degradation assessment In the study area 2019

Characteristics	In situ observation	Scale of degradation		
		high	mod	low
Deforestation	Around villages & towns	✓	-	-
Water erosion	Wadis and Khors	✓	✓	-
Wind erosion	Sand dunes areas	✓	-	-
Overgrazing	Pasture lands	✓	✓	-
Over cultivation	Arable lands	✓	-	-

Characteristics	In situ observation	Scale of degradation		
		high	mod	low
Soils low productivity	Arable lands	✓	✓	-
Drought incidences	Rural environment	✓	✓	-

Sources: Field survey May 2020

6-2 Deforestation Analysis:

Deforestation is the conversion of forest to non-forest land and can result in land degradation (IPCC SRCCL, 2019). Human ability to alter the environment has increased tremendously, whereas the capacity of environment to cope with those alterations is limited (Singh,2009). A central challenge for sustainability is how to preserve forest ecosystems (Eric et al, 2010). Sudan is undergoing a rapid loss of forests. Forest cover has declined by 11.6 percent since 1990 or approximately 8.8 million hectares. All forest lands in the study area are experiencing some sort of deforestation actions.

The urban growth presents the most critical factor that caused huge loss of forests in the study area. The strike evidence for this, is the EIObeid town urban deforestation. Table (4) shows statistically the great loss of the forests surrounding EIObeid town during the period (1970 – 2019). The town was expanded at the expense of the forest lands. All transformed forests have an economical and environmental value such ad Gum Arabic species. Fig (3) presents the change detection maps that showed the spatial extent of urban deforestation using remotely sensed data for 00-time series (1972—2000). This accounts the real impacts of urbanism upon natural land cover resources. The maps based on the remotely sensed data downloaded from USGS website and processed using ArcMap 10.2. In 1972 the area of the town was 6.181 Km², while in 2000 reached 23.786 km² compared to the estimated measurements in 2005 that reached 3.197 km². So, the total area of the forests converted into urban new extensions was about 22.871 km². All forest lands transformed had been of a high value of tree species and biodiversity.

Table (4): The Urban Deforestation Case from the Study Area EIObeid Town

Forest name	Direction to EIObeid	Area (fed)	Date	Degradation Assessment
Water resources	South	2080	15/5/1952	Total eradication
N/reserved forest	North	2285	15/5/1952	Total eradication
El-Diling road	S. West	2110	15/5/1952	Moderate
Bara Road	North	850	15/5/1952	Severe
Ganzara	N. West	960	15/5/1952	Total eradication
Qoz Ashgar	East	1165	15/5/1952	Severe
El-Ain forest	South	24809	15/4/1954	Moderate

Forest name	Direction to EObaid	Area (fed)	Date	Degradation Assessment
El-Ain Extension	South	18800	15/4/1962	Moderate
Q.Ashgar Extension	East	220	15/4/1975	Moderate
Sheikan forest	N. East	198905	15/5/1952	Severe
Fellata forest	N. West	5580	-	Total eradication
El-Petrol forest	East	605	15/5/1952	Total eradication
Abu Safia Forest	West	504	15/5/1952	Total eradication

Source: EObaid Forest Department Reports and Field Observation (2019)

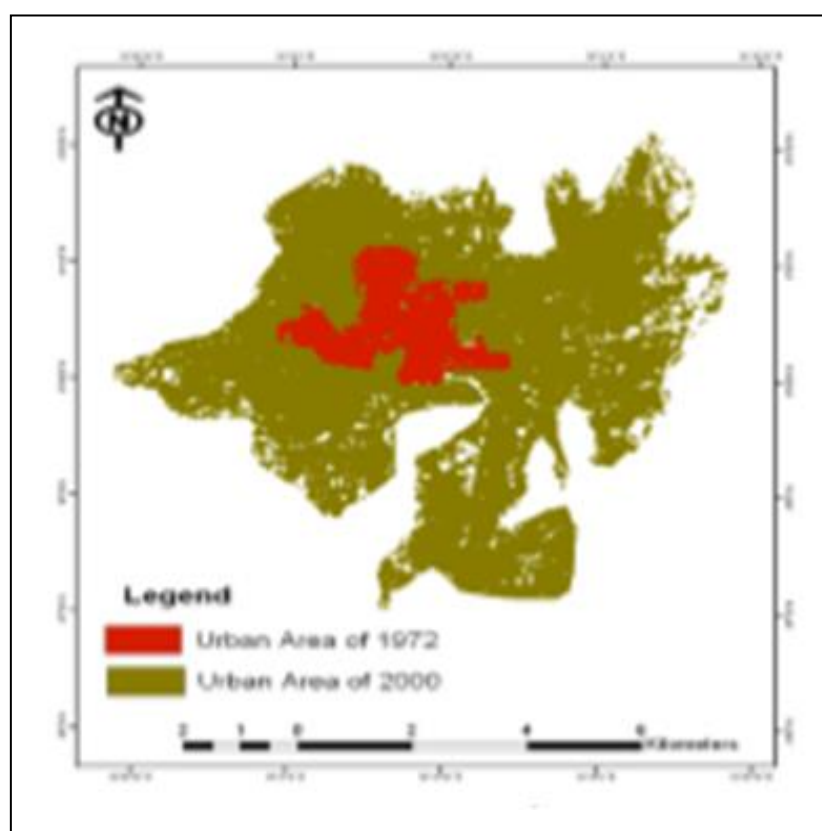


Fig (3) EObaid Town Urban Deforestation

Source: Satellite data Change detection -based processing

6-3 Village level Degradation:

The village level land degradation assessment used village buffering deforestation where the natural land cover changed. Evidences of severe degradation were taken mainly surrounding the villages. As we account degradation we mean natural vegetation degradation surrounding rural settlement, which indicates the reduction in the number as well as quality of species with regards to the vegetation composition. The buffer geo-processing tool was adopted to delineate the spatial extent of surrounding

villages degradation. The tree cover degradation decreases as we go further away from the village's perimeter. On the other hand, real image of tree cover lands degradation was observed along transect distance between villages.

Eight sample villages were selected using Google earth digitizing method Fig (4). These villages were experiencing severe kind of degradation attributed mainly to the over cutting. In the study area extensive deforestation can be found as far as half kilometer (500 meters) from a village mid-point in average.

As far as degradation impacts upon vegetation quality is concerned, the degradation of vegetation on overstocked pastures takes place in sense of qualitative loss. Useful species disappeared and were replaced by unpalatable species, for example, the poisonous scrub *Calotropis procera* (Ushar) has spread widely on exhausted soils. Unpalatable plants, such as *Cassia acutifolia* (senna senna), (horab hausa), and *Guiera senegalensis* (Gubeish) occupy vast areas and replaced palatable pasture grasses, such as *Cenchrus biflorus* (haskanit), and the *Eragrostris* species and *Aristida* species.

6-4 Drought and Environmental Degradation:

Dry lands such as in Sudan are frequently subjected to drought which is the main limiting factor on biomass production and crop yields. Impacts of drought had been stated earlier since 1950s by many writers such as: Lepoled, (1956) who was summarized the problems of environmental degradation in the statement that, "man's use of land usually means a reduction in the diversity of plant and animal species and increase in the rate of

aridity". The ultimate socio-economic impacts of climatic change will depend on the relative resilience and adaptation abilities of different social groups, (Odingo: 2002).

There is measured evidence of long-term regional climate change in several parts of the country mainly Kordofan, Darfur and Northern states. These areas were experienced some kind of fluctuation and marked variability in rainfall. Between the mid-seventies and eighties, the western Sudan was exposed to severe drought due to the changing behavior of the rainfall's frequency and intensity. This caused a significant disturbance in the biomass that seriously affected the socio-economic status of the population (Abu Sin, 1991).

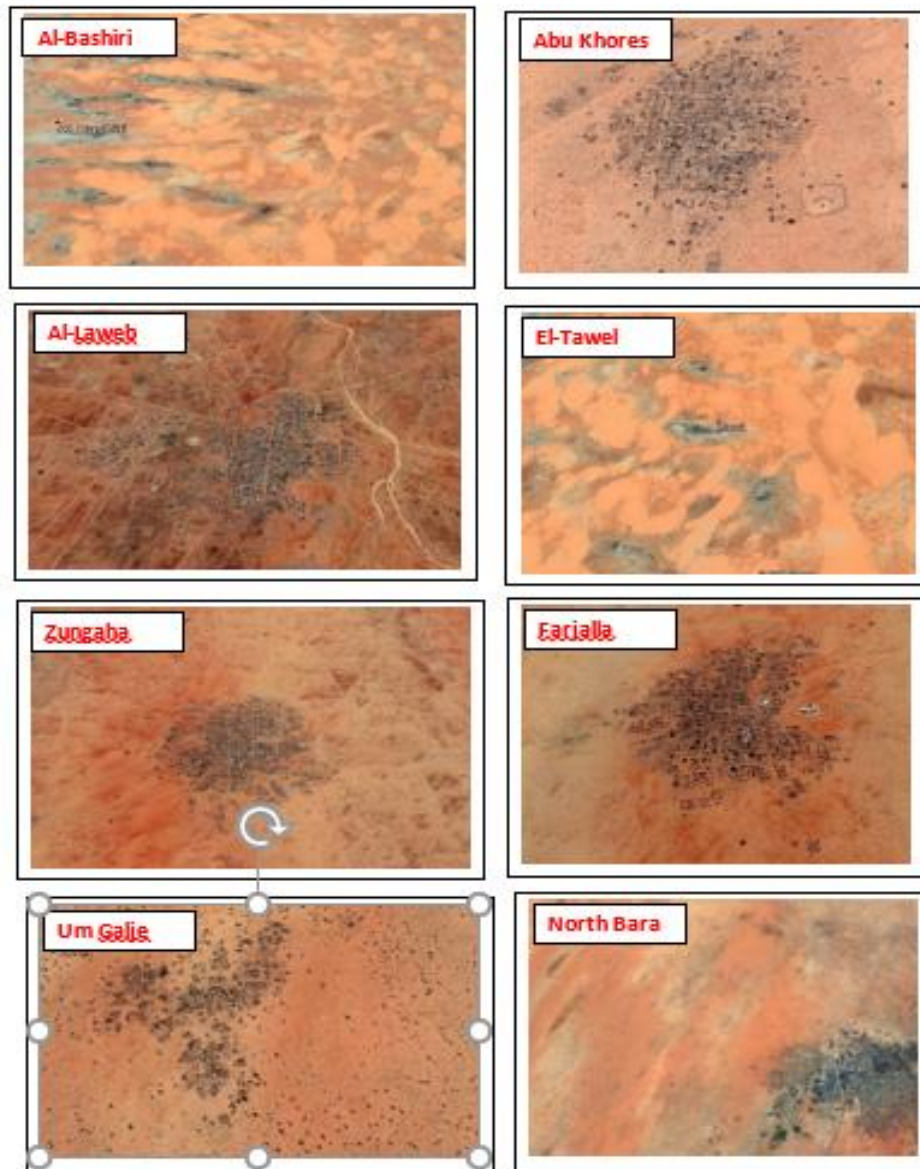


Fig (4): land Degradation Surroundings Settlements

Source: Google Earth digitizing (2020)

Some regional patterns of rainfall can be expressed in terms of variability, trends (upward or downward), and persistence. Frequent drought cycles extending over 2-3 years are common. Episodes of drought are spreading in the State at variable levels of severity. While the 1984 categorized as worst of the earlier manifestation of the drought in the 1980s. Table (5) shows some basic chronological forms and types of drought and its impacts since 1835 (Ibrahim,1984).

Table (5) basic chronological forms and types of drought

Year of Drought	Name and damage	Area Extent
1835-38	"year of famine"	Central Sudan
1888-89	Hundreds of thousands died	Central Northern and Western

Year of Drought	Name and damage	Area Extent
1888-89	No rain for a year, crops failed	Central Northern and Eastern
1890	Locusts	The Nile area
1913	Poor rain – relief brought from India	Northern Sudan mainly
1914	“the year of the flour” from India	Central Sudan
1927	Slight famine	Central and Eastern
1984	“ The great famine”	ALL STATES OF Sudan

SOURCE: Ibrahim (1985): Adjustment to Drought hazard in the Semi-Arid Areas of the Sudan.

Rainfall variability and fluctuations were occurred during 1970s droughts. More significantly, droughts have become more frequent as that presented since 1972 with the most disastrous drought in 1984 Fig (5). From the figure we noticed a downward rainfall trend and below average rainfall that indicated the drought seasons with great variations in their impacts all over the country. The worst drought years were 1983 and 1984, but before that, severe droughts were recorded in 1972, 1973, and 1977. Fig (6) shows the last nine rainfall seasons represents rainfall variability during (2011-2018) as the data concerns the main ElObeid meteorological station in the study area.

The remotely-sensed normalized difference vegetation index (NDVI) is used as a proxy; its deviation from the norm may serve as an indicator of land degradation and improvement if other factors that may be responsible (climate, soil, terrain and land use) are accounted for (Bai, 2008). Therefore, the spatio-temporal analysis of satellite imageries of two main localities in the study area for the seasons 1984 and 1990 were analyzed using NDVI index. The results of these seasons depicted that there was severe drought that affected the vegetation cover over the study area. This interpreted with the NDVI negative values that indicated sparse vegetation cover greenings Fig (7).

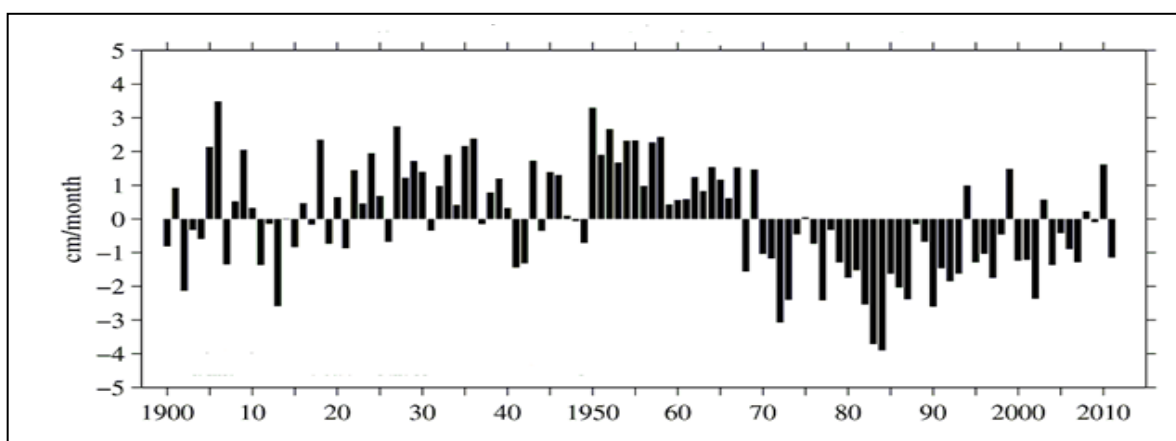


Fig (5): Rainfall Deviation from the Mean (Indicators of Drought Years)

Source: El-Mahi 1990

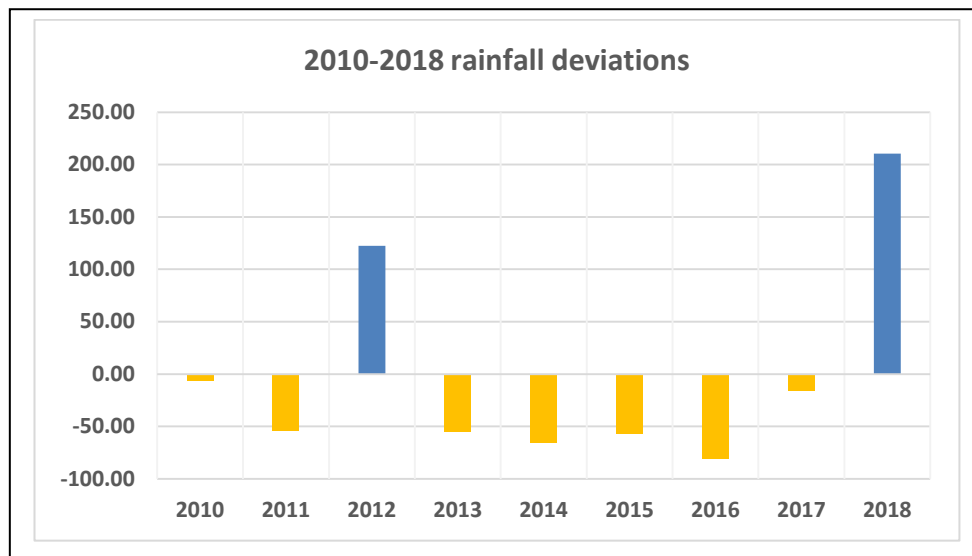


Fig (6): The most recent rainfall deviations in the study area

Source: Meteorological data Khartoum Office (2020)

The extent of drought severity scale is assessed depending on damage occurred to society, resources, economic and production system as well as to population. Land degradation and migration are closely interconnected processes, which are mediated by other intervening social, economic, political, demographic, and environmental processes, operating at scales from the local to the global (McLeman, 2014). Fig (8) presents the population displaced during 1984-85 drought in western Sudan and their destinations.

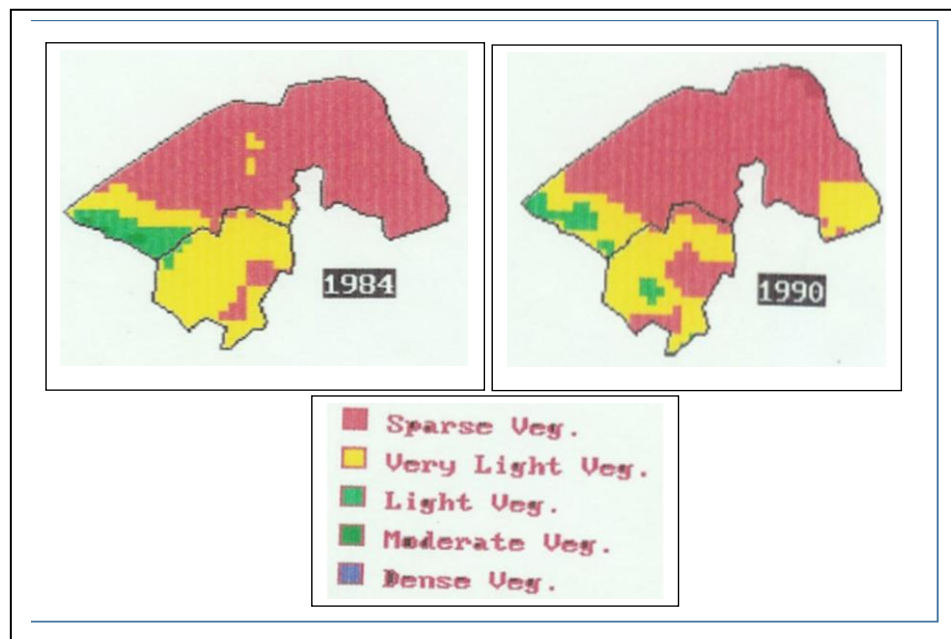


Fig (7): Sheikan and Bara localities NDVI analysis

Source: Satellite data NDVI-based processing

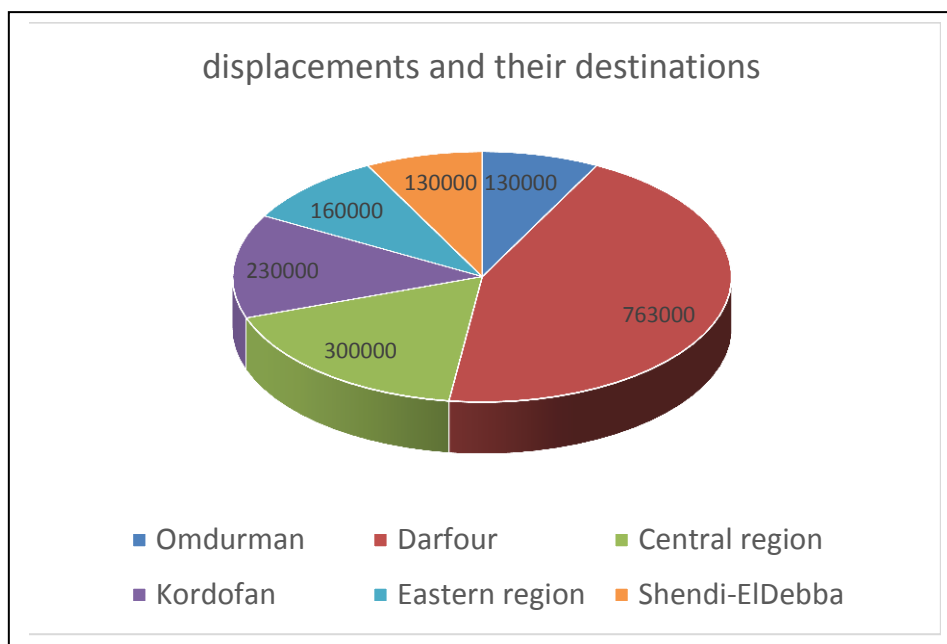


Fig (8): Displaced Population during drought in 1984-8

Source: ELObeid Ministry of Finance Reports (1985)

The study areas, carrying capacity based on pasture office seasonal survey report, is (1575) kilograms of dry forage in average per feddan and (875) kilograms in southern and northern parts respectively. During drought periods (1984 and 1990), it was measured to be (24) kilograms in the north, and (393) to the south. As a consequence of drought, the range land degraded estimated to be slight during (1960s), and severe since 1980s (Range and Pasture Administration (1997)

The study area witnessed mass death of animals during 1980s and 1990s as mortality rate were relatively high for the less drought resistant animals. Cattle and sheep were the first to be affected in all parts of the area.

At the level of village impacts, there were mass loss of thousands of heads of cattle and cows. The researchers support this analysis by taking one village as a case study. Table (6) shows statistical records based on the village council documents village's Sheikh. Before 1984-85 drought and after that, the situation was; (6880), (20996), (22400), (2890), and (2820) heads for cows, cattle, goats, camels and donkeys respectively, while the after drought the situation was (55), (1080), (3700), (221), and (893) respectively.

Table (6): Animals Lost During the Drought in 1984-1985
Case Study from N. Kordofan – Um Shook Village

Animals types	Drought		loss	%	
	Before	After		Remaining	loss
Cattle	20996	1080	19916	5.1	94.9
Cows	6880	55	6825	0.8	99.2
Goats	22400	3700	18700	16.5	83.5
Camels	4890	221	4669	4.5	95.5
Donkeys	2920	893	2027	30.6	69.4
Horses	13	5	8	38.5	61.5

Source: Filed survey focal group discussion and leader's meetings (2020)

The consequences of drought condition upon the human environment were caused a mass death among livestock sector and great loss was recorded over the grater region of Kordofan, table (7).

Table (7) livestock Mortality due to Drought % (1984-85)

Region	Camels	cattle	sheep	Goats
	mortality	mortality	mortality	mortality
Kordofan	10	80	60	20

Source: ELObeid Ministry of Finance Reports (1985)

6-5 Conclusion and recommendations:

- 1- Land degradation in the study area was culminated since the severe drought in 1984 and becoming an environmental problem, which yields socio-economic consequences affected the human activities and the way they manage the land resources.
- 2- The study area was experienced increment in the rate and extent of land degradation. This caused a dramatic change in environmental and forest resources.
- 3- Deforestation in the study area is categorized as an advanced phase of degradation resulting from human interferences (anthropogenic factors). This indicated the fact that the occurrence of deforestation in the study area is associated with the human behavior towards the environment, which are extremely leads to resource over-exploitation attributed to an inappropriate practice, such as daily cutting, open grazing, and shifting cultivation.
- 4- Environmental degradation caused one of the extreme impacts that is social and population displacement. The 1980s was witnessed the high rate of displacement over the western Kordofan includes the study area. The mass displaced rural population was measured during the drought of the 1984-85 and the people moved towards the towns and cities as documented by World Food Program (1988).

- 5- With the advanced of the environmental degradation, quality of life is continuously degrading and all living elements being suffering from its impacts. Based on this fact, the study area witnessed remarkable social, environmental and economic transformation
- 6- The extent of drought severity scale is assessed depending on damage occurred to society, resources, economic and production systems. Increased frequency of rainfall variability was caused unexpected dry spells that has an adverse impact upon natural landscapes. All these will lead to more land degradation.
- 7- At the spatial extent, the study area progressively deforestation can be occurred a buffer ranges between half to one km from the village center.
- 8- The qualitative trend of land cover degradation is appeared in the loss of tree and grass species, which have an environmental value of conservation and prevention. Over the study area, value species such as Hashab (Acacia Senegal) were degraded severely during 1980s, while less value species were replaced and covered large areas such as Usher (Calotropis Procera).
- 9- Shifting cultivation as declared by the indigenous, is the major factor behind forests depletion due to the rapidly shifting cultivation expansion by the farmers seeking more fertile land as one of the drought coping mechanism.
- 10- The level of degradation has increased basically attributed to the poor environmental awareness as well as poor environmental management at the scale of local society and the environmental governance.

Recommendations.

- 1- Based on the lack of societal attitudes towards the environment and less attention about land tenure management, the need for adopting eco-political approach in managing environmental issues is of great important and urgently recommended.
- 2- Forest lands are converted to many other land use patterns, such as, urban new extensions and to farms land. The monitoring and assessment using spatial analysis with remote sensed data and change detections techniques are the potential for decision makers to updating the planning and policies of the land resource management.
- 3- For the benefits to recover the land degradation, multi responsibilities should be involved. Local community, civil organization and environmental governance, only with collective approach can formulate appropriate strategy for environmental conservation and rehabilitation.

References.

- Abu Sayeed (2014): Causes and Consequences of Land Degradation "Conversion of Agricultural land to Non-Agricultural usages in Bangladesh: A case study on 'Keyain' village of Munshigonj District". Södertörn University | School of Life Sciences Master's Thesis. Environmental Science.
- ABU Hammad, A. and A. Tumeizi (2010): Land degradation: socio-economic and environmental cause and consequences in the eastern Mediterranean. Published online in Wiley Online Library, DOI: 10.1002/ldr.1069.
- Abu Sin, Mohamed EL Hadi (1991): Forms and types of Disaster and Hazards in the Sudan. Proceedings of the National Seminar on Disaster Prevention and Management in Sudan 17-19 March 1990, UofK and UNESCO Regional Office in Arab States (UNEDBAS) – Sudan.
- Anderson, Elina; Sara Brogaard , and Lennart Olsson (2011): The Political Ecology of Land Degradation. *Annu. Rev. Environ. Resour.* 2011. 36:295–319.
- Ayoub, Ali T., (1998). Extent, severity and causative factors of land degradation in the Sudan, *Journal of Arid Environment*, 138, 397-409.
- Badi, Kamal Hassan and Mohamed Bayoumi (1989): The Forests of the Sudan. Unoversity of Khartoum, Faculty of Forests.
- Bai, Z. G., D. L. Dent, L. Olsson, M. E. Schaepman (2008): Global Assessment of Land Degradation and Improvement: Identification by remote sensing. GLADA Report 5 Version November 2008.
- Dafalla, Mohamed Salih (2006): Mapping and Assessment of Land Use/Land Cover Using Remote Sensing and GIS in North Kordofan State, Sudan. Doctor of Natural Science. Institute of Photogrammetrie und Fernerkundung, Technische Universität Dresden.
- Eric F. Lambin aand Patrick Mayfroidt (2010): Global land use change, economic, globalization and the looming land scarcity. *PNAS* March 1.2011, Vol.108 no 9 3465-3472.
- GLASOD-ISRIC (1991): Global assessment of soil degradation. Combating aridity, soil erosion, salinity, water-logging, desertification and the effects of drought in South Asia.
- Ibrahim, F. N. (19984): the problem of overgrazing and ecological degradation in the Republic of Sudan. *At-Tasahhur*, vol. (2).
- ICRISAT (2015): Rejuvenating Degraded landscapes. Revived land. New agricultural livelihoods. Rural Communities pulled out of poverty.
- IPCC SRCCL (2019): Land Degradation, chapter four in the Final Government Distribution. Coordinating Lead Authors: Lennart Olsson (Sweden), Humberto Barbosa (Brazil).
- Joachim von BraunFranz W. Gatzweiler (2013): Land Degradation, Poverty and Marginality. Addressing the Nexus of Poverty, Exclusion and Ecology. Springer is part of Springer Science+Business Media (www.springer.com).

- Jouanjean. Marie-Agnes, Josephine Tucker and Dirk Willem te Velde (2014): Understanding the effects of resource degradation on socio-economic outcomes in developing countries. Shaping policy for development, odi.org. www.odi.org/sites/odi.org.uk/files/
- Lepold (1956): Quoted by Mother (1980): Land - use- long man group (FE) Hong Kong.
- El-Mahi, Yousef (1990): Aspects of degradation resilience and change in relation to major environmental deforestation in Semi-arid parts of Kordofan region- Sudan. PhD, unpublished, University of Durham, department of Geography.
- McLeman, Robert (2017): MIGRATION AND LAND DEGRADATION: Recent experience and future trends. GLOBAL LAND OUTLOOK WORKING PAPER. Wilfrid Laurier University.
- Morris, Julian (1995): The Political Economy of Land Degradation Pressure Groups, Foreign Aid and the Myth of Man-Made Deserts. Published by the IEA Environment Unit.
- Nkonya, Ephraim, Alisher Mirzabaev and Joachim von Braun (2016): Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development. Springer Open.
- Odingo, R. (2002): Adaptation Projects and Climate Change in Africa; Current Weather Outlook for the IGAD Region. <http://lion-meteo.go.ke/can/impact!adaptation.htm>
- Olsson, Lennart, Suruchi Bhadwal, Humberto Barbosa and Annette Louise Cowie (2019): Land Degradation. Publisher: The Intergovernmental Panel on Climate Change (IPCC), pp.345 - 436
- Cite this publication
- Pani, Padmini & Paul Carling (2012): Land degradation and spatial vulnerabilities: a study of inter-village differences in Chambal Valley, India. Journal of Asian Geographer, Volume 30, 2013 - Issue (1).
- Prince, S., Von Maltitz, G., Zhang, F., Byrne, K., Driscoll, C., Eshel, G., Kust, G., Martínez-Garza, C., Metzger, J. P., Midgley, G., Moreno-Mateos, D., Sghaier, M., and Thwin, S. (2018): Status and trends of land degradation and restoration and associated changes in biodiversity and ecosystem functions. Chapter 4 - In IPBES.
- Rajiv Chopra (2016): Environmental Degradation in India: Causes and Consequences. International Journal of Applied Environmental Sciences ISSN 0973-6077 Volume 11, Number 6 (2016), pp. 1593-1601.
- Range and Pasture Administration (1997): Report on Fire and Pasture Carrying Capacity- Kordofan, Sudan, El Obeid. Annual files reports.
- Reynolds J, Stafford Smith M, Lambin E, Turner BL II, Mortimore M, Batterbury SPJ, Downing TE, Dowlatabadi H, Fernández RJ, Herrick JE, Huber-Sannwald E, Jiang H, Leemans R, Lynam T, Maestre FT, Ayarza M, Walker B (2007): Global desertification: building a science for drylands development. Science 316:847–851.
- Robert McLeman (2017): Migration and Land Degradation: Recent experience and future trends. Global land Outlook Working Paper. United Nation Convention to Combat Desertification.

- Saodat Olimova and Muzaffar Olimov (2012): Environmental Degradation, Migration, Internal Displacement, and Rural Vulnerabilities in Tajikistan. The International Organization for Migration Development Fund.
- Salehi, Pourya and Michael Woodbridge (2017): Land degradation and cities: The essential role of local and regional governments. CLEI Briefing Sheet, No. 3 - Land Degradation and Cities.
- Singh, Katar (2009): Environmental Degradation and Measures for Its Mitigation with Special Reference to India's Agricultural Sector. Ind. Jn. of Agri. Econ. Vol. 64, No. 1, Jan.-March 2009.
- UNEP (1991): "Status of Desertification and Implementation of the UN Plan of action to Combat Desertification" UNEP, Nairobi, 88p.
- United Republic of Tanzania (2016): Reversing Land Degradation trends and increasing Food Security in degraded ecosystems of semi-arid areas of Tanzania – GEF 9132. Report No. 4364-TZ East and Southern Africa Division Programme Management Department
- WMO (2005): WMO-No. 989, World Meteorological Organization ISBN 92-63-10989-3
- Zaman. Khalid, Himayatullah Khan, Muhammad Mushtaq Khan, Zohra Saleem and Muhammad Nawaz (2011): The impact of population on environmental degradation in South Asia: application of seemingly unrelated regression equation model. Environmental Economics, Volume 2, Issue 2.