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Effect of Climate Variabilty and Change on Agricultural Resources in Gedaref State- Sudan

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ABSTRACT:

Gedaref is one of the most important States in which significantly contributes to food security in Sudan since, where about 11 million fed, is cultivated every year with field crops for domestic consumption as well as for export. In recent years, the natural resources and agricultural productivity showed continuous trend of deterioration as a result of climate change. Therefore, it became necessary to quantify the causes of agricultural resources deterioration and yield drop. Times series data pertaining climate, agricultural production, and vegetation cover for the period 1981-2012 were collected. The results of the data analysis showed an increased temperature, fluctuation of average annual rainfall, land and vegetation cover deterioration, drop in crop yield, including Sorghum and Sesame, in addition to wide spread of different pests and diseases. The study concludes that the irrational human activities and natural calamities are the causal of climate variability and change in the study area. The study recommends the introduction of new cropping pattern with emphasis on crops adapted to the new climatic conditions, establishment of agro-forestry, introduction and enforcement the rules and laws which regulate land use, natural resources utilization and conservation, encourage water harvest and spread techniques, particularly in the marginal and fragile ecosystems.

KEYWORDS: *Food security, domestic, quantifies, Sorghum. Cropping pattern*.

1. INTRODUCTION

Climate change

Climate change has several definitions; the precise one is a change in weather patterns over periods ranging from decades to millions of years, or any change in climate over time as a result of natural variability or human activity (IPCC, 2007). Its history is debatable, but, it is important to know when the climate change began? What are the driving forces? What are the consequences? Answer to such questions enables to understand this phenomenon and mitigate its severity.

However, many researchers refer the beginning of climate change to the era of industrial revolution in the 17th_ Century, while others dated back to the 19th_ Century, during the ice ages (Pantic, N., 1998), when others referred to natural changes in paleoclimate (long term climate) as well as the natural green house effect when first identified (Holli, 2005).

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Nevertheless, theories attribute climate change to volcanic forces, solar radiation and increasing carbon dioxide concentration. Generally, various interrelated and interacting forces are believed to be the cause of climate change, among these: biotic such as human activity and a biotic process like variation in solar radiation, tectonics movement and volcanic activity (Croll, 1875),

Climate variability and change:

Rainfall has direct relationship with the air. A warmer climate accelerates the hydrologic cycle, altering rainfall, magnitude and timing of run-off, increases surface moisture evaporation. Goyal (2004), stated the climate change has direct impact on crop evapotranspiration (ET). He addedthat higher temperatures and changing precipitation patterns will severely affect the production patterns of different crops as well as the agricultural productivity due to the increase of carbon dioxide in the atmosphere.

Despite, the fact that Sorghum is heat tolerant crop, but its ability to grow and produce yield at low rainfall areas can be affected by drought, (Abdalla, 2011).

Impact of climate change on:

- **Vegetation cover**

The vegetation cover in the study area varies according rainfall variability. In the northern part, particularly south to Latitudes 14^0 40' which is characterized by low rainfall, poor grazing plants, Camels, goats and sheep are the main animals found in this zone. Agricultural activity is limited to valleys and seasonal streams. Recently, Gold exploitation began.

The area that lies south to the Latitudes 14^0 40', enjoys good amount of rainfall, therefore, different plant species such as grasses and trees, especially *Acacia . seyal* and *Balanites aegyptiaca* are common. And rain-fed farming is widely practiced. The main grown field crops are sorghum, sesame, millet, sunflower and cotton. Some horticultural crops also grown in the valleys and along the seasonal streams after the rainy season (Sulieman, 2009).

Forest: It is a valuable resource from economic, social and environmental aspects. The alteration of human to the forest ecosystem; led to forest deterioration in quantity and quality. Moreover, the essential ecological services provided by biodiversity like oxygen, soil stabilization, and water purification, nutrient cycling are reduced. (Curran 2000).

Rangeland: Range land devoted for livestock production represents one of the largest land-use systems in Gredaref State. Range contributes to the income and subsistence of a large sector of pastoralists and agro-pastoralists communities (Sudan R-PP.).

Range in Gedaref State is very important and covers a big area extending from desert and semi-desert in the north to low and high rainfall savannah to the south. In the extreme north, rangeland cover is a mixture of grasses, herbaceous plants, *Acacia* trees and shrubs while in the low rainfall savannah on clay and sand is

a mixture of *Acacia* species, shrubs and a number of herbaceous plants (Ministry of Environment, Forest and Physical Planning, Higher Council for Environment and Natural Resources, (2011).

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- ***Crop Productivity:***The impact of Climate change on agriculture resulted from the complex interrelated and interacted processes at local, regional and global scales. The effect of climate change on agriculture can be viewed from different ways including changes in climate extremes (climatic elements such as temperature, rainfall humidity), changes in fauna (wild life, pests and diseases), demography and flora, change in sea level, nutrition value and food quality. Furthermore, changes in atmospheric carbon dioxide and ozone concentration both of which take place on global scale (Jerry, 2012).
  In Gedaref State, Rain-fed Mechanized Farming System along with policy are perceived as the main cause of environmental degradation, vegetation cover disintegration, habitat and biodiversity loses (EL Siddig, 2012).
- **Pests and diseases**:Studies showed that both pests and diseases have negative impacts on the genetic variability within the crops. The incidences increase with the increase in humidity (Alhadary, etal., (2007).

Rain-fed Mechanized Agricultural development in Gedaref State

Rain-fed, especially the mechanized farming was developed and established on the account of the thick forests and other plant species in the central clay plain. This development necessitated the removal ofmassive vegetation cover without replacement. However, four phases of Rain-fed Mechanized AgriculturalDevelopment are known in Gedaref area, as shown in table (1):

1. Table (1): Agricultural area development in Gedaref during 1945-2008

Period	Area in million fed.
1945-1954	0,039,124
1955-1967	0,500,000
1968-1978	2,800,000
1978-1995	8,000,000
1996-2008	11,000,000

(Source: Fedral Ministry of Agriculture and Forestry- Khartoum 2012)

11. MATERIAL AND NETHODS

2.1 Study Area

Gedaref State is located in the Eastern part of Sudan. It is situated in the arid and semi-arid zones, within the latitudes 12^0 30'-16^0 30' N and Altitudes 33^0 35'-36^0 35' E, with total area of 17m km^2 (17 million fed.).

The study area is situated in arid and semi arid regions, where the temperature is high in summer season, that could reach to more than 32.6 ^{0}C, and drops in winter to reach to about 26.6 ^{0}C. The average annual rainfall is about 200-400 mm in the north part of the state, and gradually increases from the north to the south, where the average annual rainfall could be between 600 to 800 mm**.** The rainy season lasts for 4-5 months. Therefore the distribution of vegetation follows the pattern of rainfall distribution (Department of Meteorology, Khartoum, 2012).

The area is a vast plan that lies in the central clay. The soil belongs to Fertizol, Enceptizol, Alfizol and Entizol families, with pH ranging between 7.3-8.7. The area is gently sloping, with

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some low lands and isolated scattered plateaus; particularly in the eastern part. Several seasonal streams are running across the area.

Data Collection and Analysis

Time series datapertaining to climate (temperature, humidity, and rainfall),crop production, average yield, areaunder cropping, animal wealth, vegetation cover, for the period of 1981-2012 was collected from different sources such the Ministry of Agriculture, Animal Wealth and Irrigation-Gedaref State, libraries, Department of Meteorology, Non Governmental Organization (NGOs) in addition to direct interviews with the local communities as well as the government officials. The said data was analyzed. The results of data analysis were presented in form of tables, histograms.

111. RESULTS AND DISCUSSION

Table (2): Rainfall in gedaref area during the period 1961-2012

Season	Rainfall mm
1961	750
1965	300
1969	800
1973	300
1977	970
1981	650
1985	200
1989	900
1993	200
1997	870
2001	300
2005	200
2009	500
2012	400

Source: Department of Metereorolgy Gedaref (2012)

Table: (3):Climate Normals-Al Gedaref Area during the period (1961–2012)

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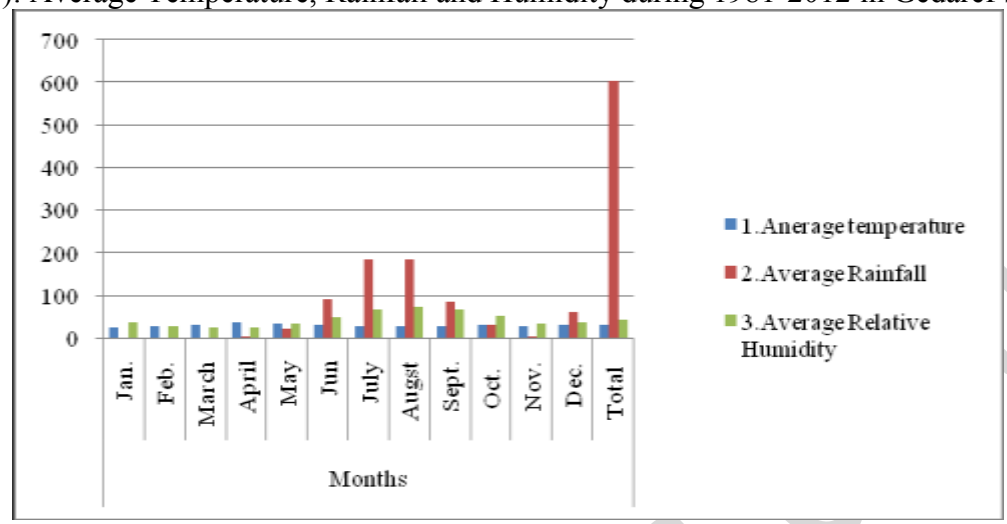
Figure (1): Average Temperature, Rainfall and Humidity during 1981-2012 in Gedaref State



The rainfall in the study area (Table 2 and Fig.1) showed a general trend of decline in the average annual precipitation,inter and intra seasonal. The lowest amount of average annual precipitation was 200 mm in 1985, 1993 and 2005 respectively, and 300 mm in 2001. Drought and famous famine occurred during1985. The, rainfall scarcity, fluctuation and frequent droughts badly affected the agricultural resources including the vegetation cover, particularly the forest and the range, when millions of animal wealth were lost due to shortage in grazing plants. The situation was aggravated by high temperature during the summer, and autumn (table 2, and Fig 2).

Temperature Changes: for the long term, monthly temperature records revealed an increasing trend in temperature about 1.5 ^{0}C.

Climatic Factors	Months												
	Jan.	Feb.	March	April	May	Jun	July	August	Sept.	Oct.	Nov.	Dec.	Total
1. Average temperature	25.5	27.5	30.3	37.7	32.7	30.1	27.1	26.3	27.4	29.3	26.6	28.7	28.7
2.Average Rainfall	0	0	0.5	3.4	21.2	90.9	183.4	184.4	85.5	31.4	3.0	60.3	603
3.Average Relative Humidity (RH)	35	28	25	23	33	49	66	71	65	50	33	36	42.8

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Table (4): Season, area (fed.) and yield of Sorghum in Gedaref State during 1981-2012

Season	Area/fed.	Yield kg/fed.
1981-1982	2,039,655	529
1982-1983	2,960,972	194
1983-1984	3,032,623	151
1984-1985	1,459,260	140
1985-1986	3,104,200	279
1986-1987	3,170,000	328
1987-1988	2,635,750	111
1988-1989	3,551,000	397
1989-1990	2,958,000	142
1990-1991	1,826,000	101
1991-1992	3,943,050	167
1992-1993	4,000,000	186
1993-1994	2,882,000	158
1994-1995	4,200,000	214
1995-1996	3,272,000	168
1996-1997	5,154,250	224
1997-1998	3,280,000	156
1998-1999	4,601,249	296
1999-2000	2,869,235	133
2000-2001	2,912,000	162
2001-2002	3,440,700	143
2002-2003	2,631,753	147
2003-2004	4,187,370	211
2004-2005	2,188,868	102
2005-2006	3,767,139	200
2006-2007	3,714,790	155
2007-2008	3,652,589	159
2008-2009	3,416,000	160
2009-2010	2,519,469	112
2010-2011	4,305,893	195
2011-2012	2,905,521	139

Source: Ministry of Agriculture, Animal Resources and Irrigation, Gedaref State, 2012

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Table (5): Season, area (fed.) and yield of Sesame in Gedaref State during 1981-2012

Season	Area/fed.	Yield kental/fed.
1981-1982	250,000	4.0
1982-1983	220,000	2.5
1983-1984	519,490	2.2
1984-1985	286,670	1.8
1985-1986	431,125	3.1
1986-1987	473,000	3.0
1987-1988	455,000	2.7
1988-1989	357,000	2.8
1989-1990	350,000	2.0
1990-1991	400,000	2.5
1991-1992	400,000	2.5
1992-1993	1,200,000	3.0
1993-1994	500,000	2.0
1994-1995	627,000	1.8
1995-1996	1,250,000	2.8
1996-1997	1,031,000	2.9
1997-1998	854,000	2.3
1998-1999	623,998	1.7
1999-2000	1,118,662	1.9
2000-2001	966,000	1.7
2001-2002	657,700	1.6
2002-2003	409,000	1.8
2003-2004	965,920	2.7
2004-2005	704,920	1.9
2005-2006	685,355	2.1
2006-2007	543,236	2.0
2007-2008	475,404	1.7
2008-2009	457,255	3.1
2009-2010	486,623	3.0
2010-2011	567,861	2.9
2011-2012	366,562	2.3

Source: Ministry of Agriculture, Animal Resources and Irrigation, Gedaref State, 2012.

Tables 4 and 5,present areas under cultivation and yield of Sorghum and Sesame in Gedaref State throughout the period from 1981 to 2012. Despite the importance of Sesame as cash crop, but the area under Sorghum always greater than the area cultivated to sesame. As far as yield concern, it is a function of seasonal rainfall in addition to other factors such as pests and diseases. During the period before 1981, when the rainfall was high, high yield was attained. During the season 1981/1982, the yield of Sorghum and Sesame was 529 kg/fed and

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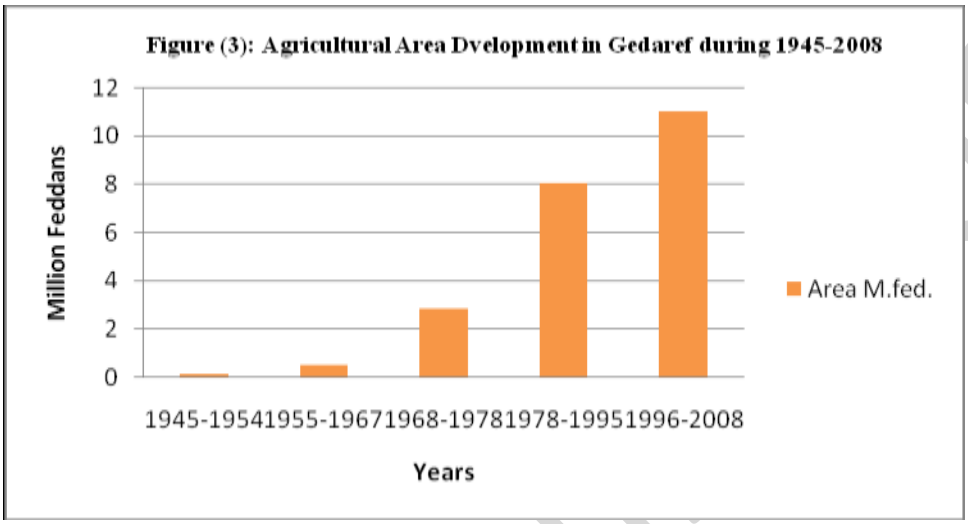
1.8kental/fed respectively. For the seasons 1984/85, 1990/91, 20001/2002 and 2007/2008, and the yields were290, 101,143, and 159 kg/fed, for Sorghum, and 1.8, 2.5, 1.6, and 1.7 and kental/fed. for Sesame respectively. The fluctuation inarea under cultivation in tables 3 and 4 can be attributed to rainfall, production of the previous season, marketing, and farmer's decision.
The dry weather conditions not only affect the crop production, it also hit pasture and water source on which the livestock lives.

Fig.3: Agricultural area development in Gedaref during 1945-2008



From table (4) and figure (2), due to anthropogenic activity, a tremendous land transformation has taken place during the period from 1945 to 2008, where progressively over eleven (11) million fed. of forest land was cleared, changed to arable agriculture land.

1V. CONCLUSION AND RECOMMENDATIONS

Conclusion

Anthropogenic activity and natural calamities are the direct or indirectly responsible for climate change in the study area. This change has negative impacts on food security, animal wealth, human health, water source, vegetation cover and other environmental elements.

Recommendations

Introduction of new cropping patterns that suite the new environmental conditions; such as heat and drought tolerance, early maturing varieties. Adoption of water harvesting and spread techniques. Introduction of a forestation and community forest programs. Rules and laws to be formulated with the participation of the communities.

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