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Impact of Climate Change on Field Crops Production in Zalingei locality, Central Darfur State,Sudan

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ABSTRACT: The current study was conducted in Zalingei locality-Central Darfur state during 2014/2015 cropping season. In this area climate is generally typical to poor and rich savanna that is locally modified by the effect of the position of Jebel Marra massif (3040 masl). Climate change is a putative threat to crop production and rural livelihoods. Crops grown include sorghum, millet, groundnut, sesame, potatoes, sweet potato, onion, tomato, sugar cane and tomatoes. The main objectives of the study were to assess the impact of climate change on agriculture production, Estimate how climate change affects the current agricultural system and project potential climate change and the options of adaptation in the study area. Questionnaires and group discussion were applied. Multi-stage random sampling technique was used. Data used covered period from 1990 – 2014, and subjected to frequency distribution using SPSS software plus Excel, correlation and multiple regression to establish the type and strength of relationship and effect of parameters on yields. Frequency distribution of farmers perception to climate change stated that production decreased and increased by 50 and 20%, while 20 and 10% said constant and don't know, respectively. The correlation analysis results between climatic variables and crop yields (1990 -2014) revealed that total rainfall is weakly positively correlated with millet (.015) and sesame (.281) and minimal negatively correlated with groundnut (-.029). While the higher the rainfall resulted in decrease of groundnut yield. Rainfall correlation with sorghum (.344*) was found to be statistically significant at five percent from zero level. Average temperature was modest positively correlated with sorghum (.313), sesame (.322) while it is almost minimal with groundnut (.002) and smallest negatively correlated with millet (-.205). Relative humidity was found smallest positively correlated with sorghum (.111), Groundnut (.102) and sesame (.117) while smallest negatively correlated with millet (-.142). The regression analysis recorded for yield crops indicated that millet, sorghum, groundnut and sesame have coefficient of determination percentage of 6, 24, 1.2, and 20.4 %, respectively. The results also showed that total rainfall and temperature were significant at five percent from zero level in sorghum (.066* and .087*) and sesame (.093*) respectively. The study concluded that climatic impact of total rainfall; temperature and relative humidity were highly significant on crop yield , while the other factors has no significant impact on crop yields.

***Keywords*:** Climate change, Field crops, Correlation, Regression, Central Darfur.

INTRODUCTION

Sudan is one of the most vulnerable continents to climate change and climate variabilityin Africa. This situation is aggravated by the interaction of multiple stresses occurring at various levels, such as endemic poverty; institutional weaknesses; limited access to capital, including markets, infrastructure and technology; ecosystem degradation; complex disasters and social conflicts. These in turn have weakened people's adaptive capacity, increasing their vulnerability to projected climate change (Zakieldeen, 2009). Sudan is one of the driest but also the most variable countries in Africa in terms of rainfall. Extreme years (either good or bad) are more common than average years. Rainfall, on which the overwhelming majority of the country's agricultural activity depends, is erratic and varies significantly from the north to the south of the country. The unreliable nature of the rainfall, together with its concentration into short growing seasons, exacerbated the vulnerability of Sudan's rain fed agricultural systems. Mean annual temperatures vary between 26ºC and 32ºC across the country. The most extreme temperatures are found in the far north, where summer temperatures can often exceed 43ºC and sandstorms blow across the Sahara from April to September. These regions typically experience virtually no rainfall, while in the southern regions, climatic conditions are more equatorial with average annual rainfall over 1,000 mm/year (Fadel-El Moula, 2005; NAPA, 2007). Climate in Central Darfur is generally typical to poor and rich savanna that is locally modified by the effect of the position of Jebel Marra massif (3040 masl). Three seasons characterized much of the area, summer is generally dry, hot and short, extending from March to May. The rainy season (June – October) is warm to moderately cool while winter is relatively cool and extending from November to winter and Autumn seasons. The mean maximum (March-June) and minimum (January) temperature were 30^0C and 20^0C respectively. Rain fall ranges from less than 450 mm in the northern parts to 500 – 600 mm in the southern parts, while that of the highlands is 650 – 800 mm (Abusarra,1996). Nowadays rainfall variability and unreliability, floods, often have devastating effects on agriculture. Rainfall variability results in reduction in soil moisture, and consequently a decline in agricultural productivity. Though these drought episodes may be natural in occurrence and origin, it is important to note that their severity is as a result of over-grazing, farming on marginal lands and deforestation from wood gathering for fuel and bricks making. Erratic rain fall have led to hunger and famine, as cereal productions dropped. Many cattle were seriously affected and died during the 2014. In Central Darfur state Climate change is a putative threat to crop production and rural livelihoods. While the poor people in general are the most vulnerable to climate change, the vulnerability of people and their agricultural systems is very complex due to interacting direct and indirect climate-related stresses. Year to year variability in climate already contributes to rural food insecurity and poverty where exposure is high and adaptive capacity is low. Climate change is already being felt in terms of gradual increases in temperature, increased variability in annual rainfall regimes and a greater prevalence of extreme events such as drought. Zalingei locality was located between latitude 14^0 – 12^0 30 N and 23^0 – 22^0 30 E. The rainy season start towards the end of June and last till October while dry season begin November and ends in mid June. Total annual rainfall is between 450 to 500 mm and mean temperature of about 25 to 27°C. The soil of the study area is clay and alluvial soils along the main valleys. Crops grown include sorghum, millet, groundnut, sesame, potatoes, sweet potato, onion, tomato, sugar cane and tomatoes. Temperature affects cereal and oil crop production by controlling the rate of physio-chemical reaction and rate of evaporation of water from crops and soil surface. Studies have shown that productivity especially in tropical crops will decrease with increase in temperatures as a result of global warming (Olawepo, 2011). Plant development depends on high atmospheric humidity in the sense that many plants have the ability to directly absorb moisture from air of high humidity.

MATERIALS AND METHODS

Data on three weather parameters (temperature, total rain fall and Relative humidity) were gathered from jebel Marra project in order to be regressed with Millet, Sorghum, Groundnut and sesame yields (ha). Fifty households were selected through questionnaires while group discussion was performed to recognize farmers perceptions to climate change. Data used covered period from 1990 – 2014 for yield and climatic data (temperature, total rain fall and relative humidity) and then subjected to frequency distribution by using SPSS software, Excel, correlation and multiple regression to establish the type and strength of relationship and effect of parameters on yields.

Descriptive statistic

Frequency distributions are used to display information about where the scores in a data set fall along the scale going from the lowest score to the highest score. Second, measures of central tendency, or averages, provide the best single numbers to use in representing all of the scores on a particular measure. Third, measures of variability provide information about how spread out a set of scores are. Fourth, the original raw scores one collects are often transformed to other types of scores in order to provide the investigator with different types of information about the research participants in a study. As standard score is a very good example of a transformed score that provides much more information about an individual subject than a raw score can (pierce, 2010).

Correlation coefficient

A correlation coefficient is a single number that represents the degree of association between two sets of measurements. It ranges from +1 (perfect positive correlation) through 0 (no correlation at all) to -1 (perfect negative correlation). The Pearson Product-moment Correlation Coefficient is a measure of the correlation (linear dependence) between two variables X and Y, giving a value between +1 and −1. It is widely used in the sciences as a measure of the strength of linear dependence between two variables (Strode,20`15). Linear relationships between variables can be quantified using the Pearson Correlation Coefficient, as follows

$$r_{XY} = \frac{\sum(X-\overline{X})(Y-\overline{Y})}{nS_XS_Y}$$

The value of this statistic is always between -1 and 1, and if X and Y are unrelated it will equal zero.

Multiple regression

Multiple regression is a statistical tool that allows you to examine how multiple independent variables are related to a dependent variable. Multiple regression is regression with two or more independent variables on the right-hand side of the equation (Baker, 2006). Regression equation can be expressed as follows:

yi = β0 + β1x1… + β2x2 + β3x3 …………..n + (εi)

Where ***Y*** is an observed score on the dependent variable (Stand for yield), *β0* is the intercept, *β* is the slope, ***X*** is the observed score on the independent variable (Stand for total rain fall, average temperature and relative humidity, respectively), and *εi* is an error or residual.

RESULTS AND DISCUSSION

Farmers perception to climate change on field crops production

Respondents were asked about the impact of climate change on their field crops, the majority stated that production decreased by 50% while 20 % said increased, 20% said constant and 10% said don't know in Zalingei and Azum localities, respectively. This results implies that climate change has an eminent effect on farmers crop production, accordingly intervention through adaptive research is vital in the study area, Table 1.It seems plausible that the 20% farmers those have stated an increase in their crop production might have adopted strategies to maintain satisfactory productivity.

Table 1. Farmers perception to climate change on field crops in Zalingei locality

Particular	Frequency	Valid percentages %
Yield decreased	25	50
Yield increased	10	20
Yield constant	10	20
I don't know	5	10
Total	50	100

Source: Author 2014

Performance of yield data, Zalingei locality

Table 2 showed that the highest yield (Kg. /ha) for the growth period (1990 - 2014) for millet (1688.5) was obtained in year 2014 followed by (1131) in year 1990, while the lowest yield (238) was in year 2001 followed by (478) in year 1992. The highest yield of sorghum (1031) was in the year 2012 while lowest (395) was in the year 2001. Groundnut gave highest yield (1989) in year 1990 accordingly; the lowest yield (474) was in year 2000. Sesame performed highest yield (657) in year 2012 and lowest yield (35) in year 2000.

Table 2. Crop yield (Kg./ha), Zalingei locality (1990 – 2014 cropping seasons)

Years	Millet	Sorghum	Groundnut	Sesame
1990	1131	510	1989	140
1991	891	745	950	154
1992	478	696	626	166
1993	619	504	789	287
1994	515	777	1112	240
1995	814	920	785	225
1996	596	798	890	201
1997	670	810	655	176
1998	915	398	1020	160
1999	840	510	580	56
2000	250	488	474	35
2001	238	395	1762	157
2002	660	714	762	159
2003	555	762	1167	191
2004	526	821	643	215
2005	510	712	952	243
2006	629	476	726	271
2007	498	710	500	186
2008	655	717	876	165
2009	690	410	1857	149
2010	714	710	707	140
2011	636	517	1640	226
2012	900	1031	676	657
2013	1129	610	671	139
2014	1688.5	950.1	1918.2	88.1

Source: Author 2014

Meteorological data for the period of 1990 – 2014, Zalingei locality

Results revealed that the highest total rainfall in mm (968.2) was occurred in year 1999 and the lowest (354) was in the year 2013. The study also indicated that the average temperature C^0 (28.8) was in year 1997 while the lowest temperature (21.4) was in year 1998. With reference to the same table, the highest relative humidity in percentages (53) was in year 2012 while the lowest (26.3) was in the year 2002, (Table 3).

Table 3. Total and average climatic data (1990 – 2014 cropping seasons), Zalingei locality

Years	Total rainfall (mm)	Temperature (^{0}C)	Relative humidity (%)
1990	342.3	27.0	42.7
1991	573.6	26.5	49.3
1992	498.5	25.7	55.3
1993	482.0	26.1	48.9
1994	968.2	25.9	46.8
1995	554.5	26.1	49.2
1996	402.2	25.9	50.7
1997	452.2	28.8	50.5
1998	667.4	21.4	38.4
1999	495	23.3	46.3
2000	457	23.4	46.3
2001	540	27.3	56.4
2002	475	26.3	26.3
2003	574	26.5	49.8
2004	568	26.5	26.5
2005	394	26.4	45.7
2006	471	27.9	26.5
2007	477	27.4	53
2008	714	25.7	50
2009	517	26.1	50
2010	618	26.7	52.5
2011	371	24.5	48.7
2012	726	26.7	55.1
2013	354	24.9	43.4
2014	621	24.8	43.3

Source: Author 2014

Correlation analysis (r), Zalingei locality

As presented in table 4, correlation analysis results between climatic variables and crop yields (1990 -2014) revealed that total rainfall is weakly positively correlated with millet (.015) and sesame (.281) and minimal negatively correlated with groundnut(-.029). This results is statistically non significant due to that the lower the rainfall the lower the yield of millet, sesame and groundnut. While the higher the rainfall resulted in decrease of groundnut yield. Accordingly there might be other factors (e.g fertilizer, pesticides, inputs) determining yield production. Rainfall correlation with sorghum (.344*) was found to be statistically significant at five percent from zero level. Average temperature was modest positively correlated with sorghum (.313), sesame (.322) while it is almost minimal with groundnut (.002) and smallest negatively correlated with millet (-.205). It probably means that temperature is not significant enough for growing such crops. This implies that sorghum sesame and groundnut require adequate average temperature to survive while millet require much of average temperature to grow well. Relative humidity was found smallest positively correlated with sorghum (.111), Groundnut (.102) and sesame (.117) while smallest negatively correlated with millet (-.142). This means that sorghum, groundnut and sesame require minimum relative humidity to survive in the study area while millet require much of relative humidity.

Table 4. Correlation analysis, Zalingei locality

Crop	Total rainfall (mm)	Temperature (^{0}C)	Relative humidity (%)
Millet	..015	-.205	-.142
Sorghum	.344*	.313	.111
Groundnut	-.029	.002	.102
Sesame	.281	.322	.117

Source: Author 2014

Regression analysis for crops across climatic variables, Zalingei locality

The regression analysis recorded for yield crops indicated that millet, sorghum, groundnut and sesame have coefficient of determination percentage of 6, 24, 1.2, and 20.4 %, respectively. This implied that climatic variables have no significant impact on millet and groundnut and only 6 and 1.2% of the variance were explained by the climatic parameters. The results also showed that total rainfall and temperature were significant at five percent from zero level in sorghum (.066* and .087*) and sesame (.093*) respectively. This results answered that 24 and 20.4 % of variance in yield were explained by climatic variables. The overall implication is that 94, 76, 98.2 and 79.6 % of the variance in millet, sorghum, groundnut and sesame yield might be explained by other factors such as low soil fertility, area cultivated, pests and diseases, conflicts and lack of peace and security as mentioned by the respondents, (Table 5).

Tablen5. Shows regression analysis of crop yield across climatic variables , Zalingei locality

Crop	Explanatory variables	Coefficients	Standard error	T. value	P. value	R	R^2 %
Millet	Constant	1870.959	1135.474	1.648	.114	24	6
	Total rainfall	.022	.466	.047	.963		
	Temperature	-37.286	41.150	-.906	.375		
	Relative humidity	-4.483	7.566	-593	.560		
Y = 1870.959 + .022 – 37.286 – 4.483 + E							
Sorghum	Constant	-648.647	604.371	-1.073	.295	49	24
	Total rainfall	.480	.248	1.937	.066*		
	Temperature	39.323	21.903	1.795	.087*		
	Relative humidity	.905	4.027	.255	.824		
Y = -648.647 + .480 + 39.323 + .905 + E							
Groundnut	Constant	878.956	1809.304	.486	.632	11	1.2
	Total rainfall	-.139	.742	-.188	.853		
	Temperature	-3.334	65.570	-051	.960		
	Relative humidity	5.879	12.056	.488	.631		
Y = 878.956 - .139 – 3.334 + 5.879 + E							
Sesame	Constant	-630.780	395.195	-1.596	.125	45	20.4
	Total rainfall	.254	.162	1.564	.133		
	Temperature	25.258	14.323	1.764	.092*		
	Relative humidity	.745	2.633	.283	.780		
Y = - 630.780 + .254 + 25.258 + .745 + E							

Source: Author 2014

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CONCLUSION

The study concluded that climatic impact of total rainfall; temperature and relative humidity were highly significant on crop yield , while the other factors has no significant impact on crop yields . The study also reached some recommendation related to factors such as soil fertility, availability of a adequate cultivated lands, pests and diseases control, extension technical packages and water harvesting technique application.

REFERENCES

Abusarr, AF. 1996. Areview of Zalingei research station. Programmes, progress achievements and future prospects. Pp 1 -3

Baker SL. 2006. Multiple regression theory. P 1.

Fadel-El Moula M. 2005. Assessment of the Impacts of Climate Variability and Extreme Climatic Events in Sudan During 1940-2000, Meteorological Corporation, Khartoum, Sudan.

NAPA. 2007. National Adaptation Program of Action. Republic of the Sudan, Ministry of Environment and Physical Development, Higher Council for Environment and Natural Resources, Khartoum

Olawepo VO, Usman BA and Tunde AM. 2011. Effects of climatic variables on crop production in Patigi L. G. A., Kwara State, Nigeria. Department of Geography and Environmental Management, University of Ilorin, Kwara State, Nigeria press. Pp 696 –699.

Pierce T. 2010. Descriptive statistic. Department of psychology, Radford university. Version 2.0

Strode PK. 2015. The Pearson product –moment correlation coefficient (r) and linear regression (r2). Fairview High School, Boulder CO. P 1.

Zakieldeen SA. 2009. Adaptation to climate change: Vulnerability assessment for Sudan. Pp 3 – 13.