Impact Of Climate Change On Some Food Crops Production In Golo Locality Of Central Darfur State-Sudan

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Abstract*—Climate change is a global concern as it severely affects the livelihoods of the world community in general and agricultural production and food security of the farming community in particular. This study was carried out in Golo locality in order to examine the impact of climate change on some crop production in 2018/2019 cropping season. Structured questionnaire of 50 households was developed. Time series data (2000-2018) for crop yields, total rain fall (mm), average temperature (c^0) and relative humidity applied run in the model. Clustered random sampling technique applied. Frequency distribution, descriptive analysis, correlation coefficient and multiple linear regression models were used. Frequency distribution observed 80% of household age groups found between 30 -50 years. Majority of households were educated (92%) while 8% were illiterate. Agriculture is the main sources of farmers' income (80%). Perceptions of households related to climate change in explored that 70% hear of climate change and 30% did not hear. Households also noted that the direct effect of climate change lower crop yield by 50%, death in animals by 40% and decrease water stable by 10%. Analysis explored 22% of households had access to extension services and 78% had no access. Correlation coefficients related to family size indicates that probability that farmer perceive to changes in temperature and rain fall decreased by -0.0209 and -0.001. Education positively related to changes in temperature (0.090) and negatively related to rain fall changes (-0.053). Results also showed that farm size positively related to farmers perceptions on changes in temperature changes (0.035) and negatively related to rain fall changes (-0.071). Multiple regression results observed that 58% of change in millet yield was attributed to average temperature. It was also shown that rain fall had positive impact on millet yield. Humidity on millet yield was found to be negative and there no significant differences on yield. Regression analysis also indicated that average temperature positively influences sorghum production with no statistical significant difference from zero level. On the other hand, relative humidity negatively impacts sorghum yield. Rain fall positively influenced sorghum with statistical significant difference at ten percent from zero level and concluded that 13% of change in yield attributed to rain fall effect. The study recommended that raising awareness of climate change hazard needed. Improved research technologies and draught tolerance crop varieties be introduced.

Keywords—Climate change, Impact, Descriptive, Multiple regressions, Correlation coefficient

1. Introduction:

The effects of climate change on crop production are international concerns, but they are particularly significant for the sustainable agricultural development of Bangladesh. This is a country of variant climatic conditions year-round due to its geographic position and physiographic status. The biggest mountain Himalayas in the north and the funnel-shaped Bay of Bengal in the south have made Bangladesh a meeting point of the life-long monsoon precipitations and the catastrophic devastation of floods, droughts, cyclones, storm surges, etc. Agriculture is always susceptible to unfavorable weather conditions and climate events. In spite of technological progress (such as improved crop varieties and irrigation potentialities), weather and climate are still key determinants for agricultural productivity and sustainability. Agriculture in Bangladesh is already under pressure, both from huge and increasing demands for food as well as from obstacles related to the degradation of agricultural land and water endowments. Any internal and external threat (social, political, natural and environmental) to agriculture directly affects food grain production as well as food security of the country. Sometimes the relation between these key factors and production losses are obvious, but often the relations are less direct. In spite of the recent strides regarding gaining sustainable development, Bangladesh's ability to restore its development is experienced with significant challenges and confounded by climate change [1]. According to [11], food security has remained the foremost objective of the Government of Pakistan. Therefore, the policymakers spend substantial time on designing sound food policy leading to food security. Various factors have impact on food security including agronomic, institutional, political factors, in addition to climatic factors. Climate change is considered the most crucial factor influencing food security. Food security includes different dimensions, namely production, distribution and accessibility. Considering food production dimension, the studies show substantial impact of temperature and rainfall on food production. Despite remarkable, oil driven economic growth of about 8 percent per year during 2000–10, Sudan has experienced unprecedented poverty and food insecurity over the past two decades brought about, in part, by the poor and inconsistent performance of the agricultural sector, which employs roughly 80 percent of the country's work force. During the 1990s, agricultural research and development (R&D) investments in Sudan declined rapidly, but this trend has reversed in more recent years due to increased recognition by the national government of the importance of agricultural R&D to agricultural development [10]. Farming constitutes the main livelihood source for over 80% of Darfur people. Crop production and livestock raising are the two main activities. Traditionally, the two activities have been organized and regulated by the Native Administration when it was strong and capable of exercising its power. Competition over resources, pasture and water has often resulted in conflicts, sometimes very serious within the same tribe or between tribes. This is true for tribes of Arabic origin and non-Arabic origin as well. The Native Administration often contains such conflicts at the local level, based on agreed upon codes and norms. Over the last 5 decades, the whole region, especially the northern part has experienced a series of drought episodes, namely in the late 50s, late 60s early 70s, the serious being in mid 80s (1983/84 famine) and early 90s. These droughts induced behavioral changes in the way people deal with the immediate environment as a coping strategy. Over-cultivation, over grazing and mass destruction of the tree cover are among the consequences of human miss-use of the natural resources that have provided good livelihood throughout the history. Conflicts have become more often and more acute, compounded by the weakening of the Native Administration and limited presence of formal judiciary and power systems that enact formal laws and codes. Migration to urban centers and mechanized/irrigated schemes in central Sudan has been a prominent practice and a way of getting along with the declining resources, especially for those with limited assets. Following the successive droughts, wide spread of poverty has been recognized. This is compounded by the limited development efforts in the region [5]. According to [2] 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 300C and 200C 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. 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. Agriculture in Golo locality is much affected by massif and huge migration of pastoralists and nomads because Jebell Marra area endowed with surface and underground water beside pasture and vegetation cover. This migration led to degradation in land, draught, overgrazing, wood cutting and deterioration in natural resources base which resulted in conflicts and wars between farmers and livestock owners. 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.

2. Research objectives

The overall objectives of the study are to know the impact of climate change on crop production in Golo locality, while the specific objectives are: -

- Assess the current climate change challenges, predicted impacts and their observed effects in the study area.
- Document and inventory technologies and practices can be adapted in agricultural-based livelihood systems, including crops.
- To know the strategy of research to address the major challenges of the dry land production systems in the context of increasing climate variability and change.

3. Study area and Materials and Methods

Golo locality lies in the Eastern side of Jebell Marra area. The estimated population of Golo locality was 29,225 [4]. Loamy and volcanic soils are dominated. Agricultural is the main sources of income for most population. Rain fall range from 700-900mm. Millet, sorghum, orange, apple, tomato, potato, garlic faba bean and onion were the most important food and cash crops for farmers.

3.1 Methodology

Structured questionnaire of 50 households was developed to know the impact of climate change on households' crop production. Time series data (2000-2018) for crop yields, total rain fall (mm), average temperature and relative humidity obtained from Jebel Marra Rural Development Project (JMRDP) meteorological station and Ministry of production and economic resources. Clustered random sampling technique applied.

Data analysis;

Data analyzed by descriptive analysis and linear regression model using the method of least squares (OLS) in studies based on multiple regressions. According to [3], OLS regression is used to identify the relationship between a set of explanatory variables and the farm household expenditure. The criterion of OLS provides estimates that possess many useful and desirable properties. If we assume, as in the case of more than two-variable regression that E(ε) = 0, then, by substitution results be:

$$Yt = \beta_0 + \beta_1 Xt_1 + \beta_2 Xt_2 + \beta 3Xt_3 +.+ \beta_k X_k + \varepsilon$$

Where:

Values *Xj* (*j* = 2, 3. *n*) represents the climatic variable factor or repressors (average temperature, total rain fall and Relative humidity)

the values *βj* (*j* = 1, 2, 3, .,*k*) represents the parameters of the regression and ε is the residual factor.

Correlation coefficient also applied to know the relationship between socioeconomic factor and farmers perceptions on climate change hazards. The Pearson correlation coefficient formula written as:-

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2}\sqrt{n(\sum y^2) - (\sum y)^2}}$$

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

4. Results and discussions

4.1 Frequency distribution, descriptive analysis and farmers perceptions on climate change

Frequency distribution analysis was shown in table 1. 78% of gender were female while 22% male. I t was observed that 80% of household age groups found between 30 -50 year. This is indicates that those people were productive in farming activities. This results goes with [9] the age bracket of 50-59 years constituted the more active and productive farming population in the Lower River Benue Basin. Results also found that 90% of household married, 2% single, 6% divorced and 2% of household widow. The household education is considered as the most important factor on farming practices and agricultural technologies adoption. Majority of households were educated (92%) while 8% were illiterate. Most households were farmers (88%), 2% farmers/traders and 8% farmer/free work. Descriptive results in table 3 observed that the average family size was 9 members. Household experience was computed to be 11 year. [8] stated that younger and less experienced farmers may be less motivated in farming and may be engaged in it more as a default livelihood strategy to survive than the urge to farm. Perceptions of households related to climate change in table 2 explored that 70% hear of climate change and 30% did not hear. 30% heard by radio, 20% television, 4% newspaper and 46% heard from relevant. 40% of households said that the negative signs of climate change came from shortage and erratic rainfall, 24% from increase in temperature, 10% floods, 6% weather fluctuations and 20% increase in temperature, floods and shortage of rainfall. Results of table 2 also noted that the direct effect of climate change lower crop yield by 50%, death in animals by 40% and decrease water stable by 10%. Relationship between climate change and food availability indicated that climate change decrease production locally and globally by 52%, decrease forest product (22%) and increase food demand by 26%. Perceptions of respondents in table 2 also revealed that climate change affect food access in increasing prices by 14%, decrease agricultural income by 74% and enhance migration by 12%. Households also ask to know their perception of climate change on food stability. 32% claimed affect adequacy of food, 25% affect income generation and 10% answered by decreasing water stable. Distribution of household according to extension services in table 2 also resulted in 22% had access to extension services and 78% had no access to extension services.

4.2 Correlation coefficient between socioeconomic factors and farmers perceptions on climate change

Table 4 displays the correlation coefficient between socioeconomic characteristics and farmers perceptions on climate change indicators. Results founded that family size negatively related to changes in temperature and rain fall. This entail that probability that farmer perceive to changes in temperature and rain fall decreased by -0.0209 and -0.001, respectively. Education positively related to changes in temperature (0.090) and negatively related to rain fall changes (-0.053). Occupation seems to increase farmers perceptions on temperature (0.198), while it decrease probability of farmers' perception on change in rain fall (-0.243). Results also noted that age positively related to changes in temperature and rain fall (0.075 and 0.075, respectively). Farm size positively related to farmers perceptions on changes in temperature (0.035) and negatively related to rain fall (-0.071). Temperature negatively related to farming experience (-0.015) and rain fall changes increased by farming experience by 0.060.

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Table: 1 frequency distribution of socioeconomic characteristics of households

variables	Frequency	valid %
Gender		
male	11	22
female	39	78
Total	**50**	**100**
Age		
less than 30 year	11	22.0
31 – 40 year	29	58.0
41 -50 year	7	14.0
51 -60 year	3	6.0
Total	**50**	**100**
Marital status		
single	1	2.0
married	45	90
divorced	3	6.0
widow	1	2.0
widower	-	**-**
Total	**50**	**100**
Education		
illiteracy	4	8
Khalwa	7	14
Elementary	28	56
primary	3	6
secondary	5	10
university	2	4
post graduate	1	2
Total	**50**	**100**
Occupation		
farmer	44	88
farmer/trader	2	4
farmer/free work	4	8
Total	**50**	**100**

Table: 2 Perceptions of households on climate change

variables	Frequency	valid %
Do you ever hear of climate change		
yes	35	70
no	15	30
Total	**50**	**100**
Mass media of hearing climate change		
radio	15	30
television	10	20
newspaper	2	4
relevant	23	46
Total	**50**	**100**
What are the negative signs of climate change		
increase in temperature	12	24
shortage and erratic rain fall	20	40
floods	5	10
affect on weather condition	3	6
increase temperature, floods and rain shortage	10	20
Total	**50**	**100**
The direct Effect of climate change		
lower crop yield	25	50
animal death and loss	20	40
decrease water table	5	10
Total	**50**	**100**
distribution of climate change on food availability		
decrease production locally and globally	26	52
decrease forest products	11	22
increase food demand	13	26
Total	**50**	**100**
distribution of climate change on food access		
increase prices	7	14
decrease agricultural income	37	74
enhance migration	6	12
Total	**50**	**100**
distribution on food stability		
affect adequacy of food	16	32.0
affect on income generation	14	25.0
lead to migration	9	18.0
lead to resources conflicts	**11**	**22.0**
Total	**50**	**100**
Access to extension services		
yes	11	22.0
no	39	78.0
Total	**50**	**100**

Source: Author 2018

Table: 3 show descriptive analysis

variables	N	minimum	maximum	mean	Std.
average family size	50	4	34	8.82	4.8363
male number	50	1	19	4.0800	2.84167
female number	50	1	11	4.0000	1.97949
children	50	0.00	15	1.4000	2.48259
experience in agriculture	50	1.00	35	11.100	8.22453
land size	50	1.00	3.00	2.0800	0.77828

Source: Author 2018

Table: 4. Correlation between socioeconomic factors and farmers perceptions on some climate change indicators

Socio-economic factors	Average temperature	Total rain fall
Family size	-.209	-.001
education	.090	-.053
occupation	.198	-.243
age	.075	.075
Farm size	0.035	-.071
Farming experience	-.015	.060

5. Climatic variables and sorghum millet production trend over seasons

Millet and sorghum were considered as the most stable food in the study area. Temperature (both maximum and minimum) enhances photosynthesis as it increases and leads to an increase in crop yield [7]. However, it was stated that extremely high temperature negatively affects the process of metabolism in plants, such as protein stability and reactions (enzymatic) in cells, leading to metabolic imbalance. In addition, high temperature also affects photo system function, and causes a reduction in photosynthesis. On the other side, the extremely low temperature may lead to injury of chilling in plants. Figure I show trend of sorghum and millet production over growing seasons (2000 -2018). In table 5 and figure 1 Sorghum and millet production greatly fluctuated. This was clear in sorghum production. Metrological data and climatic variables trend were presented in table 6 and figure 2, respectively. Average temperature and relative humidity were fluctuated slightly and there no great variation along growing seasons. Rain fall for sorghum and millet trend showed increasing overtime.

Table: 5 Production of some main crops in kilogram/feddan, by locality

Year	Crops	
	millet	sorghum
2000	174	174
2001	448	457
2002	492	511
2003	231	471
2004	178	367
2005	195	295
2006	172	144
2007	249	322
2008	198	186
2009	151	211
2010	241	245
2011	145	151
2012	455	671
2013	374.2	319
2014	411	369
2015	468	389
2016	346	332
2017	315	371
2018	416	305

Source: Ministry of production and economic resources (Eginaina and Zalingei)

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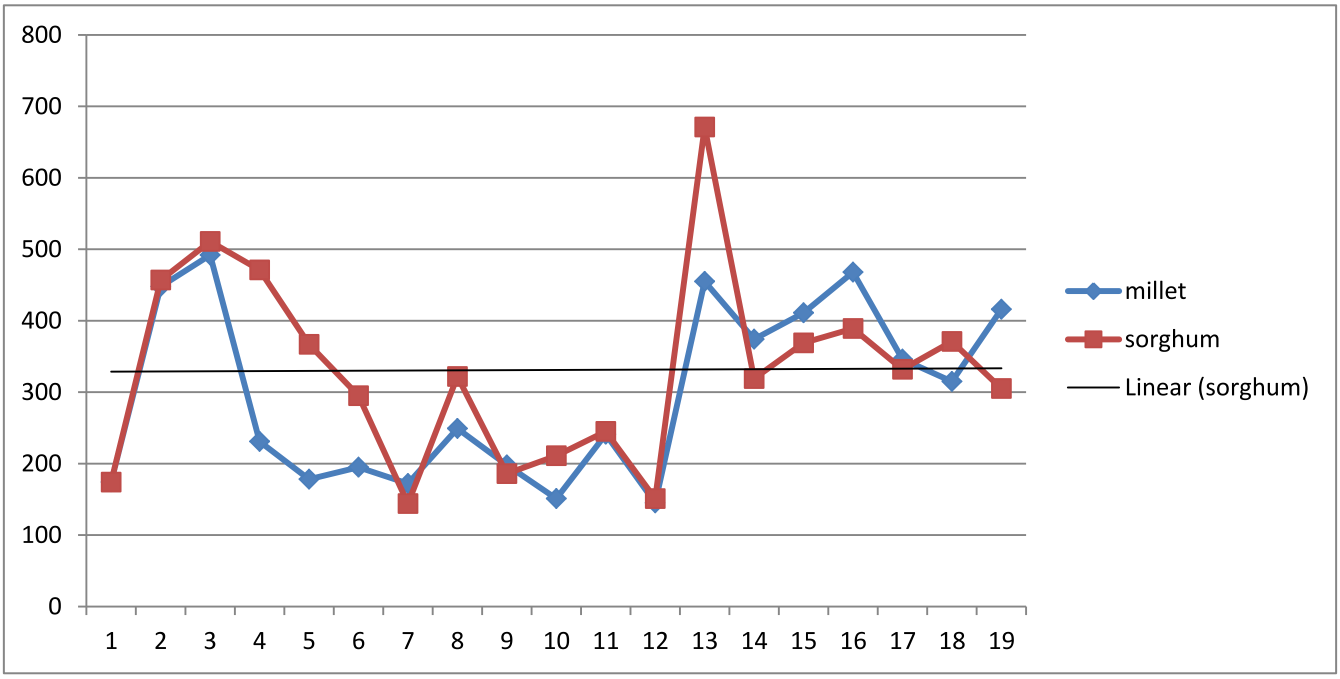

Figure:1 trend of sorghum millet production

Table: 6 Meteorological data

Year	Golo locality		
	Total rainfall (mm)	Average temperature (^{0}C)	Relative humidity (%)
2000	896	22.5	44.9
2001	961	24.0	43.7
2002	850	24.3	46.9
2003	886	21.0	47.6
2004	839	19.6	42.3
2005	836	21.2	43.4
2006	717	22.3	57.6
2007	1091	21.5	47.3
2008	762	20.9	49.1
2009	777	22.1	48.6
2010	815	21.6	48.0
2011	712	22.2	47.7
2012	860	23.3	45.2
2013	824	22.7	49.1
2014	780	22.4	60.5
2015	888	24.3	51.3
2016	786	23.1	40.6
2017	897	22.9	41.3
2018	844	23.3	42.2

Source: Jabel Marra Rural Development Project (meteorological agency)

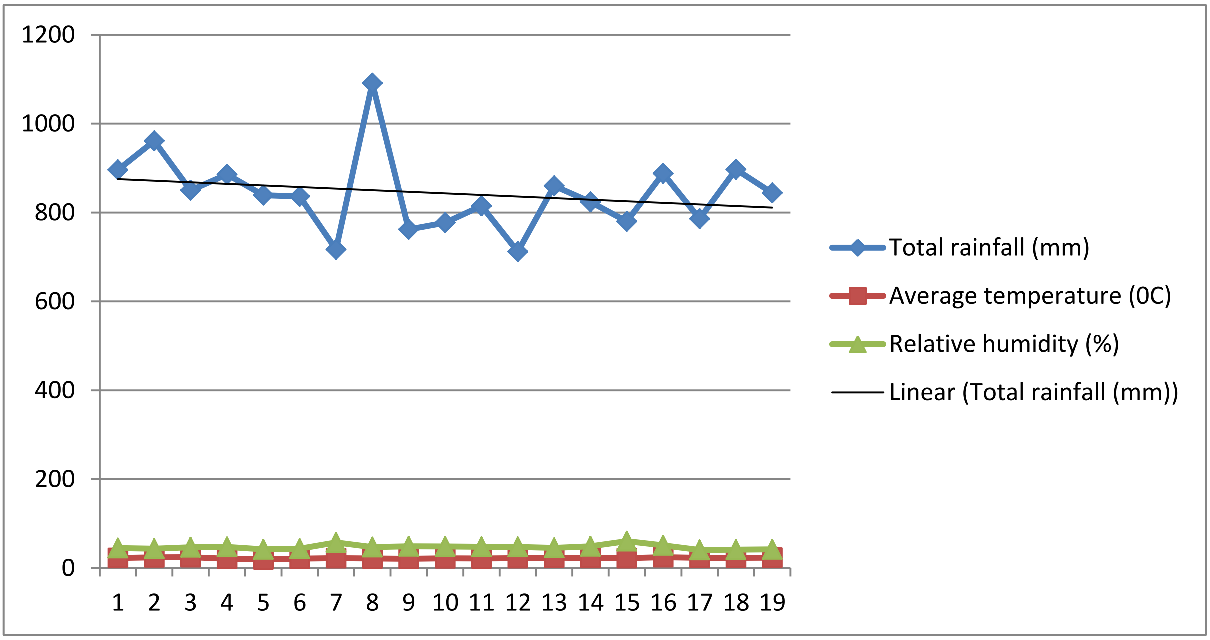

Figure: 2 Trend of climatic variable

6. Multiple regression results

6.1 Impact of climatic variables on millet yield

A result of regression analysis was shown in table 7 below. Analysis revealed that there is no statistical significant difference from zero level of average temperature on millet yield and the impact of average temperature was found to be positive. R^2 indicates that 58% of change in millet yield was attributed to average temperature. The influence of relative humidity on millet yield was found to be negative and there no significant differences on yield. Rain fall had positive impact on millet yield.

6.2 Impact of climatic variables on sorghum yield

Sorghum rank second on household food consumption in the study area. Regression analysis also indicated that average temperature positively influences sorghum production with no statistical significant difference from zero level. On the other hand, relative humidity negatively impacts sorghum yield. Rain fall positively influenced sorghum with statistical significant difference at ten percent from zero level and 13% of change in yield attributed to rain fall effect. This result coincides with what had been said by [6] there was a positive linear relation between the observed sorghum yield and AquaCrop simulated sorghum yield for June to September season. Hudo also stated that R^2 value of 0.395 indicated 39.5% of the variability in the AquaCrop simulated sorghum yield is explained by the relationship between the AquaCrop simulated sorghum yield and observed sorghum yield values.

Table: 7 regression analysis of some field crops, Golo locality

Crop	Explanatory variables	Coefficients	standard error	*F. value*	*P. value*	R^2	*Adj.* R^2
Millet	constant	-1432.67			8.94 ns	60.4	58.1
	av. Temp.	77.32753	79.28121	25.98212			
Y = -1432.67 + 77.32753 + E							
	constant	313.2673			0.955598 ns	0.00018	-0.0586
	R.H %	-0.32662	126.0517622	0.003193			
Y = 313.2673 – 0.32662 + E							
	constant	-32.8846			0.245508 ns	0.078437	0.024227
	Total rain fall	0.392223	121.0186	1.446921			
Y = -32.8846 +0.392223 + E							
Sorghum	constant	-545.143			0.13332 ns	0.07558	0.076238
	av. Temp.	39.15266	129.7849308	2.485541			
Y = -545.143+ 39.15266 + E							
	constant	602.9406			0.367387 ns	0.048021	-0.00798
	R.H%	-5.75715	135.57188	0.857544			
Y = 602.9406 – 5.75155 + E							
	constant	-215.095			0.073709*	0.176063	0.127597
	total rain fall	0.6477	126.1255132	3.632655			
Y = -215.095 + 0.6477 + E							

Source: HH survey 2018.

7. CONCLUSIONS

The purpose of this study is to know the impact of climate change on crop production in Golo locality. The socioeconomic analysis results revealed that most households were educated and majority of them practice agriculture as a source of income generation. Statistical analysis related to households' perception on climate change indicated that most households heard of climate change and climatic variables positively affect their livelihood security. The correlation coefficients results revealed that probability that farmer perceived to climatic variables change was positively and negatively affected. Regression analysis explored that millet and sorghum positively and negatively influenced by climatic variables. However, rain fall had statistical significant at ten percent from zero level on sorghum yield.

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