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Impact of climate change on food security in Elnuhood locality of Western Kordofan State, Sudan

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ABSTRACT: The current study was carried out to test and identify the impact of climate change on food security in Elnuhood locality. 62 households' participants were randomly selected through questionnaire field survey during 2012/2013-2013/2014 cropping seasons. The multi stage-stratified random sample technique was applied. Household economy approach (HEA), Linear programming (L.P), Partial crop budget, Dominance analysis, Marginal analysis, Sensitivity analysis, Time series analysis, Linear regression (L.R) and correlation coefficients as empirical approaches were applied. The households economy approach for the daily energy received per person per day in k. calories was calculated being 2242. According to WHO minimum rate of 2300 calories per person per day, this results implies that the households is marginally food insecure. Results of Linear programming (L.P) revealed a total of SDG 33706 as net income by producing and optimized only sorghum on the total of 9 hectares of land. The net crop income from this results was found lesser than the minimum livelihood requirement by 445%. Therefore, households are unable to mel the minimum livelihood requirement under the present climate conditions. Partial crop budget revealed that Higher net benefits in SDG were determined by cowpea (2999) followed by okra (2928) while a lower net return was obtained by watermelon (SDG 87). The dominance analysis results rendered 4 of nine treatment unacceptable for investment as five are other treatments with higher net returns of lower costs thereby leaving five treatments for the marginal rate of return (MRR) analysis. Analysis of marginal rate of returns revealed that T_3 (Cowpea) was higher than minimum acceptable rate of return. Therefore treatment T_2 and T_3 (millet and cowpea) were emerged as the best among the alternatives and they had positive marginal rate of return of 150.9 and 378.3 %, respectively. Accordingly every SDG 1.00 invested in crop production, farmer can expect to recover the SDG 1.00 and earned additional SDG 1.509. Sensitivity analysis that assuming costs over run by 10% keeping the benefits same, and benefits reduction by 10% keeping costs same founded that T3 (cowpea) was the best and highly stable with MRR 352% while that of benefit short fall by 10% indicated also T3 was stable with MRR 348.6 %. Linear regression results shows that p-values of trend of the average maximum temperature was significant at five percent from zero level for groundnut and Roselle while total rainfall showed noticeable significance at five percent from zero level for cowpea and watermelon with Adjusted R^2 of 79, 21, 31 and 20% respectively. This implies that the impact of climate change on food security variation can be explained by climatic factors. Results also revealed that climate has no impact on millet, sorghum, and sesame. This is highlights that variation in crop production as well as food security attributed to other non-climatic factors such as lack of extension and access to credit amongst households. In addition to examining descriptive statistics and analyzing linear trend between time and climatic variables and changes in trend (upward or downward) over the whole period (2000-2013). Results founded that there were significant and positive trend between total crop production and time at five percent from zero level on millet, cowpea and watermelon. This means that variation in production impacted by climate change during the long period. Correlation coefficient results showed that values of millet, sorghum, sesame, groundnut and Roselle production were weakly and negatively correlated with time and average maximum temperature. Cowpea and watermelon were significant at 0.5 percent from zero level with time and temperature. Groundnut production was significantly correlated (0.01) with total rainfall. However, Roselle has significant correlation at five percent from zero level with total rainfall. A weak and negative correlation relationship exists between millet, sorghum, groundnut, Roselle and watermelon and total rainfall. Moderately correlation showed by sesame and temperature. While smallest (0.195 and 0.182) positive correlation was given by sorghum and sesame against total rainfall. The above analysis implies that the effect of climate on grain production in the study area is not significant. However, the effect of average maximum temperature and rainfall on cowpea, time, groundnut and Roselle were respectively significant.

Keywords**:** Climate change, Food security, Optimal solution, Partial budget, Linear regression.

INTRODUCTION

The study was conducted in Elnuhood locality of west Kordofan State which lie between longitudes 10° 14' N and latitudes 28° 30 E. The average monthly temperature was 34.6°C. The mean temperatures in coldest months are December 14.1°C and January 13.5°C. However; the hottest months (April, May and June) with an average mean temperature exceeding 30°C. Based on average annual rainfall and according to the ratio of humid months to arid months and length of the growing season, The study area is lies in low rainfall woodland savannah (arid zone), with rain fall between 250-450 mm and covers about 52 % of Greater Kordofan State (GKS). Abdelrahim (2014).

The farming systems based on traditional systems of cropping and animal husbandry. The major crops grown are millet and sorghum (food crops), and groundnut and sesame (cash crops). Gum Arabic production and forestry products contribute significantly to the household income to a large portion of the population. Other crops grown are watermelon, Roselle (Karkadi), cowpea, maize and okra. Animals raised are mainly sheep, goats and camels in the north and cattle and goats in the south.

Climate change is a major challenge for agriculture, food security and rural livelihoods for billions of people including the poor in the Asia-Pacific region. Agriculture is the sector most vulnerable to climate change due to its high dependence on climate and weather and because people involved in agriculture tend to be poorer compared with urban residents. More than 60 per cent of the population is directly or indirectly relying on agriculture as a source of livelihood in this region. Agriculture is part of the problem and part of the solution. Asian agriculture sector is already facing many problems relating to sustainability (Dev, 2011). According to IICA (2009) to be food secure, a population, household or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security. Breima (2014) stated that one of the more comprehensive and accepted definition of food security was developed at the United Nations world food summit in 1996. Food security exists when all people, at all time, have access to sufficient, safe and nutritious food to meet preferences for an active and healthy life style. Food availability refers to sufficient supply of food for all people. According to Donnell (2008) household Economy Approach (HEA) arose from a collaboration in the early 1990s between Save the Children and the Global Information and Early Warning System (EWS) of the Food and Agriculture Organization (FAO) of the United Nations in order to improve FAO's ability to predict short-term changes in a population's access to food. Linear programming (L.P) linear programming model used to determine the optimum cropping pattern as a prerequisite to efficient utilization of available resources of land, labor, water, and capital for agriculture (yue, 2013). Term (2010) mentioned that Many statistical methods relate to data which are independent, or at least uncorrelated. There are many practical situations where data might be correlated. This is particularly so where repeated observations on a given system are made sequentially in time. Data gathered sequentially in time are called a time series.

MATERIALS AND METHODS

Econometic Methodology

Households' survey questionnaire regarding crop production activities was developed and tested in pre-survey to collect primary data through Questionnaires. A form of multistage stratified random sampling of 62 respondents was selected. Data were analyzed using descriptive analysis, Household economy approach, linear programming model (L.P), partial crop budgeting, dominance, marginal and sensitivity analyses, Time series analyses, linear regression and Correlation coefficients. Relevant secondary sources of data were used.

Household Economy Approach

The aim of household Economy Approach was to find a method that could indicate the likely effect of crop failure or other shocks on future food supply(Holt , 2000).

Linear Programming (L.P)

Pomeroy , (2005) stated that linear programming requires the information of the farm and non-farm activities and options with their respective resource requirements and any constraints on their production, the fixed requirements and other maximum, minimum constraints that limit family or farm production, cash costs and returns of each activity and defined objective function. In this context, a linear programming model has been developed to determine the area to be used for different crops for maximum contribution and for improving farmers' income. Linear programming (L.P) is a method of determining a profit maximizing combination of farm enterprises that is feasible with respect to a set of fixed farm constraints (Breima, 2006). The model expressed as follows:

The household's objective is assumed to be the maximization of calorie (Z) production

$$\text{Maximize } Z = \sum_{j=1} C_j X_j$$

CjXj…………………………………………………………...........(1)

Subject to:
aijxj ≤ bi (standard factors of production)………………….........(2)

∑AijXij ≤ bj (Resource constraint)……………………………......(3)

dj xj > □ (Climate Variables)………………………………………(4)

∑ Qjk Xjk ≥ dkj (Food consumption constraint)…………………...(5)

Xj ≥ 0 all j = 1 to m non-negativity constraint activities

Where:
Z = Gross margin
Cj = Price of production activities
Xj = level of jth production activity
aij = the ith resource required for a unit of jth activity
bi = the resource available with the sample farmers
j = refers to number of activities from 1 to n
i = refers to number of resources from 1 to m
Under constraints of land/ha, labor/MH, working capital SDG/ha, seed supply SDG, climatic variables and food consumption

(i) Land

∑aijxj≤ OL and ∑aijxj≤ RL,
Where: OL and RL are the size of owned land and rented land holding, respectively.

(ii) Family labour

$\sum atj\text{-}htxj^* \leq Lt$, $htxj^* \leq At$

Where:

Lt and At = available family labor and hired labor in the t th period.

ht = is the amount of hired labor required in the t th period for jth* activity.

Atj = is the amount of labor required in the t th period for jth activity.

(iii) Working capital

$\sum kijxj \leq WK$

Where:

WK = is the amount of available working capital

Kij = is the amount of working capital required for production and non production activities. Working capital is the value of inputs (purchased or owned) allocated to an enterprise with the expectation of a return at a later point. The cost of working capital is the

(IV) Seed supply

$\sum kijxj \leq SP$

SP= is the amount of seed supply available for production and non production activities

Kijxj= is the amount of seed supply required for production and non production activities.

(V) Climatic variables

$\sum aijxj \geq TEMP, RF$

Where: TEMP, and RF represents temperature and Rain fall respectively.

(VI) Food consumption

$\sum Qjk\ Xjk \geq dkj$

dkj is the amount of food available for consumption

Qjk is the amount of food required for households consumption

Partial crop budget

According to yue (2013) partial budgets method is a practical way to compare changes in production costs and revenue since it requires minimal data compared to other budgets. It has been used largely when production systems are subject to change, to compare two or more alternative sets of production.

Dominance analysis

Dominance analysis is carried out in order to rank the treatments in order of increasing costs that vary (Cash costs and opportunity costs). Any treatment has net benefits that are less than or equal to those of treatment with lower cost that vary is dominant (marked with D).

Marginal analysis

Marginal analysis is conducted to know returns to investment and thus the less benefited treatments were eliminated by making the use of dominance analysis. Marginal rate of return indicate what farmers can expect to gain, on average, in return for their investment when they decide to change from one practice to another. Marginal values were calculated as:

Marginal rate of returns (MRR)

$$= \frac{\text{Incremental net benefits} \times 100}{\text{Incremental net costs}}$$

Maximizing TPP when

$$\frac{dTPP}{dx} = MPP = 0$$

Where: TPP = total physical productivity (output price per unit)

Mpp = marginal physical productivity

x = input used (cost price per unit)

Sensitivity analysis

The sensitivity analysis was done to check risk factors which cause price variability. The analysis was done assuming costs over run by 10% keeping the benefits same, and then by assuming benefits reduction by 10% keeping costs same.

Time series analysis

Many statistical methods relate to data which are independent, or at least uncorrelated. There are many practical situations where data might be correlated. This is particularly so where repeated observations on a given system are made sequentially in time. Data gathered sequentially in time are called a time series (Term 2010).

Multiple linear regression

Ache (2012) stated that the situation in which economic correlations involves only two variables are very rare. Rather we have a situation where a dependent variable, Y, can depend on a whole series of factorial variables or regressions. For example, on analysis of climate change impact, the yield or net returns of specific crop depend mainly on temperature and rain fall. Thus, in practice, there are normally correlations as:

$$Y_t = \beta_1 + \beta_2 Xt_2 + \beta_3 Xt_3 + \beta_4 Xt_4 + ... + \beta_k X_k + \varepsilon$$

where values X_j (j = 2, 3, ..., n) represents the variable factor or repressors, the values β_j (j = 1, 2, 3, ...,k) represents the parameters of the regression and ε is the residual factor . Residual factor reflects the random nature of human response and any other factors other than X_j, which might influence the variable Y.

The correlation coefficient model

A correlation coefficient is a statistical measure of the degree to which changes to the value of one variable predict change to the value of another. In positively correlated variables, the value increases or decreases in tandem. In negatively correlated variables, the value of one increases as the value of the other decreases (Wigmore 2013).

Linear relationships between variables can be quantified using the Pearson Correlation Coefficient, or

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

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

RESULTS AND DISCUSSION

According to food security situation of households the average quantity of food items available and consumed per person per day was found to be positive 2242 Kcal. This result gives indication to the unbalanced food intake by households in terms of energy need and in term of net income and accordingly, the area is marginally food insecure (Table 1).

Table 1. Household weekly minimum food need and the equivalent K.cal per person per day

Food items	Seasons									
	Summar				Autaman			Winter		
	Kcal/kg	qt.kg	total Kcal	%share	qt.kg	total Kcal	%share	qt.kg	total Kcal	%share
Millet	3350	8.6	28810	26.2	8.7	29145	26.6	8.9	29815	27.1
Sorghum	3350	9	30150	27.4	9	30150	27.5	9.0	30150	27.4
wheat	3320	4	13280	12.1	4	13280	12.1	4	13280	12.1
Meat	2020	2.3	4646	4.2	2.2	4646	4.2	2.2	4646	4.2
Milk	660	4.1	2706	2.5	4.1	2706	2.5	4.1	2706	2.5
Sugar	4000	3.1	12400	11.3	3.1	12400	11.3	3.1	12400	11.3
Tea	1080	0.34	3672	3.3	0.34	3672	3.3	0.34	3672	3.3
Coffee	685	0.34	2329	2.1	0.34	2329	2.1	0.34	2329	2.1
Onion	410	2.9	1189	1.0	2.9	1189	1.1	2.9	1189	1.1
Oil	8840	1.2	10608	9.6	1.1	9724	8.8	1.1	9724	8.8
Dry Okra	350	0.66	231	0.2	0.66	231	0.2	0.67	234.5	0.2
Total			110021			109472			110145.5	
Per person/day(7)									2242	

Source: HHS survey 2014

Linear programming results revealed that nine crops were grown whereas production of one hectare requires 37, 81, 54, 50, 35, 49, 50, 50, 50, and 297, 227, 448, 28, 46, 179, 37, 32, 75 of labor man hours and working capital for the above decision variables, respectively. A total of 808 man hours of labor is potentially available, being the amount provided by family workers during season. For the objective of maximizing net income under scenario of the year 2013/14 with a given level of climate conditions and currently food consumption, farmers can make a maximum net income of SDG 33705.86 by producing only sorghum on the total of 9 hectares of land. The net crop income from this results lesser than the minimum livelihood requirement by 445%. This results was agreed with what had been said by Ketema (2013) that a household is facing a shortage to meet the minimum livelihood needs. The climate change data indicated that the average maximum temperature increased from 35.5 0c in 2007 to 36.7 0c in 2013. On the other hand total rainfall decreased from 775.6 mm in 2007 to 401.8 mm in 2013. Under this frequently changing household should not be optimally able to allocate scarce resources as an optimal response to climate change so as to withstand extreme climate change impact. Therefore under changing climate in the study area, optimality in resource allocation at farm level should no more remain (Table 2, 3).

Table 2. Linear Programming Tableau

Row name	X1	X2	X3	X4	X5	X6	X7	X8	X9	RHS
Max Z	2179	3745	1969	479	118	87	2999	2928	903	
Resource constraints										
Land/ha	1	1	1	1	1	1	1	1	1	9
Labor/MH	37	81	54	50	35	49	50	50	50	808
WC/SDG	297	227	448	28	46	179	37	32	75	2733
Seed supply/SDG ha	6	4	71	6	2	3	5	2	10	213
Food consumption	29257	30150								178220
Max. temperature	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	5025
Total rainfall	379.2	379.2	379.2	379.2	379.2	379.2	379.2	379.2	379.2	5308.4
Av. Cult. area	16	3.1	3.2	1.1	2	2	0.4	0.7	7.5	63.4

Source: HHS survey 2014

Table 3. Optimal solution output or farm plan for the base model in SDG/ha

Crop	Coefficients	Area/ha	Optimal solution	Final value SDG
millet	2179	0	0	0
sorghum	3745	9	33705	33705
Groundnut	1969	0	0	0
Sesame	479	0	0	0
Roselle	118	0	0	0
Watermelon	87	0	0	0
Cowpea	2999	0	0	0
Okra	2928	0	0	0
Gum Arabic	903	0	0	0
Total GM				33705

Source: HHS survey 2014, SDG= Sudanese Genih

The economic analysis of the farm operations using partial budget techniques presented in table 4 showed that higher net benefits in SDG were determined by cowpea (2999) followed by okra (2928) while a lower net return was obtained from watermelon (87).

Table 4. shows partial crop budget analysis (averages taken to represent season 2013 from 2012/2013-2013/2014 cropping seasons)

Crop	Yield kg/ha	Gross field benefit	Costs that vary	Net returns SDG/ha
Millet	466	2731	553	2178
Sorghum	526	1715	148	1567
Groundnut	729	3794	1825	1969
Sesame	187	1403	924	479
Roselle	144	922	804	118
Watermelon	358	1397	1310	87
Cowpea	510	3764	765	2999
Okra	218	4011	1085	2928
Gum Arabic	185	1147	244	903

Source: HHS survey 2014: Cost that vary include (costs of seed SDG/ha, costs of seed dressing SDG/ha, costs of insecticide SDG/ha, costs of labor SDG/ha rental SDG/ha and costs of by-product SDG /ha). (Treatments are listed in order of increasing total production cost)

Dominance analysis rendered 4 of nine treatment unacceptable for investment as five are other treatments with higher net returns of lower costs thereby leaving five treatments for the marginal rate of return (MRR) analysis (Table 5).

Table 5. shows dominance analysis (averages taken to represent season 2013 from 2012/2013-2013/2014 cropping seasons)

Crop	Yield kg/ha	Gross field benefit SDG/ha	Costs that vary SDG/ha	Net returns SDG/ha
sorghum	526	1715	148	1567
Gum Arabic	285	1147	244	903 D
Millet	466	2731	553	2178
Cowpea	510	3764	765	2999
Roselle	144	922	804	118 D
Sesame	187	1403	924	479 D
Okra	185	4011	1085	2928
Watermelon	358	1397	1310	87 D
groundnut	729	3794	1825	1969

Source: HHS survey 2014

With respect to the minimum acceptable rate of returns that assumed to be 100%. Analysis of marginal rate of returns ensured that T_3 (Cowpea) was higher than minimum acceptable rate of return. Therefore treatment T_2 and T_3 (millet and cowpea) were emerged as the best among the alternatives and they had positive marginal rate of return of 150.9 and 378.3 %, respectively. Accordingly every SDG 1.00 invested in crop production, farmer can expect to recover the SDG 1.00 and earned additional SDG 1.509. Hence, increasing seed rate resulted in additional marginal rate of returns of SDG 3.783 (Table 6).

Table 6. shows marginal analysis (averages taken to represent season 2013 from 2012/2013-2013/2014 cropping seasons)

Crop	Costs that vary SDG/ha	Marginal costs	Net returns SDG/ha	Marginal net returns	MRR=V/III*100%
I	II	III	IV	V	
T1 sorghum	148	-	1567	-	
T2 Millet	553	405	2178	611	150.9
T3 Cowpea	765	212	2999	821	387.3
T4 Okra	1083	318	2928	(71)	
T5 groundnut	1825	740	1969	(959)	

Source: HHS survey 2014

Sensitivity analysis that assumed costs over run by 10 % showed that T_3 (cowpea) was the best and highly stable with MRR 352% while that of benefit short fall by 10% indicated also T_3 was stable with MRR 348.6% (Table 7, 8)

Table 7. shows sensitivity analysis of costs over run by 10% in SDG hectare

Treatment	Total costs	Marginal costs	Net field benefits	Incremental net benefit	MRR % V/III*100
I	II	III	IV	V	
T2 millet	608.3	-	2178	-	
T3 cowpea	841.5	233.2	2999	821	352 %

Source: HHS survey 2014

Table 8. Shows sensitivity analysis of benefits reduction by 10% in SDG hectare

Treatment	Total costs	Marginal costs	Net field benefits	Incremental net benefit	MRR %
I	II	III	IV	V	V/III*100
T2 millet	553	-	1960	-	
T3 cowpea	765	212	2699	739	348.6

Source: HHS survey 2014

Results of multiple regression indicated that p-values of trend of the average maximum temperature was significant at five percent from zero level for groundnut and Roselle while total rainfall showed noticeable significance at five percent from zero level for cowpea and watermelon with Adjusted R^2 of 79, 21, 31 and 20% respectively. This implies that the impact of climate change on food security variation can be explained by climatic factors. This therefore suggests that climatic variation over years in study area is low except for groundnut and cowpea. Results also revealed that climate has no impact on millet, sorghum, and sesame. This is highlights that variation in crop production as well as food security attributed to other non-climatic factors such as lack of extension and access to credit amongst households. This results ensured what had been said by (Rumana, 2014) Climate change impact on the agricultural crop production indicates threat to food security in the marginal level respondents. In addition to examining descriptive statistics and analyzing linear trend between time and climatic variables, with time (t) as an explanatory variable to observe the spectacular impression about the variations and changes in trend (upward or downward) over the whole period (2000-2013). Results founded that there are significant and positive trend between total crop production and time at five percent from zero level on millet, cowpea and watermelon. This means that variation in production impacted by climate change during the long period (Table 9).

Table 9. Shows regression analysis of total crop production across climatic variables

Crop	Explanatory variables	Coefficients	Standard error	T. value	P. value	R	R2 %
Millet	Constant	1878952	1510016	1.2443	0.2392	21.1	0.00
	Max. average temperature	-50436.3	41877.67	-1.204	0.2537		
	Total rain fall mm	-117.341	137.1704	-0.855	0.4105		
	Years (time)	-7812.3	4360.434	-1.79163	0.09843*		
Y = 1878952 - 50436 – 117.341 -7812.3+ E							
Sorghum	Constant	60977.81	45845.54	1.33007	0.2104	16.2	0.1
	Max. average temperature	-1620.93	1271.447	-1.2748	0.2286		
	Total rain fall mm	2.32091	4.164626	0.55729	0.58848		
	Years (time)	-78.982	148.164	-0.5331	0.60371		
Y = 60977.81 -1620.93 + 2.33091 -78.982+ E							
sesame	Constant	-14776.1	13235.44	-1.1164	0.2880	13.4	0.02
	Max. average temperature	428.41	367.0621	1.16713	0.2678		
	Total rain fall mm	0.937327	1.202313	0.7796	0.4521		
	Years (time)	66.202	38.204	1.7329	0.108712		
Y = -14776.1 + 428.41 +0.937327 +66.202+ E							
groundnut	Constant	919527.1	365491.7	2.515863	0.0361	82	79
	Max. average temperature	-26917	10136.28	-2.6555	0.022*		
	Total rain fall mm	207.4852	33.2014	6.2493	6.27		
	Years (time)	-125.451	2587.24	-0.0485	0.96213		
Y = 919527.1 - 26917 + 207.4852 -125.451+ E							
Roselle	constant	4464.206	9568.81	0.4665			
	Av. Max. temperature	-122.255	265.3744	-0.4606	0.653	33	21
	Total rainfall	1.918707	0.869234	2.2073	0.049*		
	Years (time)	-15.5231	34.671	-0.44772	0.66232		
Y = 4464.206 – 122.255 + 1.918707 -15.5231+ E							
cowpea	constant	244821.1	92884.53	2.6357	0.023	42	31
	Av. Max.temp.	-6599.41	2575.992	-256189	0.0264*		
	Total rainfall.	-12.1456	8.43766	-1.43945	0.1778		
	Years (time)	-722.369	298.921	-2.4166	0.03258*		
Y = 244821.1 – 6599.41 – 12.1456 -722.369+ E							
W.Melon	constant	464743.9	218985	2.1222	0.057	32	20
	Av. Max. temp	-12394.5	6073.168	-2.040	0.066*		
	Total rainfall.	-24.6164	19.89268	-1.2374	0.242		
	Years (time)	-1770.7	609.26	-2.9063	0.01317*		
Y = 464743.9 – 12394.5 – 24.6164 -1770.7+ E							

Source: HHS survey 2014

Correlation coefficient shows that values millet, sorghum, sesame, groundnut and Roselle production were weakly and negatively correlated with time and average maximum temperature. Cowpea and watermelon were significant at 0.5 percent from zero level with time and temperature. Groundnut production was significantly correlated (0.01) with total rainfall. However, Roselle has significant correlation at five percent from zero level with total rainfall. A weak and negative correlation relationship exist between millet, sorghum, groundnut, Roselle and watermelon and total rainfall. Moderately correlation showed by sesame and temperature. While smallest (0.195 and 0.182) positive correlation was given by sorghum and sesame against total rainfall. The above analysis implies that the effect of climate on grain production in the study area is not significant. However, the effect of average maximum temperature and rainfall on cowpea, time ,groundnut and Roselle were respectively significant (Table 10).

Table 10. Shows Correlation coefficient analysis (r)

Variables	millet	sorghum	sesame	g/nut	Roselle	cowpea	WM	years	Av.max.tmp	Total RFL
Years (time period)	-0.459	-0.152	0.447	-0.14	-0.128	-0.572	-0.643*	1	0.533*	0.237
Av.max.temp	-0.309	-0.372	0.304	-0.432	-0.177	-0.555*	-0.475	0.533*	1	-0.113
Total RFL	-0.201	0.195	0.182	0.841**	0.562	-0.266	-0.252	0.237	-0.113	1

Source: HHS survey 2014, WM= watermelon, AV.Max.temp=average maximum temperature, RFL=rain fall

CONCLUSION

Households economy approach revealed that the quantity of cereals consumed by those food insecure groups is significantly lower than the recommended cereals ration of kcal per person per day. Linear programming results showed that large percentage of the food basket is dominated by one crop. Therefore households are unable to mel the minimum livelihood requirement under the present climate conditions and hence optimality in resource allocation at farm level should no more remain. Partial crop budget showed that all crops gave positive net returns and cowpea ranks first. Dominance analysis rendered five treatments with higher net returns of lower costs . Marginal rate of returns ensured that farmer can gain positive rate of returns. Sensitivity analysis revealed that cowpea was the best and highly stable. Results of multiple regression founded that there are significant and positive trend between total crop production and time at five percent from zero level on millet, cowpea and watermelon. This means that variation in production impacted by climate change during the long period**.** Correlation coefficient ensured that the effect of climate on grain production in the study area is not significant. However, the effect of average maximum temperature and rainfall on cowpea, time ,groundnut and Roselle were respectively significant.

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