VULNERABILITY ANALYSIS OF MAIZE FARMERS TO CLIMATE RISK IN KWARA STATE, NIGERIA

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ABSTRACT

There is an increasing concern on the vulnerability of farmers to the impact of climate change. The study analyses maize farmers' vulnerability to climate risk, it specifically determines their knowledge of climate change; examines their vulnerability; identifies the determinants of vulnerability and their management strategies. Three-stage random sampling was employed. Descriptive statistics, Likert scale, vulnerability index and stepwise regression were the tools of analysis. Result showed 79.5% of the respondents were males while 20.5% were females; 77.5% had no formal education; and their mean farm size was 2.88ha. The majority of the farmers agreed that the climate is changing which is corroborated by the meteorological data analysed. The vulnerability assessment shows that the farmers are vulnerable. The determinants of vulnerability among the farmers were years of experience, information about climate change, sensitivity of farming resource and susceptibility to drought.. The results also showed that farmers do not have the necessary capacity to mitigate against the effect of climate change. It therefore recommends that adequate climatic information, easy access to drought tolerant maize variety should be prioritize in policy making.

Keywords: Climate Risk, Kwara State, Maize Farmers, Nigeria, Vulnerability.

INTRODUCTION

The Agricultural sector is the main source of livelihood for rural communities in developing countries of the world, Nigeria inclusive (Sowummi and Akintola 2010). World Bank (2007) reported that agriculture accounts for over 70% of the active labour force, and more than 23% of the Gross Domestic Product in Nigeria (GDP). Nigeria is predominantly agrarian, the exploitation of natural resources especially in agriculture remains the driving force for the country's economic development and agriculture is solely climate dependent (Dinar *et.al.,* 2006). Maize is one of the most important cereal crops in the world. Maize or corn is a cereal crop that is grown widely throughout the world in a range of agro ecological environments. Maize has been in the diet of Nigerian's for centuries. Nigeria is the 10th largest producer of maize in the world, and the largest maize producer in Africa (MAFAP, 2013). It started as a subsistence crop and has gradually become more important crop. Maize has now risen to a commercial crop on which many agro-based industries depend on as raw materials. Maize has

been easily accepted by the local population and therefore, it has been rapidly replacing traditional starchy foods like cassava (Olaniyan, 2015). In Nigeria, it is consumed either fresh or processed. It is consumed as pap, maize pudding and so on. It is a major ingredient in infant food brewery and poultry feed industries. It is also fermented to produce hydrolysed dextrins, sugars, and syrup (Sowummi and Akintola 2010). Maize in Nigeria is usually intercropped, with yam, cassava, guinea corn, rice, cowpea, groundnut, and soybeans.

Just like many other developing countries of the world, Nigeria agricultural production is climate dependent (Dinar *et al,* 2006). According to (Adejuwon, 2006; Ziervogel, et.al., 2006) temperature, sunlight, water, relative humidity are the main factors influencing crop growth and yield. This is primarily because rain-fed agriculture is extremely vulnerable to climate. Climate change is attributed to natural climate cycle and human activities which has adversely affected agricultural productivity in Africa (Ziervogel *et al*., 2006). As the planet warms, rainfall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent (Zoellick, 2009). Vulnerability to climate change has become a source of global contention and several studies have emerged in the area (Adger, 1999; Kelly and Adger, 2000; Allen 2003; Adger, 2006; Adger *et.al.,* 2007).

In Nigeria, the vulnerability to climate change can be seen in the devastating effects of recent climate disasters in the various geopolitical region of the country, the various prolonged droughts that are currently witnessed in some parts of Northern region and the late arrival and early cessation of rain (Apata *et al.,* 2009). Nigeria is highly vulnerable to the whims of climate change because of its long (800km) coastline which is prone to sea level rise and the risk of fierce storms (Apata *et al.,* 2009). The incidence of climate change is becoming detrimental economically to farmers as it forces these rural farmers out of business. Small scale farmers in Nigeria, particularly resource poor farmers, are highly vulnerable to climate change. In Northern Nigeria where bulk of maize farmers are found, there is struggle to grow food in a harsh environment characterized by sparse and varying rainfall and changes in weather (Banziger and Araus, 2007). Maize is one of the most important cereal crops in Nigeria (Bankole *et.al.,* 2015) and there is increasing concern about the impact of predicted climate change on the production and productivity of Maize production in Nigeria.

In the light of the foregoing, this research work seeks to answer the following pertinent questions; are maize farmers knowledgeable and aware that they face risk in their farming activity as a result of climate change? What is their level of vulnerability to climate risk? What are the determining factors of their vulnerability? What are the farmers' management strategies to climate risk? It is believed that answers to these questions will go a long way towards providing an understanding of the possible effects of vulnerability to climate on maize farmers and probably adaptive strategy that may lead to sustainable economic scheme and policy. The major objective of this study is, therefore, to carry out vulnerability analysis of maize farmers to

climate risk in Kwara State, Nigeria. The specific objectives are to: determine maize farmers' knowledge and awareness of climate change; examine maize farmers' vulnerability to climate risk; identify the determining factors of household vulnerability and elicit their management strategies to climate risk.

METHODOLOGY

Study area

The study was carried out in Kwara State, Nigeria. The state is predominantly occupied by small scale maize farmers who depend solely on rain-fed agriculture. The topography is mainly plain to slightly gentle, agriculture is the major occupation in the state with over 70% of the population being farmers. The state has two distinct climatic seasons, namely the dry and wet season. The climatic pattern, vegetation and the fertile soil make the state suitable for the cultivation of a wide range of food crops such as maize, cowpea, cassava and tree crops, such as cashew and mango; maize being a prominent crop (KWMANR, 2004).

Sampling technique

A three-stage random sampling procedure was employed for this study. At the first stage, one agricultural zone (Zone D) was purposively selected out of the four ADP zones in the State due to the proponderance of maize farmers in the zone. At the second stage, three Local Government Areas (LGAs) were randomly selected from the seven LGAs in the zone. At the third stage, two villages from the Local Government were randomly selected to ensure adequate representation of villages giving a total of six villages. A total of two hundred (200) questionnaires were administered on maize farmers.

Analytical tools

Descriptive analysis was used to describe the socio-economic characteristics, the respondent's perception to the trends of climate elements in the last ten years, which was also complemented by investigating from the secondary data on climate element in the last ten years and eliciting the management strategies used by the farmers. Also five-point Likert scale was used to analyse the management strategies used by the farmers and investigate the perception of the respondents on the effect of climate change. Vulnerability assessment was used to analyze the vulnerability of maize farmers to climate change. Vulnerability index was constructed using various vulnerability indices such as the Livelihood Vulnerability Index, Environmental Sustainability and Human Development Index which was developed by United Nations development project (Cutter *et.al.,* 2003; Shah *et.al.,* 2013). Thefactors influencing household vulnerability of the farming households were determinedusing step-wise Ordinary Least Square.

Model specification

Maize farmers' climate change vulnerability index

There are two types of approaches to indicator selection; theoretical approach and statistical approach. The theoretical approach is known as deductive approach while statistical approach is known as inductive approach. The indicators used for the components include usually both biophysical (primarily for exposure and sensitivity) and socio-economic adaptive capacity (Adger, et.al., 2004; Yohe and Tol, 2002). The Table for the steps in creating vulnerability index is presented in Table (1). While the indicators used for this study is presented in Table 2.

The values of the indicators were standardized using the formula $(\boldsymbol{x_{1j} - x_1 *)/sd_1}$. Where, $\boldsymbol{x_{1j}}$ is the indicator's value; $\boldsymbol{x_1 *}$ is the mean of the indicators across all respondents; $\boldsymbol{sd_1}$ is the standard deviation.

Table 1: Steps in creating vulnerability Index

Household M ROWS	W_{ij}	X_{ij}	Y_{ij}	Z_{ij} K COLUMNS

Source: Author, 2015

Table 2: Components of Vulnerability and their Indicators

Components	Indicators
Exposure	The frequency of occurrence to hazards.
Sensitivity	Severity and degree of impacts of exposure on respondents
Adaptive capacity	Coping ability to hazards

Source: Author, 2015

For this study the benchmark of the intergovernmental panel on climate change (IPCC) (2001) was used to create the index from the standardized indicators. Vulnerability is seen as the difference between adaptive capacity (socio-economic) and sensitivity/exposure (biophysical):

Vulnerability = (adaptive capacity) – (sensitivity + exposure) (1)

As the adaptive capacity of the farmer increases relative to his sensitivity and exposure, the farmer becomes less vulnerable to climate change risk likewise as adaptive capacity of the farmer decreases relative to sensitivity and exposure, he becomes more vulnerable.

$RHVI = (A_1X_{1j}+A_2X_{2j}+....+AnXnj) – (A_{n+1}Y_{1j}+A_{n+2}Y_{2j}+…+An+nYnj)$ (2)

Where; RHVI is respondents' household vulnerability index, Xs= elements of adaptive capacity, Ys = Elements of exposure and sensitivity. (The values of X and Y was obtained by standardization using their mean and standard errors.) A_i = Principal component result of factors. The whole matrix of variables of adaptive capacity (Xij) and variables of exposure and sensitivity (Yij) appears as follows:

$$X_{ij} \div Y_{ij} = \begin{matrix} (X_{11} + \cdots & X_{2n}) - & (Y_{11} + \cdots Y_{2n}) \\ . & . & . \\ X_{l1} + \cdots & X_{ln} & (Y_{l1} + \cdots Y_{ln}) \end{matrix} \quad (3)$$

Where: *i* is the number of rows (in this case is the 200 individual households); *j* number of columns (in this case is the 20 variables of adaptive capacity, exposure and sensitivity). The vulnerability index of each household was obtained using the equation

$$\text{RHVI} = \begin{matrix} A_1 \\ . \\ A_n \end{matrix} \times \begin{matrix} (X_{11} + \cdots & X_{2n}) - & (Y_{11} + \cdots Y_{2n}) \\ . & . & . \\ X_{l1} + \cdots & X_{ln} & (Y_{l1} + \cdots Y_{ln}) \end{matrix} \quad (4)$$

Where; RHVI= respondent's vulnerability index

In calculating the direction of the relationship of the vulnerability indicators, a negative value was assigned to both exposure and sensitivity. The justification is that households which are highly exposed to climate shocks are more sensitive to risk and damage.

Ordinary Least Square

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+\beta_8X_8+\beta_9X_9+\beta_{10}X_{10}+ U_i \quad (5)$$

Y= vulnerability index; X_1 = income diversification (Dummy: 1 = Yes, 0 = No); X_2= farm size (ha); X_3= household size (total no of household member); X_4= agricultural experience (years); X_5= educational level (years); X_6= exposure of farm to risk (Dummy: 1 = Yes, 0 = No); X_7=susceptibility to hazards (Dummy: 1 = Yes, 0 = No); X_8= information about climate change (Dummy: 1 = Yes, 0 = No) ; X_9=sensitivity of farming resources (1 = Sensitive, 0 = not sensitive; X_{10}=access to extension agents (Dummy: 1 = Yes, 0 = No); β_i are estimated parameters; U_i is the disturbance term,

RESULTS AND DISCUSSION

Socio-economic characteristics of the maize farmers

The socioeconomic characteristics of the respondents in this study are presented in Table 3. The table shows that 79.5% of the respondents were male while 20.5% were female, signifying that female involvement in farming is low compared to male. This could be as a result of the patriarchal culture that persists in most Nigeria ethnic groups. The household size ranges between 11 and 13; the mean age in is 44 years. It was also observed that 77.5% of the respondents had no formal education, 8.5% had primary education, 13% had secondary education and only 1% had tertiary education. This probably will affect their level of knowledge in adaption and mitigation to climate change. The mean farm size was2.88 hectares, which is corroborated by the findings of Olawusi and Tijani (2013) while the mean monthly income of the respondents was ₦23,098.50. On the farm size and their income, the values in Table 3 suggest that these farmers are subsistent farmers. This income is possibly small to mitigate the effect of climate change on the farming household considering the fact that average household size was large. The mean experience of the respondents was 25 years, indicating that these

farmers have been in farming for a reasonable time to identify the possible changes observed in climate change.

Table 3: Socio-economic Characteristics of the Respondents

	Frequency	**Percentage (%)**
Gender		
Male	159	79.5
Female	41	20.5
Total	200	100
Household Size		
7 – 10	44	22
11 – 13	82	41
14 – 16	74	32
Total	**200**	**100**
Mean	**11.50**	
Age	**Frequency**	**Percentage (%)**
30 – 35	16	8
36 – 40	28	28
40 – 45	77	38.5
46 – 50	47	23.5
51 – 55	27	13.5
56 – 60	5	2.5
Total	**200**	**100**
Mean	**44.38**	
Educational level	**Frequency**	**Percentage (%)**
No formal education	155	77.5
Primary Education	17	8.5
Secondary Education	26	13
Tertiary Education	2	1
Total	**200**	**100**
Income	**Frequency**	**Percentage (%)**
₦ 15000 to ₦ 20000	95	47.5
₦ 20000 - ₦25000	66	33
₦ 25000 - ₦ 40000	34	17
≥ ₦ 40000	5	2.5
Total	**200**	**100**
Mean	**₦ 23098.50**	

Farming Experience	Frequency	Percentage (%)
10 – 15	25	12.5
16 – 20	60	30
21 – 25	30	15
26 – 30	38	19
31 – 35	20	10
36 – 40	27	13.5
Total	**200**	**100**
Mean	**24.92**	
Farm Size	**Frequency**	**Percentage (%)**
0.01 -1.00	32	16
1.01 - 2.00	43	21.5
2.01 - 3.00	55	27.5
3.01 - 4.00	59	29.5
5.01 - 6.00	11	5.5
Total	**200**	**100**
Mean	**2.88**	

Source: Field Survey, 2015

Perception on changes in trends of climatic elements

The perception on the trend of climate elements in the last ten years show that the respondents perceived that there are changes in the climatic elements. The results are presented in Table 4. Results showed that the majority (76%) of the respondents indicated that rainfall has been reducing in the last ten years, 23.0% stated that there is no change in the trend of rainfall, while 1% stated that rainfall was increasing. Also, 50% of the respondents stated that temperature has been on the increase in the last 10 years, 30.5% stated that temperature is reducing, while 24.5% stated that there is no change. Majority (98%) of the respondents stated that rainfall is highly unpredictable, while 2% of the respondents stated that rainfall is predictable in the last ten years. The respondents, 78.5% also reported that arrival of rain is too late while 11% stated that it's too early and 10.5% of the respondent stated no changes. Majority (67.3%) of the respondents stated that there is early cessation of rain while 32.7% stated that there is late cessation of rain. Also, 89.1% of the respondents indicated that there are changes in the amount of rainfall while 10.9% of the respondents indicated that there are no changes. Majority, 97.5% of the respondents stated that there are changes in the timing and length of the average rainy season while 2.5% stated that there is no change in the length and timing of the average rainy season. The respondents' perception of trends of climate elements was compared with meteorological data for temperature and rainfall from the weather station in the state. The results obtained from the perception were in consonance with the climate data obtained in the

last ten years (2004-2014) obtained from the weather station in the state and found to reflect their claim. This is presented in figures (I) and (II) respectively.

Table 4: Perception on Trends in Change in Climatic Elements.

Climate Elements	**Increasing (%)**	**Decreasing (%)**	**No Changes (%)**
Rainfall	1	76	23
Temperature	50	34.5	24.5
Climate Elements	**Predictable(%)**	**Unpredictable (%)**	**No Idea(%)**
Predictability Of Rainfall	98	2	
Climate Elements	**Too Late (%)**	**Too Early (%)**	**No Changes (%)**
Arrival Of Rain	78.5	11	10
Climate Elements	**Yes (%)**	**No (%)**	
Late Cessation Of Rain	67.3	32.7	
Changes in Amount of Rainfall	81.9%	10.1%	
Changes in the Length and Timing of average Rainy Season	97.5%	2.5%	

Source: Field Survey, 2015

Perception of climate change effects

Farmers' knowledge and perception about climate change is important determinant of what actions they adopt in trying to mitigate its effects. The result on farmer perception is presented in Table 5. The mean scores for the perceived effect of climate change shows that the respondents agree that climate change bring about negative impact of Maize productivity which agree with the findings of Falaki et al., (2011) which reported that increasing climate variability brings about low agricultural productivity.

Table 5: Perception of climate change effects

Perception	**Mean Score**	**Majority Of Respondent**
Crop pest infestation and diseases	4.61	SA
Decline in crop productivity	4.64	SA
Decline in forest resources	4.34	A
Decline in livestock productivity	4.34	SA
Delayed rainfall	4.62	SA
Desertification	4.34	A
Dry weather	4.14	A

Excessive de-vegetation	4.35	A
Farmer seriously affected	4.80	SA
Food shortage/insecurity	4.31	SA
Frequent death of livestock	3.98	A
High incidence of drought	4.45	SA
High incidence of flooding	4.10	SA
Increase in cost of food	2.90	SA
Rise in temperature	2.27	SA

Source: Field survey, 2015 SA = strongly agree; A = Agree;

Vulnerability assessments analysis

Social vulnerability

The result of the vulnerability assessment apparently showed that farmers have a diverse social vulnerability. The negative sign showed that the variable under consideration decrease the vulnerability of farmers to climate change and vice versa. Table 6 presents some of the social variables as related to vulnerability and their effects on vulnerability level. It can be observed that 77.5% of the respondents do not have ability to read and write. This in turn reduces household's capacity to understand climatic information, understand and adopt improved technology, easy access to market information. Farming experience and Access to extension services is a measure of reducing vulnerability and fostering adaptive capacity to climate change. However, 23% of the respondents have stated that they do not have access to extension agents. In summary, it is clear that vulnerability level of respondent to the frequently occurring natural shocks from their social capital endowment perspective is high. Individuals in a community often vary in terms of economic status.

Table 6: Social vulnerability variables

Social vulnerability variable	Percentage	Contribution to Vulnerability
Sex (female farmers)	20%	+
Educational level (no education)	77.5%	+
Marital status	100%	-
Farming status (full time)	96.5%	+
Farming experiences (less than 15)	5%	+
Access to extension agent (no)	23%	+

Source: Field survey 2015

Key: + increase in vulnerability, - decrease in vulnerability

Economic vulnerability

The economic vulnerability assessment mainly focuses on the economic status of respondents. The economic characteristics of the respondents' shows that majority of the respondents

survive on undiversified income and small farm size. This indicates a high level of economic vulnerability of the respondents to shocks. Table 7 displays the economic characteristics related to vulnerability of climate change and their effects on vulnerability level. Apparently, large majority of the farmers are economically vulnerable to the impact of climate change. For instance, most respondents (68.5%) do not have access to alternative income sources apart from agriculture, this is likely to affect their economic stability since they are not income diversified. Also, 46% of the respondents engage in income diversification through alternate source of income are also affected.

Table 7: Economic vulnerability

Economic vulnerability	Percentage	Contribution to Vulnerability
Are you well informed about climate change (no)	98.5%	+
Access to information (no source of information)	23%	+
Land size (less than 2 hectare)	16%	+
Do you engage in income diversification (No)	68.5%	+
Climate change affect your income diversification (yes)	46%	+
Climate change affects access to market (no)	72%	-
Climate change cause variation on the quality of produce (yes)	37.5%	+

Key: + increase in vulnerability, - decrease in vulnerability

Source: Field survey 2015

Classification of Households by the range of their vulnerability index

In order to analyse the vulnerability level of each the respondent household, variables were used to measure the differences between the adaptive capacity and the exposure/sensitivity. The vulnerability index of each respondent household was calculated as shown in Figure III. About 53% of the respondent's households were vulnerable due to small land size, fragmented farm, low productivity of land (yield) due to low fertility. Moreover, this category of farmers has less diversified livelihood options, lower level of access to technology, lower level of access to early warning information as calculated from data collected from the field. Similarly, around 33% of the respondents less vulnerable where they can cope with climate change risks as shown by the vulnerability index. They are still exposed and serious level of climate change can draw them to vulnerable level. On the other hand, 14.5% of the respondents' households are highly vulnerable. This is presented in Table 8

Table 8: Classification by the range of their vulnerability index

Vulnerability index	Vulnerability	Percentage
+ 0.022938 to +3.794606	Less vulnerable	33.0
-2.98797 to -0.09073	Vulnerable	52.5
-4.60677 to -3.02295	Highly vulnerable	14.5
Total		100

Source: Field survey, 2015

Determinants of household vulnerability

The results of the stepwise ordinary regression analysis Table 9 showed that years of experience (significant at 1%), information about climate change (significant at 1%), sensitivity of farming resource (significant at 5%) and susceptibility to drought (significant at 5%) is the most important determinant of vulnerability to climate risk. Increase in the farmers' experience will increase their vulnerability to climate change by 14.00%; this is likely to mean that the farmers will be reluctant to change their method of farming or probably adopt technologies that may reduce their vulnerability. The result also showed that the more susceptible farmers to drought, the more their vulnerability to climate change (54.53%). This is expected; drought is one of the major evidence of climate change, farmers prolonged exposure to drought will make them more vulnerable. Information about climate change will reduce farmers' susceptibility by 86.56%. These probably mean that farmers will prepare ahead using the information received to adopt strategies that will help them mitigate against climate change. Reducing the sensitivity of farming resources of farmers will reduce their vulnerability by 34.08%. This will probably mean the resources are well managed in right time and proportion in such a way that it minimizes waste that may result due to climate change.

Table 9: Stepwise ordinary regression analysis output

Variables	coefficients	standard error
agricultural experience	0.140*	0.045
susceptibility to hazards	5.453*	1.654
information about climate change	-8.656**	2.613
sensitivity of farming resources	-3.408**	1.444

*Significant at 1%; ** Significant at 5%

Source: field survey 2015

Management strategies adopted by farmers to combat climate risk

It is unfortunate that despite the visible and empirical evidence of climate change, farmers are incapacitated to mitigate its effect, the management strategy analysis showed that majority of the farmers' vulnerable to climate risk might not be coping well. Only 5% of the respondents engage in small scale irrigation while the remaining 95% stated that they do nothing after planting except trust in God; their reason being that they cannot afford to irrigate.

Table 10: Mitigation Strategies adopted by the respondent

Management strategies	Frequency	Percentage
I do nothing and trust in God	190	95
I do small scale irrigation	10	5

Source: field survey 2015

CONCLUSION AND RECOMMENDATIONS

The study highlighted the socio economic features of the maize farmers, their perception of trends of climate elements and effects of climate change around their surroundings, their vulnerability to climate risk, factors determining their household vulnerability and the management strategies adopted by the respondents to combat climate risk. Based on the findings of this study, it can be concluded that there is a very high incidence of vulnerability to climate risk among maize farmers in Kwara State. Respondents were vulnerable to climate risk and have little or no management strategies to combat climate change. Due to the various determinants observed to influence households' vulnerability to climate risk, polices emphasis should be on access to small scale irrigation, adequate information dissemination, availability and easy access to drought tolerant varieties of maize.

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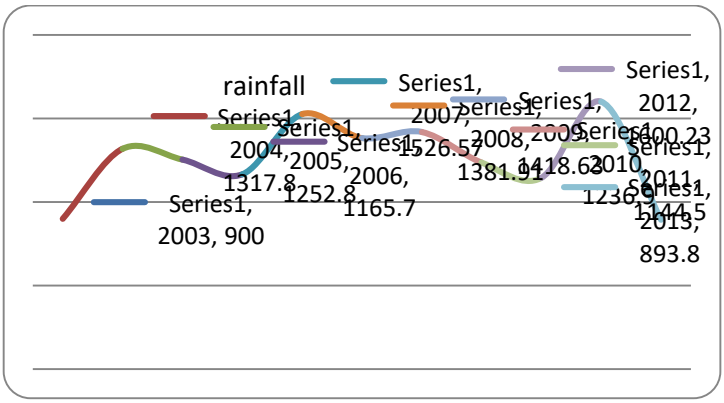
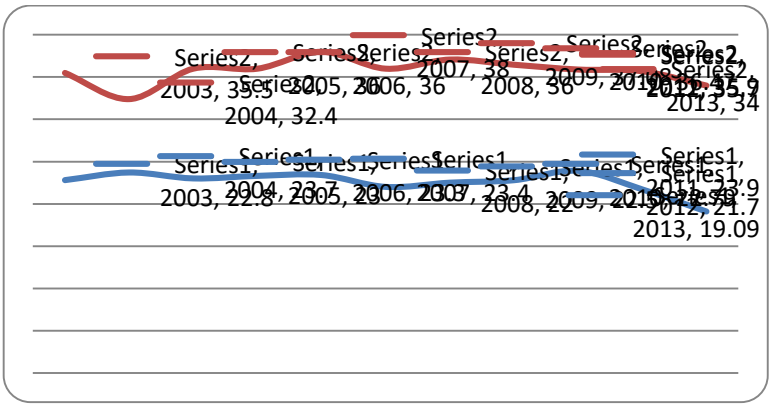
FIGURES

Figure I: Trend of Rainfall pattern in the study area in the last 10 years



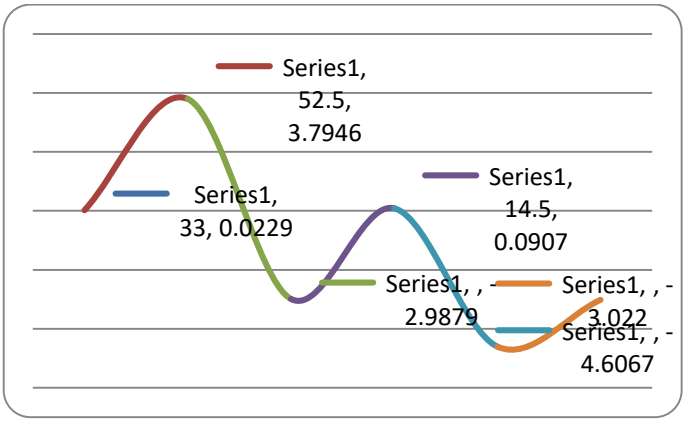
Source: KWMAR (2004)

Figure II: Trend of Temperature in the study area in the last 10 years



Source: KWMAR (2004)

Figure III: Vulnerability index by RHVI. Source: Author, 2015



Sources: Computed using the vulnerability index developed